A CAHNERS PUBLICATION

OCTOBER 1, 1987

EDN®

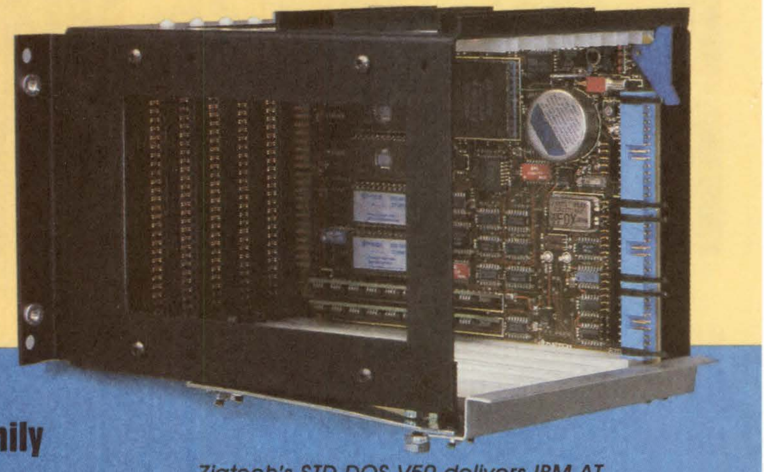
KEEPING AMERICA COMPETITIVE

Engineering decisions strengthen US's competitive stance

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Manufacturers serve up a variety of surface-mount connectors

From the Company That Wrote the Book on STD DOS...



The Industrial Strength Computer Family

STD DOS is Ziatech's implementation of IBM PC DOS on the rugged, low-cost STD Bus, giving industrial control applications access to the huge library of IBM PC software. In other words, a PC tough enough for industrial applications. Ziatech offers a complete family of STD DOS target systems and development tools designed to meet your application's specific requirements.

Single Board IBM AT Performance

The STD DOS V50 system delivers IBM AT performance and software compatibility on a single board STD Bus computer. Its unique surface mount design packages the functionality of many boards into one including: on-board 16-bit data bus, 832K memory capacity, real-time battery-backed clock, AC/DC power-fail protection, interrupt controller, DMA, two serial channels and three counter/timers.

Ziatech's STD DOS V50 delivers IBM AT performance and software compatibility.

Low Cost DOS, Under $600

STD Mini-DOS runs PC DOS on a single 8088-based STD Bus computer for applications with physical size constraints requiring less than 62K application program memory. Instruments, data-collection terminals, and machine control applications can be equipped for under $600 in single quantities.

The Original STD DOS with More Memory

Ziatech's original two-board set includes an 8088-based single board computer and a DRAM memory board for applications with large memory needs. Both Mini-DOS and the original STD DOS feature two parallel ports, five counter/timers, a serial port, interrupt controller and provisions to add an Intel 8087 math co-processor.

Video Options, New Driver Support, and More

System developers wanting to see more of the STD DOS family can choose from a growing list of options, including an EGA video/keyboard controller, disk subsystems, multiprocessing, solid-state disks, a device driver library called STD DDP, and a soon-to-be-released CMOS STD DOS system.

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CIRCLE NO 79

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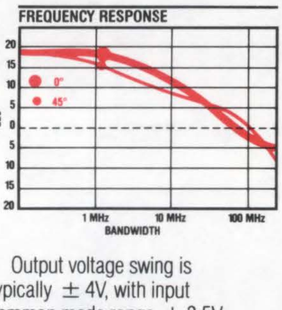
These op amps have DC performance parameters similar to the industry-standard OP-27, but with extended AC performance, optimized for ± 5V power supplies.



Output voltage swing is typically ± 4V, with input common mode range ± 3.5V.

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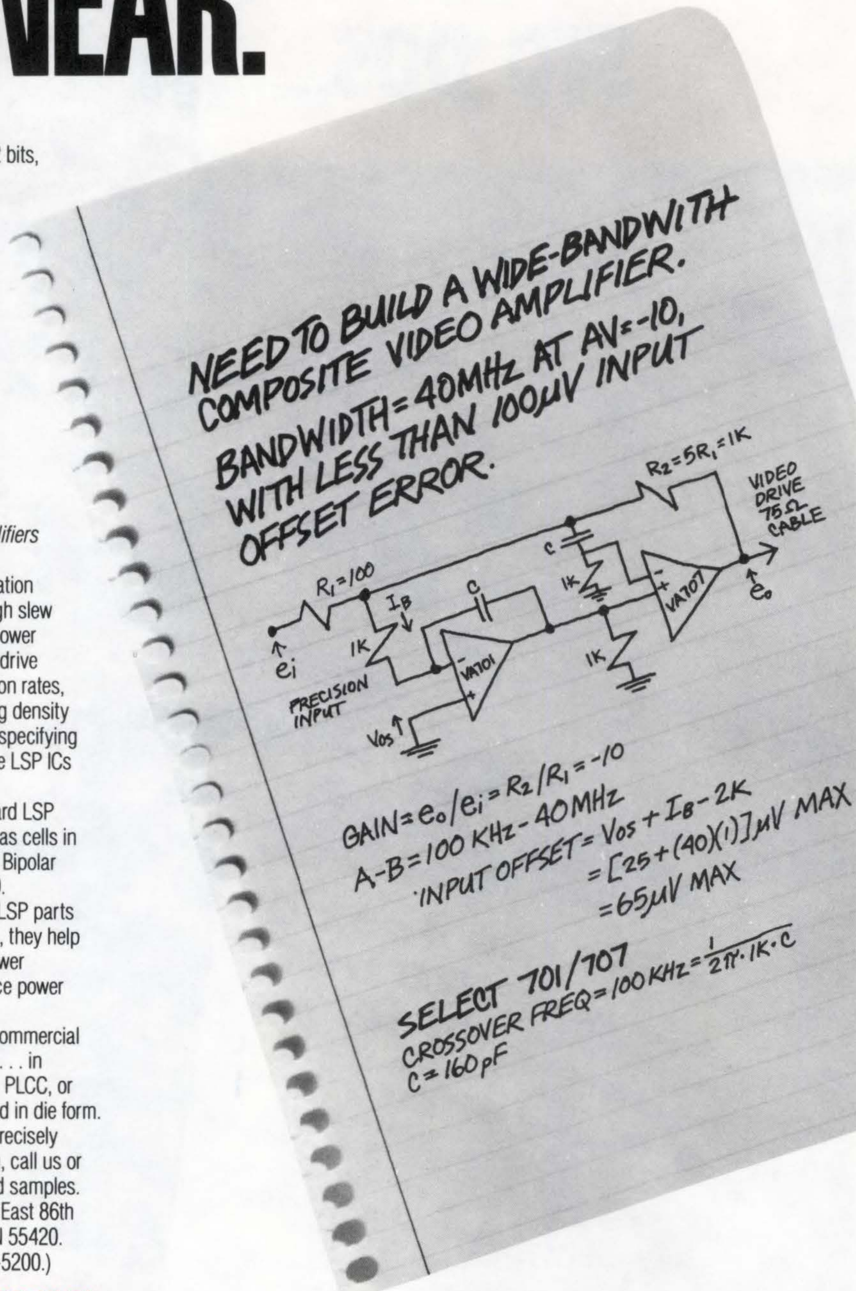

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Now that Wavetek has built a new home for test instruments, look who's dropping in.

Imagine a full-size rack loaded with the highest performance instruments available.

Now picture all that performance in a much smaller space—inside the chassis of the new Wavetek Model 680, an open-architecture system of instruments on cards. Select from instruments made by Wavetek and other top manufacturers like Racal-Dana and Datron.

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Best of all, the Model 680 is available now. For details, call or write us today. Wavetek San Diego, Inc., 9045 Balboa Ave., San Diego, CA 92123; Telephone 619/279-2200.

WAVETEK

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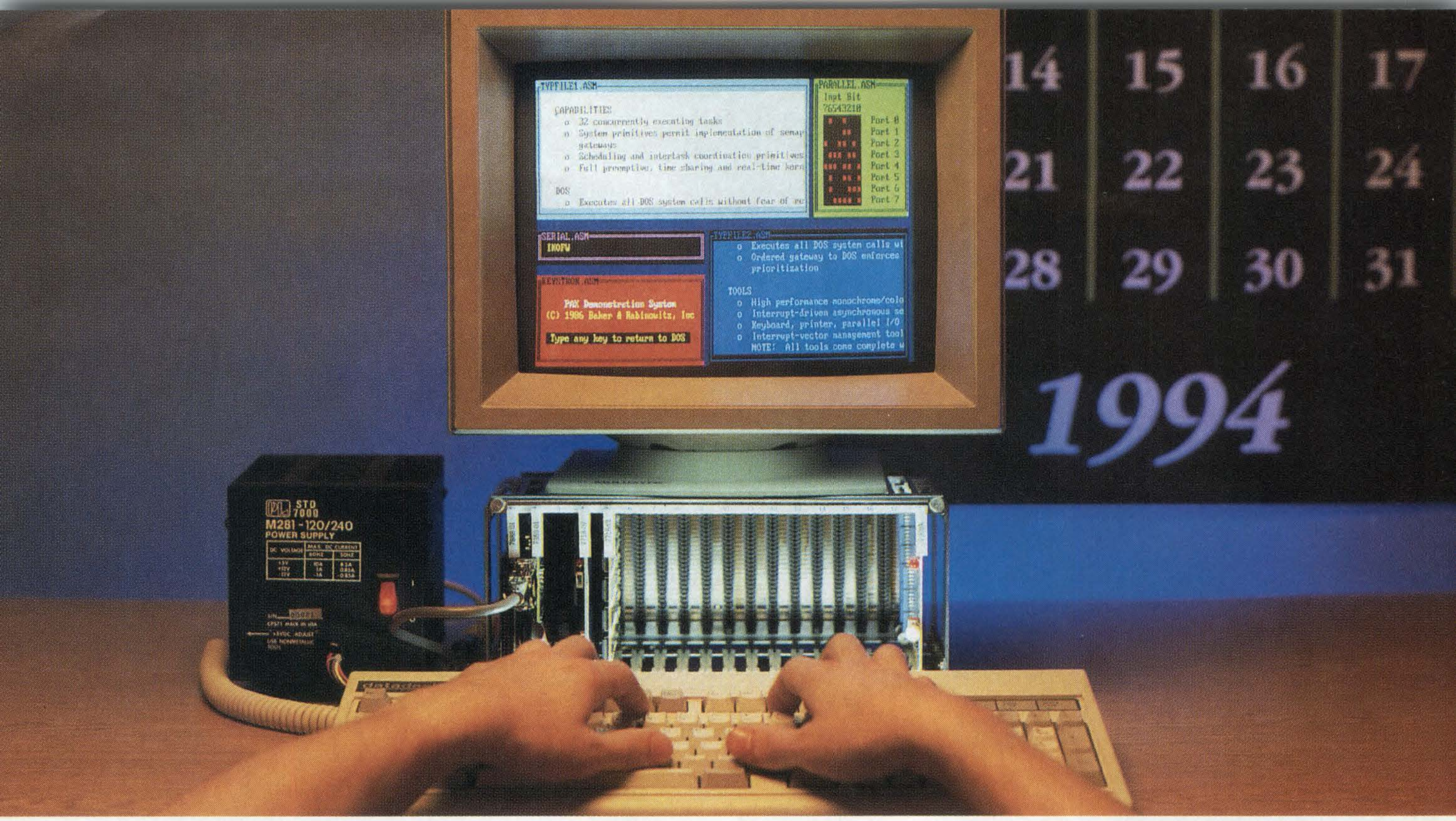
Circle 99 for demonstration



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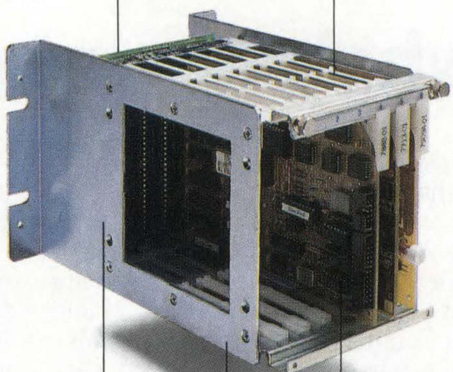
Grew up in the school of hard knocks. Secured on 4 sides, System 2 withstands 10gs of shock

No fan or heat sink needed, could be battery powered. Consumes as little as 1.25 watts



Works in places you wouldn't. 0° to 65°C operating temperature range

If it fails, down-time is minimized. All boards can be replaced in under 5 minutes

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PL055

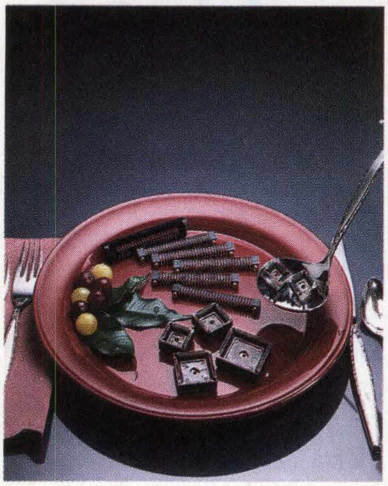
INDUSTRIAL COMPUTERS PRO-LOG IN CONTROL QUALITY

Volume 32, Number 20

EDN

October 1, 1987

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Surface-mount connectors won't eat up your valuable pc-board space. A knowledge of soldering techniques and connector configurations will help when evaluating a manufacturer's bill of fare. See pg 142. (Photo courtesy Methode Electronics)*

DESIGN FEATURES

Continued on page 7

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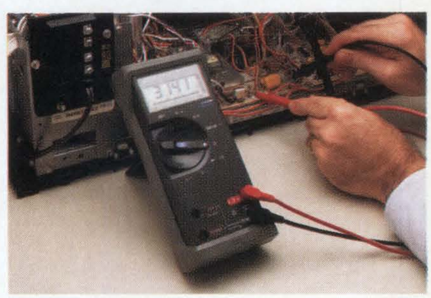

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Continued from page 5

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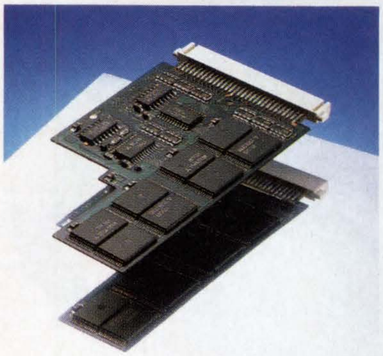
October 1, 1987



***You can use smart cards** for applications ranging from customization of terminals and peripherals to mass storage for computers that must run in hostile environments (pg 61).*

Continued on page 9

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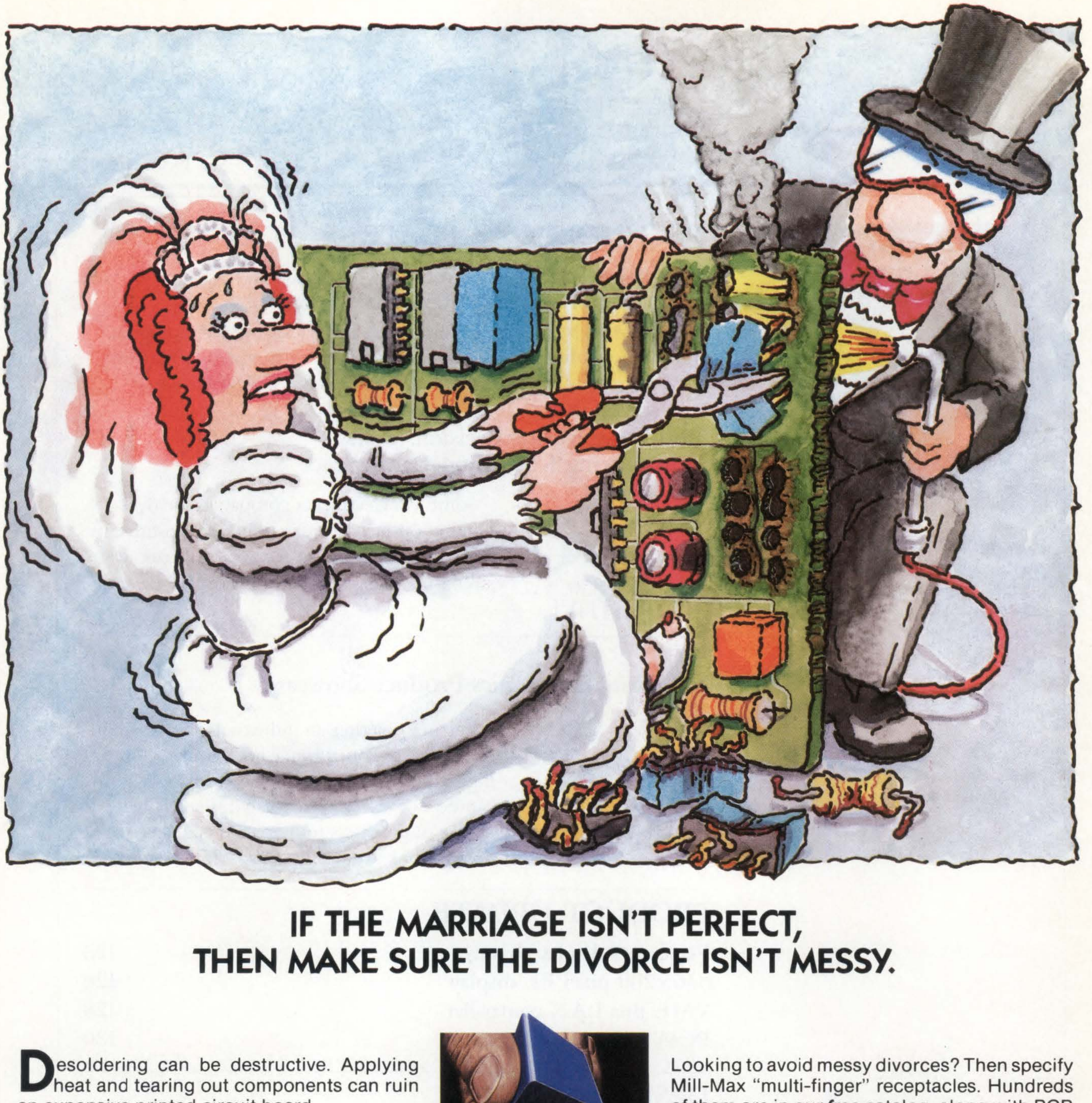

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EDN

October 1, 1987

KEEPING AMERICA COMPETITIVE

EDITORIAL

Technology alone won't give you a competitive edge.

NEW PRODUCTS

PROFESSIONAL ISSUES

The frustrating and fine art of independent consulting.—*Deborah Asbrand, Associate Editor*

LOOKING AHEAD

VLSI ATE becomes a critical issue . . . Signal-generator market to top $775M by 1993.

DEPARTMENTS

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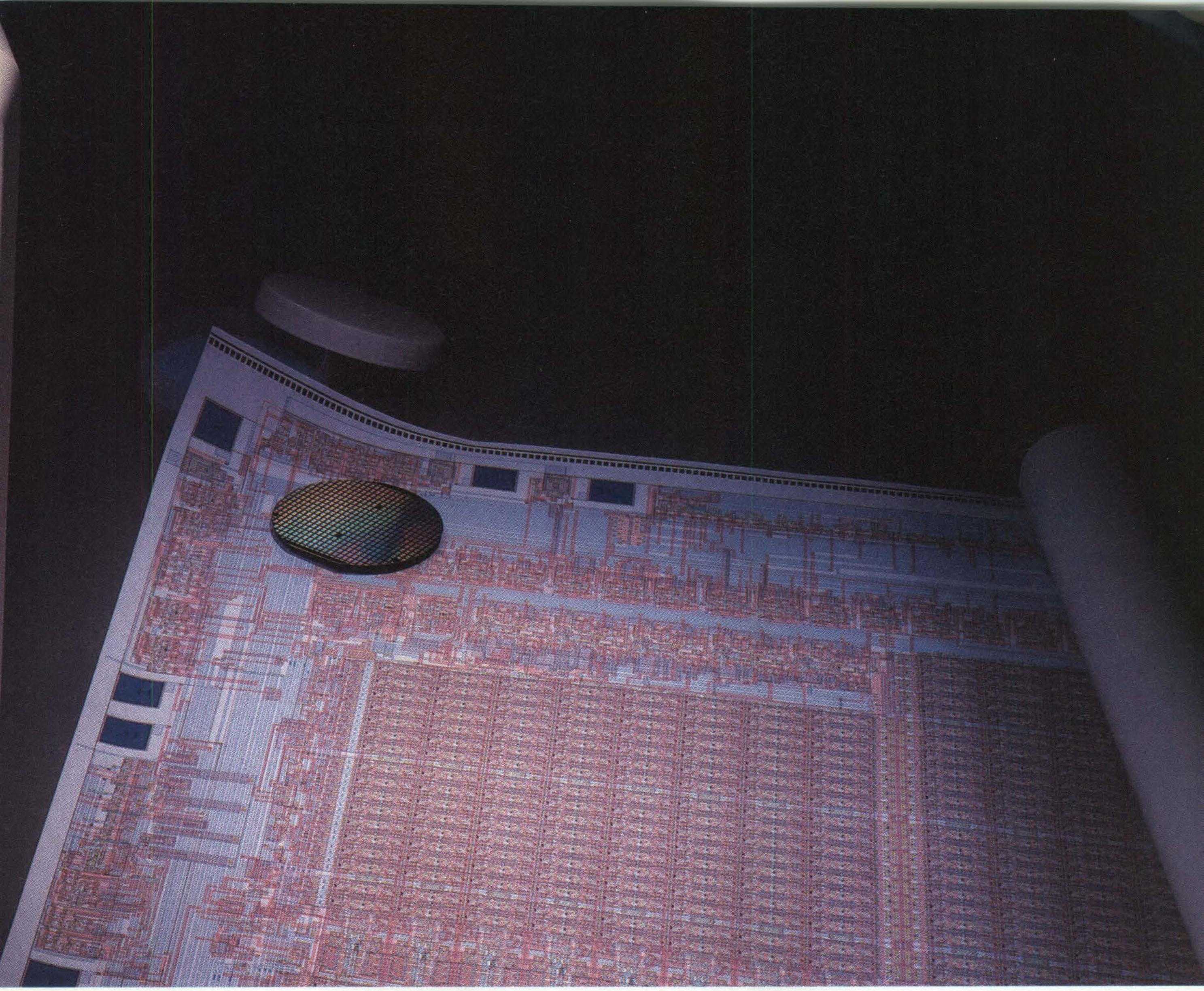

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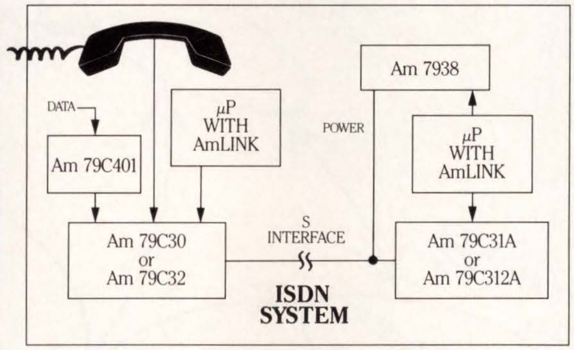
With AMD's five chip set, everything is included. All designed to work together. And to conform to the CCITT recommendations.



The set is so highly integrated, you won't need extra chips for things like dialing and ringing.

Each of AMD's chips was designed to take advantage of the most efficient technology for its function, including bipolar and CMOS. The set consists of the Am79C30 Digital Subscriber Controller, the Am79C31A/312A Digital Exchange Controller, the Am79C32 ISDN Data Controller, and the Am7938 Quad Exchange Power Controller which works with the Am79C31A/312A. And it won't be long before we'll have protocol devices like the Am79C401 Integrated Data Protocol Controller.

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Once you've got hardware, you'll probably be needing some software. That's easy. AMD has everything from low level device drivers to AmLINK, our LAPD software.

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We also provide well documented development boards that come complete with demonstration software. Understanding the capabilities, flexibility and functionality of complex ISDN chips has never been easier.

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There's one more good reason why you should pick AMD. Our ISDN chips are in field trials with Illinois Bell, Mountain Bell, the Deutsche Bundespost and others. The chips were certified in field trial test beds. And they're still in use today.

Get in touch with AMD for more information. Then get your product off to a great start. And finish.

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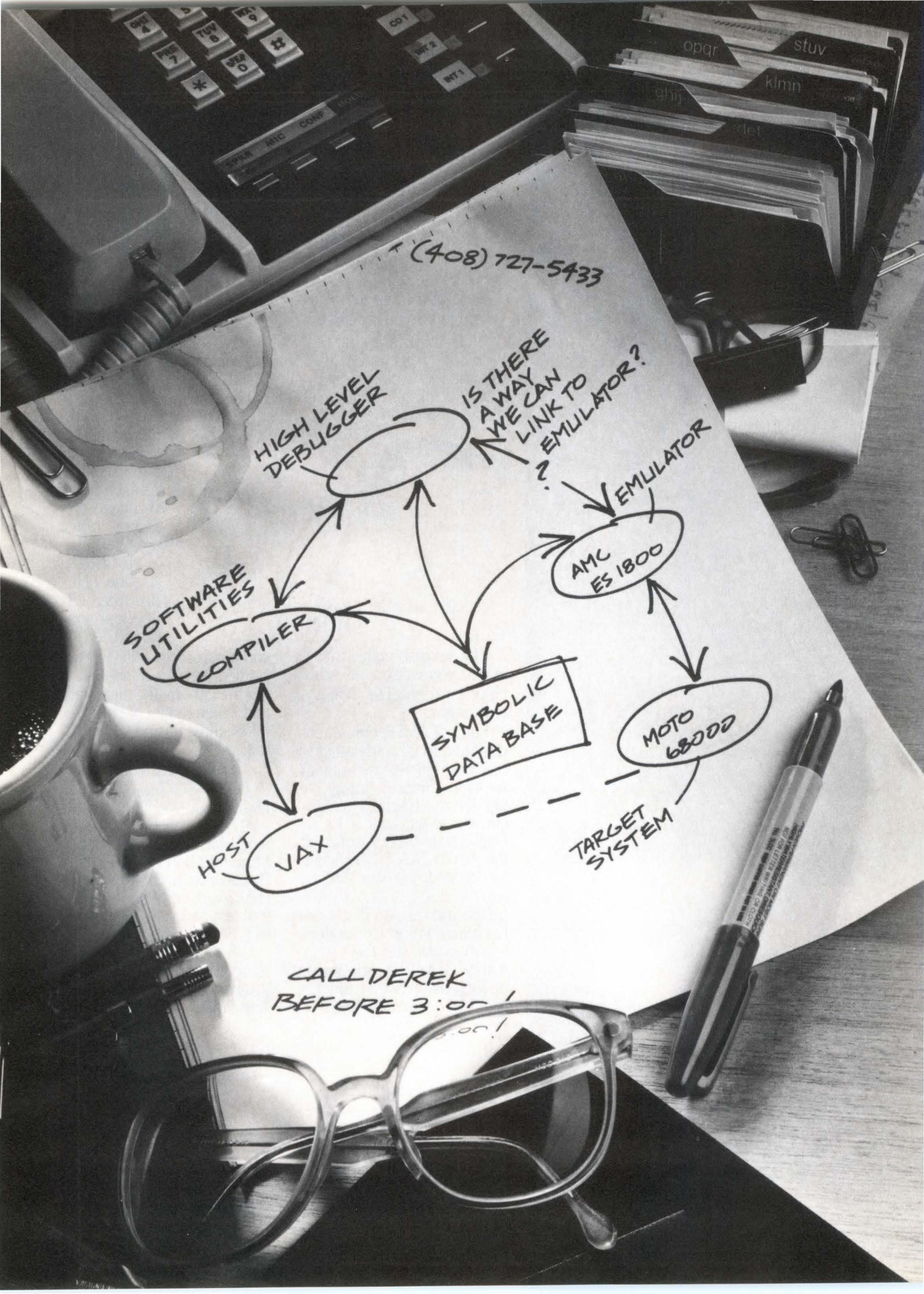

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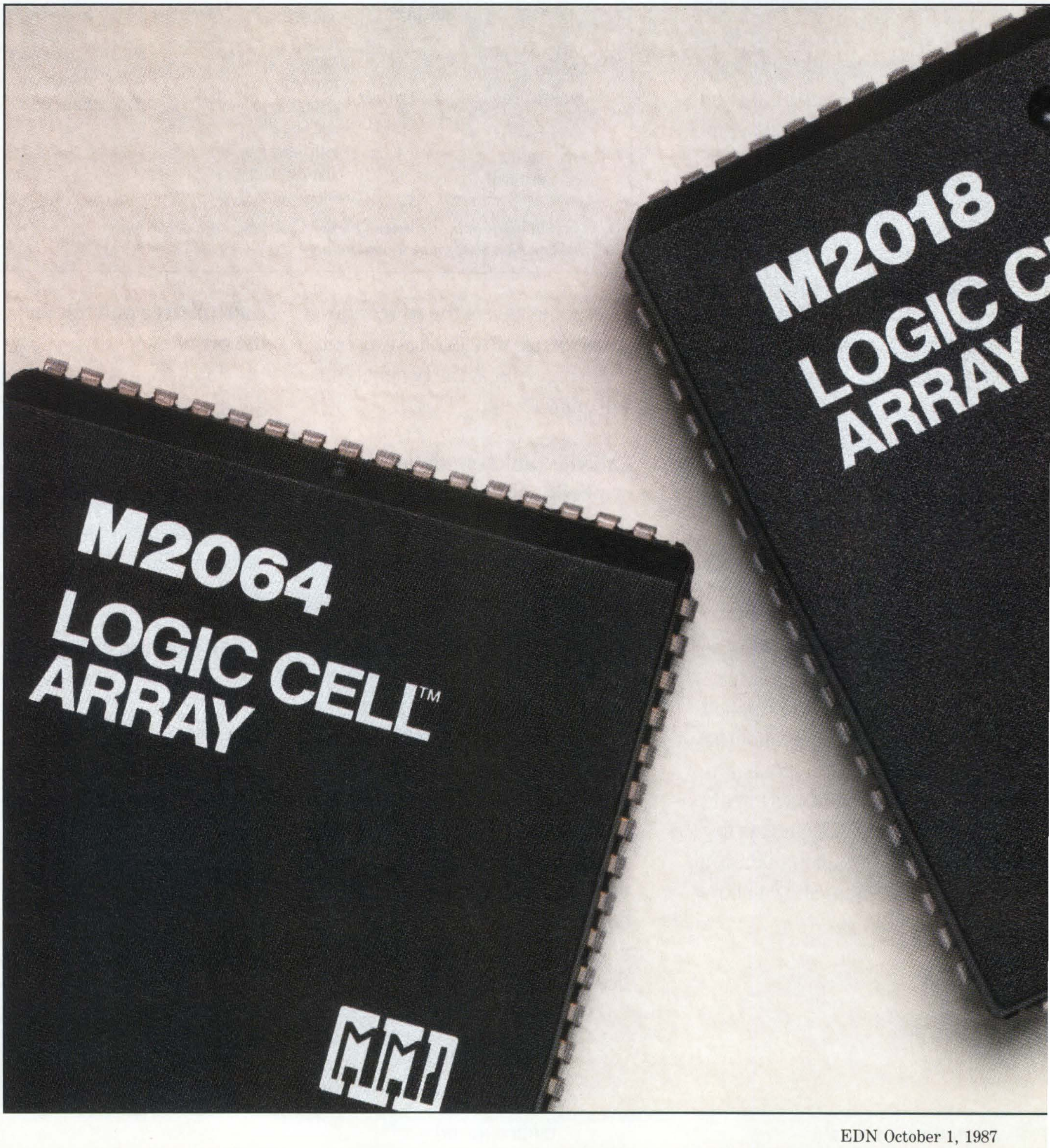

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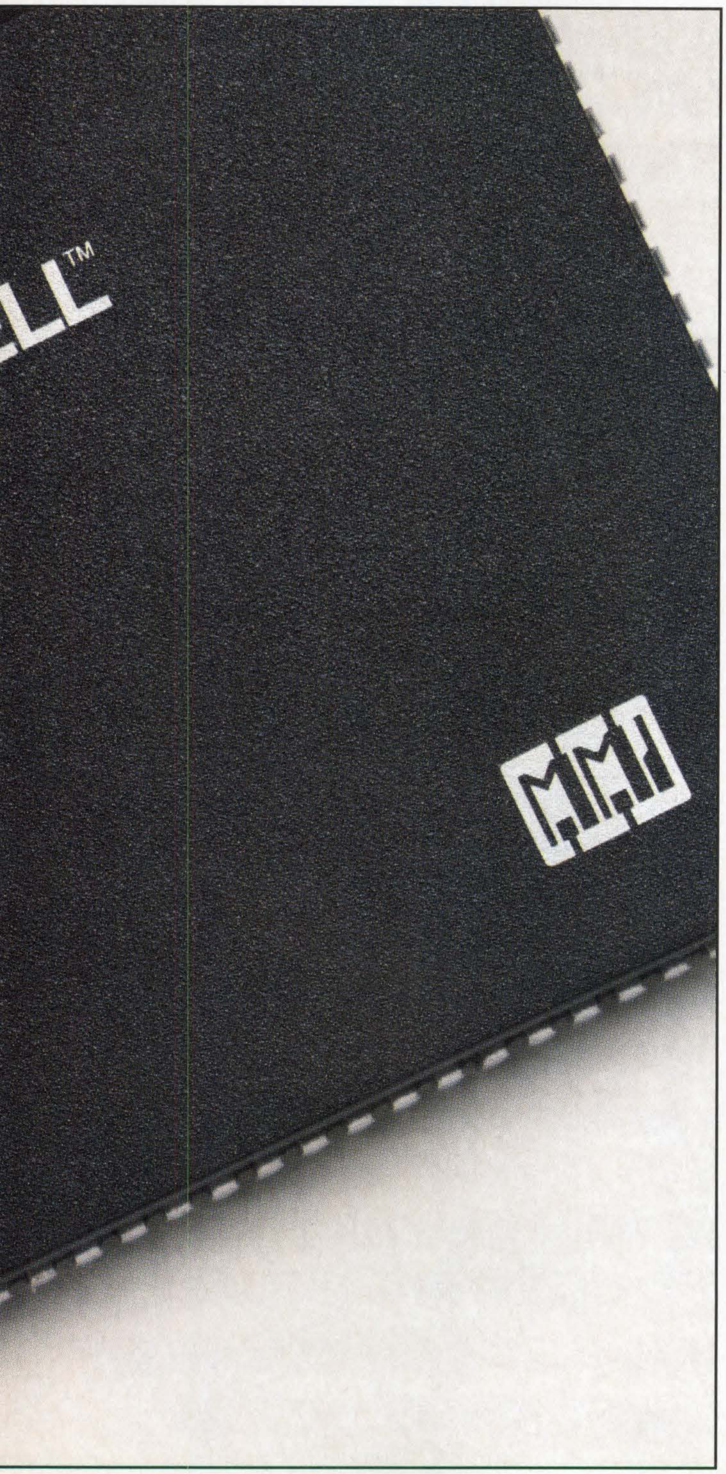

You also get a choice of surface mount, pin-grid or DIP packages. In speeds up to 70MHz.

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With our easy-to-use XACT™ software, you simply draw the design and let your IBM® PC XT/AT computer convert it to code. You can use our library of over a hundred macros or define your own. Let the software perform the interconnections automatically (unless you specify something unique). And generate documentation at the touch of a button.

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Because there's nothing else like having the right part from the right company.

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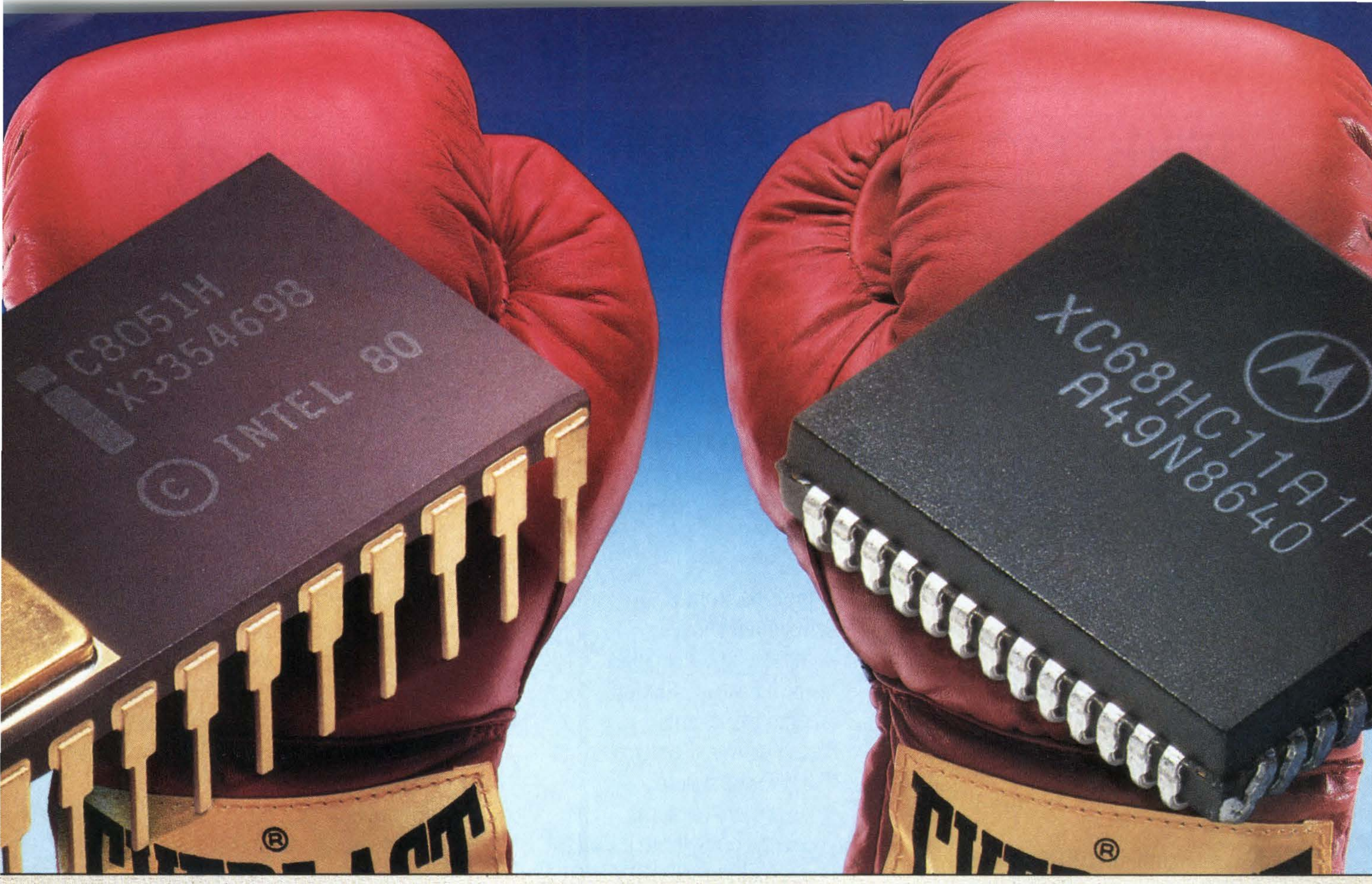

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***Processors supported by Microtek:** 80386, 80286, 80186, 80188, 8086, 8088, 68020, 68010, 68008, 68000, 6809, 6809E, 6502, Z80, NSC800, 8085, 8032, 8051, 8031, 8344, 8048, 8049, 8050, Z8, SUPER 8, 68HC11, 64180, 80515.

NEWS BREAKS

EDITED BY JOAN MORROW

80286-COMPATIBLE μP CHIP OFFERS LOW-POWER OPERATION

The first CMOS μP chip that is directly compatible with the 80286 chip is available from Harris Semiconductor (Melbourne, FL, (305) 724-7418). The CMOS 80C286 chip operates with a speed-power factor of 20 mA/MHz, which translates to about 40% of the power needed to run an NMOS 80286 chip at 12.5 MHz. Although the static 80C286 chip's clock rate can be as fast as 12.5 MHz, low-cost 10-MHz versions of the chip are also available. The manufacturer expects to offer a 16-MHz version of the chip late this year. Samples of the 80C286, which operate in the commercial temperature range (0 to 70°C), are available now in 68-pin PGA packages; PLCC packages should be available in early 1988. Prices range from $125 (100) for the 10-MHz version (CG80C286-10) to $170 (100) for the 12.5-MHz version (CG80C286-12). Military- and industrial-temperature-range chips are scheduled for introduction by the middle of 1988.—Jon Titus

BOARD ADAPTS PERSONAL SYSTEM/2 TO SCSI

Future Domain Corp (Tustin, CA, (714) 259-0400) offers a SCSI (Small Computer System Interface) host adapter for the IBM PS/2 Series computers. The MCS-350 host adapter operates with the PS/2 Models 50, 60, and 80, and provides compatibility with the IBM Microchannel: The board comes with an IBM-assigned ID number. The board transfers data at 1.67M bytes/sec and will operate in multitasking software environments such as Xenix and OS/2. Evaluation units of the $390 board will be available in this month; you can expect production quantities to be available by the end of the year. The company also offers software support and a software tool kit to OEMs.
—Maury Wright

FET POWER DEVICES HAVE AVALANCHE-MODE ENERGY ABSORPTION

E-FET power MOSFETs from Motorola Inc (Phoenix, AZ, (602) 244-4911) feature an enhanced and specified ability to absorb energy while in the avalanche mode. The vendor achieved this enhancement through a new manufacturing process called TMOS IV that features improved geometries and diffusion techniques. The family includes 12 device types covering a 50 to 100V range with current capacities to 50A. Each device's data sheet includes unclamped inductive switching ratings for multiple conditions and specifies the device's commutating safe operating area. Prices range from $0.54 (100) for the MTP15N05E, rated at 50V and 15A, to $2.80 (100) for the MTP50N05E, rated at 50V and 50A.

Specifications for the E-FETs as well as for more than 1600 of the vendor's power MOS and bipolar devices appear on a data disk available from Motorola's sales offices or for $2 from the company's literature distribution center (Box 20924, Phoenix, AZ 85063). The disk, which is formatted for IBM PCs, includes an embedded database manager that provides answers to component queries in seconds.—Steven H Leibson

RELATIONAL DATABASE AVAILABLE FOR LANs AND PS/2

Version 2.01 of a relational database software package called Paradox provides an Expanded Memory Specifications (EMS) module that lets you access as much as 8M bytes of system memory in your IBM PS/2 Model 50 and 60 computers. The LAN version of this package permits as many as six users to access and update a single database simultaneously. Manufactured by Ansa Software (Belmont, CA, (415) 595-4469), Paradox is not copy protected, comes with extensive documentation, and includes telephone customer support. The LAN version costs $995; the single-user version is $725. If you already have version 2.0, the upgrade is free.—J D Mosley

NEWS BREAKS

FDDI CHIP SET EASES DESIGN OF 100M-BPS LANs

A 5-chip set from Advanced Micro Devices (Sunnyvale, CA) allows local-area networks to achieve 100M-bps operation via fiber-optic links. The Supernet family consists of the Am7984 receiver, the Am7985 transmitter, the Am79C83 ring media access controller, the Am79C82 data path controller, and the Am79C81 RAM buffer controller. The chip set complies with the proposed ANSI X3T9.5 standard commonly referred to as the Fiber Distributed Data Interface (FDDI). Samples are available now; the 5-chip set costs $625 (100).—David Shear

PC BOARD SET SIMULATES NAVY TACTICAL DATA SYSTEM INTERFACE

An ANEW/NTDS board set for PC/XTs, ATs, and compatibles from Sabtech Industries (Anaheim, CA, (714) 630-9335) simulates the Navy Tactical Data System (NTDS)/NATO software and hardware parallel data interface. (This interface is used in most shipboard data-distribution networks.) The single-slot board set, comprising an adapter board and a daughter board, lets you inexpensively create the Navy's AN/UYK computer environment. You can program the board set for full-duplex 8-, 16-, 24-, or 32-bit-wide parallel word transfers, as well as select DMA or programmed I/O. The ANW1632/NT1632FS board set includes software and its source code, interface ribbon cables, and a loopback test adapter board for $3250.—Margery S Conner

ARCNET CARD GIVES YOU SWITCHABLE PERFORMANCE OPTIONS

The TC6042 Arc-Card CE (Compatible/Enhanced) from Thomas-Conrad Corp (Austin, TX, (512) 836-1935) is a half-size card that plugs into your IBM PC or compatible computer to provide either standard or enhanced Arcnet performance at the flip of a switch. When run in its standard (compatible) mode, the TC6042 is a drop-in replacement for other Arcnet network interface cards, such as Novell's RX-Net and SMC's PC100/110. In its enhanced mode, the TC-6042 operates in all 8088-, 80286-, and 80386-based PCs with bus speeds as fast as 20 MHz. This $495 card works with a variety of PC add-in boards, such as EGA, EMS, and emulation adapters; the card includes software drivers to accommodate as many as five dedicated interrupt request (IRQ) lines. A $40 optional autoboot PROM lets you access your LAN via a diskless PC.—J D Mosley

TV/VIDEO SYNC POD LOCKS SIGNALS ONTO DIGITAL-SCOPE SCREENS

Hewlett-Packard's (Palo Alto, CA) HP1133A TV/video sync pod helps digital oscilloscopes make timing and amplitude measurements on composite video signals by generating synchronization pulses from the composite signal and providing dc restoration. The $275 instrument provides clamped and unclamped versions of the test signal and contains a variable-gain amplifier to aid small-signal measurement. When coupled with the stability of a digital oscilloscope's timebase, the pod allows you to easily inspect video frames, fields, horizontal and vertical intervals, and vertical-interval test signals.—Steven H Leibson

POWER DARLINGTON HAS SAFE-OPERATING-AREA PROTECTION

For applications that require a self-protected 400V power Darlington, you can use the VB010 from SGS Microelettronica SpA (Agrate, Italy, TLX 330131). The device has a maximum output current of 8A and protects itself from damage caused by output short circuits or operation outside its safe operating area (SOA). In addition, it incorporates thermal shutdown circuitry to prevent excessive power dissipation.

In the event of short circuits, SOA violations, or thermal shutdown, the Darlington output stage is turned off, and the device activates a fault-diagnosis logic output. The VB010's control input is TTL/CMOS compatible, and you can program the base current to the Darlington by adding an external resistor in the device's control logic supply. Samples of the VB010 will be available in the first quarter of 1988. Production parts will cost approximately \$3.50 (100,000).—Peter Harold

SINGLE EUROCARDS PUT IBM PC-COMPATIBLE COMPUTER ON STE BUS

A set of four single-Eurocard boards from Arcom Control Systems Ltd (Cambridge, UK, TLX 94016424) allows you to install IBM PC compatibility into an STE bus computer system. You can use the system for program development, and you can extend it with a wide range of STE bus I/O boards to implement target systems. The CPU card has an 8088 microprocessor, an 8087 math coprocessor, 256k bytes of RAM, and sockets for firmware EPROMs. It is accompanied by a floppy-disk-controller board, a CGA/EGA graphics board, and a serial/parallel interface board. The CPU card is supplied with a legal BIOS that makes it 100% IBM PC compatible—for example, the system runs Microsoft's Flight Simulator. The 4-board set sells for around £1000.

—Peter Harold

16K ECL RAM BOASTS AN ADDRESS ACCESS TIME OF 8 nSEC

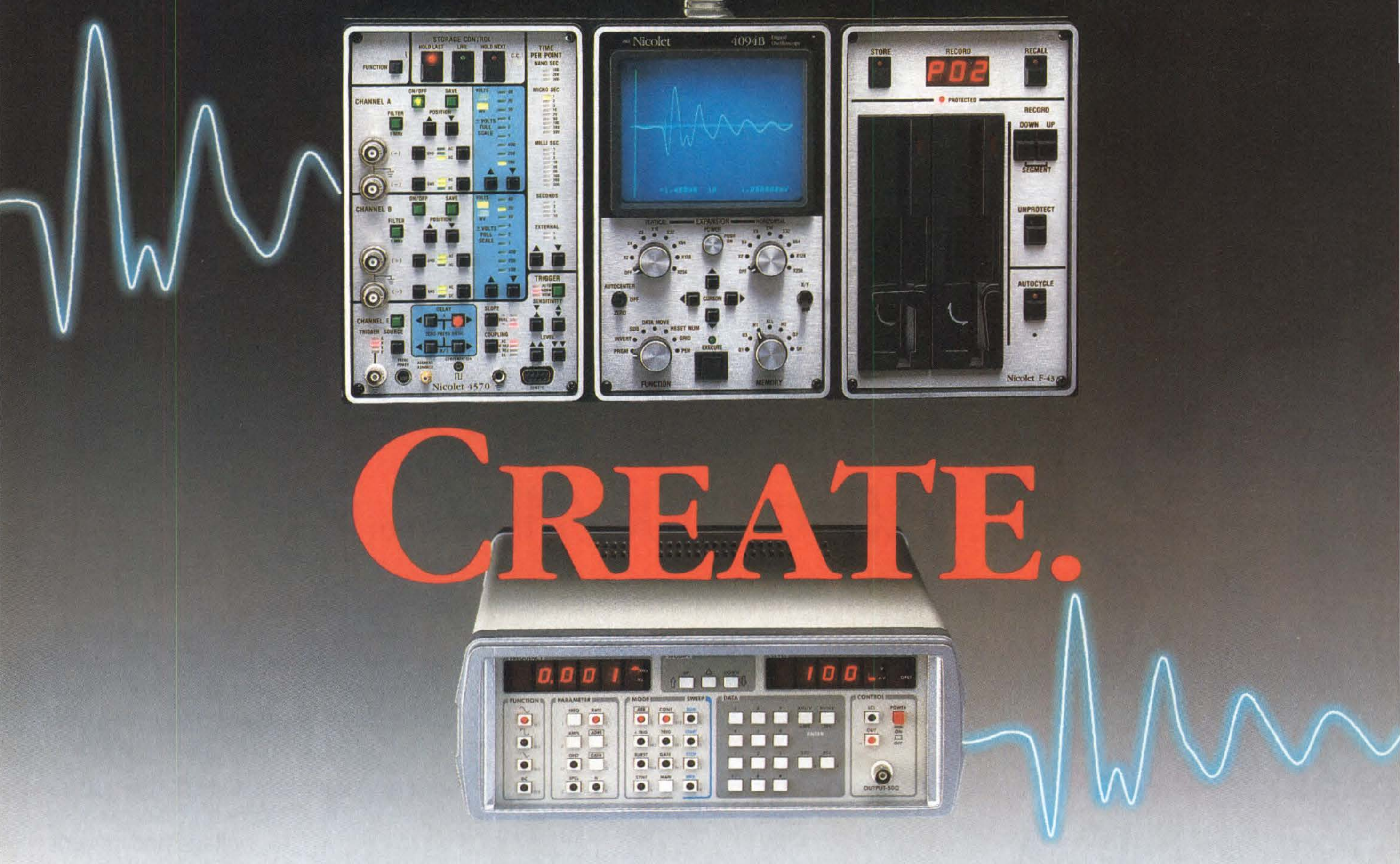
Fujitsu Ltd (Tokyo) has introduced a 16K ECL RAM with an address access time of 8 nsec max. You have a choice of two versions: the MBM10484A.8 (10K), which has a supply voltage of −5.2V, and the MBM100484A.8 (100K), with a supply voltage of 4.5V. Samples are available for ¥12,000 (\$80). In the US, contact Fujitsu Microelectronics (Santa Clara, CA, (408) 562-1382; TWX 910-338-0190.)—Clare Mansfield

DATACOMM ANALYZER SAMPLES AT 72k BPS MAX

The AE-5105 data-communications analyzer from Ando Electric Co Ltd (Tokyo, phone (03) 733-1151, TLX 2466425; in the US, Rockville, MD, (301) 294-3365) features a data-sampling rate of 72k bps max to test on-line networks. The device analyzes X.25-frame, X.25-packet, SDLC, and BSC protocols; optionally, it can analyze ISDN LAP-D, X.75, and SNA/SDLC protocols.

A 3½-in. floppy-disk drive with 640k bytes of memory stores setup conditions and test programs. The AE-5105 can also store a simulation program with up to 1000 steps and 39 commands, allowing it to simulate system components. The 14.5-lb (6.5-kg) unit costs approximately \$6000.—Joan Morrow

CAPTURE.



CREATE.

Stimulate experiments with real-time analog waveforms reproduced from your actual captured data!

Connected via the GPIB interface, the Nicolet Model 4094 digital oscilloscope teamed up with the Nicolet Model 42 arbitrary function generator provides instantaneous waveform storage and generation.

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Nicolet Digital Oscilloscopes

Incoming signals digitized by Nicolet's high accuracy 12-bit, 10 MHz digitizers or high speed 8-bit digitizers allow you to see things you've never seen before. Zoom expansion to X256 allows you to see the details in waveforms composed of up to 16k points. Cursor readout of measurement values, continuously variable pretrigger positioning, and built-in disk drives all contribute to Nicolet's tradition of measurement power and ease of use.

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NEW!

Outgoing signals are accurately generated from the 12-bit by 2k arbitrary waveform memory in the Model 42. Real-time duplication of the captured signal can be produced at speeds up to 1 μSec per data point.

Continuous, triggered, gated, and burst output modes are possible. A unique feature, arbitrary sweep, allows you to accurately program the output frequency. Standard waveforms (sine, triangle, square, sawtooth, pulse), 10 mV_{p-p} to $20V_{p-p}$ amplitudes, are all available at speeds up to 4 MHz.

Nicolet
"Instruments of Discovery"

CIRCLE NO 111

rugged plug-in amplifiers

0.5 to 1000MHz from $13.95 (5 to 24 qty)

Tough enough to meet full MIL-specs, capable of operating over a wide -55° to +100°C temperature range, in a rugged package...that's Mini-Circuits' new MAN-amplifier series. The MAN-amplifier's tiny package (only 0.4 by 0.8 by 0.25 in.) requires about the same pc board area as a TO-8 and can take tougher punishment with leads that won't break off. Models are unconditionally stable and available covering frequency ranges 0.5 to 500MHz and 0.5 to 1000MHz, and NF as low as 2.8dB.

Prices start at only $13.95, ***including*** screening, thermal shock -55°C to +100°C, fine and gross leak, and burn-in for 96 hours at 100°C under normal operating voltage and current.

Internally the MAN amplifiers consist of two stages, including coupling capacitors. A designer's delight, with all components self-contained. Just connect to a dc supply voltage and get up to 28dB gain with +9dBm output.

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MODEL	FREQ. RANGE (MHz) f_L to f_u	GAIN dB min	flatness††	MAX. OUT/PWR† dBm	NF dB (typ)	DC PWR 12V, mA	PRICE $ ea. (5-24)
MAN-1	0.5-500	28	1.0	8	4.5	60	13.95
MAN-2	0.5-1000	19	1.5	7	6.0	85	15.95
MAN-1LN	0.5-500	28	1.0	8	2.8	60	15.95

††Midband $10f_L$ to $f_{u/2}$, ± 0.5dB † 1dB Gain Compression
Max input power (no damage) +15dBm; VSWR in/out 1.8:1 max.

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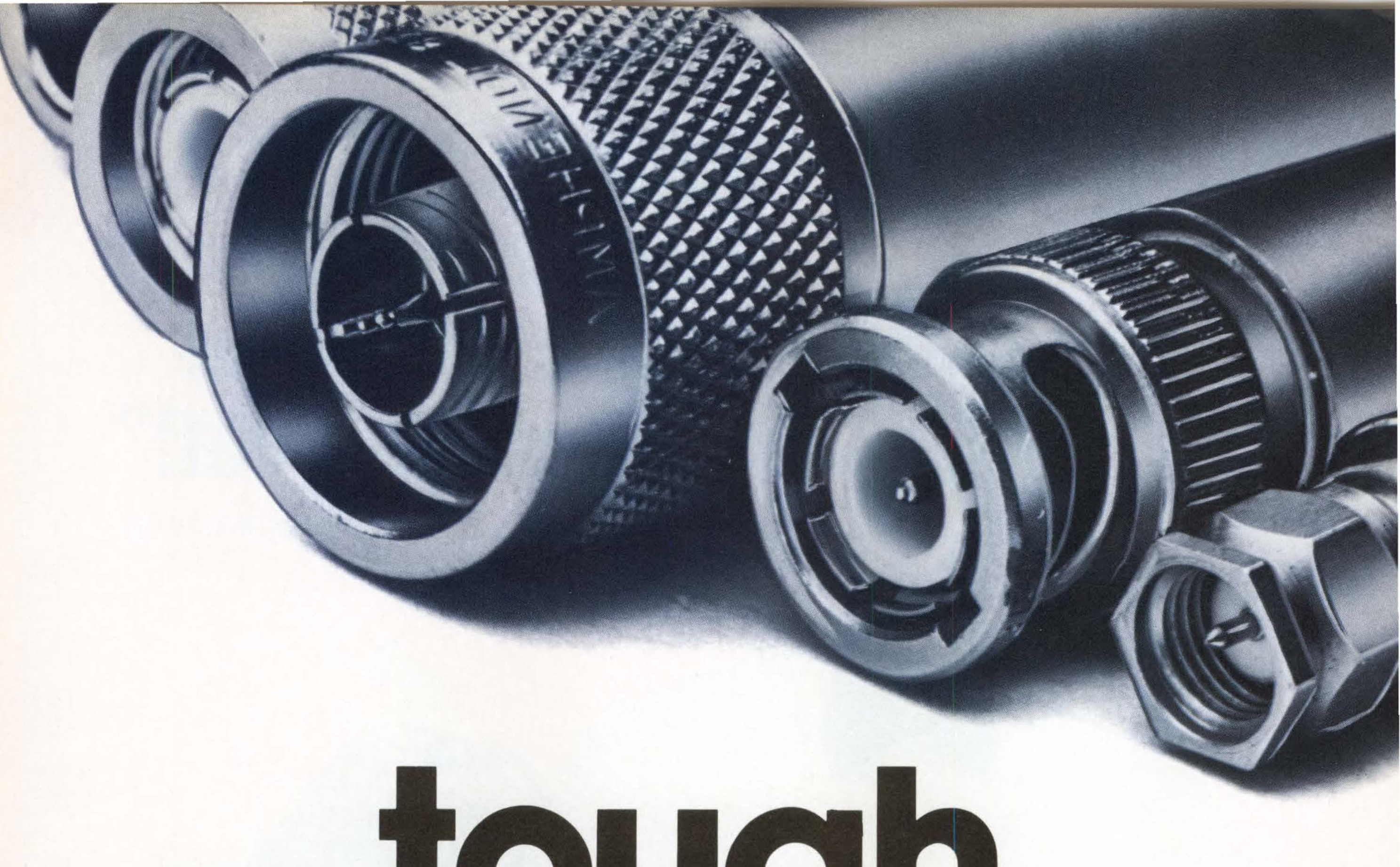
CIRCLE NO 114

C118 REV. A



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Sam Shine, Proprietor

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Bobbi Smith
Sales

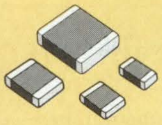
Brian Thurston
Engineering

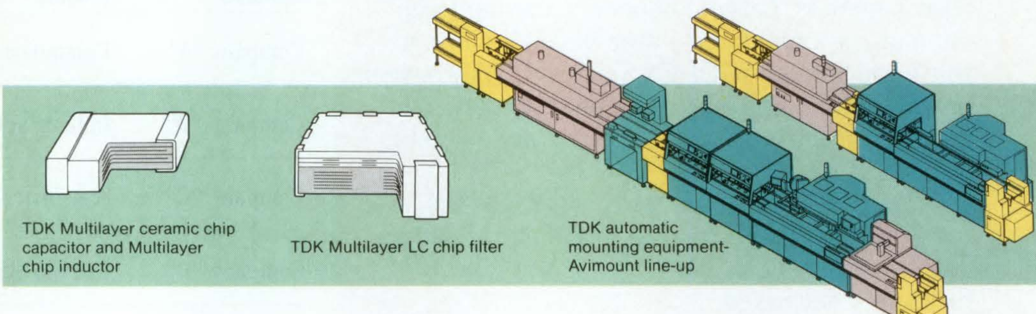
In Surface Mountable Components, TDK Quality Is More Than Skin Deep.

As boards are getting thinner, TDK is helping that diet succeed by providing a variety of extra-slim surface mountable components. Nourished by TDK's expertise in ferrite and ceramic materials, these miniaturized components feed on TDK —developed multi-layerization and multi-functionalism. How do we know the exact needs of high-quality automated board production? Well, a fair share of the world's automatic mounting equipment—the Avimount series—comes from TDK.

Multilayer Ceramic Chip Capacitor

C1608 (CC0603) C: 0.5~22,000pF
C5650 (CC2220) C: 5,100pF~1.5μF
C2012 (CC0805) C: 0.5~100,000pF
C3216 (CC1206) C: 0.5~220,000pF
C3225 (CC1210) C: 750~470,000pF
C4532 (CC1812) C: 2,400pF~1μF



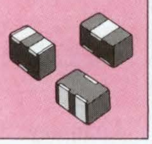


Multilayer Ceramic Chip Capacitor (High Frequency, Low Loss)

FC1414 C: 0.5~3,300pF
FC2828 C: 0.5~22,000pF
FR1414 C: 0.5~3,300pF
FR2828 C: 0.5~22,000pF

Multilayer Chip Transformer

MTT4532 L: 10~200μH



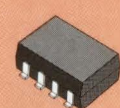
Multilayer Chip LC Filter

MXF4532H HPF (Tuner)
MXB5050D Delay Line (VCR)
MXF4532B BPF (FM radio)
MXB5050B BPF (VCR)
MXB5050L LPF (VCR)

A variety of characteristics are available. Please specify when ordering.

SM Active Delay Line

FDL Delay time: 20~75 nsec.



Leadless Inductor (Wound Chip Inductor)

NL322522 L: 0.01~220μH
NL453232 L: 1.0~1,000μH
NL565050 L: 1,200~10,000μH
NLF453232 L: 1.0~1,000μH (Shielded Inductor)

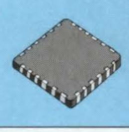
Multilayer Chip IFT

MIA4532 F: 455, 459, 464kHz
MIF4532 F: 10.7MHz

Multilayer Chip Capacitor Network

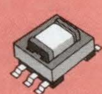
MCN7575 TC: CH, 1~100pF (10 capacitors)
SL, 10~1,000pF (10 capacitors)

Class II, 100~470,000pF (10 capacitors)



SM Transformer/ Inductor

EE5
ER9.5
ER11
T2



A variety of characteristics are available. Please specify when ordering.

Multilayer Chip Inductor

MLF3216 L: 0.047~33μH
MLF3225 L: 39~220μH

Multilayer Chip LC Trap

MXT4532 F: fo ±2%

Ferrite Chip Beads

CB201209 Zo: 7, 10, 11Ω
CB321611 Zo: 19, 26, 31Ω
CB322513 Zo: 31, 52, 60Ω
CB453215 Zo: 70, 120, 125Ω

SM Step-up Inductor (Piezoelectric Buzzer)

OL3.3 x 1.6
OL3.3 x 2.1

Inductance values are representative, please specify value when ordering.

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CIRCLE NO 117

SIGNALS & NOISE

High-tech weapons prevail over low-tech ones

Jon Titus's editorial "Score: Low Tech 1, High Tech 0," (EDN, July 9, pg 53) indicates that he has little or no appreciation for the technology of weaponry. His invoking George Santayana's famous line is hilarious, at least insofar as the examples he chose. History, if it does anything, teaches us that he is dead wrong.

The laughter around our office area at the description of the Exocet as a low-tech, inexpensive weapon was deafening. The Exocet is a very-high-speed, wave-skimming missile with a sophisticated terminal seeker. It is considerably more sophisticated than the Styx used in 1967 against the Elat.

The low-tech General Belgrano, originally the USS Phoenix, was launched on March 12, 1938, according to *Weyer's Warships of the World*. That would make it pre-World War II technology, and, from the logic of Mr Titus's argument, invulnerable to the much newer technology incorporated in the British nuclear submarine that sank it. It would have been difficult for the British to have deployed a conventionally powered submarine 8000 miles from home to fire any type of torpedo. The British success in fighting off the brilliant Argentinian air strikes was due in large measure to the high-tech Harrier aircraft firing sidewinder missiles.

The two Exocet missiles that did not sink the USS Stark did not so much penetrate US naval defenses as catch them in the "low-tech," off position. The automatic defenses, including Phalanx, are potentially so deadly that Captain Brendel put them on manual for fear of shooting down a friendly party. The Stark was defeated by a very high-tech weapon that was too much for the Mark I, Model 0 human to handle without high-tech assistance.

The reference to Israeli reliance on low-tech weapons is also funny. In almost every case where they have used American weaponry, the Israelis employed them in very dramatic, and sometimes extremely innovative, ways. Tow, Hawk, Sparrow, and Sidewinder missiles, for instance, are not your basic low-tech weapons. In the same way that Shrike and Harm missiles are "old," I'll concede, the Mach 2 F-4 and Mirage aircraft, with their radar and fire-control systems, are low-tech extensions of WWII technology.

In Vietnam, the USAF used up the WWII and Korean War iron bombs to hit hard targets such as bridges. The result was that many more raids and many more planes were required, and there were more casualties and POWs. When "smart" weapons were finally used, we came to appreciate the high price we paid for the use of low-tech, inexpensive weapons.

Just as the B-17 with the Norden bombsight was criticized as being too sophisticated, and just as the WWII-type torpedoes that Mr Titus lauds were called too complex, today's state-of-the-art weapons are scourged by the shortsighted, shallow thinkers of our time. History has shown us that if new systems are properly developed and adequately tested, and if they are refined based on combat experience, the more capable weapons prevail.

Certainly, we must resist using high tech for its own sake. However, when you can expect to be outnumbered significantly on the battlefield, and when your enemy always has the advantage of choosing when and where the first engagement will occur, it is stupid to advocate yielding to him the high ground of technology also.

Ted Bluestein
Tucson, AZ

DSP chip runs efficiently from looped code

The ADSP-2100 DSP processor from Analog Devices is seriously misdescribed in the article "Digital signal processing enters the mainstream," (EDN, August 6, pg 111). The ADSP-2100 was designed to operate with off-chip memory while maintaining single-cycle access. This scheme lets the ADSP-2100 efficiently implement very complex algorithms, algorithms that won't fit into DSP processors with on-chip memory. For these other chips, the benefits of on-chip memory evaporate when off-chip program accesses are required, because these accesses typically require multiple cycles.

Jim Wiegand, the author, misunderstood the role of the ADSP-2100's on-chip, 16-word instruction cache. Its purpose is to allow the execution of loops entirely from the instruction cache, thereby freeing the instruction bus for a second, parallel data transfer. As a result, the ADSP-2100, unlike other processors, runs *more* efficiently from looped code than from straight-line code. This on-chip cache is a key reason that the ADSP-2100 can accomplish a 1024-point FFT in 4.6 msec at an 8-MHz clock rate. (Faster versions will be available soon.) The instruction cache has nothing directly to do with the ADSP-2100's memory architecture except that, because the optimized, looped code is typically very compact in comparison with straight-line code, very

sophisticated signal processing takes place in the ADSP-2100's 16k-word program address space.

Finally, the price quoted in the article was our early-1986, single-piece engineering-sample price. An ADSP-2100 in a PLCC starts at \$78 (1000).

David Fair
Analog Devices
Norwood, MA

Company offers 16-bit emulator

Our client, Arium Corp, is at a loss to understand why it was omitted from EDN's July 23rd article on 16- and 32-bit emulators ("In-circuit emulators keep pace with 16- and 32-bit μPs," pg 252). All of the company's competitors were represented.

Arium offers one of the most sophisticated, powerful development systems on the market. The system is a widely recognized product, and we feel it deserves the same coverage that the competing products receive in articles of this nature.

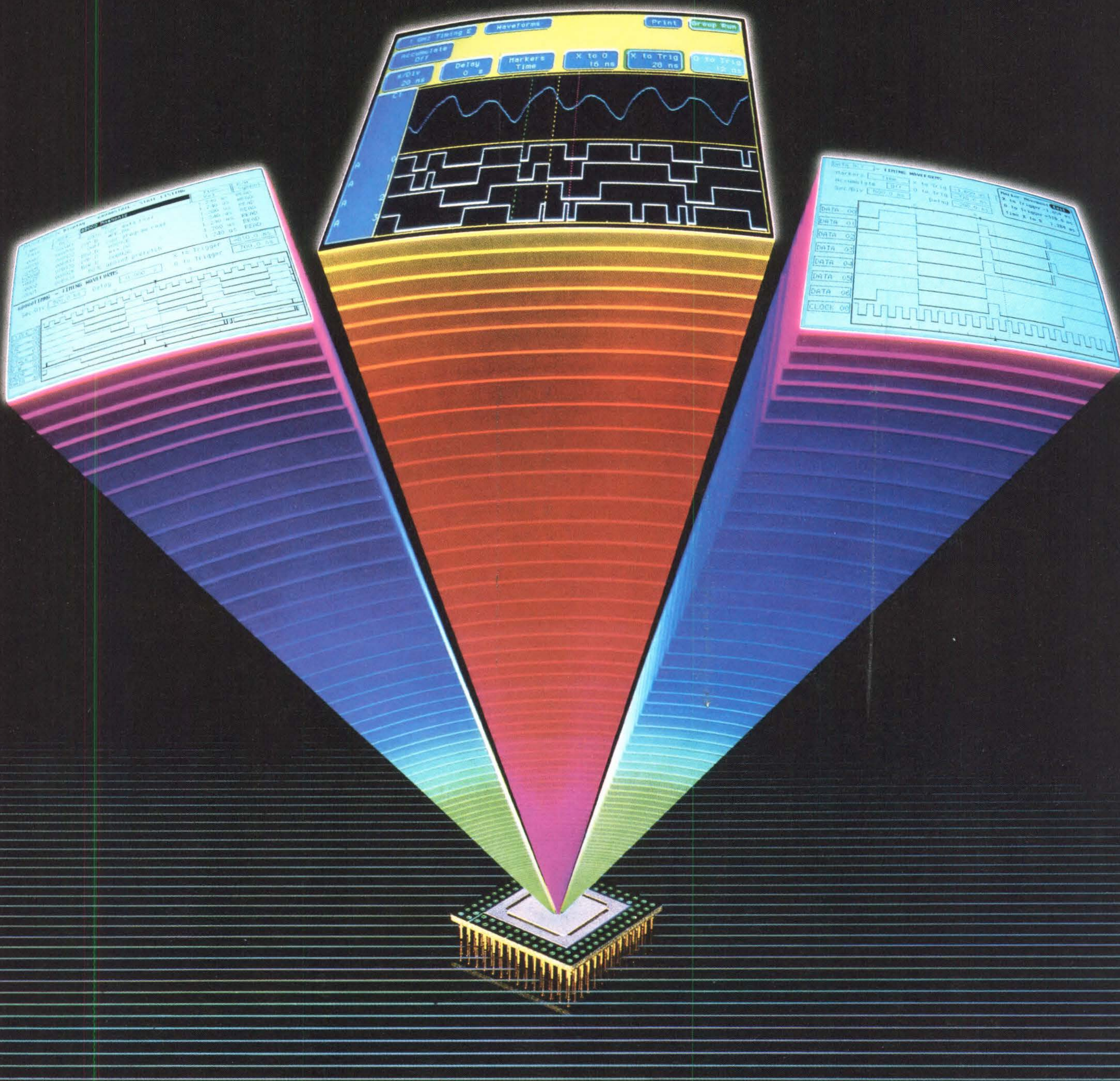
Ernest H Rankin
The Rankin Group
Fountain Valley, CA

(Ed Note: Arium makes a 16-bit emulator for the 68000/68010 μP. The product runs at 16 MHz and works with the company's Echo μP-development system. For more information, ***Circle No 618****)*

WRITE IN

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

Hewlett-Packard's new logic analyzer family offers you something not found in other logic analyzers...



HP's new logic analyzer family gives you more of what you want in logic analyzers. For less.

So now measurements are easier to make. And high-quality HP logic analyzers are easier to buy!

You get the performance that best suits you: from 32 to 400 channels of 100 MHz transitional timing/25 MHz state, and up to 80 channels of 1 GHz timing analysis.

Our new family also offers you easy operation, powerful triggering, a CAE link, an oscilloscope, pattern generation, portability, built-in mass storage, simple probing, optional 3-year protection, and much more.

The small secret behind the big value.

To give you more for your money, HP developed a Logic-Analyzer-on-a-Chip containing a complete state analyzer, timing analyzer, and acquisition memory. This proprietary HP IC makes exceptional value possible...80 channels of 100 MHz transitional timing for only $7,800*.

You can assign state or timing in 16-channel increments. Get fully independent state, timing, state/timing, or state/state setups. Even time-correlate measurements on complex multiprocessor systems.

Operational simplicity runs in the family.

We've made our controls even easier than before, without sacrificing performance.

You can make timing or state measurements using just three menus, so you never get lost. Triggering setups, from the simple to the complex, are a snap. And autoscale gives you one-button setup for timing analysis.

You even get a color touchscreen and knob, or optional mouse with the new HP 16500A. Color lets you quickly distinguish between menu choices, measurements, and results...and find glitches more easily.

Probing made easy.

HP's new passive probes are lightweight and flexible...specially designed to grip easily and securely to your device under test. Plus, our preprocessors give you quick setups with most popular 8, 16, and 32-bit μPs, including the Motorola 68020 and Intel 80386. And if you've already invested in HP preprocessors, we offer you an easy upgrade path.

HP 1651A: full-featured logic analyzer for only $3,900.*

With 32 channels of 100 MHz transitional timing for just $3,900*, the HP 1651A gives the hardware engineer a highly economical, yet powerful debugging tool.

It's a full-featured logic analyzer with no compromises in state and timing capabilities (25 MHz state/100 MHz transitional timing on all channels), memory depth, triggering, or I/O features. It supports most popular 8-bit μPs with full inverse assembly. Plus it's compact, weighs just 22 lbs., and has an optional carrying case for easy transport.

HP 1650A: the new standard in general-purpose logic analysis for just $7,800.*

The HP 1650A features time-correlated state/state or timing/state operation on 80 channels. Plus eight sequence levels to meet your toughest triggering tasks. Yet it's priced below $8,000!

You get 25 MHz state/100 MHz transitional timing on all 80 channels, and preprocessor support for 8, 16, and 32-bit μPs. And, the

Excellent reliability, service, and support.

When you purchase a logic analyzer from HP, you get high reliability. The support you need to be productive with your instrument quickly. And a worldwide sales and service network to ensure your continuing satisfaction for years to come.

we never stop asking "What if..."

HP 1651A $3,900 *

The HP 1651A is a general-purpose, low-cost 32 channel logic analyzer with many features normally found on more expensive analyzers.

- 100 MHz transitional timing on all 32 channels.
- 25 MHz state on all channels.
- Support for most popular 8-bit μPs.
- Fully programmable, with built-in disc drive and hardcopy output.
- Portable and compact — weighs just 22 lbs.
- Optional 3-year protection.

HP 1650A $7,800 *

The HP 1650A is a general-purpose logic analyzer with a range of features to satisfy many requirements in design and test.

- 100 MHz transitional timing/25 MHz state on all 80 channels.
- Support for most popular 8, 16, and 32-bit μPs.
- Configurable as 2 totally independent analyzers.
- Fully programmable, with built-in disc drive and hardcopy output.
- Eight sequence levels with storage qualification, pattern and range recognizers.
- Glitch capture on all channels.
- Optional 3-year protection.

HP 16500A

The HP 16500A is a modular, configurable system solution that can meet a wide variety of logic analysis, oscilloscope, and stimulus-response measurement requirements.

- Configurable through your choice of performance modules:
  - 25 MHz state/100 MHz transitional timing (80 channels per module) $5,200 *
  - 400 Ms/sec 100 MHz bandwidth digitizing oscilloscope (2 channels per module) $5,500 *
  - 1 GHz timing (16 channel master) $7,800 *
  - 50 Mbits/sec pattern generation (12/48 channels per module) $3,700/$4,000 *
  - Mainframe $7,200 *
- Color touchscreen and knob, with optional mouse.
- Intermodule triggering.
- Two built-in disc drives.
- Fully programmable, with RS-232 and HP-IB interfaces.
- Optional 3-year protection.

* U.S. list price.

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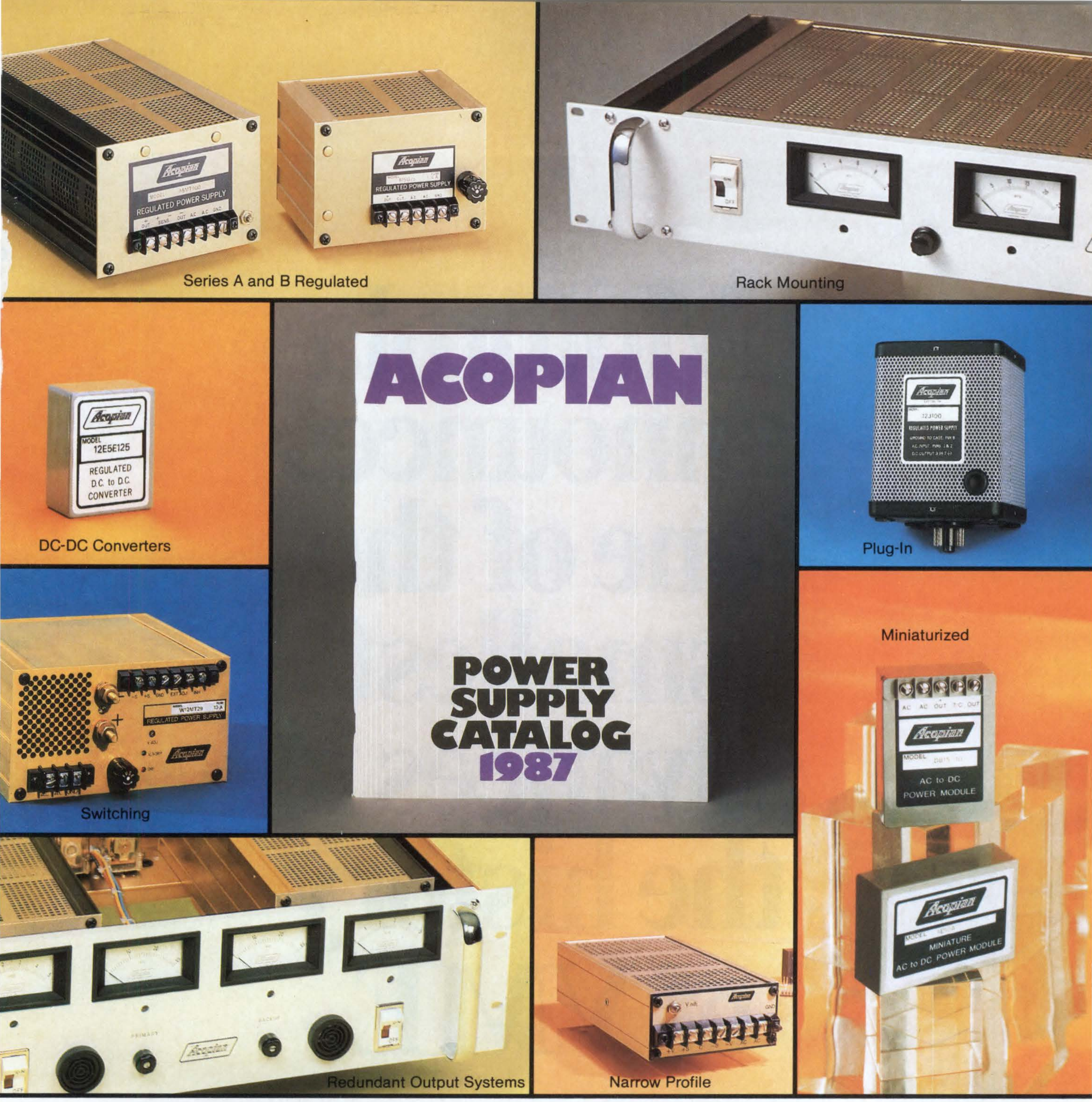

New 56-page 1987 catalog

Acopian single, dual and triple output power supplies featured in our new catalog for 1987 are shipped in three days. Included are PC-board-mounting and chassis-mounting mini modules. DC-DC converters. General-purpose modular supplies with outputs to 200 Vdc and current ratings to 32A. Narrow-profile supplies a mere 1.68" thin. Plug-in supplies. MIL-tested supplies. Unregulated supplies for economically driving relays and displays. Voltage programmable supplies. Our rack-mounting power supplies and systems, and redundant output systems are shipped in nine days. The catalog contains complete specs and pricing information. Call or write for your copy.

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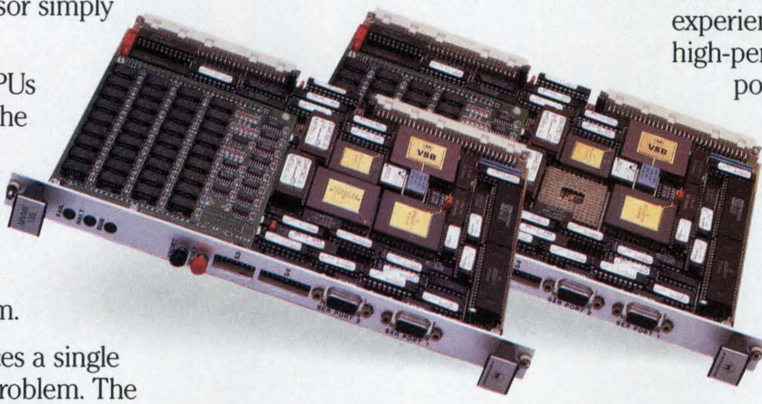
DC POWER SUPPLIES SHIPPED IN 3 DAYS

CIRCLE NO 40

Motorola puts awesome multiprocessing performance on two new single-board computers.

As computer applications get more complex, OEMs are turning more to multiprocessing designs. To handle things like CAD/CAM, robotics, signal processing, simulation and large-scale data acquisition, a single processor simply can't keep up.

Adding several CPUs to a system off-loads the main processor, but what happens to the system bus? It frequently reaches saturation, slowing down the entire system.



Motorola introduces a single chip solution to this problem. The **V**ME **S**ubsystem **B**us, a fast, 32-bit secondary bus, has been implemented on a gate array at Motorola.

The end of the multiprocessor traffic jams.

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MVME135/136 Highlights

Model	Description
MVME135	VMEbus 32-bit SBC; 16.67-MHz MC68020 CPU; MC68881 FPU; 1Mb on-board DRAM; up to 512 Kb EPROM; two RS-232-C serial ports; two 16-bit timers; master/slave interface; MP control and status registers; system controller
MVME135-1	Same as MVME135, but with 20-MHz MC68020 CPU
MVME136	Same as MVME135, but with MC68851 PMMU

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IEEE Fifth Biennial Careers Conference, San Diego, CA. IEEE, 1111 19th St NW, Suite 608, Washington, DC 20036. (202) 785-0017. October 14 to 16.

6th Annual Pacific Northwest Computer Graphics Conference, Eugene, OR. University of Oregon Continuation Center, 1553 Moss St, Eugene, OR 97403. (503) 686-3537. October 25 to 27.

Expo SMT, Las Vegas, NV. Expo SMT, Box 1869, Los Gatos, CA 95031. (408) 354-0700. October 26 to 29.

International Fiber Optic Communications and Local Area Networks Exposition, Anaheim, CA. Information Gatekeepers, 214 Harvard Ave, Boston, MA 02134. (617) 232-3111. October 26 to 30.

Government Microcircuits Applications Conference (GOMAC '87), Orlando, FL. Palisades Institute for Research Services, 201 Varick St, New York, NY 10014. (212) 620-3371. October 27 to 29.

Unix Expo, New York, NY. National Expositions Co, 49 W 38th St, New York, NY 10018. (212) 391-9111. October 27 to 29.

Hands-On Expert Systems Design and Development (short course), Anaheim, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. October 27 to 30.

Hands-On Graphics Programming Using GKS/VDI Tools (short course), Boston, MA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. October 27 to 30.

Troubleshooting Microprocessor-Based Equipment and Digital Devices, Cincinnati, OH. Micro Systems Institute, 73 Institute Rd,

CALENDAR

Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. October 27 to 30.

Designing Signal Processors with DSP and Bit-Slice Chips (short course), Washington, DC. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. November 3 to 6.

Hands-On Microprocessor Software, Hardware, and Interfacing (short course), Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. November 3 to 6.

Troubleshooting Microprocessor-Based Equipment and Digital Devices, Atlanta, GA. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. November 10 to 13.

Advanced SMT Design Techniques (short course), San Jose, CA. Surface Mount Technology Plus, 1786 Technology Dr, San Jose, CA 95110. (408) 943-0196. November 16 to 17.

Designing Signal Processors with DSP and Bit-Slice Chips (short course), Anaheim, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. November 17 to 20.

Troubleshooting Microprocessor-Based Equipment and Digital Devices, Norfolk, VA. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. November 17 to 20.

9th Interservice/Industry Training Systems Conference, Washington, DC. Ralph Nelson, ADPA, Rosslyn Center, Suite 900, 1700 N Moore St, Arlington, VA 22209. (703) 522-1820. November 30 to December 2.

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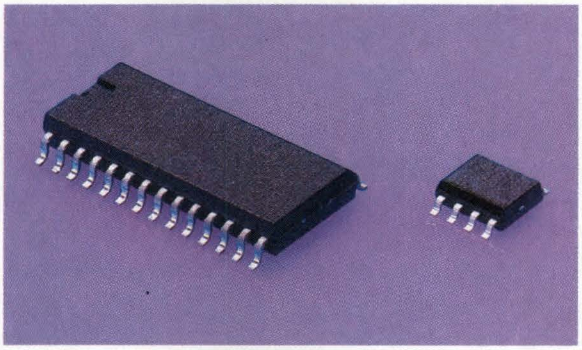

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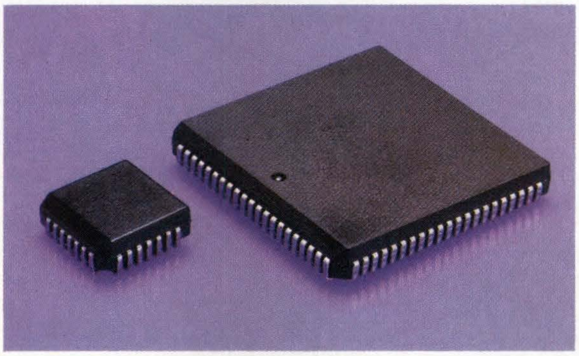

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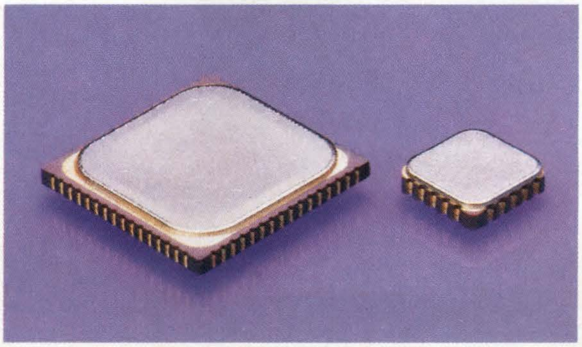

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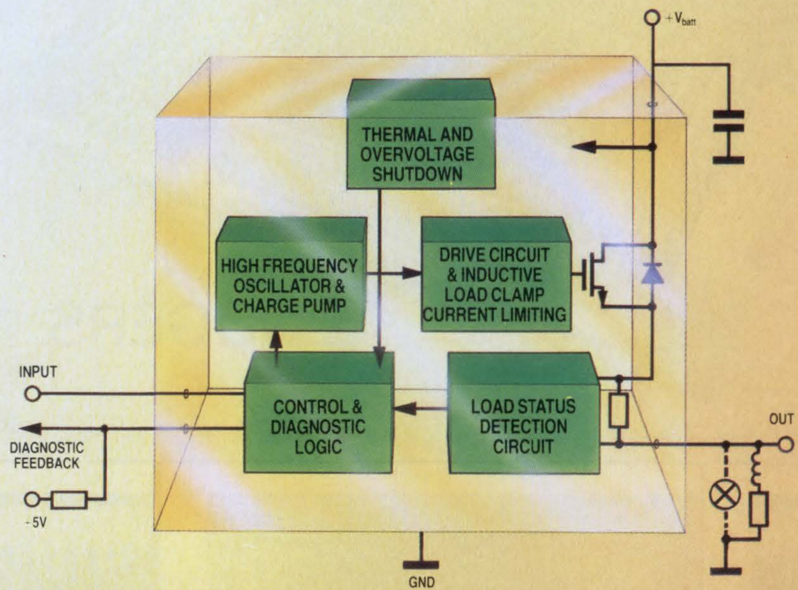

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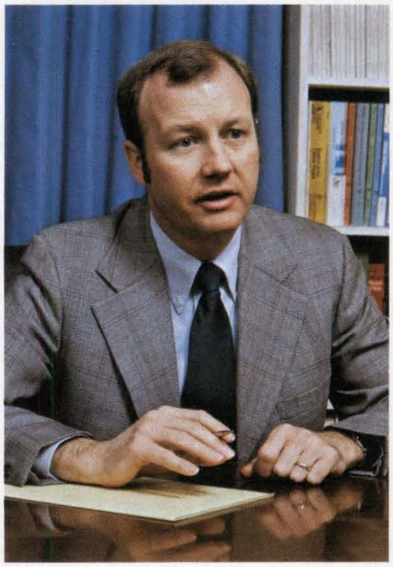
EDITORIAL

Competition involves everyone



KEEPING AMERICA COMPETITIVE

Regional Editor Margery Conner takes a different approach to engineering through an article in this issue about competition. Specifically, she focuses on three companies and how they develop competitive products. Because you are an engineer or an engineering manager, Margery concentrates on the engineering aspects of these companies' efforts. Other Cahners publications are simultaneously exploring competitive issues that affect their readers, and you'll read more about competitiveness in EDN in the months ahead. Although competition often brings to mind large waves of imported goods flooding domestic markets, competition goes beyond products. Competition is a philosophy that must permeate every corner of a company and every aspect of its business.

Often, a sense of mission can increase a company's competitiveness. For example, several years ago an insurance company faced great difficulty in getting clerks to finish depositing receipts in the company's bank accounts by day's end. Managers tried many motivation techniques without success. Finally, someone said to the staff: "Look, if you don't make the deposits by the end of the business day, the company stands to lose millions of dollars. That money comes from the interest that other companies pay us for loaning them money overnight. The interest is part of the company's profit." Once the staff members knew how important their job was, they were pleased to comply. After all, they weren't just keeping records, they were contributing to the company's profit.

General Motors' president, Robert Stempel, spoke about something similar in a recent commencement address. He said that in today's business world, the product often takes a back seat to other considerations. Too many executives concentrate on management and financial details, and fail to understand their product and how it is designed or produced.

Likewise, you cannot regain or maintain a competitive lead in today's markets by simply developing a product or incorporating new technology in it. Redesigning a product so that it uses no screws, incorporates surface-mount technology, or provides built-in test routines is no panacea. A competitive philosophy must extend beyond the engineering department to the entire company, from the mailroom to the president's office. As Stempel also said, "Competitiveness is a responsibility for everyone. It's a cause to which we must all be passionately dedicated."

Jon Titus

Jon Titus
Editor

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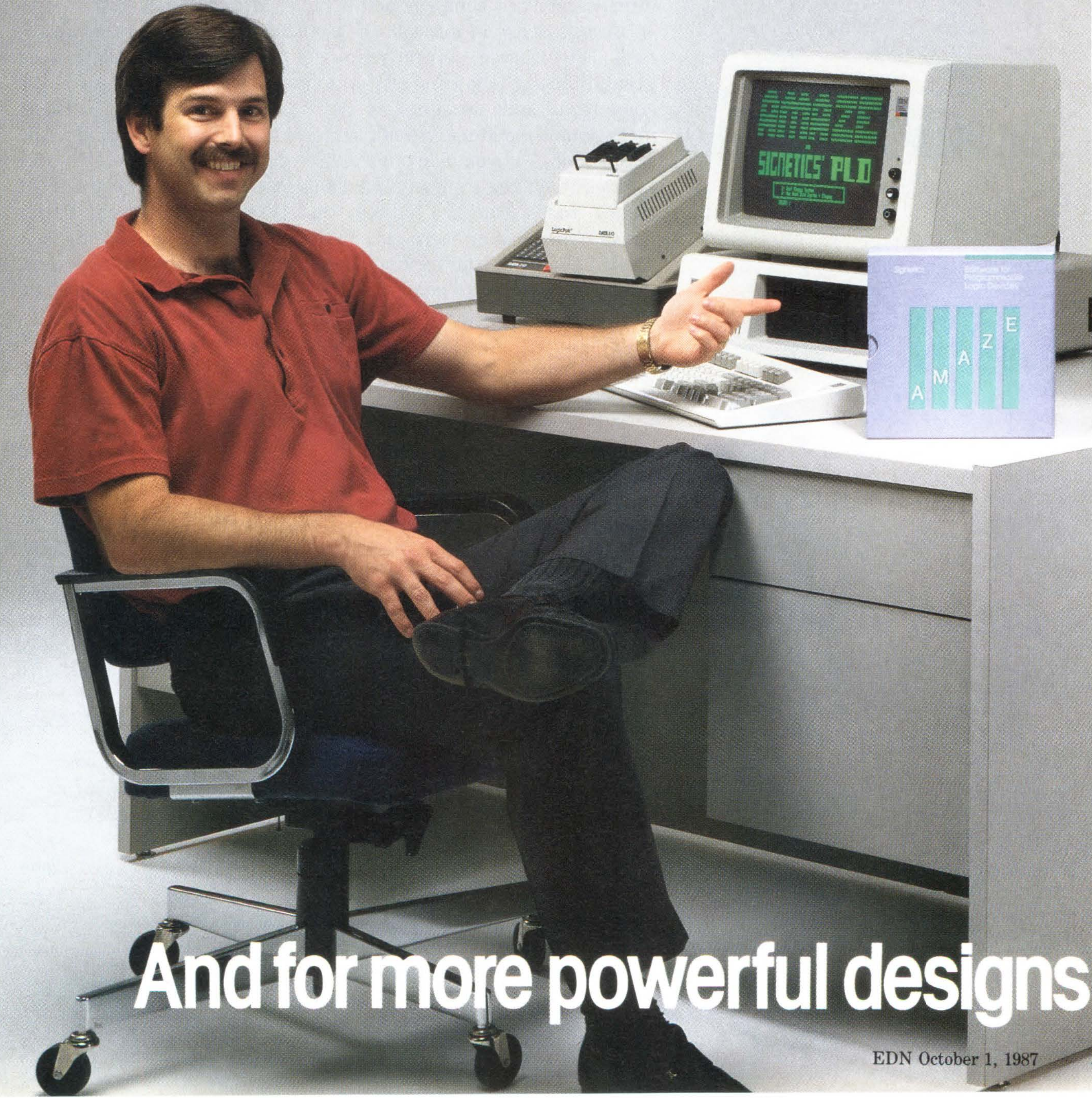

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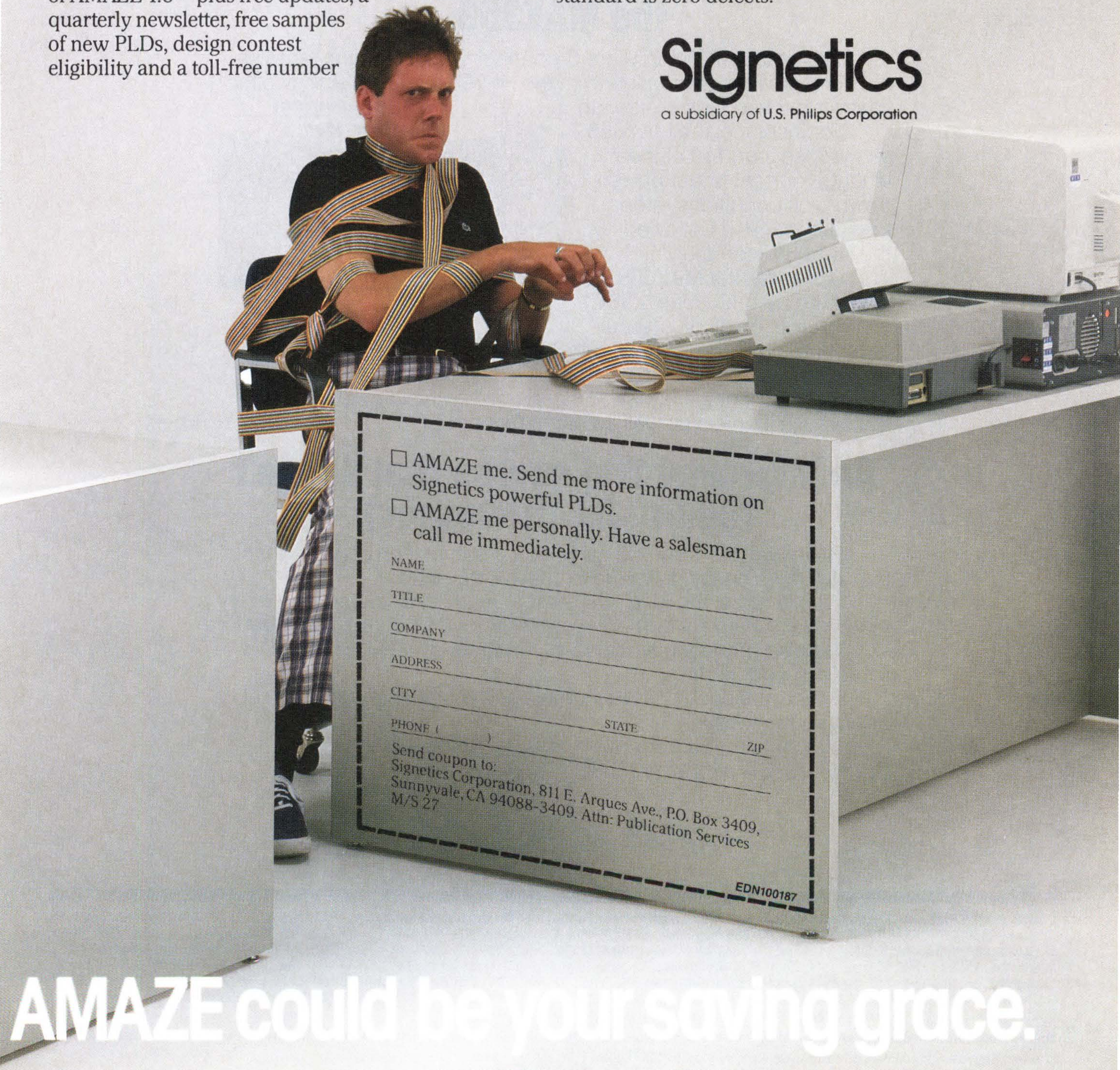

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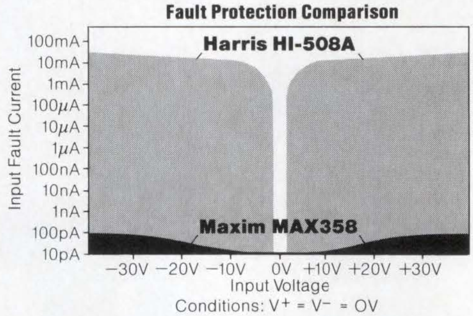
Fault Protection Comparison



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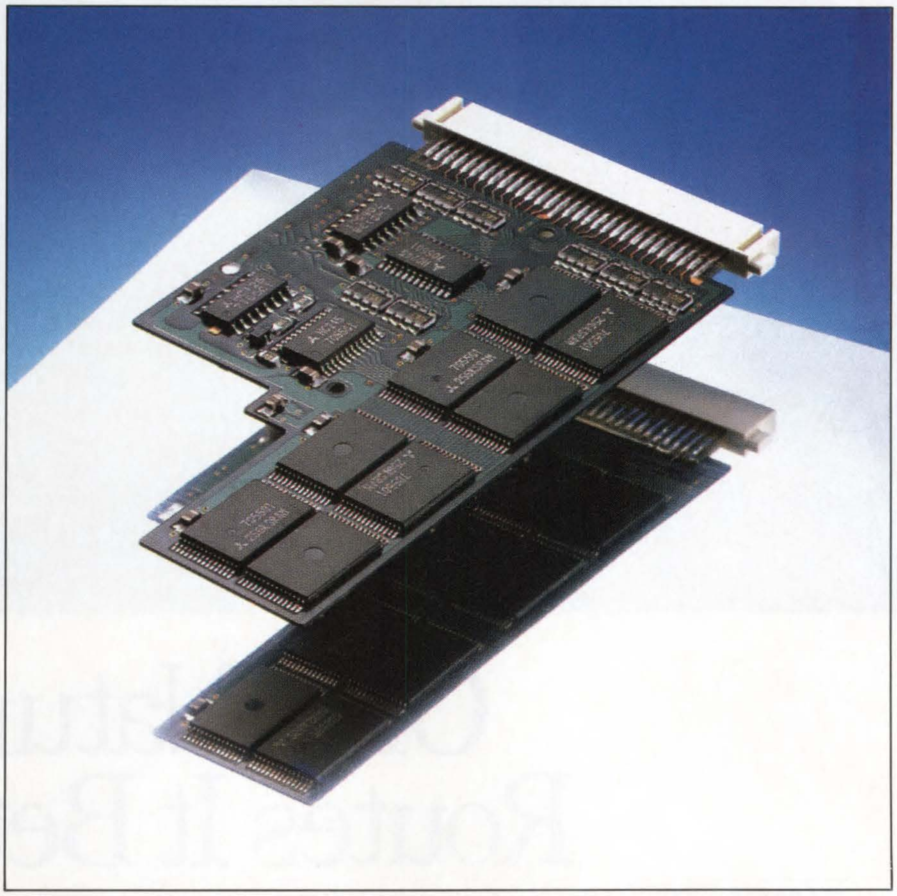
Smart cards yield high memory capacities for mass-storage and data-security uses

Chris Terry, *Associate Editor*

Thanks to advances in IC fabrication and packaging technologies, you can now obtain high-capacity memories or complete μP-driven systems in credit-card-sized packages. These memory cassettes, or so-called smart cards (they really don't have any intelligence), suit an extremely wide variety of applications, ranging from the customization of terminals and other peripherals, to data logging, and to mass storage for computers that must run in hostile environments. The cards also have varying memory capacities: They can store as little as 2k bytes to as much as 512k bytes of battery-backed static RAM, as much as 1M bytes of EPROM, or as much as 2M bytes of masked ROM.



This smart card has a 4-layer pc board *and 16 VSOP ICs, which have built-in ESD protection to 25,000V. The female 2-P connector mates with male pins to provide a gas-tight seal. The card, available from Mitsubishi Electronics, can provide as much as 512k bytes of battery-backed static RAM or a maximum of 2M bytes of masked ROM.*

Physical considerations

The VSOP (very-small-outline package) is primarily responsible for the smart cards' introduction and availability. A VSOP is 2½ times thinner than standard surface-mount-device packages and spaces the external leads on 50-mil centers. Although vendors have standardized the memory cards' length (3⅜ in. or 85 mm) and width (2⅛ in. or 54 mm), the thicknesses vary from 0.76 mm to as much as 3.6 mm (about five times the thickness of a credit card), depending on the application.

Most of the cards use 34- or 60-pin connectors guaranteed for 10,000 or more insertion cycles. Mitsubishi's and Du Pont's static-RAM cards each have a replaceable lithium battery that maintains data integrity for a minimum of 2½ years; the vendors believe that the cards' actual life may be as long as 10 years, but tests haven't been performed long enough to substantiate the higher figure.

Interfacing the memory cassettes to the host is generally simple, and vendors claim that, with the aid of the accompanying interface documentation, you should be able to get a prototype system operating in approximately four hours. Dallas Semiconductor's cards have 30-pin connectors, which are arranged so that you can connect to the host with a flat cable and header that matches a standard 28-pin memory socket. (The 30-pin limit doesn't place any constraint on the addressing scheme because internal paging logic lets you access the full memory space.)

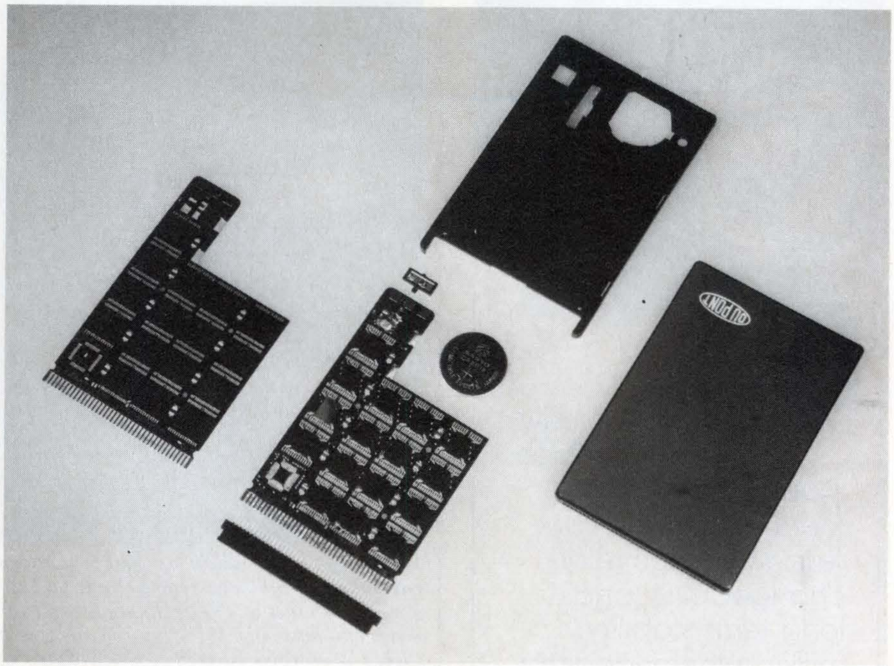
The smaller memory cards, with less than 1M-bit capacity, are suitable for use as personality modules for customizing terminals, printers, and other peripheral equipment, and in autos, meteorlogical instruments, and other software-driven instrumentation. Moreover, they can considerably reduce the cost of configuring and upgrading peripherals.

If your product has many custom-

er-selectable options, one of your greatest expenses is probably the configuration cost: Burning and inserting the configuration PROMs is time-consuming, and you have to retest each deliverable item to ensure that it is properly configured to the customer's specification. If your customer later wants to upgrade the equipment, you may have to send a field engineer to change the configuration PROM.

With the help of the highly reliable memory card, you can do the programming and verifying from a personal computer in less time than it takes to burn-in a PROM. You can then plug the card into the equipment without opening the case—saving yourself even more time. If your customer later wants to upgrade the equipment, you can mail out an upgrade card containing the new configuration; you don't need to send a field engineer to the site because the customer simply has to remove the old card and insert the new one.

For applications that involve equipment for collecting large amounts of data, either automatically at a remote site or by means of a handheld-entry device, a memory cassette can help to reduce both the weight and the power consumption of the collector device. At the end of a collection run, you can remove the cassette from the collection device and insert it into a slot on a host computer, which can read all of the data and transfer it to disk in a few milliseconds. Alternatively, a remote device can upload the data to the host over a telephone line, clear the cassette, and be ready for another collection run. Du Pont offers a 128k-byte, 250-nsec static-RAM card for $120 (100) that is well suited to such an application.



A credit-card-sized memory cassette *from Du Pont comes in RAM and ROM versions and can store as many as 1M bits. The replaceable 3V lithium battery retains data for at least 2½ years. The card is fully protected against EMI and static discharge.*

Card can replace floppy disk

Another typical application for a smart card is as a mass-storage device for a computer that must operate in a harsh environment. Most small process-control computers in the PC/AT class are disk-based, and the steam, dust, and oil that circulate in the air around an assembly line mean sudden death to floppy disks—and may even penetrate an imperfectly sealed hard disk.

Some vendors have suggested bubble memory as a substitute for disks, but bubble memory is expensive and slower than the slowest floppy disks. Memory cassettes offer a smaller, faster, and less-expensive alternative.

Dallas Semiconductor offers memory cassettes that emulate floppy-disk drives for programming purposes. You can combine as many as eight of these cassettes in a removable assembly (cartridge clip) that yields 4M bytes of read/write storage with an access time of 250 nsec. You can, of course, preload the assemblies with programs that the computer can download to its main memory for execution; the computer can use the remainder of the capacity for data storage. In OEM quantities, each of these 512k-byte cassettes costs $605.

For applications that demand high capacity but don't need read/write capability, you can use a card containing either a one-time, field-programmable ROM, or a masked ROM that is programmed during manufacture. An example of such an application is an embedded computer that executes very large programs, which are rarely modified. EPROM or masked-ROM cassettes are also useful for storing very large data tables or translation tables that seldom change.

Mitsubishi Electronics' Melcards are suitable for such applications and come in three configurations: battery-backed, 200-nsec static RAM with capacities from 32k to 512k bytes; 250-nsec EPROMs with 64k- to 1M-byte capacities; and a 250-nsec masked ROM with 128k- to 2M-byte capacities. A 256k-byte static-RAM card costs $125 (10,000).

Some provide data security

Telecommunications is yet another promising application area for smart cards. If your end-product is related to data or site security, for example, Multimil's Memocard provides electronic security features that include a nonaccessible password, a user-modifiable personal identification number (PIN), and

You can put as many as eight memory cartridges *into this cartridge clip from Dallas Semiconductor. The assembly fits into the space of a half-height, 5¼-in. disk drive and yields a storage capacity of 4M bytes of RAM. The access time is 250 nsec.*

single- or dual-key encryption. Optionally, the card can include a standard magnetic stripe, a photo ID, and a bar code.

The Memocard contains either 2k or 8k bytes of EEPROM, an 8-bit μP that has its own PROM (not accessible to the user), RAM workspace, and I/O facilities. You can program the card with a short card that plugs into an IBM PC or with an interface unit that can connect to any host computer via an RS-232C link.

You can assign an authorization level to each card and define the maximum number of incorrect access attempts. In addition, the vendor offers a $500 telephone that accepts a Memocard and allows an authorized user to display the stored customer data and dial any of the stored numbers. An 8k-byte Memocard costs $62.55 (10,000); the Smart Card Development Kit for programming the card costs $489. If you don't want to program the Memocard yourself, you can have the manufacturer do it for you.

Although all of the smart-card vendors agree on the length and width of the cards and their application potential, they are divided on the issue of EMI suppression. All of the cards do have some form of built-in protection against electrostatic discharge, however.

Mitsubishi encloses both sides of the card's substrate with metal to protect the circuitry against electrostatic charges and suppress the radiation caused by operating a memory at high clock speeds. In addition, the company supplies a version of the card equipped with a zero-insertion-force (ZIF) connector behind a shutter that is operated by insertion or removal and that provides extra shielding and protection.

The Du Pont cards have a metal cover attached to the substrate, primarily as protection against ESD. The vendor takes the view that the radiation from low-power CMOS is negligible, particularly if the card is housed inside a shielded enclosure.

Another issue on which the manufacturers are divided is whether the

For more information . . .

For more information on the smart cards discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the manufacturers directly.

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Du Pont Connector Systems
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New Cumberland, PA 17070
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Mitsubishi Electronics America Inc
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Sunnyvale, CA 94086
(408) 730-5900
Circle No 721

Multimil Inc
770 International Parkway
Suite 190
Richardson, TX 75081
(214) 644-7724
Circle No 722

memory cards should include microprocessors. Multimil advocates a µP-driven card for applications where data security or physical-access security is important. In France, for instance, the banking system has adopted a µP-driven smart card, and in this country Visa is conducting a test of a similar card in Florida and other states.

One of the arguments for including microprocessors is that, even though the extra logic may reduce capacity and increase cost, distributing the security algorithms allows a wide variety of devices at many different sites to accept the cards and thus provides better security.

Vendors of the high-capacity memory cards, however, disagree. They believe that a small amount of logic on the card provides a certain amount of security by preventing access to the data until the user has provided an access code (which may have as many as 64 bits). They also feel that encryption of the data stored in the card is more effectively performed by the host computer.

Moreover, they argue that the inclusion of additional logic or µPs that have built-in, preprogrammed masked ROM not only reduces the room available for memory, but also makes the cards less flexible—and all the memory-card vendors feel that flexibility is the key to wide acceptance.

Dallas Semiconductor, for example, weighed the drawbacks of the cards used in the French system, as well as the advantages, and concluded that a memory card with minimal built-in access security would best satisfy current customer requirements, while leaving the card adaptable to improvements, upgrades, and new applications.

As for future developments and potential, Mitsubishi foresees some reduction in access time, perhaps down to 120 nsec. The organization of future cards will also depend on developments in microprocessor architectures. Although most memory cards follow the JEDEC standard of 8-bit words, it's possible to special order cards with 16-bit words. Even 32-bit memories aren't inconceivable—as long as paging, or a departure from the de facto 60-pin connectors, is acceptable to accommodate the extra data and address lines that would be necessary. **EDN**

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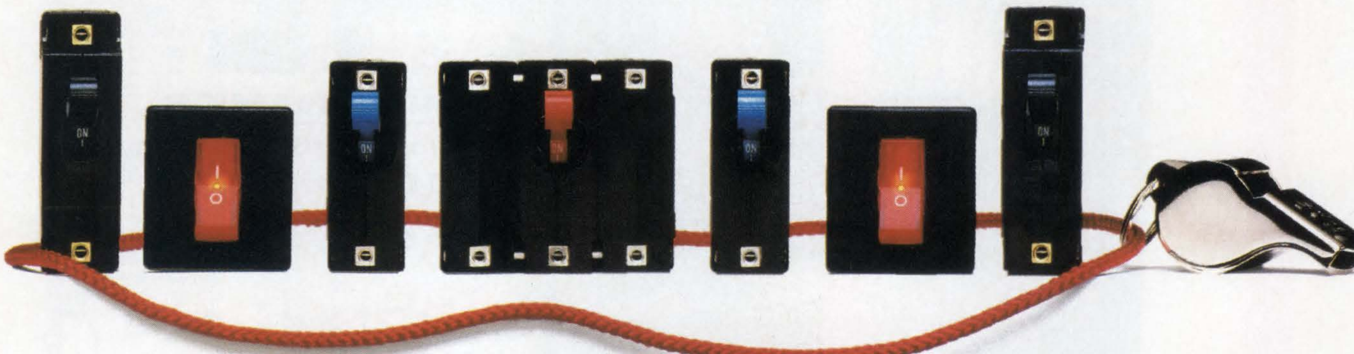

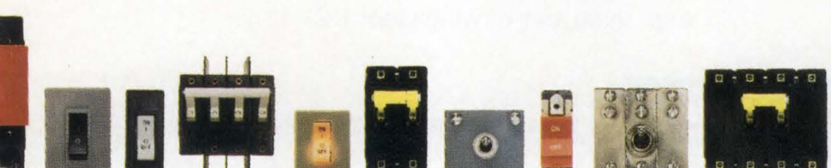

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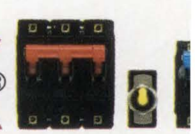


CAMBRIDGE DIVISION

CIRCLE NO 58

KEEPING AMERICA COMPETITIVE

Good engineering decisions are key to improving US's competitive stance

"Are the good times really over for good?"
—Merle Haggard

Ken Condon

Margery S Conner, *Regional Editor*

It's been hard recently to pick up a business magazine without seeing an article paraphrasing Mr Haggard's song title. The business community is asking: Can the United States remain competitive in the world market, or are we doomed to slide further into manufacturing mediocrity?

From a nontechnical, businessman's point of view, the chances of successfully regaining our competitive stature may appear slim: The obstacles—such as the problem of obtaining capital, interest rates, high labor costs, and foreign trade restrictions—are imposing. Yet some US electronics companies are overcoming these obstacles by tapping the United States' great reservoirs of technical strength. As three US companies are proving, the practices that can halt our slide into mediocrity lie not in the domain of the nontechnical manager, but in that of the design engineer.

These strategies include designing products for fast, cost-effective manufacturing; developing in-house expertise in new technologies rather than purchasing outside advice or designs; and designing products that are responsive to customers' needs. The three companies—Tektronix, Western Digital Corp, and Paradise Systems—are putting these practices to work, and are consequently competing very well.

Tektronix (Beaverton, OR), for example, solved the problem of remaining competitive in an increasingly tough oscilloscope market by designing products for fast, efficient manufacture. A couple of years ago, the company faced serious competition from other scope makers, especially foreign ones. Although the foreign scope makers didn't challenge Tektronix's scopes in complexity, they did condition customers to expect more and more capabilities and enhancements. For the price of a Tektronix plug-in, for instance, customers could buy a whole scope from a Japanese company.

Tektronix found itself facing a dilemma. To compete with other manufacturers, the company had to produce scopes of increasingly greater complexity, but lower their prices. Yet the production costs for Tek's complex scopes were high. If the relationship between the scopes' complexity and their production costs remained the same, Tektronix would soon have to give up making scopes—a fate as unthinkable as Levi's not making jeans.

Clearly, the company needed to reduce the cost of designing and manufacturing its future scope products. Researching the problem, Tektronix's engineers found that one of the company's largest manufacturing costs came from testing the scopes. The company had been following the same test procedures used by virtually all manufacturers of medium- to large-volume board assemblies: It tested all the board components, assembled the boards, tested the boards on an in-circuit tester, then plugged the boards into the system and hoped they would work. Finally, it used custom-designed functional testers to troubleshoot any systems that failed.

This approach is as accepted in the electronics industry as buying IBM equipment: No one ever got fired for recommending it. For testing Tektronix's late-model, complex scopes, however, the approach was very expensive. Because of the increasing complexity of the chips and boards inside the scopes, the in-circuit testers were taking longer to program. "Keep in mind that the least expensive part of an in-circuit testing system is probably the equipment itself," says Doug Rowe, a Tektronix hardware/software engineer. "Maintenance, particularly of the test software, is the major cost."

Another problem was that the company's technicians found it difficult to recreate the in-circuit test conditions for a board that passed an in-circuit test yet failed a system test. In-circuit testers were too expensive for repair technicians to use in troubleshooting boards.

The road less traveled

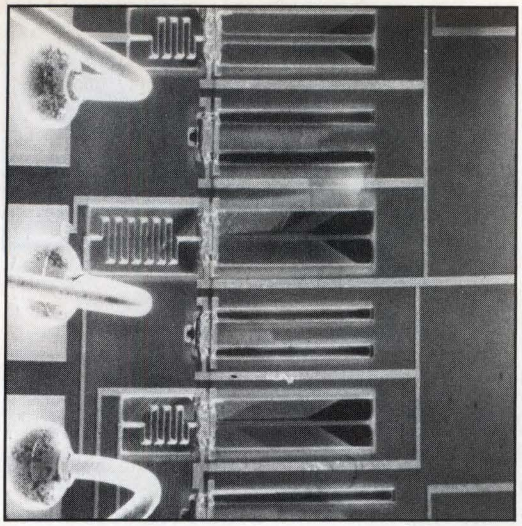
The design team for the Tektronix 11400 Series oscilloscopes came up with a solution: They incorporated built-in test (BIT) capabilities in the scopes at both the board level and the chip level. The BIT approach greatly reduced manufacturing costs for the 11400 scopes. Giving each board its own self-test capabilities allowed Tektronix to dispense with the expensive and time-consuming in-circuit test procedures it had used for earlier scopes.

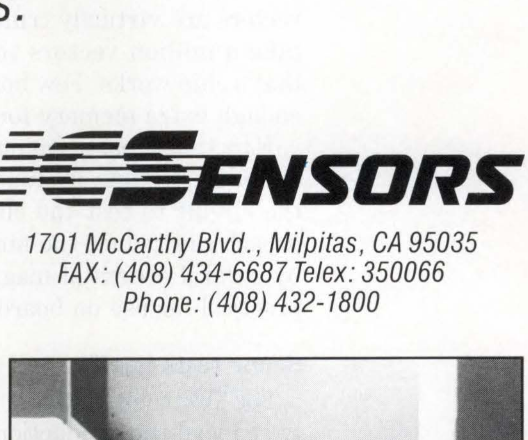
The company found that the BIT capabilities not only reduced the scopes' assembly time, but also facilitated calibration and field-service procedures. As an added benefit, the approach was attractive to customers, who appreciated the scopes' ability to test themselves and perform much of their own calibration.

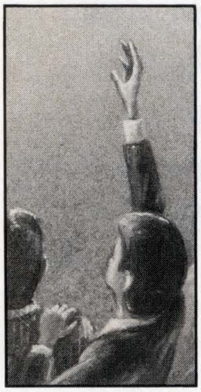
The usefulness of BIT in manufacture as well as throughout the life of a scope made the added cost of the BIT circuits and pc-board area economical. Tom Dye, who designed many of the 11400 systems' BIT programs, estimates that BIT can require anywhere from 5 to 20% of pc-board or chip area. Although such an investment may be impractical for a less-complex product with a short lifetime, it can reduce the lifetime cost of a more elaborate system such as a 11400 Series oscilloscope.

Design for testability

To incorporate BIT in each board of the 11400 Series scopes, Dye and the design team used a test approach called functional parti-







tioning, which is simpler than other techniques, such as scan-path testing and the use of random-pattern generators.

Functional partitioning refers to the partitioning of a circuit (an IC or a pc board) in order to isolate and observe sections of the circuit that support a single function. If necessary, designers may add hardware, particularly when they must break a feedback path; however, the extra hardware mustn't decrease the circuit's performance.

As Dye points out, developing test vectors or sequences to perform self-tests isn't as easy at the board level as it can be at the chip-design level. You can obtain CAE simulation packages that generate test vectors to simulate a chip's response, and you can find packages that generate test vectors for use with ASIC testers, but the memory requirements for such tests are very large. These test vectors are virtually truth-table tests; it may take a million vectors to thoroughly verify that a chip works. Few boards can incorporate enough extra memory for so many vectors.

Functional partitioning, however, lets you stimulate circuits by function, using parts of the circuit to test the circuit itself. This approach can reduce the number of test vectors by several orders of magnitude, making BIT practical for use on boards.

Scope tests itself

For Tektronix, putting BIT on board greatly reduced the production and manufacturing time that went into the 11400 Series scopes. Because the scopes contain all the software and hardware needed for self-test, every scope has the potential to be a production tester. The firm's assembly-line workers test each board simply by plugging it into a known-good scope and seeing if it works. The scope can diagnose any problem and identify the area of the board on which it resides. Boards that fail go to a repair technician, who can recreate any failure condition and troubleshoot the board on his own test scope.

The new approach necessitated some changes in Tektronix's production line. Rather than trying to fill all its production jobs with nontechnical people, the company now employs some workers who are technically familiar with the product. Because the scopes can identify the board area—and sometimes even the chip—on which a fault resides, these technicians can troubleshoot certain board or system problems very efficiently. The nontechnical people who perform the bulk of the assembly and test rotate jobs to stay interested in their work.

When design on the 11400 Series scopes began two years ago, Tektronix's management viewed self-test merely as an interesting engineering experiment. Now self-test is a company policy: Tektronix has made the commitment to standardize a built-in test procedure for all its scopes. The commitment has paid off for the 11400 line: The new scopes are actually less expensive to produce than many of the older, less-complex models still being manufactured on the company's conventional lines. For example, although the company still needs nine hours to test and calibrate a 7854 scope, it can perform those procedures for a 11400 oscilloscope in 45 minutes.

A 70s identity crisis

Western Digital Corp (Irvine, CA) has also used engineering solutions to compete successfully in a tough market. The company, which now sells 40% of its products overseas, got its start in the 70s by making chips primarily for handheld calculators. It also developed a successful floppy-disk-controller chip.

The company ran into trouble with competition fairly suddenly in the mid to late 70s, when the calculator market became one of the early electronics markets to succumb to foreign domination. Japanese companies were making the majority of calculators, and Western Digital was left with no strong market for its chips. In 1977, it was forced to reorganize under the protection of Chapter 11 bankruptcy.

Western Digital discovered that its troubles stemmed from its corporate self-image. The firm had considered itself *only* an LSI IC designer and manufacturer; it sold its ICs to

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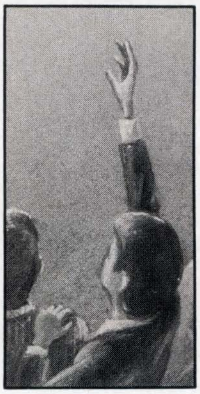

OEMS and ignored the system-level products those manufacturers made from its chips. It also ignored the needs of the end users of those products.

To change its fortunes, Western Digital changed its self-image. It eliminated all its divisions except those supporting a single market focus: technology for personal-computer peripherals. The company now saw itself in a much broader sense. It was no longer merely an LSI chip maker—it now served the PC peripheral market, which meant making boards as well as chips. Serving the PC peripheral market also meant making *small* boards. This requirement led Joe Baia, an engineer who is one of the company's founders, to investigate surface-mount technology (SMT).

Many board companies still regard SMT with apprehension. Compared with through-hole-board technology, SMT tolerances are much tighter, and an SMT production line requires a greater capital investment. Yet Western Digital made the commitment to develop an SMT-board line over two years ago, when all work in SMT was at the pioneering level.

The person ultimately responsible for this decision was Roger Johnson, president and CEO of Western Digital. When asked how, without a technical background, he was able to make the seemingly tough decision to gamble on SMT, Johnson looked mildly surprised at the question. "It was actually a very easy decision, for two reasons: smaller package size and improved product quality. Smaller package size is a strong competitive advantage in the peripheral-controller market, because the control electronics have to shrink along with the drives. We get higher quality because the automated assembly process leaves very little room for human error."

Although many board companies have found SMT difficult to handle, Western Digital, the IC manufacturer, did not. Says Randy Ring, the firm's director of SMT manufacturing: "After holding LSI process tolerances, SMT was easy."

Ring does't mean to imply that developing the SMT line was easy, however. "We initially tried, with no luck, to find consultants in setting up an SMT line. When we finally did find some, they were worse than none at all. So we decided to develop the line ourselves."

Far from regretting that no experts were available, Ring is convinced that his company's lack of board-manufacturing experience was not a weakness but a major advantage. Instead of viewing SMT as another way to make boards, the company viewed it as a process, just as LSI IC fabrication is a process. The company exploited its thorough familiarity with process design and control to learn the new techniques of SMT design. This strategy has had a good deal of success: Western Digital has replicated its initial SMT production line in three other plants.

Success in the graphics market

One of the most keenly competitive markets for electronics products is the market for graphics products. The personal-computer-graphics sector is particularly volatile. Paradise Systems (South San Francisco, CA) has been competing successfully in this market for three years.

Tom Van Overbeek, Paradise's president, claims the company's self-image is crucial in allowing it to move with and anticipate the market. The company got its start three years ago, when it began manufacturing video controller boards for the PC. From the beginning, the company identified itself not just as a maker of generic pc-board add-ins, but as a video-controller manufacturer. Paradise's clear focus also simplified its decisions about what technologies to invest in: The company realized that the future of video controllers lay in custom ICs.

Because it understood the competitive graphics market, Paradise also realized that it needed to produce these ICs in volume, and *quickly*: A typical graphics product has a life of about six months before an upgrade is introduced. Emphasizing design speed left the company no room for error, either in the initial chip design or in its manufacture.

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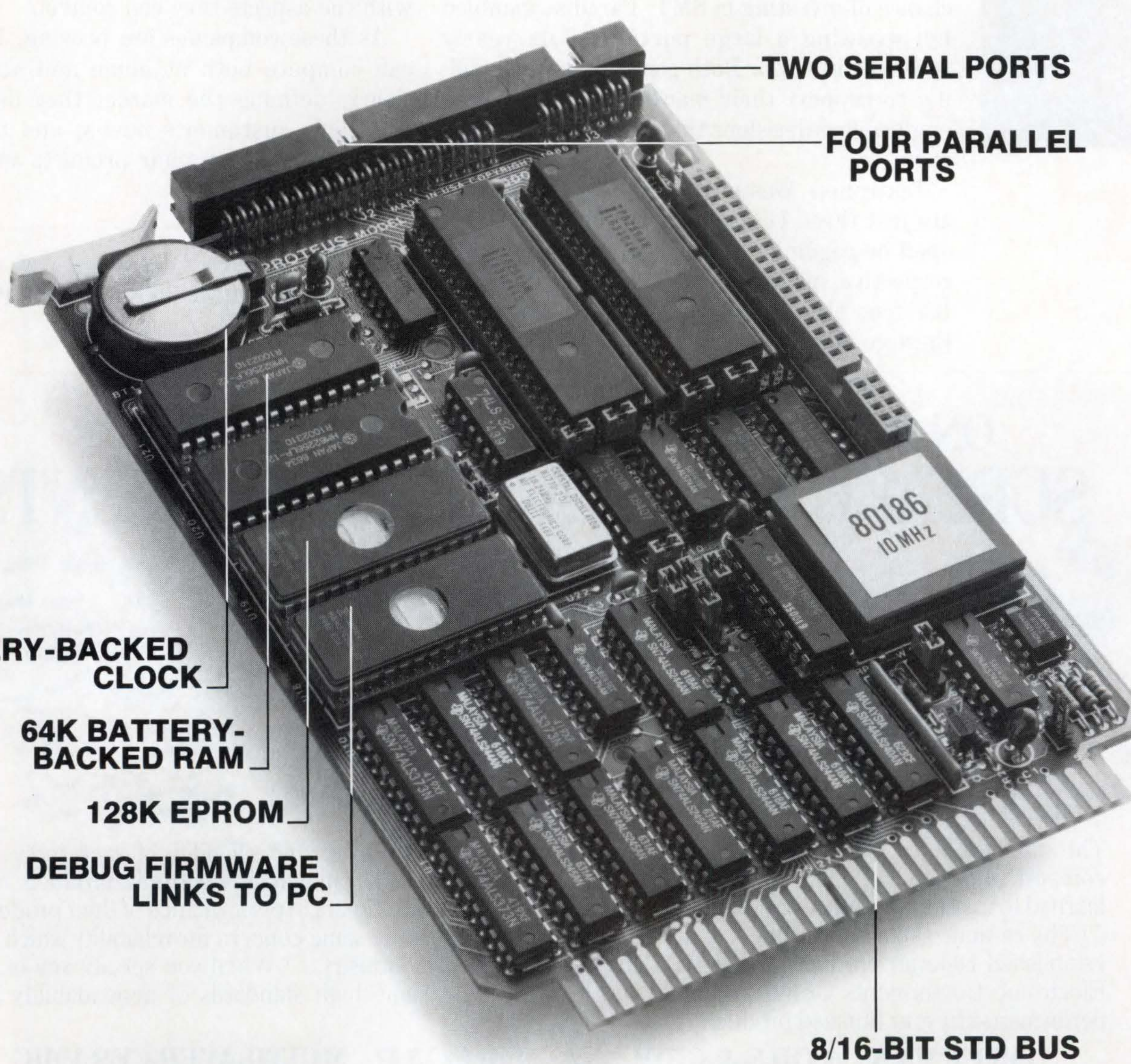

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CIRCLE NO 136

first-time designs, Paradise invested heavily in CAE hardware and software for ASIC design and simulation. What was apparently a hard purchasing decision was made easy by the company's commitment to support its market focus in any way necessary.

Like Western Digital, which took the chance of investing in SMT, Paradise gambled by investing a large portion of its yearly revenues in CAE. Both companies were willing to support their marketing focuses with engineering decisions that at the time seemed risky.

Tektronix, Western Digital, and Paradise are just three US companies that have developed or regained a competitive lead in their respective markets; there are many others. It's true that when you talk with people at these companies, you'll hear a certain amount of complaining: They still face some serious economic and business problems that cannot be solved merely by a change in engineering direction. But the companies' complaining is like farmers' complaining about the weather—yes, they are vitally affected by it, but they can't do much about it, so they just get on with the aspects they can control.

As these companies are proving, US firms can compete both at home and abroad by clearly defining the market they design for and their customer's needs, and by being willing to support their products with engineering solutions. **EDN**

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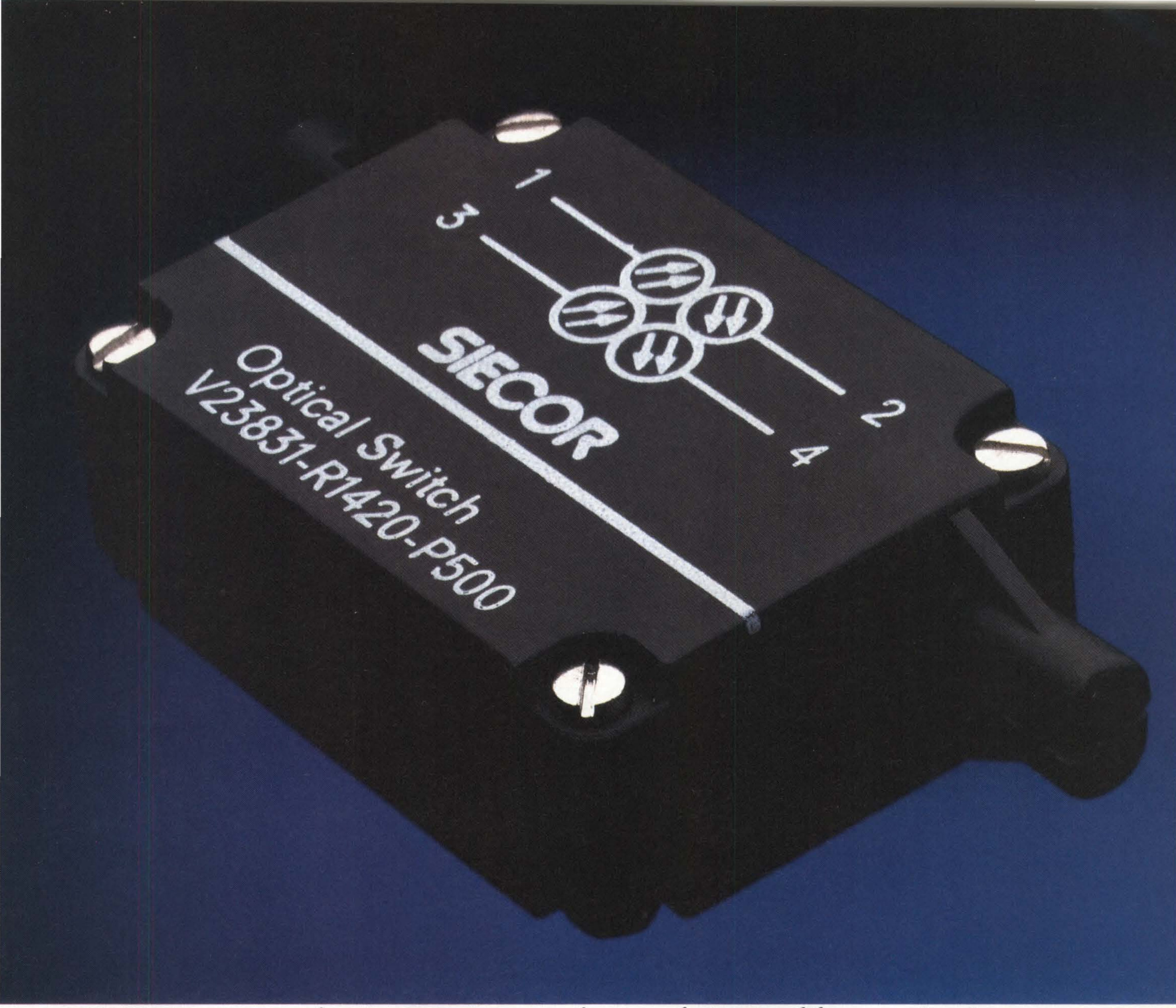
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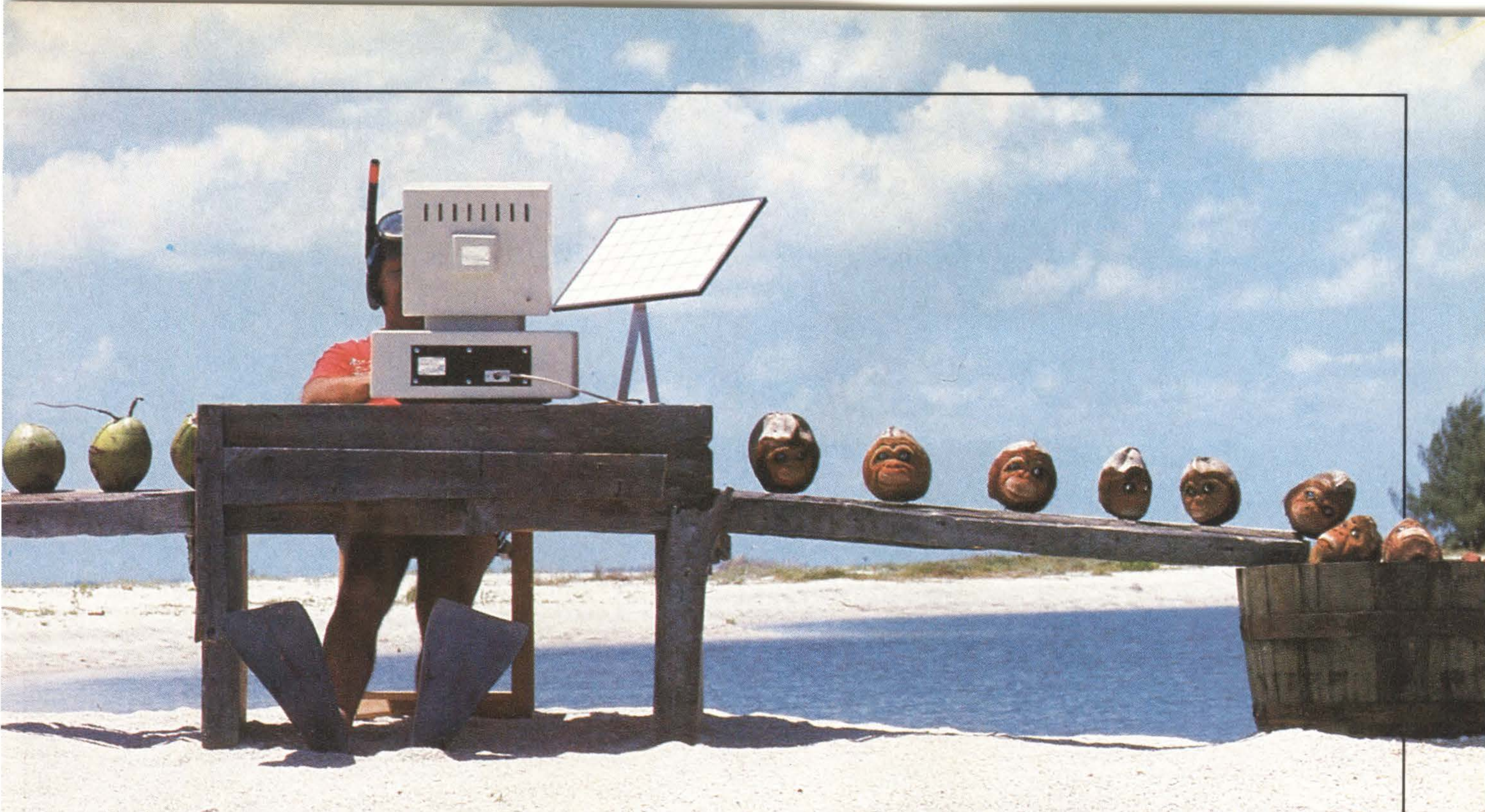

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CIRCLE NO 135

THE ADVANCED FAMILY WITH A

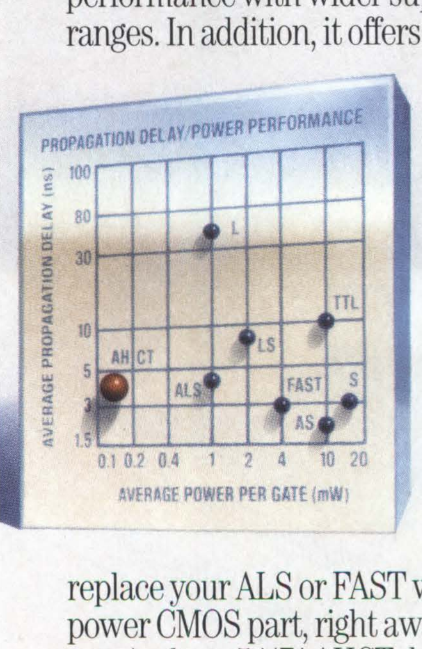
CMOS LOGIC DIFFERENCE: It is available now.

Samsung's 54/74 AHCT advanced CMOS logic family is available in production quantities now. And you can get samples, free. This means you can design our logic into your product, now. And move into production, now. No waiting.

Design in the Performance You Need

Our 54/74 AHCT advanced high-speed CMOS logic family gives you speeds and drives equivalent to, or better than, ALS, and can be used as direct plug-in replacements for ALS and FAST.™ In fact, 24mA drive is guaranteed for bus drivers.

54/74 AHCT achieves advanced bipolar performance with wider supply and temperature ranges. In addition, it offers the superior noise immunity, rail-to-rail output voltage swings and the low input currents of CMOS.



Pin For Pin Replacement

Samsung's AHCT CMOS logic family, with 157 part types, has the most comprehensive selection of standard logic functions, so you can replace your ALS or FAST with our much lower-power CMOS part, right away.

And our 54/74 AHCT does not have a premium price tag. In fact, it costs the same as ALS. Which means you'll actually save money in your system cost because of lower power requirements and improved reliability.

CIRCLE NO 94

CMOS LOGIC KS74AHCT Part Types

Gates and Inverters

00	20
01	21
02	22
03	27
04	30
05	32
08	51*
09	58*
10	86
11	132*
12	133*
14*	266

Buffers & Line Drivers

125*	367
126*	368
210	465*
240	466*
241	467*
244	468*
365	540
366	541

Flip-Flops

73	399*
74	534
76	564
78	574
107	670*
109	794*
112	821*
173*	822*
174	823*
175	824*
273	825*
374	826*
377*	

Latches

75*	793*
77*	841*
259	842*
373	843*
533	844*
563	845*
573	846*

Transceivers/Registered Transceivers

242*	643	652*
243*	645	658*
245	646	659*
640	648	664*
	651*	665*

Counters

160	190	590*
161	191	591*
162	192	592*
163	193	593*
168	390*	
169	393	

Decoders/Encoders

42*	148*	238
138	154*	239
139	155*	

Multivibrators

121*	123*	423*

Multiplexers

151	253*
153	257
157	258
158	352*
251	353

Shift Registers

164	299*
165	595*
166	596*
194	597*
195*	

Arithmetic Circuits

280*	680*
518*	682*
519	684*
520*	686*
521	688*
522*	689*
679*	

*Part Types Available in Q4—All Other Part Types Available Now.

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54/74 AHCT________(2 ea.)

54/74 AHCT________(2 ea.)

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☐ Have a salesperson call me.

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Title: ____________

Company: ____________

Address: ____________

City/State/Zip: ____________

Telephone: (   ) ____________

Send coupon to: Samsung Semiconductor, CMOS Logic Marketing, 3725 N. First Street, San Jose, CA 95134-1708. EDN100187

Products for the factory emphasize automation,

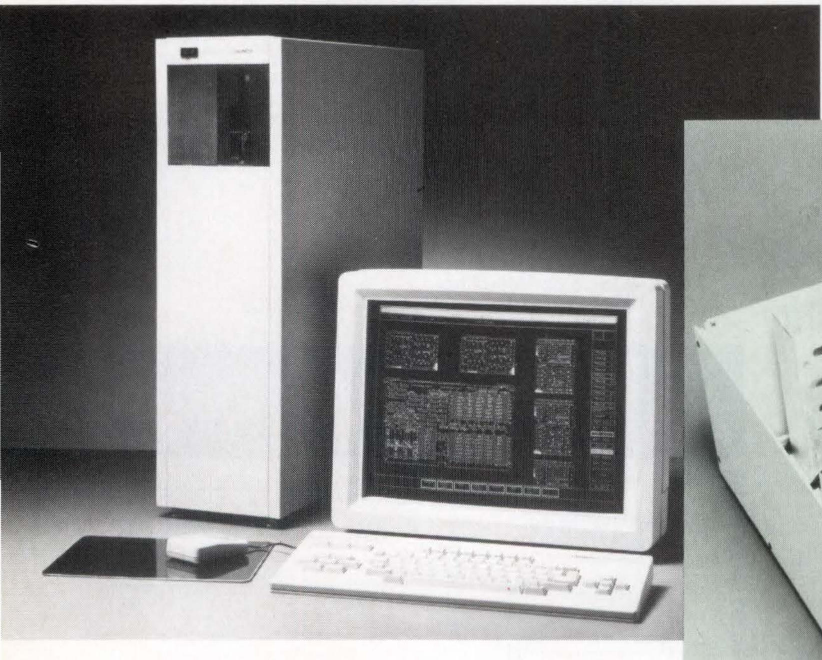
Putting together an industrial-grade system for a process-control, machine-control, or high-volume incoming-inspection application can be a complex task: The factory floor is a hazardous place, and you must take into account possible temperature extremes, airborne particles, and vibration and noise. Those considerations notwithstanding, staying competitive in today's industrial market clearly requires increasing automation and ease of assembly.

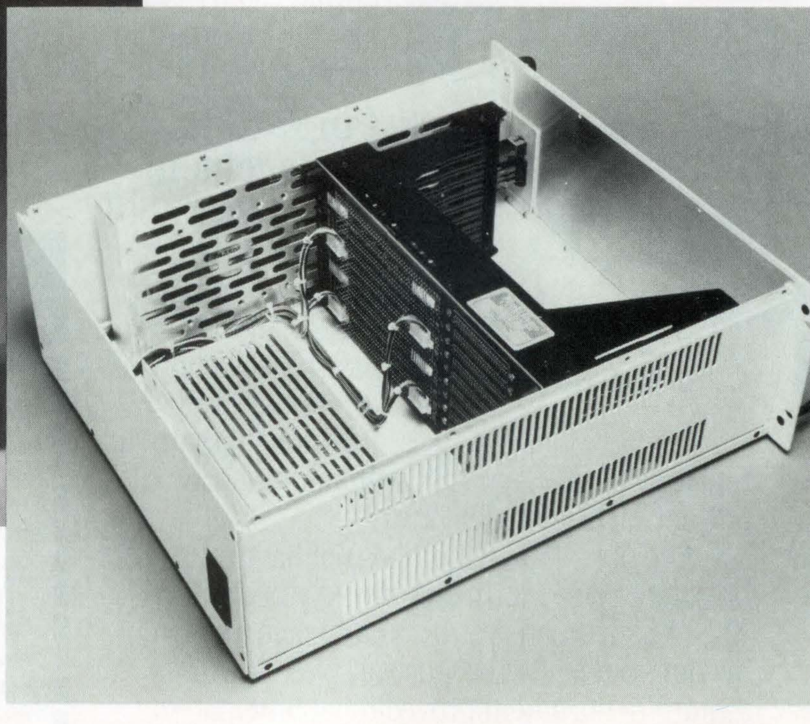
EDN's Industrial Electronics Product Showcase focuses on system-level industrial products and on components specifically designed for use in systems intended for harsh industrial environments. You'll note that many of the system-level products covered in the showcase are based on the IBM PC; these computer-controlled systems can facilitate the manufacturing process.

The 4000AT, for example, an IBM PC-compatible computer system from Adac, consists of a signal-conditioning front end and an 8-slot XT/AT backplane in a rugged enclosure with a shock-mounted Winchester disk drive. The system is intended for PC-based data acquisition and control in a plant environment.

Xycom's PC/AT-compatible 4150, on the other hand, has a 5-slot backplane and a front panel that's sealed to NEMA standards. And, because its mother board isn't preconfigured, you can match its μP to your application. Another computer system, Pro-Log's PC/XT-compatible System 2 Model 10, has optional driver routines for 22 STD Bus cards.

You'll also have the chance to evaluate various system enclosures. Mupac Corp manufactures a series of lightweight enclosures to accommodate bus-specific (VME Bus, Multibus, or Multibus II) backplanes, which the company also produces. Sigma Information Systems' SA-H155 enclosure incorporates a 14-slot Q Bus backplane that is compatible with LSI-11 and MicroVAX systems. Constructed of 14-gauge steel and standing





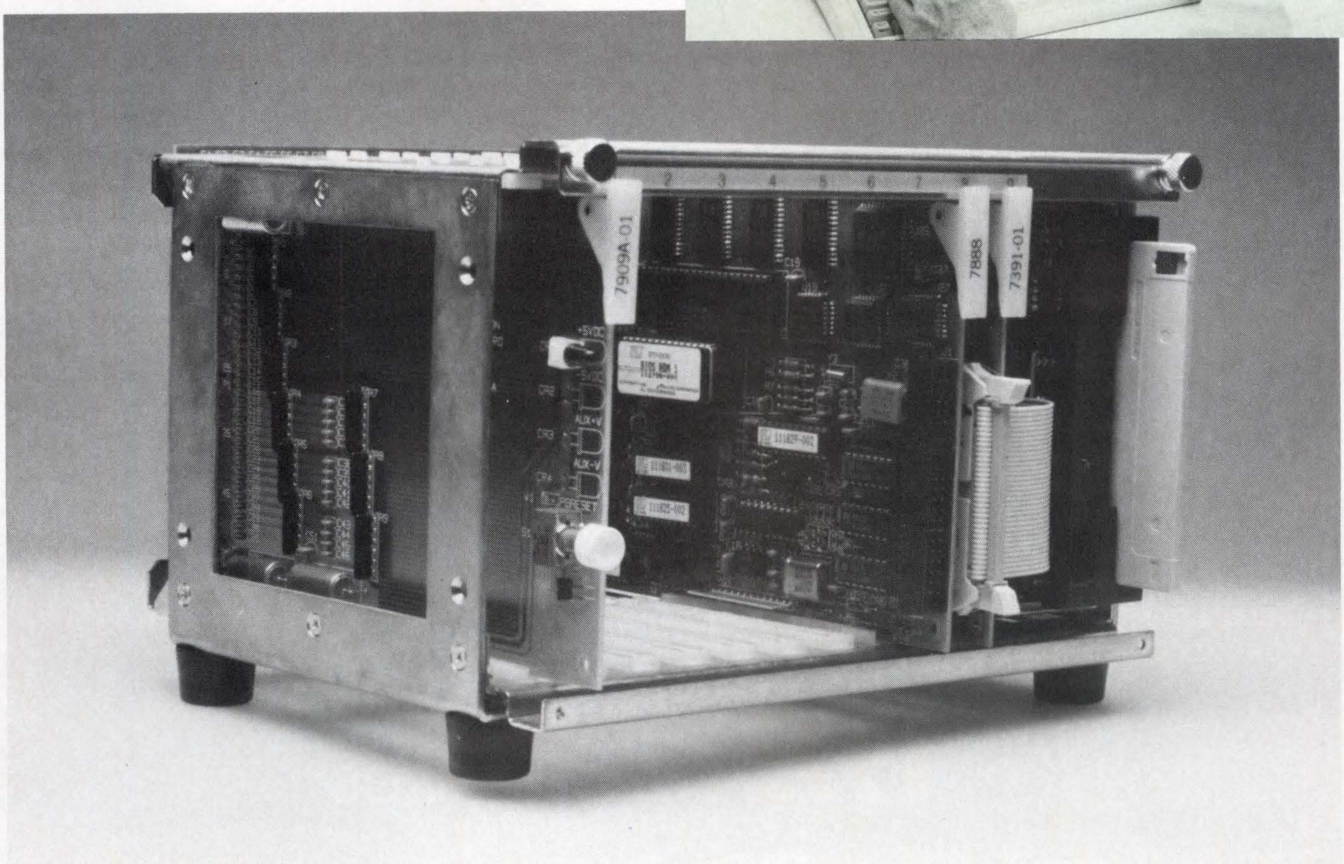
environment ease of assembly

KEEPING AMERICA COMPETITIVE

12¼ in. high, the enclosure has room for three 5¼-in. drives.

You can also choose from numerous controller boards and control systems. The Expert Controller from Umecorp is a dedicated, programmable expert system with a host-independent, asynchronous-processing μC and proprietary software. Its natural-language interface alleviates the need for the user to learn programming languages before creating a knowledge base.

In contrast, the CDI-Ladder control system from Computer Dynamics combines STD Bus hardware with a standard relay ladder-logic language. Nontechnical workers can easily program and maintain this type of control system with an IBM PC. As you can see from the products in this year's Industrial Electronics Products Showcase, the IBM PC is proving to be an important tool for streamlining the manufacturing process.



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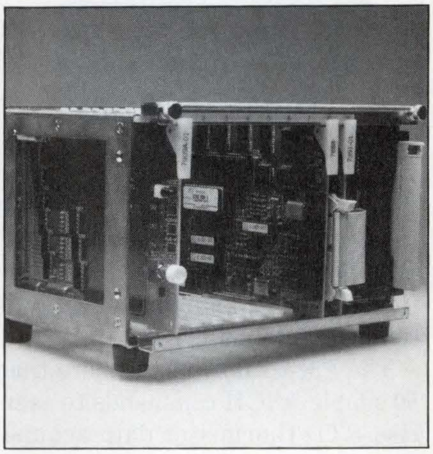
CIRCLE NO 95

Computer system brings IBM compatibility into industrial applications

The System 2 is rugged enough to operate on the factory floor and in other industrial applications. It is fully compatible with the IBM PC/XT—both at the DOS level and at the BIOS and hardware/chip levels.

You can expand System 2 with memory, mass-storage, and interface options using STD Bus cards. Two versions are available—one with semiconductor-based mass storage (Model 10), and the other with floppy- and hard-disk storage (Model 20).



Model 10, with 128k bytes of CMOS static RAM (expandable to 640k bytes) and two semiconductor disk drives, is designed to be embedded in systems where temperature extremes, vibration, moisture, and airborne particles pose potential hazards. Model 20 has 128k bytes of CMOS static RAM (expandable to 640k bytes) and one 3½-in. floppy-disk drive; a second floppy-disk drive and a 3½-in., 20M-baud hard disk are optional.

Both models contain a serial port, time-of-day clock, and from seven to 20 expansion slots. They also include the MS-DOS 3.2 operating system and full documentation. Both can operate after power-up with no operator supervision, and they can connect to any RS-232C device. Options include driver routines for 22 STD Bus cards and a software library that provides initialization. Model 10 (RAM-disk version), \$1195; Model 20 (floppy-disk version), \$1595.

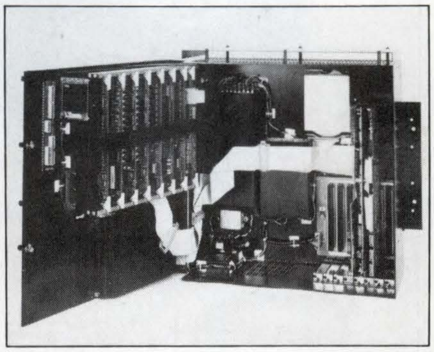
Pro-Log Corp, 2560 Garden Rd, Monterey, CA 93940. Phone (800) 538-9570; in CA, (408) 372-4593. TWX 910-360-7082.

Circle No 638

Rugged XT/AT-compatible system features an 8-slot PC configuration

Model 4000AT combines an 8-slot signal-conditioning front end with an 8-slot XT/AT-compatible backplane in a single rugged enclosure for practical PC-based data acquisition and control in the plant environment. The dual backplanes assure the user of full I/O and full PC-slot availability in completely independent card cages.

The system enclosure includes a shock-mounted Winchester disk. You have a choice of more than 35 plug-in signal-conditioning modules. Front-panel wire termination for as many as eight plug-in modules lets you interface to hundreds of I/O points without using additional enclosures. You can change the I/O modules without disturbing any field wiring.



The PC/XT- and PC/AT-compatible backplane accepts four full and four half-size PC-compatible cards for a full range of CPU and housekeeping functions. The 4000AT provides automatic interface between the I/O and PC backplanes and offers full field signal isolation from the CPU and PC function cards. A choice of PC/XT or PC/AT CPU's is available.

The 4000AT features an all CMOS design to minimize power consumption and keep operating temperature low. The convection-cooled enclosure needs no fan. An icon-based, programmable process-control software package featuring icon-driven system configuration and full-color graphics is available as an option. From \$1700 (without mass storage).

ADAC Corp, 70 Tower Office Park, Woburn, MA 01801. Phone (617) 935-6668. TLX 951802.

Circle No 641

Precision process monitor solves temperature-monitoring problems

The PM-5060 accepts low-level analog signals from RTDs (resistance temperature detectors) and a variety of thermistors. The monitor filters an input signal, amplifies it, and then converts it to digital data using voltage-to-frequency conversion techniques.

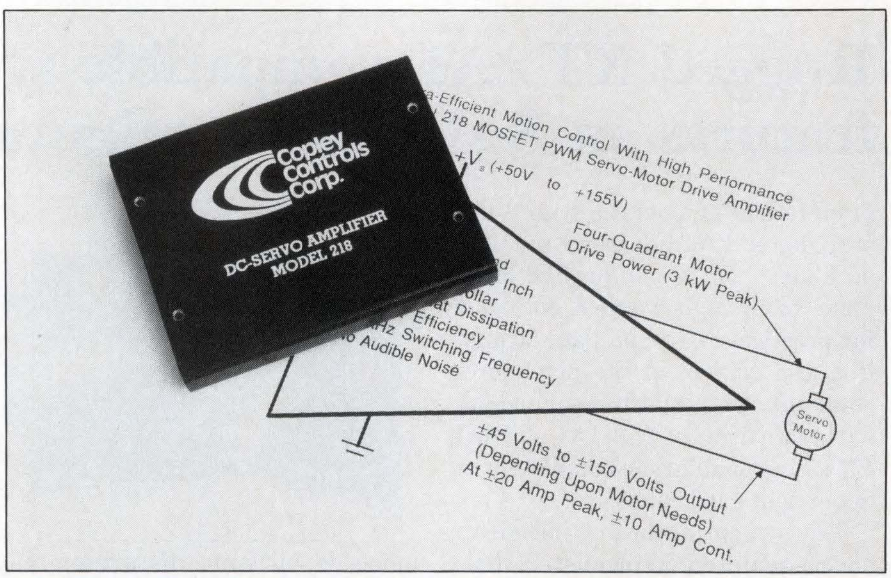
The monitor's onboard μP linearizes and calculates the temperature and feeds data to the vacuum-fluorescent display. It measures temperature in degrees C or F at a resolution of 0.1 or 1 degree. The 5060 has a 5-digit display. You can configure it for 2-, 3-, or 4-wire RTD inputs. Input type and configuration are selectable either by the front-panel keypad or an RS-232C port. You type in all monitor functions; the alphanumeric display is completely menu-driven.

The PM-5060 supports more than 50 simple ASCII commands to exercise RTD/thermistor data-acquisition functions. It is equipped with four optoisolated setpoint outputs that respond to a preset temperature. The display indicates the setpoint status. The solid-state MOSFET relay outputs can drive 100 mA/300V loads and are individually programmable for high- or low-going, absolute or relative temperatures with user-selectable hysteresis. The monitor is available in models that accommodate American, European, and Japanese power systems. $395.

Datel, 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 339-9341. TWX 710-346-1953. TLX 951340.

Circle No 640

98% efficient servoamplifier mounts on a pc board



Measuring only 6×4×0.8 in., the Model 218 PWM servoamplifier readily mounts on a pc board or in a small NEMA enclosure. It has a 98% efficiency and provides 1500W (±150V at ±10A) continuous output; it can thus power dc servomotors with ratings to 2 hp. It can also provide 3000W for short periods to give higher torque for motor acceleration and reversal.

The amplifier features a 22-kHz switching frequency that provides a 1-kHz bandwidth and eliminates hum well above the range of the human ear. A built-in dc/dc converter develops a variety of voltages for powering internal circuits, allowing the amplifier to operate from a single supply voltage in the 25 to 155V range. A MOSFET bridge output circuit develops the output from the supply voltage.

The amplifier is protected against short-circuit, overvoltage, and undervoltage conditions, and excessive temperature. It also responds to end-of-travel, beginning-of-travel, and emergency-stop inputs. The 22-kHz switching frequency allows the Model 218 to drive servomotors with internal inductance as low as 250 μH without the need for a series smoothing inductor. $516. Delivery, four to six weeks ARO.

Copley Controls Corp, 375 Eliot St, Newton, MA 02164. Phone (617) 965-2410.

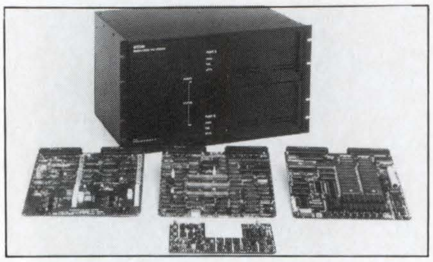
Circle No 645

Industrial Product Showcase

Multiport drive test system can test 128 units simultaneously

The 7000 test system is designed for use on the production floor and for high-volume incoming inspection. It can perform complete digital and analog tests on any mixture of 5¼- and 3½-in. full- or half-height Winchester disk drives. The system analyzes drives that have a variety of interfaces, including ST506/ST4412, SCSI, and ESDI.

A host PC/AT-type computer controls each of the system's 128 test ports independently. You can thus test a number of drives simultaneously, sending any desired combination of company-standard or user-



programmed tests to each unit. A full 128-port system occupies as little as 36 ft^2.

Two system configurations are available. The 7002 is a completely self-contained, rack-mountable chassis that contains two independently powered test ports. You can expand this version by adding extra racks. The second configurations (7016 or 7032) are made up of multiple rack-mounted test ports stacked side-by-side and one above the other.

The system produces an individual report for every unit tested. The computer can also generate archival reports for off-line trend analyses or on-line failure analyses. $70,000 for a 16-port system.

Wilson Laboratories Inc, 2237 N Batavia St, Orange, CA 92665. Phone (714) 998-1980.

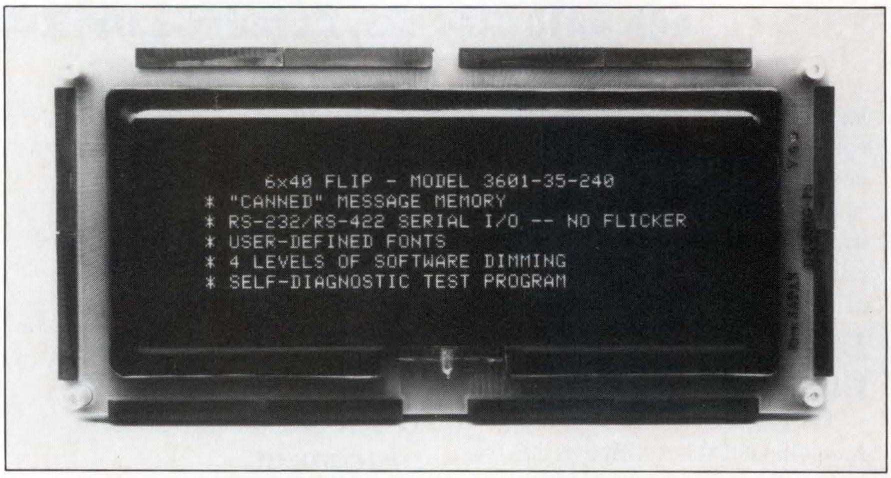
Circle No 649

Vacuum-fluorescent display with CMOS RAM features canned messages, battery backup

The Model 3601-35-240, an addition to the Flip family, is a 6-line×40-character vacuum-fluorescent (V-F) display that can store and retrieve user-programmed canned messages. The module's 8k-byte CMOS RAM stores as many as 127 messages, which an onboard battery-backup retains.

The display also incorporates a self-diagnostic test program that checks all display functions. This program checks and displays user settings for data configuration and rate, the condition of the battery-backup circuit, the line drivers and receivers, and the RAM available for canned messages. At the conclusion of the test, the module displays its repertoire of 96 ASCII characters.

In addition to the standard ASCII set, the module can display alternate character sets (for example, scientific, Scandinavian, and

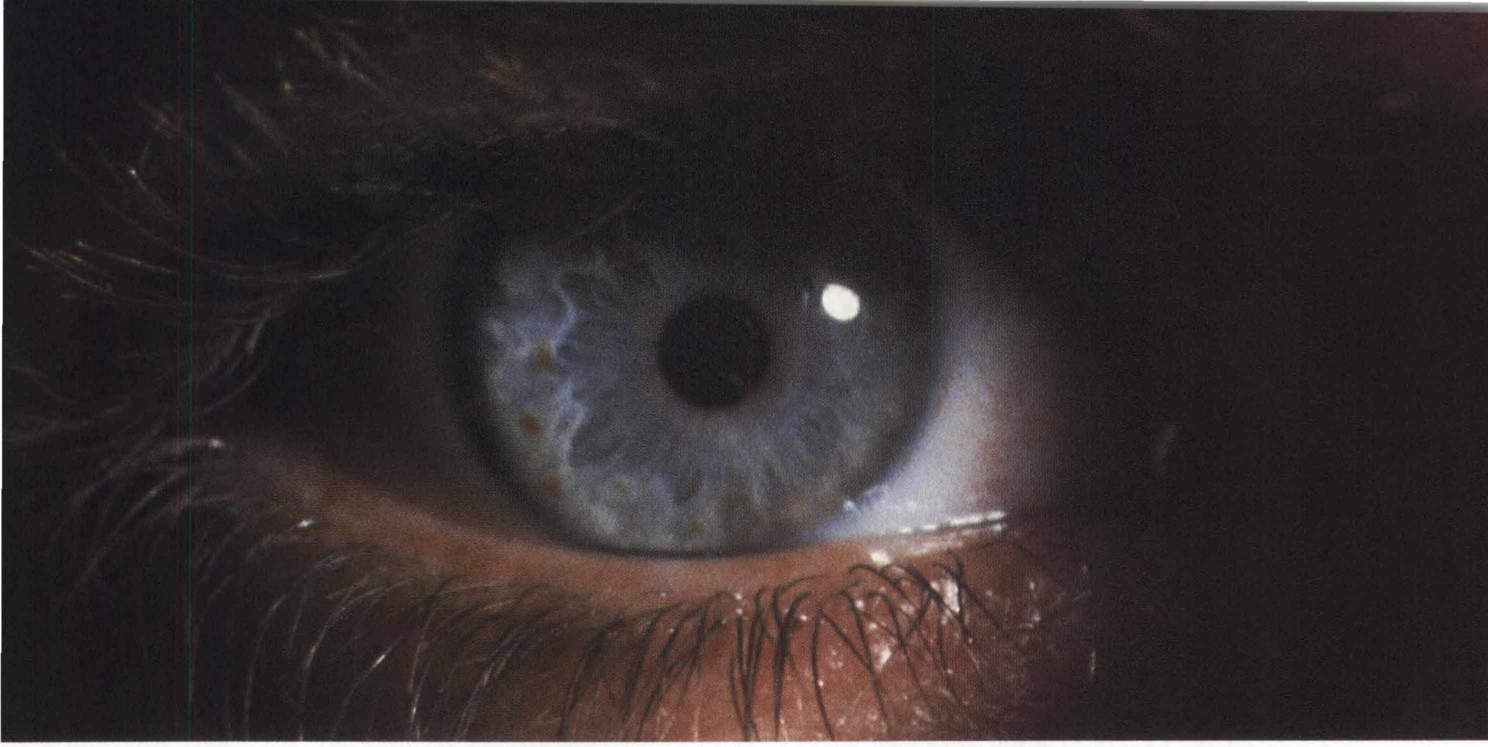


German). You can also define your own character patterns and download them into any or all of the 96 ASCII locations.

The 3601-35-240 operates from one 5V supply. An onboard μP controls all display functions as well as the serial data interface with the host system. This interface can conform to either RS-232C or RS-422 standards and can accept data at 1200 or 9600 baud. Each of the display's 240 5×7-dot matrix characters is 5 mm high. $538 (100). Delivery, four to six weeks ARO.

IEE Inc, Industrial Products Div, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556.

Circle No 644



How to uncover PWB defects with Augat's VIP™ sockets and this amazing inspection instrument.

Wouldn't it be more efficient if you could spot PWB surface defects before the boards went to testing? Well, Augat has introduced a removable carrier for DIP, pin grid and custom footprints that makes it possible.

After the VIP socket is wave soldered into place, the carrier is removed to permit visual inspection of the terminals.

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Name__________

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Street Address__________

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Mail to: Augat, Inc. Interconnection Components Division, 33 Perry Avenue, Attleboro, MA 02703
(617) 222-2202.
FAX: 617 222 0693

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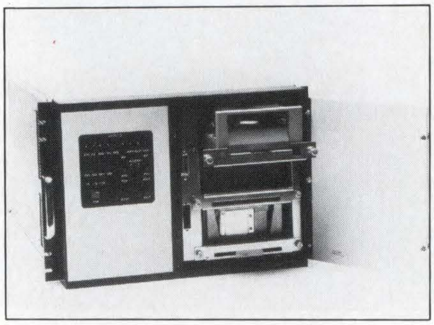
CIRCLE NO 100

Ruggedized industrial enclosure holds three disk drives

The SA-H155 is a 12¼-in.-high ruggedized system enclosure for three pluggable 5¼-in. drives that you remove individually via a door in the front of the chassis. The enclosure is for environments where the entire computer system is subjected to shock, vibration, dust, dirt, and high ambient temperatures.

Constructed of 14-gauge steel, the SA-H155 includes a 480W switching power supply. The disk drives are located at the right of the unit; the front control panel includes switches and indicators for system control.



The SA-H155 incorporates a 14-slot Q bus backplane for use with either LSI-11 Series or MicroVAX systems. Five fans help secure a good wash of air over the backplane, power supply, and drives. Two of the fans are located at the left of the chassis to move air from the rack and to pressurize the unit. Three other fans are located at the rear of the chassis to exhaust the system through the backplane and power supply at the rear.

The SA-H155 operates over 0 to 50°C and in noncondensing humidity as high as 95%. The unit will withstand 15g shock levels. $4500.

Sigma Information Systems, 3401 E La Palma Ave, Anaheim, CA 92806. Phone (714) 630-6553. TLX 298607.

Circle No 642

µC-based real-time system controller suits factory-floor and other applications

The Expert Controller—a dedicated, programmable expert system—consists of a host-independent, asynchronous processing µC and proprietary software. A natural-language interface allows users to create a knowledge base without having to learn programming languages.

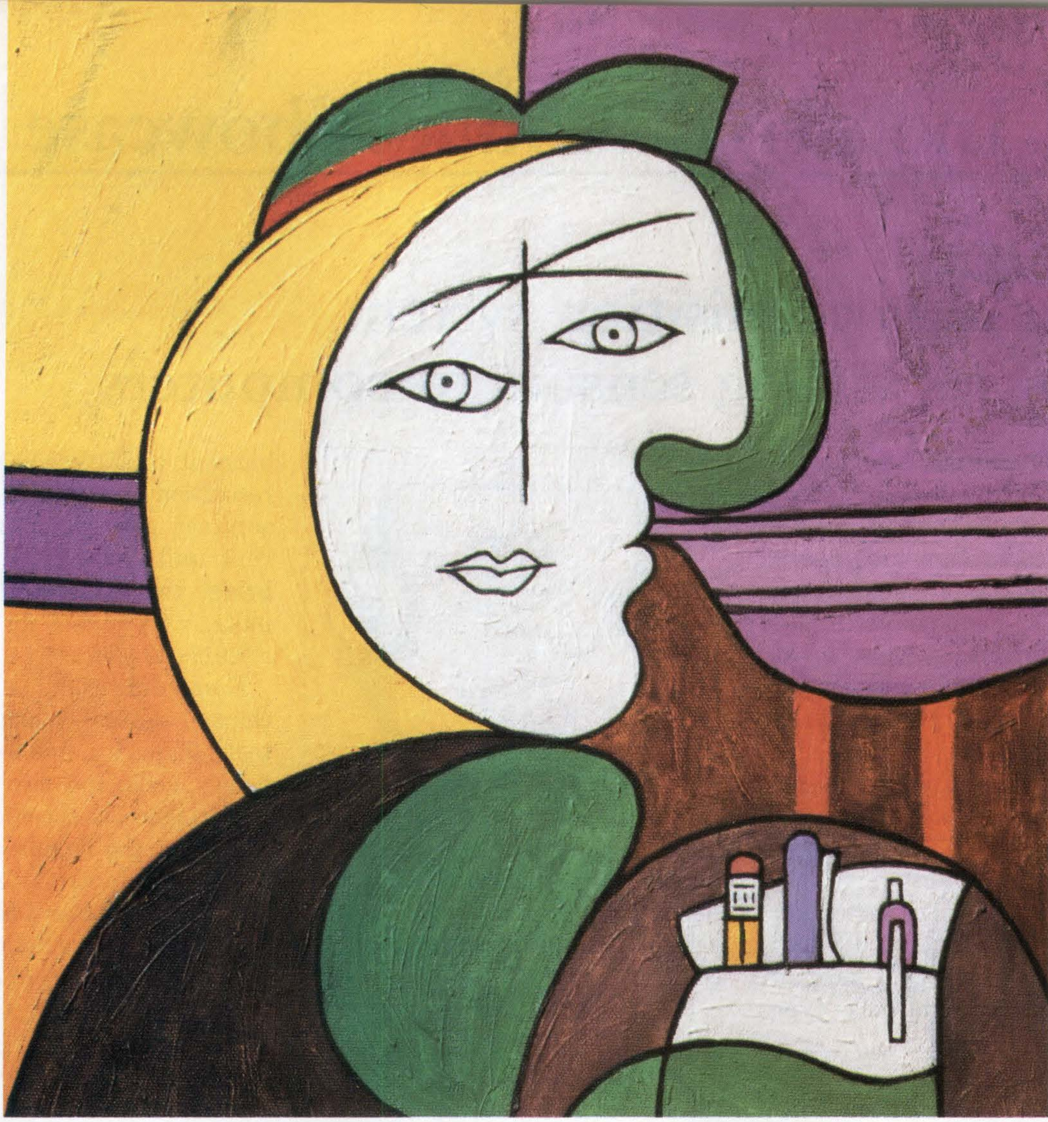
You can configure the controller as a stand-alone system or, for larger-scale AI applications, combine several units in a rack. It features environmentally resistant industrial packaging and comes with battery-backed static RAM or EPROM for knowledge bases. The power supply is built in.

The Expert Controller uses proprietary AI algorithms and a multiprocessing architecture that interprets knowledge bases containing as many as 10,000 rules. The system uses a combination of rule-based, frame-based, and object-oriented approaches to represent machine-control knowledge.

A dedicated inference engine uses high-speed logical search mechanisms to interpret knowledge bases developed by users. Search techniques include goal-driven backward chaining and event-driven forward chaining. The system can process more than 100,000 logical inferences/sec with a real-time throughput of as much as 8000 complex rules/sec. From $5500.

Umecorp, 700 Larkspur Landing Circle, Suite 200, Larkspur, CA 94939. Phone (415) 925-2000. TLX 330248.

Circle No 639



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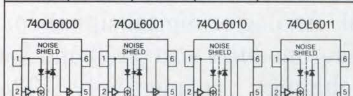
PART NUMBER	LOGIC COMPATIBILITY INPUT	LOGIC COMPATIBILITY OUTPUT	LOGIC FUNCTION	OUTPUT CONFIGURATION
74OL6000	LSTTL	TTL	BUFFER	TOTEM POLE
74OL6001	LSTTL	TTL	INVERTER	TOTEM POLE
74OL6010	LSTTL	CMOS	BUFFER	OPEN COLLECTOR
74OL6011	LSTTL	CMOS	INVERTER	OPEN COLLECTOR



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CIRCLE NO 101

Smart data-acquisition system interfaces analog sensors to computers

The Series D2000 smart data-acquisition and control modules let you interface nonstandard analog sensors to any computers with a serial port. The modules let you download as many as 25 breakpoints through the port; you can use these breakpoints to program virtually any transfer function into a module. Software takes care of all scaling, linearization, and calibration tasks, so potentiometers, switches, or adjustment hardware are unnecessary.

The 24 modules in the series communicate in ASCII over an RS-232C or RS-485 link. Voltage, current, bridge, frequency, and pulse types of modules are available. Each module has digital I/O lines for on/off control using solid-state relays or TTL signals.

The input is protected against burnout to 250V ac. Measurement resolution is 1 part in 50,000. The accuracy rate for voltage and current units is within ±0.02%; for bridge units, ±0.05%; for frequency units, ±0.1%; and for pulse units, ±0.01%+5 μsec.

Communication features include channel address, a baud rate of 300 to 38.4k, parity, line feed, byte time delays, echo, and check sum. Rated performance is specified from 0 to 70°C, but the modules can operate from −25 to +85°C. $275 to $350.

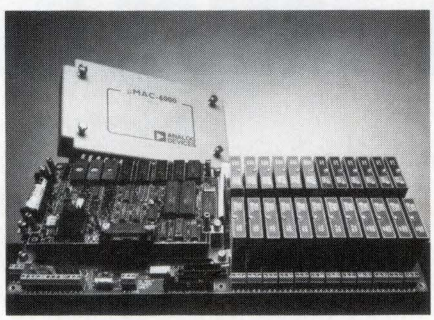
DGH Corp, Box 5638, Manchester, NH 03108. Phone (603) 622-0452. TWX 510-601-6112.

Circle No 648

Modular industrial processor has extra processing power for expansion

Using integrated hardware and software modules, the μMAC-6000 combines computer circuitry, analog signal-conditioning modules, and direct sensor connections on a single board. The signal-conditioning modules address a single channel each, which lets you customize your I/O configuration. The system is built so that processing power increases as I/O point count increases, allowing it to maintain high performance in large applications. You can install the modules or reconfigure them without disturbing field wiring. Each socket can be either an input or output channel.

The system uses an 80188 μP and features 12- or 14-bit data conversion. It has 64k bits of PROM and a 256k-bit battery-backed user RAM for stand-alone applications. An EEPROM is provided for user storage of calibration constants and correction coefficients.

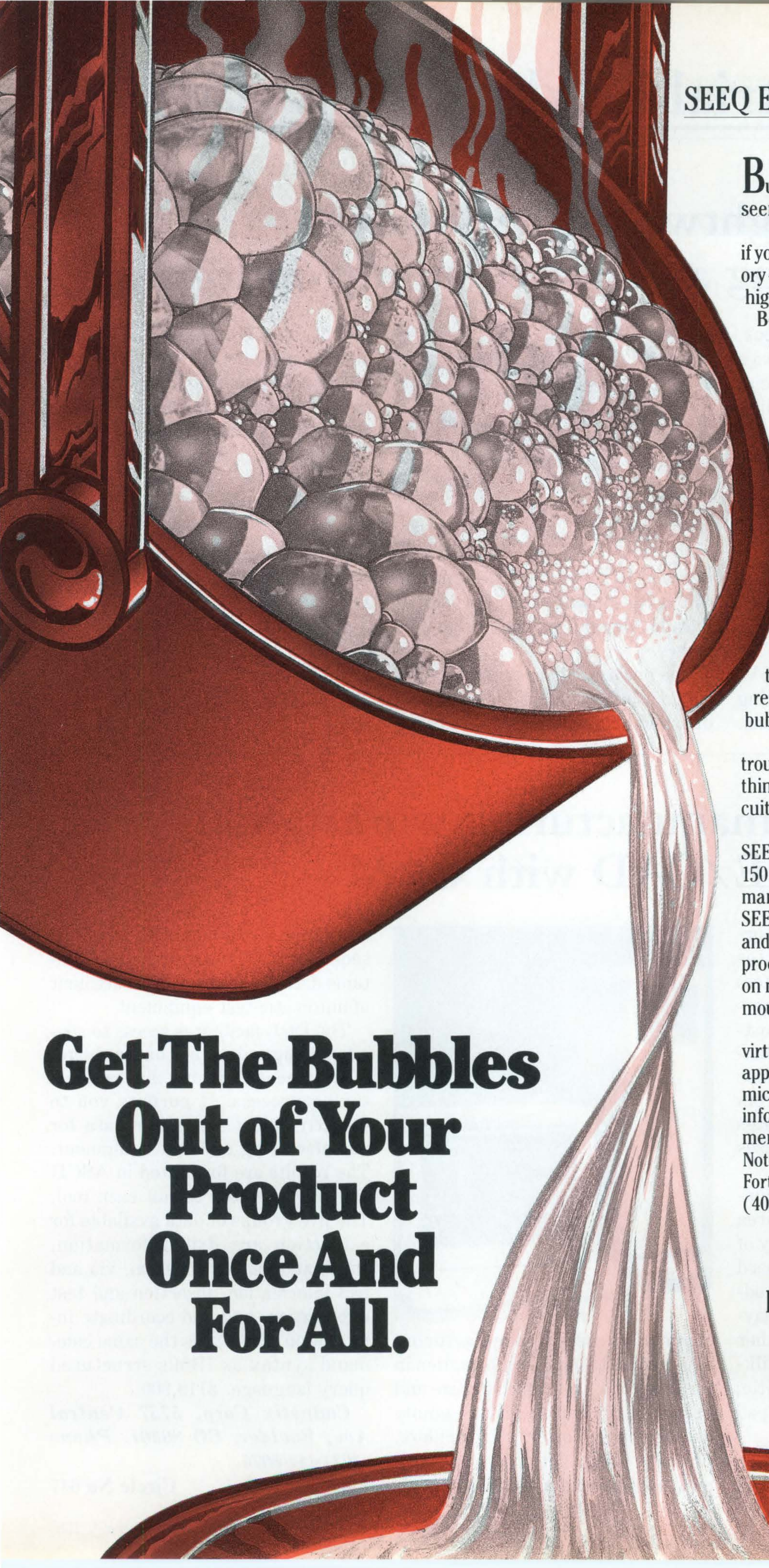


In addition to its 24 analog I/Os, the μMAC-6000 supports as many as 256 digital I/O points. It also provides 16 low-speed counters, two high-speed counters, six frequency inputs, two pulse outputs, and a watchdog timer. The communication ports include an RS-422 port, two RS-232C ports, and one IEEE-488 port. For distributed applications, the μMAC-6000E intelligent expansion unit offloads the CPU and A/D converter of the main unit. In multiple configurations, each host computer can interact with 10 other 6000s, each of which may have three 6000E slaves.

The system requires one 5V supply and operates over 0 to 60°C. The $3395 system includes the backplane and the CPU enclosure with μMacBasic software already in PROM. Analog or digital signal-conditioning modules cost $150 and $50 per channel, respectively. The μMAC-6000E costs $2295.

Analog Devices Inc, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 461-3712. TWX 710-394-6577. TLX 174059.

Circle No 643



Get The Bubbles Out of Your Product Once And For All.

SEEQ EEPROMs In The Factory.

Bubble memories as a technology seem to be bursting all over the place.

Which is one sound reason why—if you use bubbles for non-volatile memory—you may want to replace them with high-density EEPROMs from SEEQ.

Because let's face it, bubbles just don't stack up against SEEQ E^2s.

Compare speed, for example. Since bubble memories access data serially—like tape drives—they're slower than molasses in January. A typical bubble read cycle will get you about 17-18.5K bytes per second. In that same time, a SEEQ E^2 gives you 5 Megabytes. Write times for E^2s are also faster by an order of magnitude.

SEEQ E^2s not only work faster, they work harder in harsh environments. They operate over extended and full military temperature ranges, with greater inherent reliability than any electromagnetic bubble. Or any other E^2.

SEEQ E^2s aren't a lot of toil and trouble for designers, either. For one thing, with all their coils and support circuits, bubbles can be real current hogs.

But not E^2s. A 256K part from SEEQ draws just 60 mA in active mode, 150 μA in standby. And by including many peripheral functions on board, SEEQ E^2s make it easy to build hardware and software interfaces to popular microprocessors. Plus E^2s fit comfortably on most system boards, using surface mount packages.

At SEEQ, we can help you with virtually any non-volatile memory application—from high-density E^2s to micro-computers with E^2 on board. For information on bubble memory replacement, call us today for our Application Note #24. SEEQ Technology, Inc., 1849 Fortune Drive, San Jose, CA 95131. (408) 432-9550.

seeq

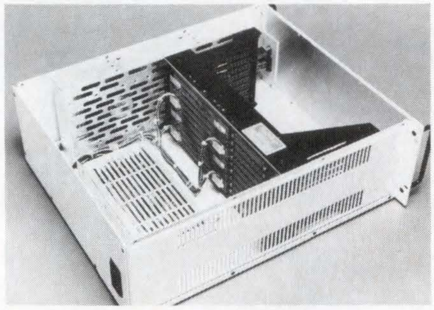
E^2 Is Our Middle Name.

CIRCLE NO 143

Bus-specific lightweight enclosures provide cooling and power-supply options

Designed for VME Bus, Multibus, and Multibus II systems, the Series 508 lightweight packaging enclosures feature a number of cooling and power-supply options that let you customize the product to your specific application. The enclosures are currently available in 3.5-, 5.25-, 7-, and 8.75-in. heights and include 4- to 10-slot card racks.

All 508 Series units feature pressurized and filtered plenum air cooling for even cooling of both the power supply and card rack. Four supply options are available—5V, 12V, −12V, and −5V. By removing two screws, you can access the fans.



Because of the airflow design, you can slide-mount the enclosures without degrading cooling performance.

The enclosures are constructed of rugged, lightweight aluminum with brushed or polyurethane textured finish. Configurations include a desktop model, a model dedicated to 19-in. rack mounting, and a desktop model with EIA mounting flanges so you can remove the front panel when the enclosure is loaded in a 19-in. rack.

The enclosures are available with front, rear, or top access. Each model will accommodate any of the company's bus-specific backplanes. From $1400.

Mupac Corp, 10 Mupac Dr, Brockton, MA 02401. Phone (800) 225-0398; in MA, (617) 588-6110. TWX 710-345-8458.

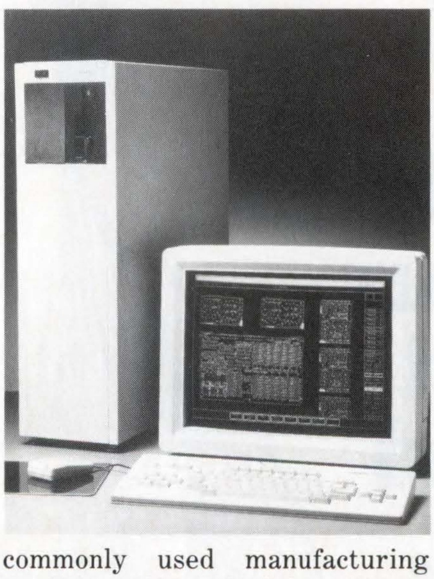
Circle No 646

68020-based manufacturing workstation integrates CAE/CAD with CAM

The 32-bit CDX-6000S manufacturing workstation features 8M bytes of RAM (expandable to 12M bytes) and 160M bytes of hard-disk storage. It includes a panel editor, postprocessor, and a database query language (DQL) facility. The database accepts pc-board design input from a variety of sources and generates data for equipment from all phases of manufacturing.

The panel editor lets you construct a multiple-image tooling area for the manufacture and assembly of a pc-board design. Multilayer board images are easily analyzed and modified using the editor's 24 trace layers and 24 drafting layers. Another 12 layers are dedicated to silkscreen process; assembly; title; board and package outlines; and pad and via manipulations.

The workstation offers a selection of postprocessor interfaces to most



commonly used manufacturing equipment. Using the information in the database, you can configure and prepare fabrication and assembly data for photoplotters, N/C drillers, profile routers, autoinsertion tools, pick and place tools, punch and reinsert tools, board handlers, and axial sequencers. The database also contains data that drives an assortment of automatic test equipment.

The DQL facilitates access to specific design details that are frequently needed during the manufacturing process. It permits you to directly select and tailor data for manufacturing and test equipment. The results are formatted in ASCII and can be edited to suit each tool. The five groups of data available for extraction are drill information, shape and pad information, via and pad information, insertion and test information, and pad coordinate information. DQL uses the same command syntax as IBM's structured query language. $119,900.

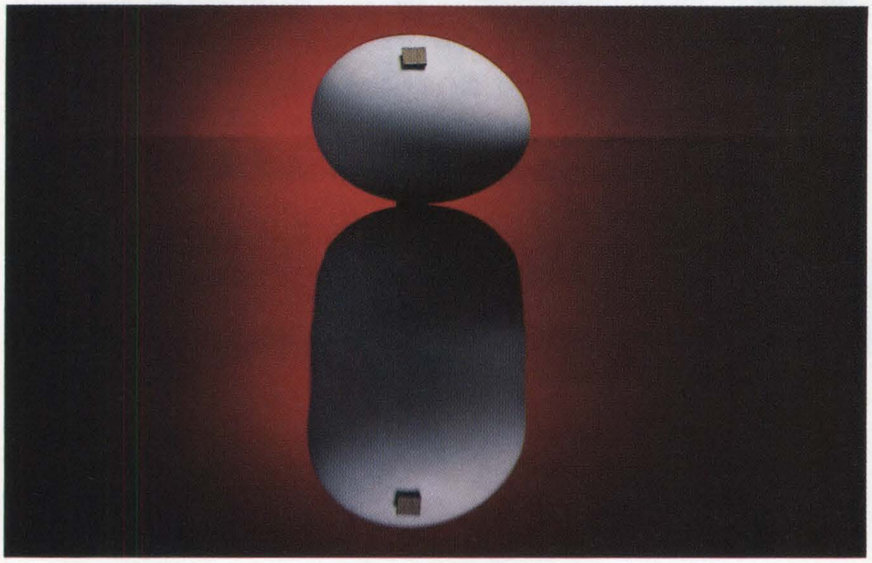
Cadnetix Corp, 5757 Central Ave, Boulder, CO 80301. Phone (303) 444-8075.

Circle No 647

Chip-on-Board III

AVX TechFile Series

TECHNICAL INFORMATION FROM THE LEADER IN MLCs



Reducing Thermal Stress in MLC Chips

Surface mount manufacturing processes directly expose components to soldering temperatures which can cause reliability problems when the rate of rise in temperature is too rapid. Multilayer ceramic capacitors (MLCs) like many components are sensitive to this thermal shock. This sensitivity is not only due to their material properties but also their construction, design, manufacturing and assembly techniques. Toward decreasing this thermal stress, AVX has been studying the effects of ceramic formulations, electrode configurations, chip dimensions, end terminations, mechanical flaws, and soldering parameters.

Equation 1
THERMAL STRESS

$$\sigma = \frac{E\,\alpha}{(l-\mu)}\;\frac{s\,\phi\,t^2}{(k/\varrho\;C_p)}$$

E	: ELASTIC MODULUS (DIFFICULT TO CHANGE)
α	: COEFFICIENT OF THERMAL EXPANSION
ϕ	: RATE OF CHANGE OF TEMPERATURE (CAN BE CONTROLLED)
t	: HALF THICKNESS FOR A PLATE (CAN BE EASILY CHANGED)
μ	: POISSON'S RATIO (CHARACTERISTIC OF THE SYSTEM)
s	: SHAPE FACTOR (CHARACTERISTIC OF THE SYSTEM)
$k/\varrho\ C_p$	: THERMAL DIFFUSIVITY (CAN BE CHANGED BY ADJUSTING METAL TO CERAMIC RATIO)

Thermal Stress

When ceramics are subjected to a rapid change in temperature (such as plunging MLCs into a solder bath) stresses result because the surface reaches the new temperature almost instantly while the interior remains at some lower temperature causing a temperature gradient, $\triangle T$.

As shown in Equation 1, thermal stress is the function of the square of the chip thickness. Therefore, this parameter is very important in chip design and subsequent thermal shock behavior.

Test Results

Solder tests were run by directly dipping various chip thicknesses into molten solder at 260°C with no preheat. Chip formulation and termination known to have cracking problems under these conditions were chosen for the test. The chips were then visually inspected for any cracking. The results are plotted in Figure 1. They confirm that as the thickness increased the number of visual cracks increased. It should also be noted that as the part size increased for a constant chip thickness the visual cracks increased. This would be expected since the larger the geometries the greater the internal thermal mismatch.

EFFECT OF THICKNESS ON THERMAL SHOCK OF MLC CHIPS

SOLDER DIP TEST RESULTS AT 260°C, NO PREHEAT

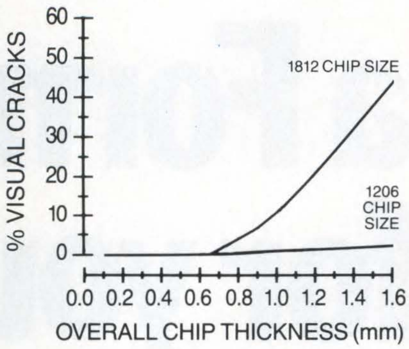


Figure 1

Discussion

This information along with data on other parameters is being utilized by AVX to design MLC chips for minimum thermal stress in soldering operations. For a technical paper discussing these parameters, complete and return the coupon below.

☐ Please send me the AVX Technical Paper "Factors Responsible for Thermal Shock Behavior of Chip Capacitors."

☐ Please send me literature describing AVX MLCs.

NAME ____________

TITLE ____________

COMPANY ____________

ADDRESS ____________

CITY ____________

STATE ____________ ZIP ________

PHONE ____________

EDN100187

Send to: AVX Corporation
P.O. Box 867
Myrtle Beach, SC 29577

AVX Technology For The Times

CIRCLE NO 144

Driving to work in an ordinary car isn't so bad if there's a Formula 1 waiting for you at the office.

Power up an Apollo Series 4000™ and you'll think you're sitting in a cockpit rather than at a keyboard. For it won't take more than a moment to realize you're in control of more horsepower than has ever been packed into a machine in this price range.

You'll feel the muscle of a 25 MHz 68020 central processor that performs at 7100 Dhrystones. That's enough energy for engineering applications as demanding as electronic design simulation and finite element analysis.

You'll experience the authority of a 25 MHz 68881 floating point chip. A processor whose performance exceeds that of systems costing twice as much in both single and double precision Whetstones.

And you'll enjoy an impressive abundance of storage. Including 32 MB of main memory, a full gigabyte of virtual address space, and up to 348 MB of ESDI disk. Enough to satisfy the hungriest of artificial intelligence applications.

Finally (as if all the above isn't enough in a $14,000 workstation), you'll witness high resolution monochrome and color graphics so brilliant they'll leave those working on competitive machines green with envy.

The Series 4000 workstations. Starting at under $14,000 for monochrome, and under $19,000 for color. Either way, it's the fastest you can go while sitting still.

apollo

The difference is Domain.®

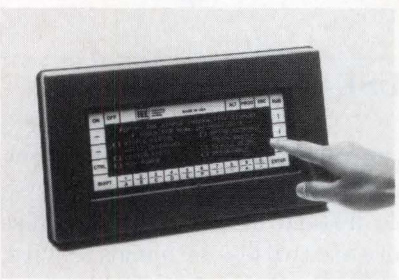
Apollo, Series 4000 and Domain are trademarks of Apollo Computer Inc.

For more information on the Series 4000, including benchmark results for Dhrystones and Whetstones, call or write Apollo at 330 Billerica Rd., Chelmsford, MA 01824, MS 41, (617) 256-6600 x4889. In Canada call (416) 297-0700.

CIRCLE NO 145

DISPLAY MODULE

The 4283-01 vacuum-fluorescent display module integrates a 6-line×40-character display with an infrared touchscreen. The module uses no overlays, features 969 active switch locations, and is immune to false triggering by light as strong as direct sunlight. Each of the display's two hundred forty 5×7 dot-matrix characters is 5 mm high. The blue-green color provides comfortable viewing, and three software-con-



trolled brightness levels are available (ranging to 185 fL max). Colored filters are available to fit different applications.

The module has the ability to store and retrieve user-programmable canned messages; 8k bytes of CMOS RAM can store 127 canned messages. An onboard battery retains the messages even after power is lost. The module operates from a 5V supply. An onboard μP controls display and touch-input operations, a self-diagnostic test program, and the serial data interface to the host computer. From $478 (100).

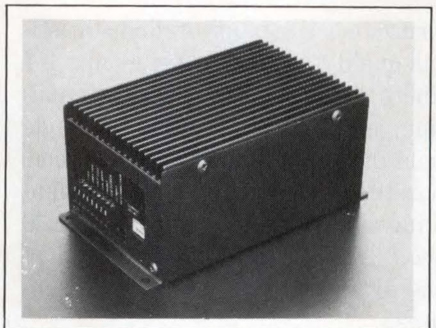
IEE Inc, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556.

Circle No 550

MOTOR DRIVE

The CMD-110 step-motor driver offers the translating and driver stages needed to control virtually any hybrid step motor rated to 7A. It uses MOSFET amplifiers, a 20-kHz chopping frequency, and H-bridge technology.

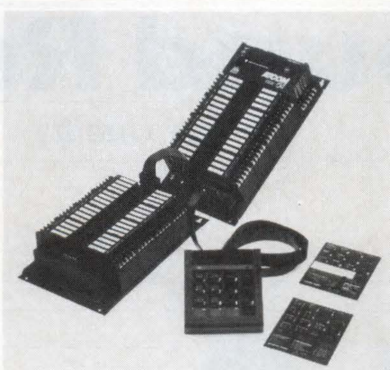
The unit can operate in full- and half-step modes. The logic inputs are optically isolated—user control



lines must be able to sink 15 mA. In many applications, all you'll need to operate the CMD-1109 is a supply voltage (24 to 60V dc unregulated), a step signal, and a direction signal. The pulse and direction inputs employ Schmitt triggering. Users can also choose between circulating- and noncirculating-current control modes. The driver includes low-power (70% current reduction) and no-power modes for emergency shutdown situations. Its operating range spans −40 to +85°C. $350.

American Precision Industries, 3229 Roymar Rd, Oceanside, CA 92054. Phone (619) 439-7500.

Circle No 551



CONTROL SYSTEM

The ATCOM-64 control system is designed for machine- and process-control applications with moderate I/O requirements that nevertheless need control features not currently available in small programmable controllers. It stores and displays user-defined messages, and includes an RS-232C port as a standard feature.

The system offers timing and counting capabilities plus mathematical operations. An inexpensive console functions as a programmer, diagnostic tool, and operator interface for interactive operation.

You can program the system by using an English-based language called Snap. The main chassis provides as many as 32 inputs/outputs; an optional expansion chassis provides 32 more. A system that includes the main chassis, the console, and a 24V power module costs $700; the expansion chassis is $165.

Automatic Timing and Controls Co, 201 S Gulph Rd, King of Prussia, PA 19406. Phone (215) 337-5500. TLX 846437.

Circle No 552

MOTION ANALYZER

The HSV motion analyzer captures (on videotape) high-speed events occurring in areas such as automated manufacturing, product development, product testing, and other areas where high-speed video is required to produce slow-motion playback and analysis. It consists of three subsystems: a shuttered video camera that operates at 400 fields/sec and delivers 400 lines of resolution, a high-speed videotape recorder, and a high-intensity strobe light.

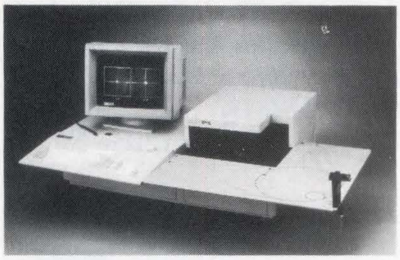
The camera's ability to capture a different picture every 2.5 msec provides the slow-motion capability. The camera's shutter speed—1/2500 to 1/10,000 of a second—provides stop-action capability, which produces blur-free pictures. You can get faster exposure times by using a 1/50,000-sec strobe light.

System options include an X-Y

coordinator with a digitizing tablet for data reduction and motion studies, parallel or serial interfaces for networking with PCs and peripherals, and a wave inserter for superimposing an analog signal directly on the video image. $44,950.

Instrument Marketing Corp, 820 S Mariposa, Burbank, CA 91506. Phone (213) 849-6251. TLX 673205.

Circle No 554



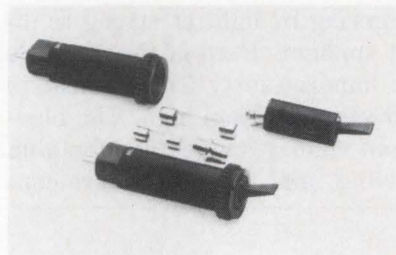
FIBER TESTER

Designed expressly for manufacturers of single-mode fibers and cables, the Model 2200 measures the three characteristics monitored in statistical quality-assurance programs for fibers and cables: spectral attenuation, cutoff wavelength, and mode field diameter. In addition, it incorporates a feature that reduces handling time per fiber end to under 30 sec, thereby reducing the time of the overall test to less than 2 minutes.

Designed for production testing, the system provides all-digital signal-processing electronics and a production-oriented clamp and fixture system that prepares fiber ends off-line and automatically aligns them for test. A bar-code reader speeds data entry. The system architecture includes a test language and file structures that facilitate database retrieval of test results and interaction with other factory automation equipment. The PC/XT architecture lets you integrate the system in an automated cable- or fiber-production line. $69,200. Delivery, six weeks ARO.

Photon Kinetics Inc, 9350 Southwest Gemini Dr, Beaverton, OR 97005. Phone (503) 644-1960.

Circle No 554



FUSE-SWITCH

The PS1 combines a fuse and a switch in a single package. The combination requires only one mounting hole instead of two. Also, because there are two less terminals to wire, you save wire and assembly time. And changing fuses will be easier for the end user of your product.

The circuit-protection ratings de-

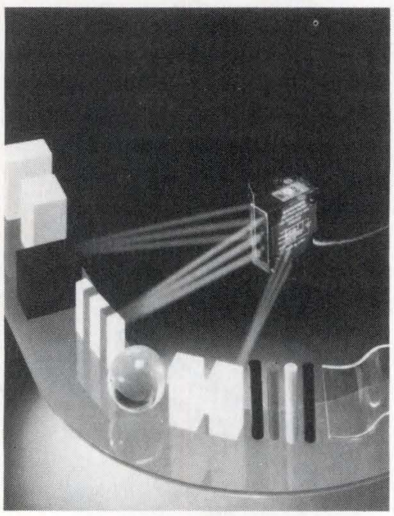
CIRCLE NO 112

Industrial Product Showcase

pend on the fuse you choose: The maximum ratings are 20A at 120V ac, 15A at 250V ac, and 20A at 32V dc. The fuse-switch is designed to use standard 0.25×1.25-in. fuses; however, the vendor offers an adapter for international-size (5×20-mm) fuses. $2 (1000).

Heinemann Electric Co, Box 6800, Lawrenceville, NJ 08648. Phone (609) 882-4800.

Circle No 556



OPTICAL SENSORS

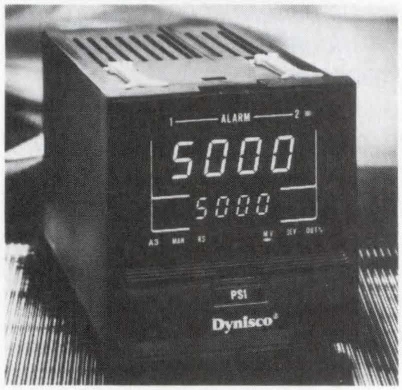
MQ triple-beam photoelectric sensors are available in three versions that offer sensing capabilities ranging from 1 in. to more than 2 ft. An optical range-measurement principle provides consistent range detection regardless of the color, material, or surface condition of the detected object, according to the manufacturer.

Because the units have a preset sensing region, background movement has no effect on the sensors' operation. This feature makes them useful in material-handling applications that are beyond the capabilities of conventional equipment.

The maximum switching speed of 250 operations/sec makes the sensors compatible with high-speed detection or counting applications. The measurement technique minimizes the effect of soiled lenses because detection is based on light angles rather than on light intensity. $50 to $75 (100).

Aromat Corp, Industrial Products Div, 250 Sheffield St, Mountainside, NJ 07092. Phone (201) 232-4260. TWX 710-997-9536.

Circle No 555



PRESSURE CONTROLLER

The μPC 659 is designed for single-loop pressure-control applications. Its features include two or three programmable alarms, easy-to-read dual LED displays, fully adjustable PID (proportional integral and differential) control, 100-msec max conversion time, and an accuracy of ±0.2%.

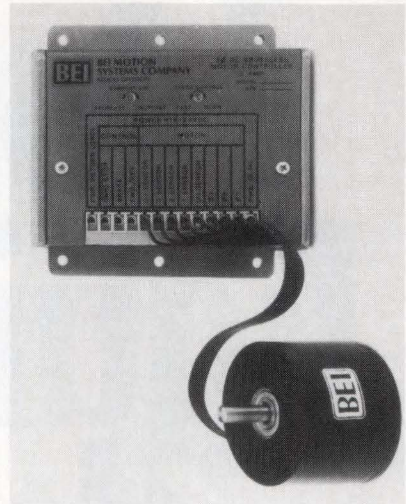
The controller's μP allows you to tailor the μPC 659 to the exact requirements of an application. You enter scaling, calibration, alarm-action, and control parameters via the keyboard. The dual LED display prompts you during programming. You can program the upper display to indicate process condition, deviation from setpoint in engineering units, or percent of manual power output in manual control. A debounced switch, located behind the front door, provides transitions between automatic and manual modes.

Model μPC 659 features a galvanically isolated keyboard-selectable control output. It accommodates RS-232C, RS-422, and RS-485 serial-communications formats. $1295.

Dynisco, 10 Oceana Way, Norwood, MA 02062. Phone (617) 769-6600.

Circle No 559

Showcase



MOTOR CONTROLLER

The MCH05-24 is a 5A, 12 to 24V, open-loop commutation controller for brushless dc motors. The unit can control the direction of rotation and start, stop, and brake functions via manual switching or TTL inputs. You can adjust the speed (over a 4:1 range) by varying the dc-voltage input levels or by using the controller's built-in potentiometers. The unit incorporates an overload-protection circuit to prevent motor and/or controller failure under locked-rotor conditions.

The controller is available on a 4×4.1-in. board; if you wish, you can integrate the controller in a motor housing to obtain a compact, replaceable motor-control package. $250.

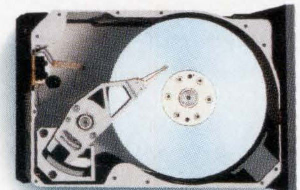
BEI Motion Systems Co, Kimco Div, Box 1626, San Marcos, CA 92069. Phone (619) 744-5671. TWX 910-332-1168.

Circle No 557

DISPLAY

The Model 77/719 LED display accepts analog input, converts it to digital information, scales it in accordance with preset scale-factor switches, and displays the data in 3.3-in. digits. Various standard voltage and current ranges are available; special ranges are also available.

Flashing nines indicate under-

WHAT DRIVES  A LEADER?

You do.
We do.
On one hand, there's your drive to find new applications and new markets. On the other, there's our drive to meet your needs.

And as partners, we both end up in the lead.

You give us the impetus to stay a generation or more ahead of the competition. And we give you the products to do the same.

Like our high-performance, high-capacity Winchester drive families, from 85MB to 760MB. And our first high-capacity optical product, a 5¼-inch, 800MB WORM drive.

So keep pushing us.

Because the further you drive Maxtor, the further we'll drive you.

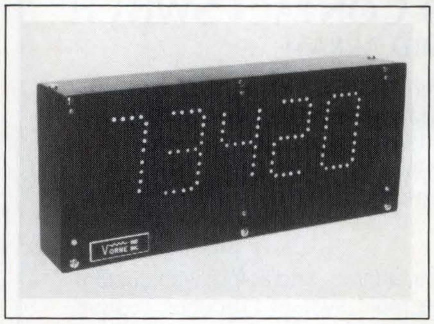
Maxtor Corporation, 211 River Oaks Parkway, San Jose, CA 95134, (408) 432-1700, TELEX 171074.

Sales offices: Austin (512) 345-2742, Boston (617) 872-8556, Orange County (714) 472-2344, New Jersey (201) 747-7337, San Jose (408) 435-7884, Woking, England (44)/4862-29814.

Maxtor

Distributed by: Anthem Electronics, Inc., Lionex Corporation, Pioneer-Standard Electronics, Inc., Quality Components, Inc., Storex Corporation.

Industrial Product Showcase

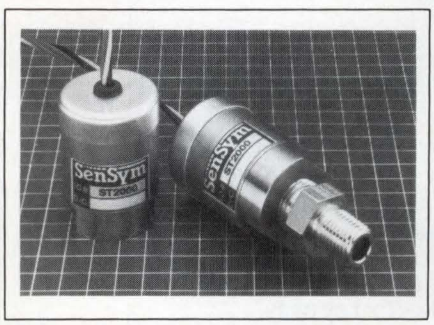


range and overrange analog-input conditions. Two sets of rotary DIP switches are available for scaling the display. One set defines the bottom of the analog-input range, and the other establishes the top. Between the two setpoints, the display is linear.

The display, which can have two to six digits, provides a viewing distance of 100 ft min. The standard color is red, but yellow and green are also available. The unit has four analog-input ranges—0 to 1V, 0 to 5V, 0 to 10V, and 4 to 20 mA. The display is accurate to 3 significant digits, and it operates over 0 to 65°C. It runs on 115V ac. $350 to $450.

Vorne Industries Inc, 5831 Northwest Hwy, Chicago, IL 60631. Phone (312) 775-9440.

Circle No 558



TRANSDUCERS

The ST2000 Series devices are temperature-compensated, signal-conditioned pressure transducers. Fabricated of stainless steel, they are designed to measure hostile media in harsh environments. The devices are available in versions that measure from 0 to 15 psig through 0 to 300 psig, with output-span options ranging from 1 to 6V or 2.5 to 12.5V dc for each pressure range.

The transducer design utilizes an IC pressure-sensor element. The design minimizes oil requirements for optimal performance over temperature, and also provides the ability to handle extreme burst pressures. The transducers' accuracy is guaranteed to be within ±0.5%. Internal voltage regulation allows the units to operate with any supply voltage from 12 to 30V dc. The pressure connector accepts a variety of fittings. In addition, the package provides resistance to shock and vibration, as well as to EMI/RFI problems. $100 (100).

Sensym, 1255 Reamwood Ave, Sunnyvale, CA 94089. Phone (408) 744-1500. TWX 910-339-9625.

Circle No 560

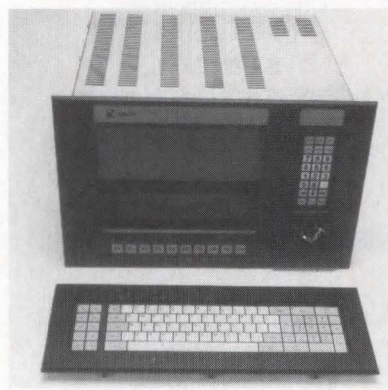
ENCLOSURE

The Flat-Top enclosure is engineered especially for the control-room environment. It features a sturdy 14-gauge steel frame reinforced with four 11-gauge corner gussets, and welded-seam components. A 19° front vertical slope provides the maximum possible depth for slope-mounted equipment.

You can choose from three panel widths, four frame depths, and three slope openings. The enclosure is also available in two versions: The C (computer) version has decorative trim; the S (industrial) unit has square corners and no trim. Various accessories and sizes are also available. From $400. Delivery, four to six weeks ARO.

Cabtron Systems Inc, 200 Anets Dr, Northbrook, IL 60062. Phone (312) 498-6090.

Circle No 561



COMPUTER SYSTEM

The 4150 industrial computer system combines the power and versatility of an IBM PC/AT-compatible computer with a rugged industrial terminal package. It includes a 5-slot PC/AT passive backplane, an EGA/CGA color monitor, data-entry and function keypads, hard- and floppy-disk facilities, and a number of expansion capabilities. The front panel is sealed to NEMA standards, and the CRT is protected by an impact-resistant Lexan shield.

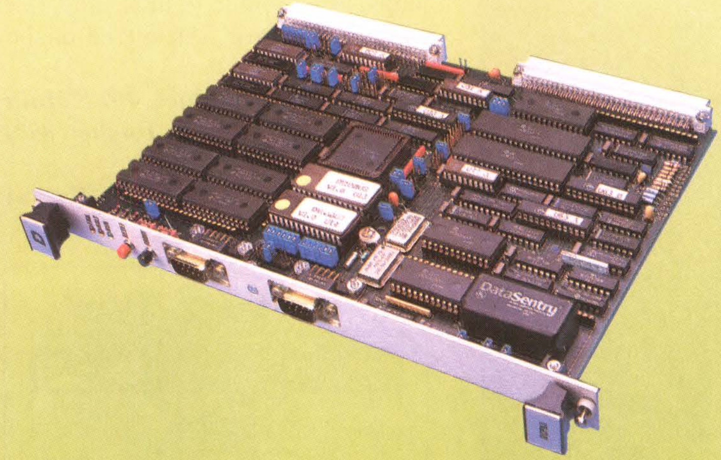
Options include a PC/AT computer CPU board, a 3½-in., 20M-byte hard-disk drive; a 3½-in., 720k-byte floppy-disk drive; bubble memory; an EGA controller; and a full-size sealed keyboard. You can order the unit with or without pc boards and disk drives. Because the computer's motherboard isn't preconfigured, you can select a specific µP to suit your application. From $3600.

Xycom Inc, 750 N Maple Rd, Saline, MI 48176. Phone (313) 429-4971. TWX 810-223-8153.

Circle No 562

The Highs and Lows.

- **High Quality**
- **High Performance**
- **High Speed**
- **Low Power**
- **Low Temperature**
- **Low Cost**



100% CMOS VME.

- I/O oriented CPU module with two serial ports, 40 programmable parallel lines, three 16-bit timers and a real-time clock/calendar.
- 100% CMOS VME board with low power, low heat dissipation (CMOS 68000 CPU at 8, 10, 12.5 MHz)
- Programs can be prepared on an IBM or compatible PC and down loaded
- Up to 512 Kbytes no-wait, dual ported static RAM, 128 Kbytes PROM
- VME master and slave, receive and generate 7 levels of interrupt
- Low cost

Sometimes there's more to high technology than just the highs. A good CPU board delivers high quality, high performance, and high speed. A great CPU board can deliver all that with low power consumption and low heat dissipation—all at a low cost. That's why Dynatem's DCPU1 is a great CPU Board — a perfect blend of the highs and lows. The DCPU1 achieves this perfect blend by combining 100% CMOS technology on the VMEbus with a high performance I/O oriented board.

With two serial ports, 40 programmable parallel I/O lines plus three 16-bit timers, and a real-time clock/calendar, the DCPU1 meets the performance challenges of many industrial applications.

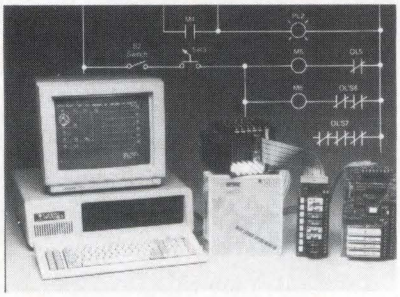
Round out the highs and lows with a feature that makes development on the DCPU1 surprisingly easy—you can prepare programming on an IBM (or compatible) PC XT or AT and download to the module—and you've got a great CPU Board.

You've got Dynatem's DCPU1.

DYNATEM

Dynatem Inc., 19 Thomas, Irvine, CA 92718
Call toll-free 1-800-543-3830
In California 714-543-3830
TWX 910 595 2603

CIRCLE NO 113



CONTROL SYSTEM

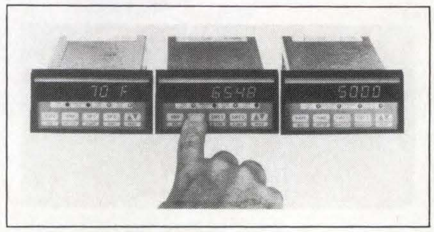
The CDI-Ladder industrial-control system combines popular STD Bus computer hardware with a standard relay ladder-logic language. With the STD Bus, the same hardware can be the core of a small or large system.

The standard system includes the RD-1000 software, an 80188 or Z80-based single-board computer (which includes two serial ports and battery-backed RAM), and a 6-slot card cage with a power supply. Because the computer performs all the necessary functions (including 24 parallel I/O lines), five slots are available for analog and digital I/O expansion.

You program the unit with an IBM PC; nonengineering personnel can program and maintain the system. It can accommodate as many as 416 analog and 1152 digital I/O points, and can support 40 PID (proportional integral and differential) loops, 32 stepper drums, and full 4-function math. An 80188-based system costs $1295.

Computer Dynamics, 107 S Main St, Greer, SC 29651. Phone (803) 877-8700.

Circle No 564



CONTROLLERS

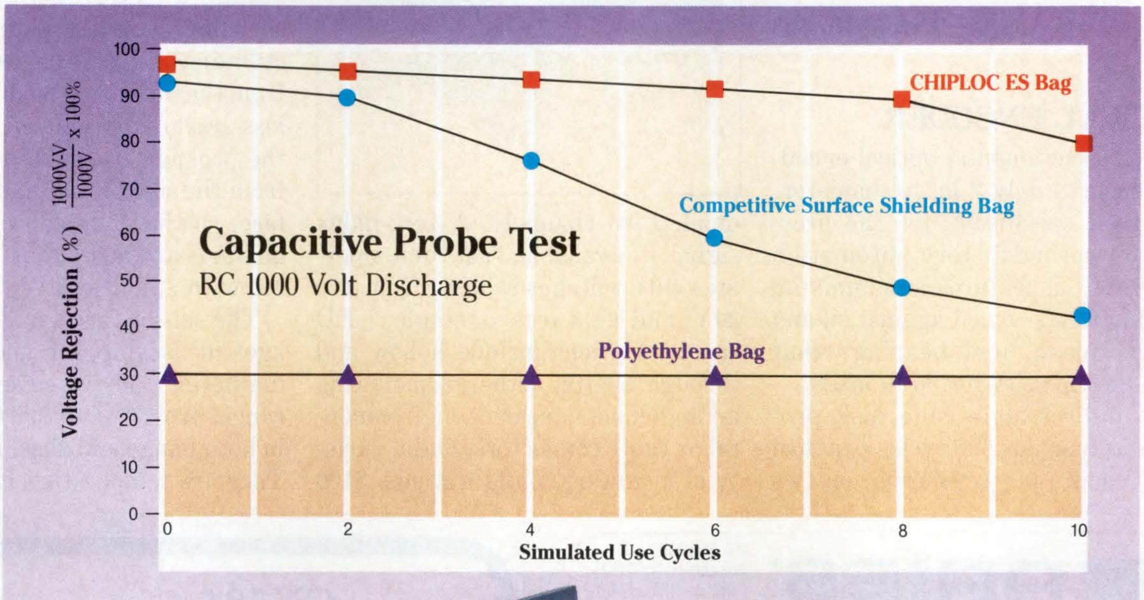
The 2800 Series ⅛-DIN μP-based digital controllers are programmable via a front-panel keypad. Each features two limits based on time and two limits based on the variable being measured. You can install 1A relays for any or all of these limits.

At keyboard command, the controller displays the total process run-time, rate of change in units per minute, and the high and low peaks of the variable. Options include an analog output and an RS-232C or RS-422 serial port.

Three models are available. Model 2810, a temperature controller, accepts inputs from seven different thermocouple types and features programmable setpoint ramping for precise control. The 2820 process controller offers keypad scaling and offset, as well as a programmable difference limit that

Introducing CHIPLOC Bags from Dow:

CHIPLOC ES Delivers *Up To 80%* More Static Protection Than The Leading Surface Shielding Bag.



Capacitive probe tests show that CHIPLOC* ES static shielding and dissipative packaging from Dow has up to 80% more shielding capability than the leading surface shielding bag on the market.

CHIPLOC ES has a thin, high-quality conductive metallized layer† designed specifically to minimize the penetration of electric fields from highly charged objects. It provides superior Faraday cage protection of the most sensitive electronic devices.

It is reusable, too, because of the exclusive "buried shield" construction used in CHIPLOC ES. Two layers of static dissipative film protect the metallized layer against abrasion, tears and punctures. Such damage, more common in bags with surface metallized layers, can dramatically reduce shielding effectiveness. In fact, tests†† show that after just eight simulated use cycles, competitive exposed-film bags retain only 52% of their shielding ability. CHIPLOC ES retains 92%.

Free Samples

For the complete CHIPLOC story, including free samples and a copy of the brochure "Two New Solutions to ESD Problems," call 1-800/258-2436, Extension 32/CHIPLOC. Or write: The Dow Chemical Company, Packaging and Industrial Foams Dept., 2020 Willard H. Dow Center, Midland, MI 48674.

Advancing The Science of Electronics

DOW*

†Manufactured of STATICURE* static dissipative films.
††Test results available upon request.

CIRCLE NO 89

makes process batches. The Model 2830 counter, rate, and rpm controller works with square wave, sine wave, or pulse inputs and can control both the value of the input and the rate of change of this value over a programmable number of minutes. $449.

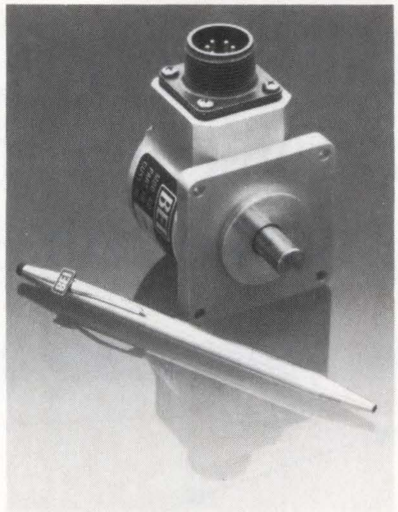
Sycon Corp, Box 491, Marion, OH 43302. Phone (614) 382-5771. TLX 3775688.

Circle No 563

OPTICAL ENCODER

The H20 incremental optical encoder measures only 2 in. in diameter. Designed specifically for the process-control and factory-automation industries, it features an aluminum housing that's sealed against oil and water splash, and bearings that have the capacity for 80-lb loads.

An unbreakable code disk provides as many as 600 cycles per turn (2400 counts per revolution) on two quadrature channels. A zero-index signal is available. The unit operates with voltages ranging from 5 to 24V and features a single LED source. Options include hollow and through shafts, tethered mounting arrangements, sealed environmental or cable connectors, and a variety of mounting configurations. $100 (OEM qty).



BEI Motion Systems Co, Industrial Encoder Div, 7230 Hollister Ave, Goleta, CA 93117. Phone (805) 968-0782. TLX 888069.

Circle No 565

PRESSURE SENSORS

The NPI Series pressure transducers use a piezoresistive silicon sensor chip housed in a stainless-steel, cylindrical package and isolated from the measured media by a stainless-steel diaphragm. A fluid inside the package transmits the pressure from the membrane to the chip surface, so the units can operate with all fluids and gases that are compatible with stainless steel.

The sensors are available in packages measuring 0.6- and 0.75-in. in diameter. They cover pressure ranges from 0 to 15 to 0 to 10,000 psi in both gauge and absolute versions. They are temperature compensated

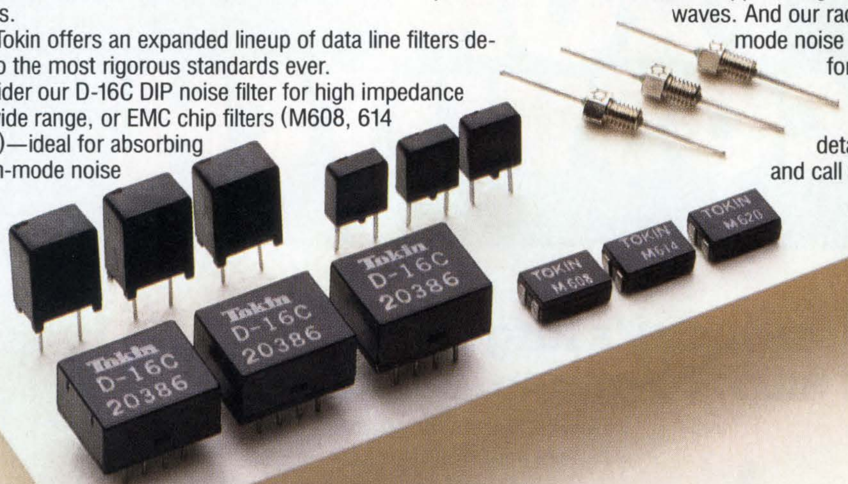
Advanced emission control. EMC Data Line Filters from Tokin.

Tough world EMI/EMC standards such as FCC, VDE and VCCI (Japan) demand effective countermeasures—for both power and data lines.

And Tokin offers an expanded lineup of data line filters designed to the most rigorous standards ever.

Consider our D-16C DIP noise filter for high impedance over a wide range, or EMC chip filters (M608, 614 and 620)—ideal for absorbing common-mode noise in signal transmission lines. Tokin feed-through filter capacitors (30F102P) suppress high-frequency noise emissions—even microwaves. And our radical lead micro-inductors for normal mode noise absorption come into two series: SNT for high currents and SBT for high frequencies.

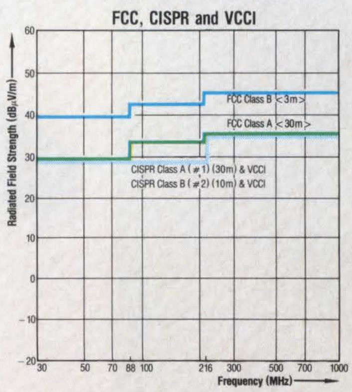
But these are just a start. For details, pick up the phone and call us today.



Specifications

	Circuit Diagram	Impedance (kΩ)	Insertion Loss (dB)
SB Coil SBT Series (SBT-0440T)		≧0.9 (at 100MHz)	–
SN Coil SNT Series (SNT-S20)		≧0.4 (at 100MHz)	–
EMC Chip Filter (M608)		≧0.3 (at 100MHz)	–
DIP Noise Filter (D16C)		≧0.3 (at 100MHz)	–
Feedthrough Filter Capacitor (30F102P)		–	≧60 (at 450MHz)

Limits for Radiated Emissions

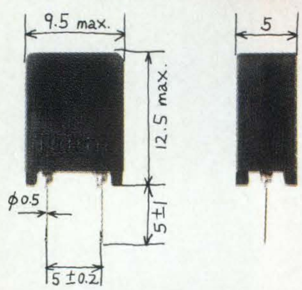


ETCL (EMC Test & Component Laboratory)

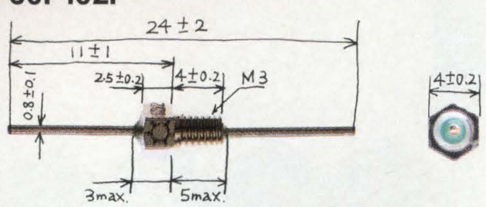
Tokin America's ETCL provides a full range of EMC technical services including measurement, countermeasures and consulting. Call us for details.

Shapes and Dimensions

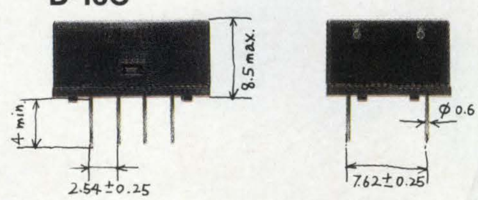
SNT-S20



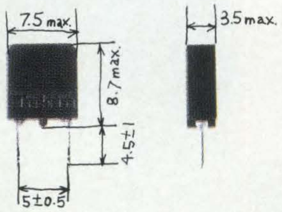
30F102P



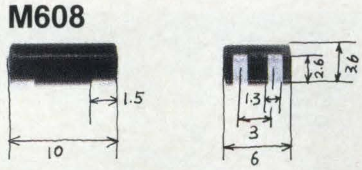
D-16C



SBT-0440T



M608



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CIRCLE NO 64

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Fax: Tokyo (03) 497-9756
Telex: 02422695 TOKIN J

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over 0 to 70°C. Because of the design, you can interchange the units and still retain calibration to within 1%. Other key parameters for the sensors include ±0.1% of full-scale-output (FSO) static accuracy (combined linearity, hysteresis, and repeatability), and ±0.5% FSO thermal accuracy over the 0 to 70°C range. $25 (OEM qty). Delivery, eight weeks ARO.

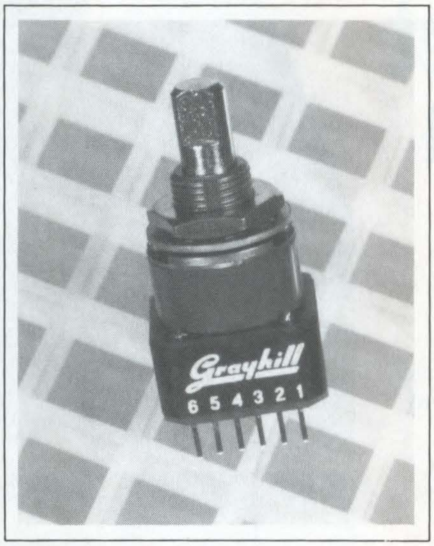
NovaSensor, 1055 Mission Ct, Fremont, CA 94539. Phone (415) 490-9100. TLX 990010.

Circle No 566

PANEL CONTROL

The Series 61 rotary switches, in combination with appropriate software, can replace a dedicated keyboard or a touchscreen in measuring or monitoring applications. The switches provide a choice of quadrature 2-bit code, 2-bit counting code, and 3-bit counting-code outputs. You can actuate a switch to provide data entry when the rotary shaft is pushed.

These devices do not use electromechanical contacts for switching. Rather, a rotating disk passes or interrupts light to a pair of phototransistors to provide the coded output. The output can sense the direction of rotation as well as the number of steps. You can design the software to translate the code to cursor movement on a screen or to change the value of a system parameter. The Series 61 rotary encoder switch is available with 16 or 24 detent positions. Approximately $20. Delivery, four to six weeks ARO.



Grayhill Inc, 561 Hillsgrove Ave, La Grange, IL 60525. Phone (312) 354-1040.

Circle No 568

COMPUTER SYSTEM

The ECX Model 188 processor operates from a single 5V supply and can be programmed to perform machine control, process control, data acquisition, and other fixed-program tasks. The processors have two ranges of processing power, so they can satisfy a broad range of product-automation applications.

Ferranti covers the small signal mosfet market from N to P.

Offering one of the most comprehensive ranges of small signal mosfets, Ferranti Semiconductors covers the market with a complementary line of N & P channel devices.

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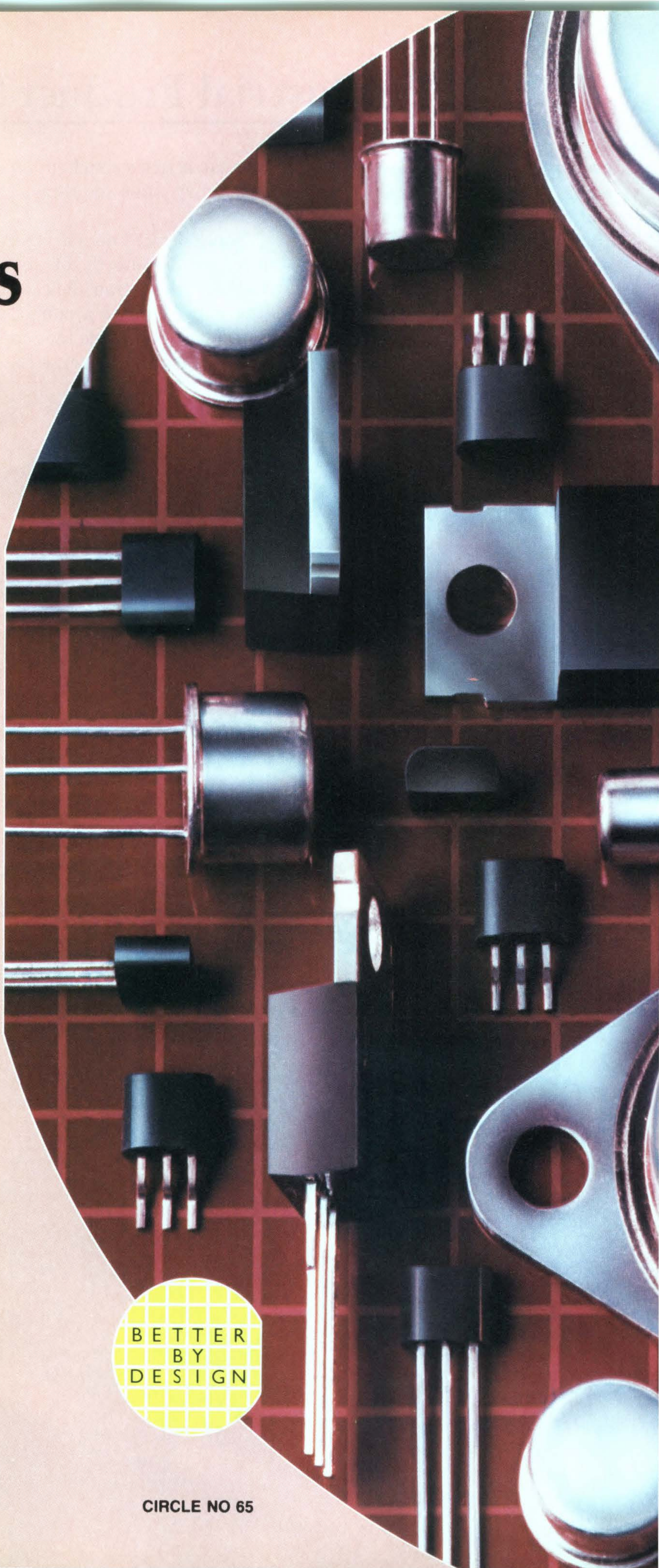

EDN100187

Yes, I'd like to receive your free mosfet package.

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Phone ( )________________

Detach and mail to: Ferranti Semiconductors
87 Modular Avenue, Commack, NY 11725

CIRCLE NO 65

You can interface an ECX processor to your product's I/O in one of four ways: You can use a set of ECX discrete I/O lines, attach your own I/O circuitry to the ECX expansion channel, use an optional adapter that accommodates a variety of industry-standard I/O boards, or design high-speed circuitry to attach to the ECX expansion channel. Because the ECX processors are compatible with the IBM PC, developing software for them is relatively simple. $600 (50).

Micro/sys Inc, 1011 Grand Central Ave, Glendale, CA 91201. Phone (818) 244-4600.

Circle No 567

ENCLOSURE

The E Series Eurocard-type electronic enclosures feature a built-in fan tray that holds one to nine fans. A 3M filter material is available in six densities for various applications. These filters snap in, making replacement a simple task.

The enclosures are designed for 3U (E3) and 6U (E6), 19-in. subrack applications. Complete companion subracks and accessories that accommodate VME Bus and Multibus II are available as options. The enclosures are constructed of steel mounting frames, die-cast aluminum extrusions, and sheet metal. If you need slide rails to support a subrack or chassis, you can obtain snap-in inserts to attach such hardware to the side extrusions. Retractable pull-down feet are standard. $270 for the E3; $290 for the E6.

Tracewell Enclosures Inc, 7032 Worthington Galena Rd, Columbus, OH 43085. Phone (800) 848-4525; in OH, (614) 846-6175.

Circle No 570

DIGITAL ENCODER

Model 721 is a digital modular incremental encoder suitable for servosystem, motor-speed-control, plotter, machine-tool, medical, and robotic applications. It features a rugged metal base, self-alignment, automatic gap adjustment, and a snap-on cover for easy installation.

The unit has resolution ratings ranging to 1800 cycles. The quadrature outputs are TTL compatible, and the operating frequency ranges to 100 kHz. Model 721's cover meets UL-94V-0 requirements, and its cable is UL/CSA approved when shielded. Standard options include a differential line driver for 5V operation. You can also obtain units that can operate at voltages ranging to 24V. $30 (OEM qty).

Litton Systems Inc, Encoder Div, 20745 Nordhoff St, Chatsworth, CA 91311. Phone (818) 341-6161. TWX 910-494-1229.

Circle No 569

MONITOR-CONTROLLER

You can link as many as 32 remote ITG 2600 Control Masters on an RS-485 serial link to provide 64 analog inputs, 128 alarm and/or control outputs, and thirty-two 20-mA analog outputs. Each instrument can have its own address. The controller can automatically upload to the computer—or send on command—scaled input data, process-variable type, and digital output status for every A/D conversion (approximately every 50 msec).

The ITG 2600 combines multiple signal-conditioning functions, dual isolated inputs, a 17-bit A/D converter, four open-collector outputs for alarm or control, and a scalable 20-mA analog output that can drive loads ranging to 1 kΩ. Its accuracy is 0.01% of reading, and the stability specification is 5 ppm/°C typ over 0 to 60°C. Its programmable math package can operate on input and/or output values, and can create user-defined control and linearization algorithms. $425.

Analogic Corp, Industrial Technology Group, 14 Electronics Ave, Danvers, MA 01923. Phone (617) 246-0300.

Circle No 571

OPTICAL LINK

The ODCL1 optical digital-communications link extends the transmission length of an RS-232C, RS-422, RS-485, or TTL data link to 3 km. It consists of two full-duplex electrical-to-optical modems. A D-subminiature connector provides the electrical interface, and the signals are fully compatible with the specified protocol.

The optical interface consists of either SMA or DIN connectors. The modem contains an 850-nm LED transmitter and a PIN photodiode detector. The coupled power into a 100/140-μm fiber is −12.2 dBm typ; and the receiver's sensitivity measures −31.5 dBm.

The modems are available in both data-terminal- and data-communication-equipment versions. You can supply power for the units through the 25-pin connector or through a separate power supply connected to 110V ac. $140 per modem.

Siecor Electro-Optic Products, Box 13625, Research Triangle Park, NC 27709. Phone (919) 549-6571. TLX 216910.

Circle No 573

HIGH POWER FROM POWER-ONE!

THE ULTIMATE 1500W POWER SYSTEM

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A True World Market Power System. The International High Power Series meets the toughest safety requirements of VDE, IEC, UL and CSA, plus the EMI limits of VDE and FCC. Along with worldwide AC input capabilities, it is the clear choice for products marketed not only in the U.S., but internationally as well.

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 CIRCLE NO 160

VME + FCC
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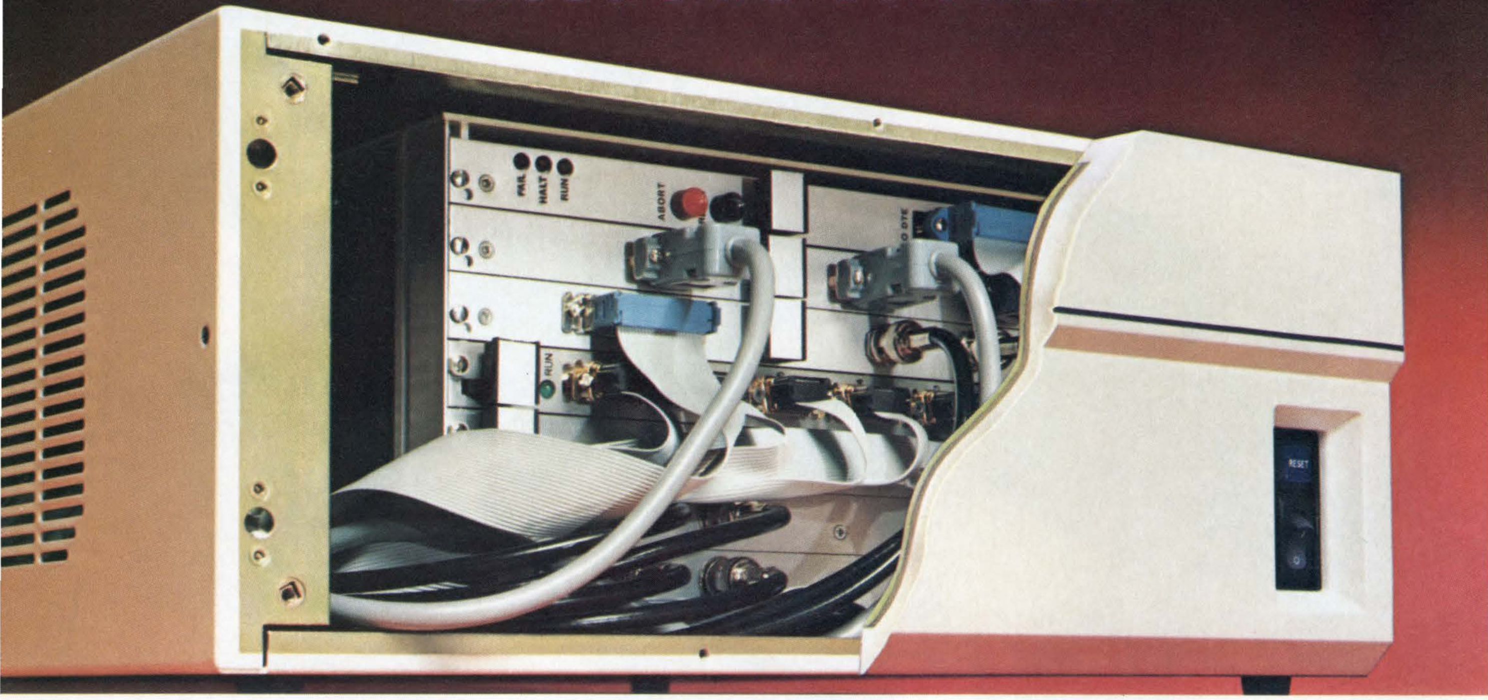

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With Electronic Solutions VME enclosures you don't have to take any static about FCC compliance. Because your VME system can meet or exceed FCC Class A Part 15 EMI/RFI standards. No other enclosure manufacturer can make that statement.

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

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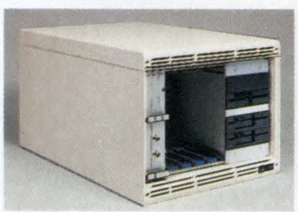
Electronic Solutions enclosures for VME—and Multibus I/II—come assembled complete with card cage, backplane, power supply, room for peripherals and more. You can get slim enclosures with 3 slots all the way up to multi-system enclosures with 40—count 'em—40 slots. And you buy them ready for your system at a tiny fraction of what it would cost to develop your own packaging.



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BAUART GEPRÜFT IEC380 FCC

In addition, there are a few other agencies besides the FCC that can help multiply your system's success. So Electronic Solutions enclosures pass UL, CSA, and TUV/IEC 380 as well.

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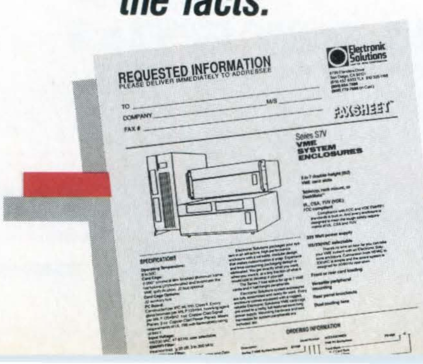

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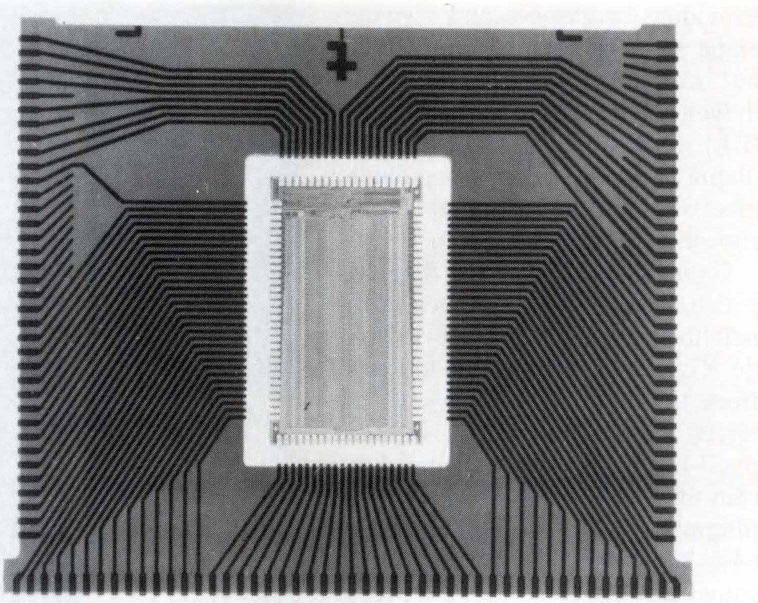
CIRCLE NO 162

Flat-panel display driver scans LCDs at multiplex rates as high as 1:256

Providing an interface between industry-standard flat-panel display controllers and liquid-crystal displays, the PCF2201 LCD driver can control as many as 81 row lines or 80 column lines of a dot-matrix LCD. As a result, you need only 21 of the drivers to scan a 640×400-pixel display; typically, the drivers consume only 100 mW. The PCF2201 can drive twisted-nematic LCDs and super-twisted birefringence-effect LCDs at multiplex rates as high as 1:256, which is about 30% higher than the rates other currently available devices offer.



***The tape-automated-bonding package** and leadouts of the PCF2201 LCD driver allow you to mount the device on the rear side of a flat-panel display, using single-plane interconnect patterns.*

To operate the device as a row driver, you serially clock row-select data through an internal 81-stage shift register. The maximum clock rate for the shift register, and hence the maximum row-scan rate for the display, is 100 kHz. The shift register is bidirectional, allowing you to scan the LCD in either direction. The chip's control outputs let you cascade drivers to scan displays having more than 81 rows.

When the IC operates in column-driver mode, the shift register functions as a set of static latches that holds parallel output data for 80 of the display's column lines. A data buffer, provided by 80 more data latches, allows you to assemble more column information while the driver sends the current column information to the LCD. You can enter data in the data buffer either serially or in 4-bit nibbles. The maximum clock frequency for transferring data into the buffer is 4 MHz; in 4-bit nibble mode, therefore, the driver has a maximum data-transfer rate of 16M bps, which is about 20% higher than the rate possible with other currently available LCD drivers. Data is automatically rearranged in the buffer to suit the display-scanning direction you select.

The one remaining shift-register latch, which is not used for column data, provides an additional column output that you can control via a separate single-line input. In certain flat-panel displays, you can use this additional column driver to eliminate the colored border that can occur around the edges of super-twisted birefringence-effect LCDs.

The PCF2201 provides internal level shifters that shift the logic-level row/column data contained in the shift register to the voltage levels required by the LCD. The driver can handle drive voltages as high as 25V, and the level shifters require four bias voltages between 5V and −25V. Depending on the data in the shift register, and on whether you're operating the device as a row or a column driver, the LCD drive outputs switch between two appropriate voltage levels under the control of an external ac chopping-frequency input.

The display driver draws a typical operating current of 0.4 mA and a standby current of 15 μA, and it provides on-chip overtemperature protection. All of its data and control inputs are 5V CMOS compatible. The driver is supplied on reels in a tape-automated-bonding package with 120 leadouts. It costs around Swiss Fr 8 (10,000).

—Peter Harold

Philips, Elcoma Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757005. TLX 51573.

Circle No 633

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

Circle No 634

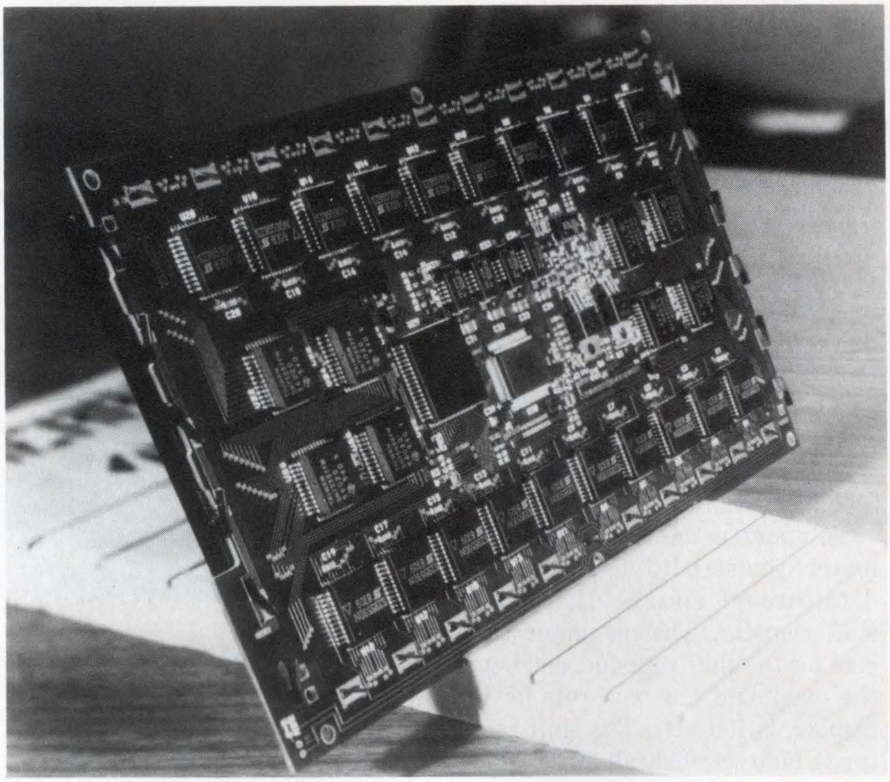
Bright, 640×200-pixel EL display offers high contrast, long life

Providing brightness and viewing-angle specs comparable to a CRT's, but weighing only 22 oz, the dc-driven EL1C electroluminescent (EL) display panel is the thinnest display available. Including driver electronics, this flat-panel display measures less than 0.575 in.

Unlike capacitive ac EL displays, which require input voltages in the neighborhood of 400V, this resistive dc EL panel operates at voltages from 120 to 180V. As a result, the EL1C avoids the voltage-induced pixel-failure problem (caused by thin-film dielectric breakdown) that plagues ac EL displays. The 640×200-pixel dc EL panel consumes 20W typ.

The EL1C is also an improvement on older dc EL models. Older ones typically could fail from four different causes: load-line flattening, softening, excessive forming, and undesirable lagging of the light-rise time versus applied current. Load-line flattening occurs when temperatures exceeding 120° cause a progressive increase in the resistance of the display's copper-coated back layer. Eventually, the increased resistance limits current, dimming the panel. In the EL1C display, the addition of silver to the copper coating prevents load-line flattening. The silver also inhibits softening, which happens when the display's threshold voltage degrades, resulting in undesirable background light.

Excessive forming is a problem that occurs when the threshold voltage increases until the drive circuits can no longer draw sufficient current to operate the display. In the EL1C, the use of vacuum baking and a current-limited drive solves this problem. The addition of sulfur prevents defects in the phosphor that can cause the light-rise time to lag behind the applied current. As a result of these improvements, the EL1C display specs a pixel luminance of 25 fL, with a degradation not exceeding 30% in 10,000 hours.



Providing 25 fL of brilliant amber light, *the EL1C dc electroluminescent display is less than 0.575 in. thick, runs on less than 180V, consumes 20W, and costs only $250 (10,000).*

The EL1C provides a flicker-free image and a viewing angle of greater than 120°. It operates over 0 to 55°C. The frame rate is typically 60 Hz, and the unit can withstand a shock as great as 50g.

You can select from two versions of this amber display. The EL1C-G000 has an 8.956×3.898-in. active display window. Including the bezel, the overall package measures 10.74×5.9×0.6 in. The active display in the EL1C-I000 measures 7.7×4.8 in.; the overall package is 10.54×7.8×0.6 in. The -G000 has 0.01×0.0171-in. pixels, and the -I000's pixels measure 0.008×0.02 in.

The technology used to manufacture the EL1C promotes high production yields, because few processing steps are needed and clean-room conditions aren't necessary. The panel has two thin-film layers; pin holes don't impair their functioning. The 25-μm phosphor layer can vary in thickness.

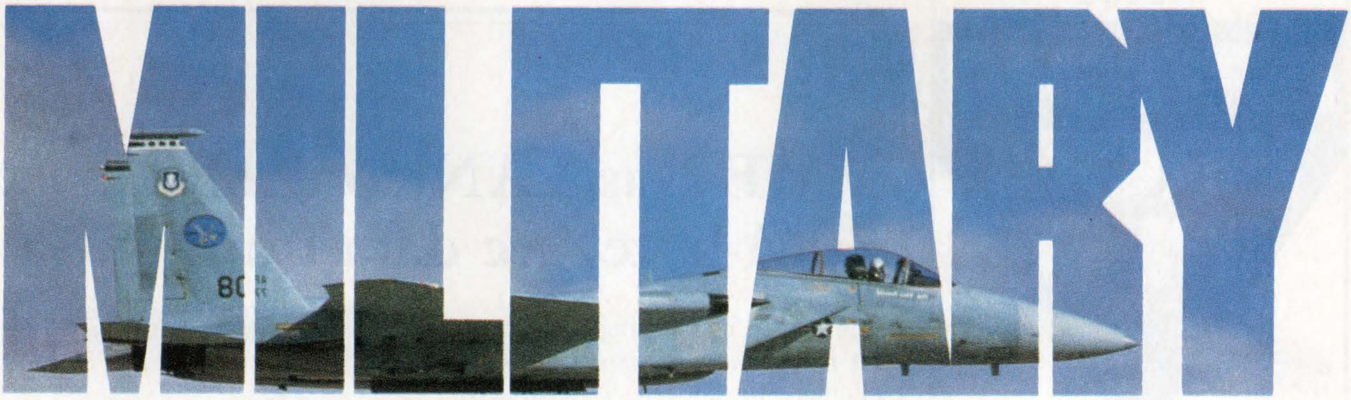
Pricing starts at $800 for a single display, but drops to $385 in 5000-piece quantities and $250 when you order more than 10,000.

—J D Mosley

Cherry Electrical Products, 3600 Sunset Ave, Waukegan, IL 60087. Phone (312) 360-3500.

Circle No 635

Z I L O G



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Zilog's commitment to the military market has always been strong. Of course, the best proof of our ongoing focus is the performance of our top quality military standard microprocessors and peripherals– and the fact that we're already designed into more than 50 major military programs including F15, F16, PERSHING, HAWK, HARPOON and RAPIER.

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BUS SIZE	CPU FAMILY	SOFTWARE COMPATIBILITY	883	DESC	JAN	SYSTEM SOFTWARE
32-BIT	Z80,000		△			ADA
16-BIT	Z8001		X	X	X	ADA
	Z8002		X	X	X	
	Z8005		X			
	Z8030 Z-SCC		X	X		
	Z8530 SCC		X	X		
	Z8036 Z-C10		X	X		
	Z8536 C10		X	X		
	Z8581 CGC		X	X		
	Z8038 FIO		X			
8-BIT	Z280		△			C
	Z180		△			
	Z80		X	△	X	
	Z8420 PIO		X	X		
	Z8430 CTC		X	X		
	Z8440 SIO		X	△		
	Z8441 SIO		X	△		
	Z8442 SIO		X	X		
	Z8444 SIO		X	△		
	SUPER8		△			FORTH
	Z8		X	△		

X = available. △ = coming soon.

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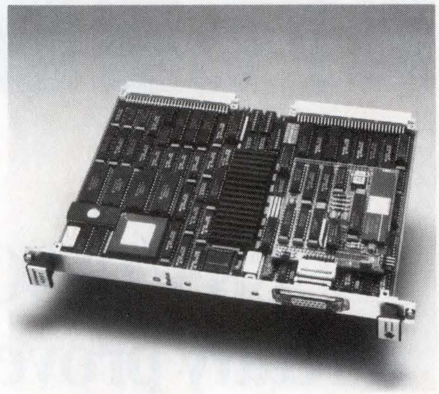
EXXON Corporation

VME Bus LAN controller specs 30M-byte/sec data transfers

The key to maximizing data-transfer rates over any system bus is to eliminate the bottlenecks created by the various processors and peripherals that battle for control of the bus. The V/Ethernet 4207 Eagle, a board intended for Ethernet communications over the VME Bus, is able to perform DMA transfers at rates exceeding 30M bytes/sec by providing a 16-MHz 68020 hardware platform and a 32-bit bus.



***Using bus transceivers and pipeline registers to isolate processor functions** and maximize bus-activity efficiency, the Eagle VME Bus/Ethernet controller board can transfer data at speeds exceeding 30M bytes/sec.*

The node controller also adds to its data-transfer capability by segregating the flow of data along its local bus from the activity occurring on the processor's bus. Transceivers decouple the 68020 μP and its 32k×32-byte scratchpad RAM from the local data bus that passes data from Ethernet to the VME Bus, thus isolating the processor and maximizing its duty cycle.

Another key design feature that boosts the Eagle's data-transfer speed involves its pipeline registers. The registers prevent the controller's Lance communication processor from locking up the local data bus as it controls the data flowing to and from Ethernet. In addition, a proprietary 1k-byte Buspacket FIFO buffer provides 40-nsec, single-cyle data transfers to the VME Bus from a 512k-byte block of RAM that's located on the local data bus.

You can use the Eagle's 64k-byte EPROM to store diagnostics and protocol codes, or you can use the 68020's zero-wait-state scratchpad RAM for protocol storage. The board also provides you with 32 bytes of nonvolatile RAM for boot routines and other critical data.

The Eagle operates in any of three modes: DMA, slave, or mixed. In DMA mode, the host computer acts as the bus master, writing data to the Eagle's 512k-byte I/O RAM. From there, the data shifts to the VME Bus under DMA control. In the slave mode, the I/O RAM has a 300-nsec cycle time. At this speed, the board uses the I/O RAM as fast system memory and allows the Lance to operate without wait states. Under mixed-mode operation, the Eagle examines data-packet headers in slave mode, then passes the rest of the data packet to the VME Bus at DMA rates.

The $3495 (100) Eagle is currently just a hardware platform—you must write your own communications protocol software using the rudimentary drivers that come with the board. Although the manufacturer does plan to offer specific protocols such as TCP/IP (Transmission Control Protocol/Internet Protocol) as soon as various beta sites complete their development tasks, no firm availability dates for such software are forthcoming at this time.

—***J D Mosley***

Interphase Corp, 2925 Merrell Rd, Dallas, TX 75229. Phone (214) 350-9000.

Circle No 637

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CIRCLE NO 159

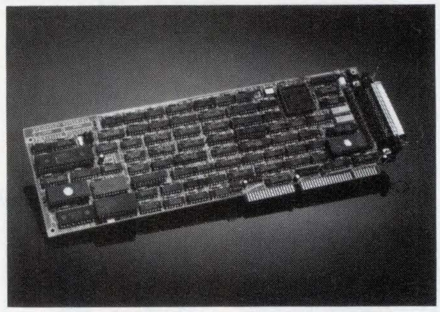
PC/AT bus adapter transfers data to host at 10M bytes/sec

System integrators can now purchase a high-performance SCSI host adapter, the AHA-1540, to connect disks and other peripherals to personal-computer-class machines. The PC/AT bus-compatible board sends bursts of data across the host bus at speeds as high as 10M bytes/sec. Furthermore, it performs 2M-byte/sec asynchronous transfers and 5M-byte/sec synchronous transfers to SCSI bus peripherals.

To meet the needs of high-performance applications, PC/AT-class 80286/386-based computers need faster I/O channels just as much as they need faster processing power and faster memory-access times. Traditional ST-506 disk controllers for the PC/AT bus perform host data transfers at much less than 1M bytes/sec, and the ST-506 interface limits the disk data rate to less than 1M bytes/sec. Even IBM has realized the need for speed improvement and uses an ESDI in its Personal System/2 machines.

The AHA-1540 offers system integrators and designers advantages for I/O-subsystem implemention for PC/AT bus-to-SCSI bus applications. The host adapter can act as an interface for various disk, tape, and other peripherals that have embedded-SCSI controllers. Further, the SCSI bus suits a multitasking I/O environment, and new PC/AT-class machines operate in Unix, Xenix, and other multiuser, multitasking environments.

The AHA-1540 has a programmable mailbox architecture to implement multitasking in the I/O subsystem. The host CPU communicates with the host adapter through 255 memory-resident mailboxes. The host adapter's local μP continuously scans the mailboxes and accepts or delivers commands and data. Each mailbox represents a task that is currently active in the I/O subsystem. The host adapter only interrupts the host CPU on completion of a task. In MS-DOS applications, the host adapter emulates a standard PC/AT bus disk controller.



Capable of synchronous and asynchronous data-transfer modes, *the AHA-1540 SCSI host adapter accommodates the high-performance disks needed for multiuser, multitasking IBM PC/AT bus applications.*

The board can also operate as a PC/AT bus master with programmable bus control. In fact, it employs first-party DMA to achieve its 10M-byte/sec transfer rate. The SCSI transfer rate results from the company's recently introduced AIC-6250 SCSI protocol IC, which resides on the board.

The host adapter includes disconnect/reconnect, arbitration, and command-linking and -queuing features. It also automatically recognizes synchronous and asynchronous peripherals concurrently tied to the bus. Samples are available now, and production quantities, which will be available in the fourth quarter, will sell for $285 (100).

—***Maury Wright***

Adaptec Inc, 580 Cottonwood Dr, Milpitas, CA 95035. Phone (408) 432-8600.

Circle No 636

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CIRCLE NO 163


MOTOROLA

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With protocol controllers from Motorola, designing data communications is easier and their markets are more universal than ever before. Standard protocols are built into silicon so there's no need to burden your host. Built with Motorola's proven HCMOS technology, they offer the reliability you've come to expect and the advanced designs you demand.

Communicate now with our family of protocol controllers.

Our M68000 Family offers three different protocol controllers to handle all your data communication needs; whether it's across the building or around the world there's a Motorola device that will make your job easier. With our '68000 Family you can choose the protocol and system designs that get you on line quickly and economically.

X.25 Protocol Controller 1984 CCITT X.25 LAPB.

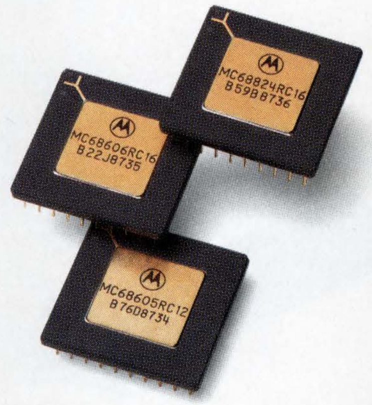
The MC68605 Protocol Controller (XPC) implements the 1984 CCITT Recommendation X.25 Link Access Procedure Balanced (LAPB) for U.S. and European T1 applications. By generating link-level commands and responses, the XPC relieves the host processor of communication link managerial tasks. It's also fully DDN certifiable.

Our XPC features an optional transparent mode which allows the implementation of other HDLC-based protocols, with user generation of all frames. The XPC handles full-duplex synchronous serial data rates up to a maximum 10 Megabits Per Second (Mbps) for high-speed computer links.

Multi-link LAPD Controller CCITT Q.920/Q.921 LAPD.

The MC68606 Multi-link LAPD (MLAPD) Protocol Controller fully implements CCITT Recommendation Q.920/Q.921 Link Layer Access Procedure (LAPD) protocol for ISDN networks. The MLAPD is designed to handle both signalling and data links in high-performance ISDN primary rate applications.

This VLSI device provides a cost-effective solution to ISDN link-level processing with simultaneous support for up to 8K logical links. The MC68606 is an intelligent communications protocol controller compatible with AT&T specifications for ISDN devices and features low power consumption and high performance, with an aggregate data rate in excess of 2.048 Mbps.



Token Bus Controller IEEE 802.4 MAC.

The MC68824 Token Bus Controller (TBC) is the only single-chip solution to implement the IEEE 802.4 Media Access Control (MAC), specified by Manufacturing Automation Protocol (MAP). The TBC implements four levels of message priority and the Request With Response (RWR) frame type to meet the real-time needs of factory floor communications and MAP 3.0.

The TBC conforms to the IEEE 802.4G standard MAC to Physical layer serial interface to support broadband, carrierband, and fiber optic networks. The TBC's low power consumption coupled with its extended temperature range versions make it ideally suited for factory automation applications.

Token Bus Frame Analyzer Software speeds development of token bus networks.

The MC68KTBFA Token Bus Frame Analyzer Software (TBFA) is a real-time software tool that speeds development of token bus networks. The TBFA keeps track of statistics while monitoring network performance. By using the simple menu-driven interface, the user can define triggers to selectively store and display frames, creating a powerful tool for network analysis.

The TBFA is a set of four EPROMs which runs on a VMEbus MVME372 Token Bus Controller board and requires a modem, a VT100 terminal, and a power source. The cost-effective TBFA sells for about one-tenth the cost of existing token bus protocol analyzers.

One-on-one design-in help.

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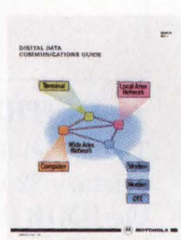

To: Motorola Semiconductor Products, Inc.
P.O. Box 20912, Phoenix, AZ 85036

Please send me information on the following:

☐ MC68606 Multi-link LAPD Protocol Controller ☐ MC68824 Token Bus Controller
☐ MC68KTBFA Token Bus Frame Analyzer ☐ MC68605 Protocol Controller (X.25)

335 EDN 100187

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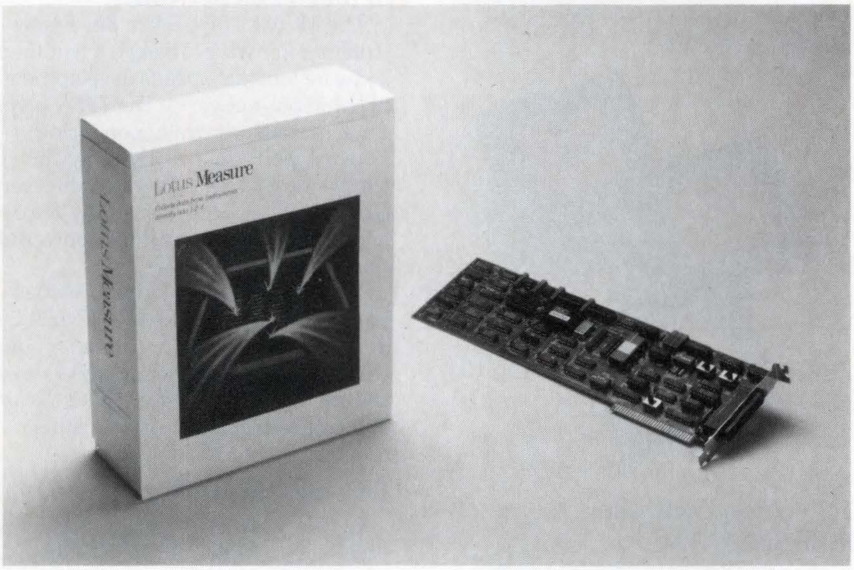
READERS' CHOICE

Of all the new products covered in EDN's **July 23, 1987,** 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 **July 23, 1987,** issue.



◀ DATA-ACQUISITION SOFTWARE

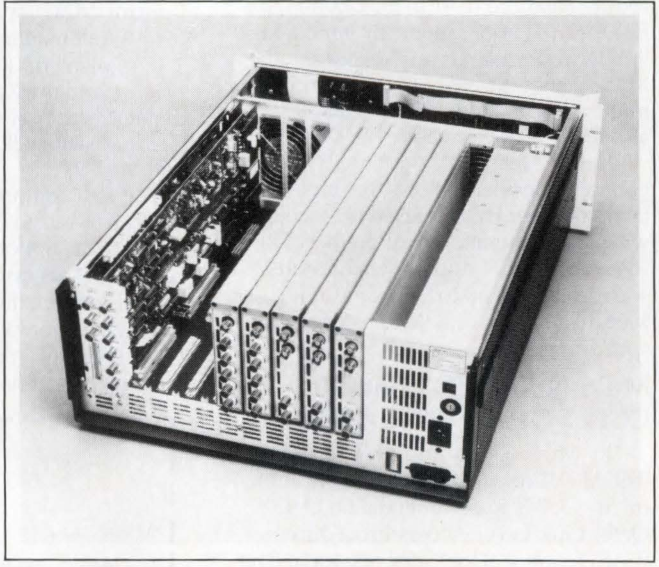
Measure is a software package for personal computers that lets you acquire data via the Metrabyte DAS-16 and DAS-16F boards and store the values directly in the vendor's 1-2-3 spreadsheet (pg 244).
Lotus Development Corp.
Circle No 603

2,7 ARLL CONTROLLER BOARDS

The ACB-238X controllers for the IBM PC/AT utilize 2,7 ARLL (advanced run-length-limited) encoding to increase both the data capacity and transfer rate of a drive by 100% (pg 112).
Adaptec Inc.
Circle No 601

HUMIDITY SENSOR

You can use the RH-8 sensor and the SCMC signal-conditioning microcircuits for constructing humidity transmitters (pg 197).
General Eastern Instruments.
Circle No 602



▲ INSTRUMENTATION BUS

The Model 680 instrument system incorporates a proprietary 32-bit bus based on the VME Bus and called the HMIB (high-speed modular instrument bus) (pg 267).
Wavetek.
Circle No 604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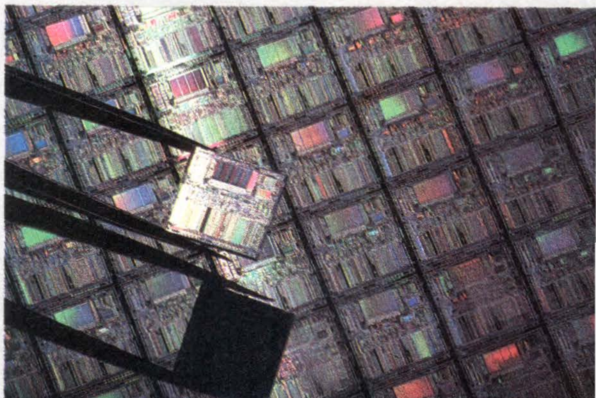
CIRCLE NO 157

Digital has it now.



"Our Dracula™ layout design verification software was developed and based on Digital systems, and for very good reason," states ECAD President Jim Hill. "Our customers in Integrated Circuit design regard Digital's VAX™ systems as the standard. Recognizing that, we've developed a line of software products that have made us the standard of our industry."

According to Mr. Hill, Digital's unmatched software compatibility offers real benefits in creating customer acceptance. "We know that whatever Digital system the customer has purchased, our software will run on it successfully. That kind of confidence is rare in the IC design industry. And Digital's hardware and

"ECAD seized an 80% world market share – the key was writing our design software to the industry standard, Digital."

software consistency helps us deliver a better product, faster and at a lower cost."

"We're aggressively pursuing a worldwide market," Mr. Hill adds. "And Digital has the worldwide presence to help us sell each market with strong local support. Our software and Digital's systems sell each other. ECAD and Digital have evolved a strategic partnership, one that gives us a proven competitive advantage in the marketplace."

To get your competitive advantage now, write to: Digital Equipment Corporation, 200 Baker Avenue, West Concord, MA 01742. Or call your local Digital sales office.

digital™

CIRCLE NO 158

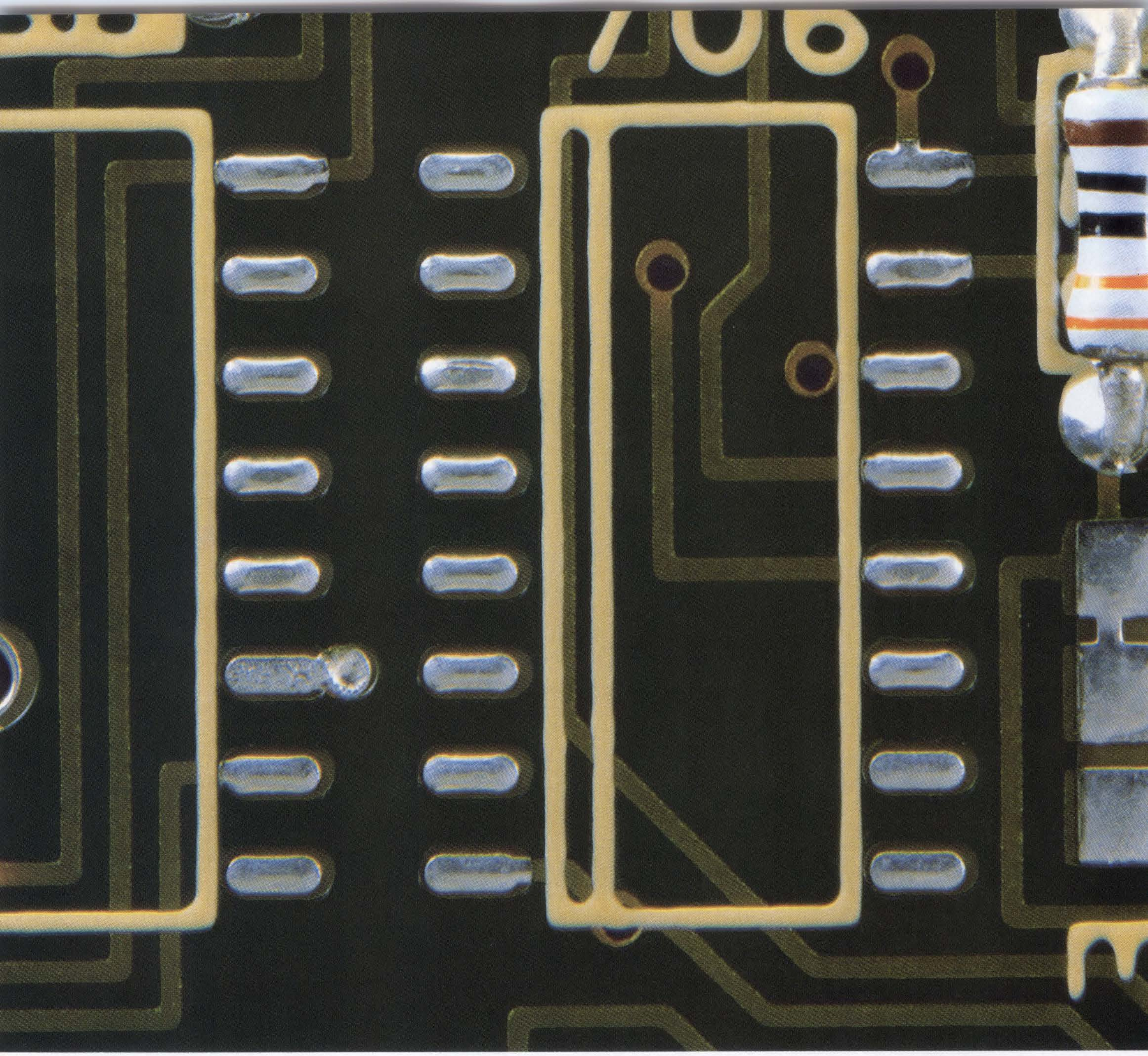
LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	0	25	50	25	0	0	8.6	5.9
Pot-Core	8	15	46	23	8	0	9.7	7.7
Laminate (power)	0	40	27	27	6	0	9.2	6.7
CONNECTORS								
Military panel	0	0	75	25	0	0	9.9	5.3
Flat/Cable	27	27	40	6	0	0	5.0	4.3
Multi-pin circular	0	29	71	0	0	0	6.6	7.9
PC	0	44	56	0	0	0	5.8	5.6
RF/Coaxial	17	33	42	8	0	0	5.6	6.6
Socket	37	26	32	5	0	0	4.1	5.2
Terminal blocks	19	43	38	0	0	0	4.3	5.7
Edge card	19	19	43	19	0	0	7.0	5.8
D-Subminiature	20	20	47	13	0	0	6.4	6.3
Rack & panel	7	8	69	8	8	0	8.9	7.7
Power	9	46	36	9	0	0	5.7	6.9
PRINTED CIRCUIT BOARDS								
Single-sided	5	54	36	5	0	0	5.3	4.9
Double-sided	3	35	48	14	0	0	7.0	5.2
Multi-layer	0	12	63	25	0	0	9.3	8.1
Prototype	5	70	25	0	0	0	4.1	3.8
RESISTORS								
Carbon film	38	31	28	3	0	0	3.7	3.1
Carbon composition	38	33	29	0	0	0	3.3	3.2
Metal film	36	29	32	5	0	0	4.1	3.5
Metal oxide	18	29	41	12	0	0	6.0	2.8
Wirewound	14	24	48	9	5	0	7.2	6.6
Potentiometers	27	27	46	0	0	0	4.5	6.9
Networks	19	31	31	19	0	0	6.3	5.1
FUSES	35	35	20	10	0	0	4.2	2.6
SWITCHES								
Pushbutton	26	21	32	21	0	0	6.4	5.6
Rotary	15	35	35	15	0	0	6.2	6.7
Rocker	18	29	35	18	0	0	6.4	5.0
Thumbwheel	0	25	42	33	0	0	9.3	6.4
Snap action	15	31	31	23	0	0	7.0	5.5
Momentary	23	15	39	23	0	0	7.1	5.8
Dual in-line	30	20	20	30	0	0	6.9	5.9
WIRE AND CABLE								
Coaxial	33	20	47	0	0	0	4.3	2.8
Flat ribbon	33	22	34	11	0	0	5.1	4.1
Multiconductor	15	23	54	8	0	0	6.2	3.8
Hookup	48	28	24	0	0	0	2.8	1.6
Wire wrap	50	33	17	0	0	0	2.3	5.0
Power cords	36	18	27	14	5	0	6.0	4.4
POWER SUPPLIES								
Switcher	20	33	27	20	0	0	6.2	7.4
Linear	10	40	30	20	0	0	6.7	8.2
CIRCUIT BREAKERS	16	47	21	16	0	0	5.6	7.5
HEAT SINKS	11	56	28	5	0	0	4.8	4.8
RELAYS								
General purpose	32	37	21	10	0	0	4.4	6.1
PC board	10	37	21	32	0	0	7.7	7.4

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
Dry reed	0	50	17	33	0	0	8.0	7.9
Mercury	17	33	17	33	0	0	7.5	7.6
Solid state	8	50	17	17	8	0	7.5	6.0
DISCRETE SEMICONDUCTORS								
Diode	39	29	21	7	0	4	4.8	8.0
Zener	37	26	21	11	5	0	5.4	7.4
Thyristor	8	25	42	25	0	0	8.0	6.6
Small signal transistor	9	37	27	27	0	0	7.5	5.5
MOSFET	15	23	31	31	0	0	7.9	6.2
Power, bipolar	20	20	20	40	0	0	8.4	5.4
INTEGRATED CIRCUITS, DIGITAL								
Advanced CMOS	8	17	50	25	0	0	8.4	11.7
CMOS	26	21	32	21	0	0	6.4	8.9
TTL	27	27	26	20	0	0	6.0	6.5
LS	44	6	25	25	0	0	6.1	6.6
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	11	11	56	22	0	0	8.2	6.3
OP amplifier	14	21	36	29	0	0	7.9	7.9
Voltage regulator	21	26	42	11	0	0	5.8	6.8
MEMORY CIRCUITS								
RAM 16k	20	20	30	30	0	0	7.7	7.9
RAM 64k	23	15	39	23	0	0	7.1	8.3
RAM 256k	37	0	27	27	9	0	8.7	7.8
RAM 1M-bit	17	17	33	17	16	0	10.0	8.8
ROM/PROM	30	0	50	20	0	0	7.1	9.0
EPROM 64k	21	14	36	29	0	0	7.7	9.4
EPROM 256k	17	8	42	33	0	0	8.8	8.8
EPROM 1M-bit	13	12	50	25	0	0	8.3	13.9
EEPROM 16k	10	20	40	30	0	0	8.5	12.3
EEPROM 64k	10	30	30	30	0	0	8.0	13.0
DISPLAYS								
Panel meters	7	29	21	36	7	0	9.9	6.6
Fluorescent	0	0	40	60	0	0	12.5	10.1
Incandescent	14	29	14	43	0	0	8.6	7.6
LED	30	15	20	35	0	0	7.5	6.0
Liquid crystal	0	27	33	40	0	0	9.7	9.9
MICROPROCESSOR ICs								
8-bit	14	33	33	20	0	0	6.8	8.9
16-bit	13	13	47	27	0	0	8.3	8.1
32-bit	0	9	36	46	9	0	12.5	8.5
FUNCTION PACKAGES								
Amplifier	0	22	45	33	0	0	9.4	7.5
Converter, analog to digital	0	20	50	30	0	0	9.3	8.3
Converter, digital to analog	0	25	50	25	0	0	8.6	8.3
LINE FILTERS	20	0	60	20	0	0	7.9	7.9
CAPACITORS								
Ceramic monolithic	28	32	32	8	0	0	4.8	5.9
Ceramic disc	38	19	33	10	0	0	4.7	6.0
Film	38	19	31	12	0	0	5.0	7.3
Aluminum electrolytic	18	41	27	14	0	0	5.5	8.2
Tantalum	35	15	35	15	0	0	5.6	7.3
INDUCTORS	21	22	43	14	0	0	6.3	5.8

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



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Du Pont VACREL photopolymer film solder masks totally encapsulate fine-line circuits with a tough, uniform, high-resolution photopolymer film that provides excellent dielectric, mechanical, and electrical protection.

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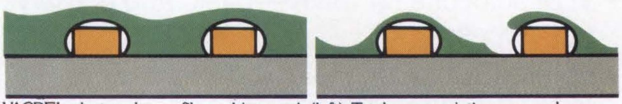
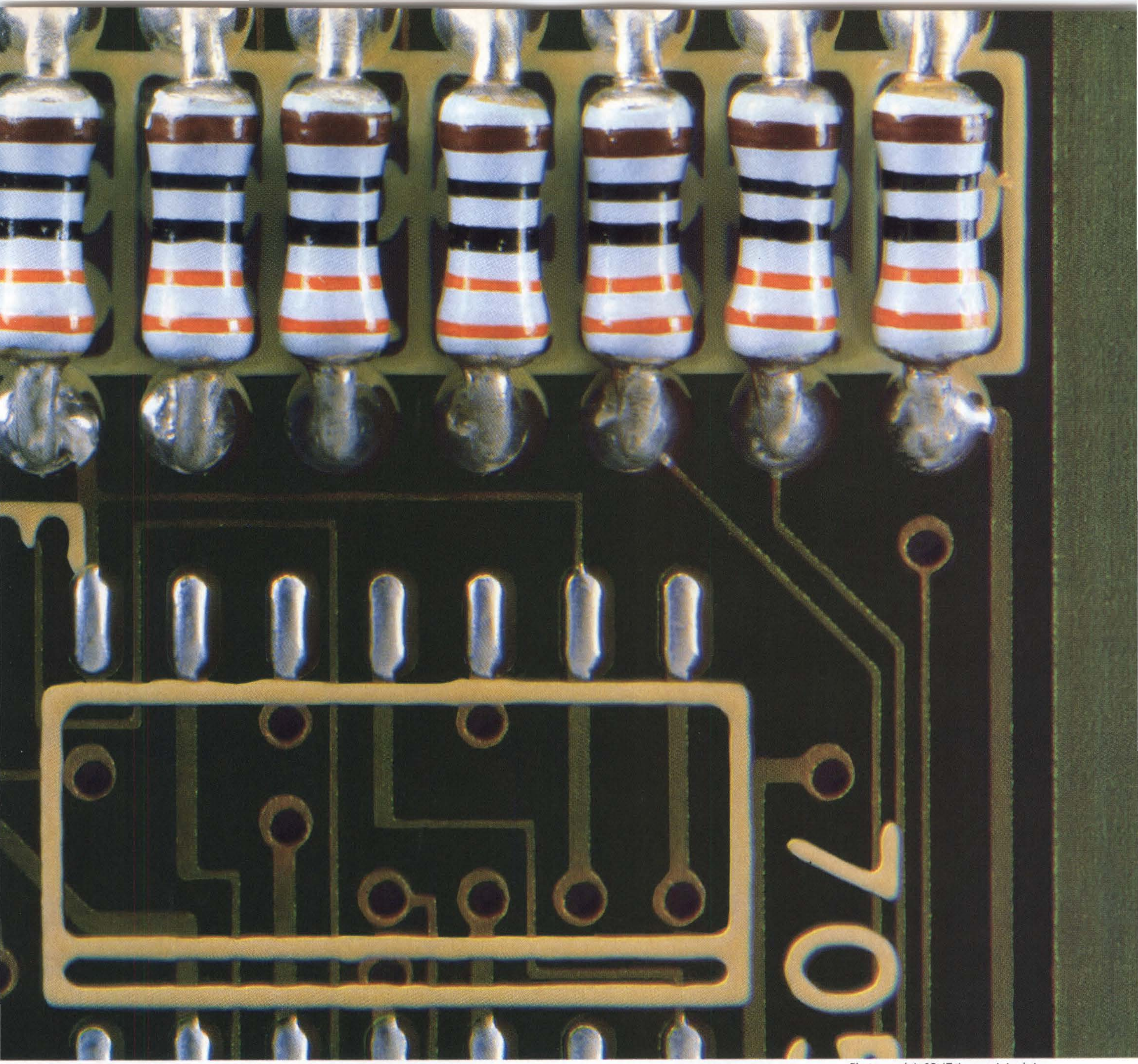
Tighter designs are possible due to accurate image registration and reproduction with masks of VACREL, even on large panels having two or more



VACREL photopolymer film solder mask (left). Total encapsulation means less damage in assembly, greater reliability in use, and reduced potential for field failures.

Screen-printed solder mask (right) may leave voids, pinholes, and incomplete encapsulation.

circuit lines between pads and as little as 0.13-mm (5-mil) spacing between conductors. VACREL helps lower per-function cost by allowing more functions



Photograph is 13.47 times original size.

functions into less real estate at less cost.

per board, with high first-pass assembly yields, less solder bridging, fewer retests and rejects, and less potential for field failures. Lower incoming inspection costs are possible, thanks to the accuracy of VACREL.

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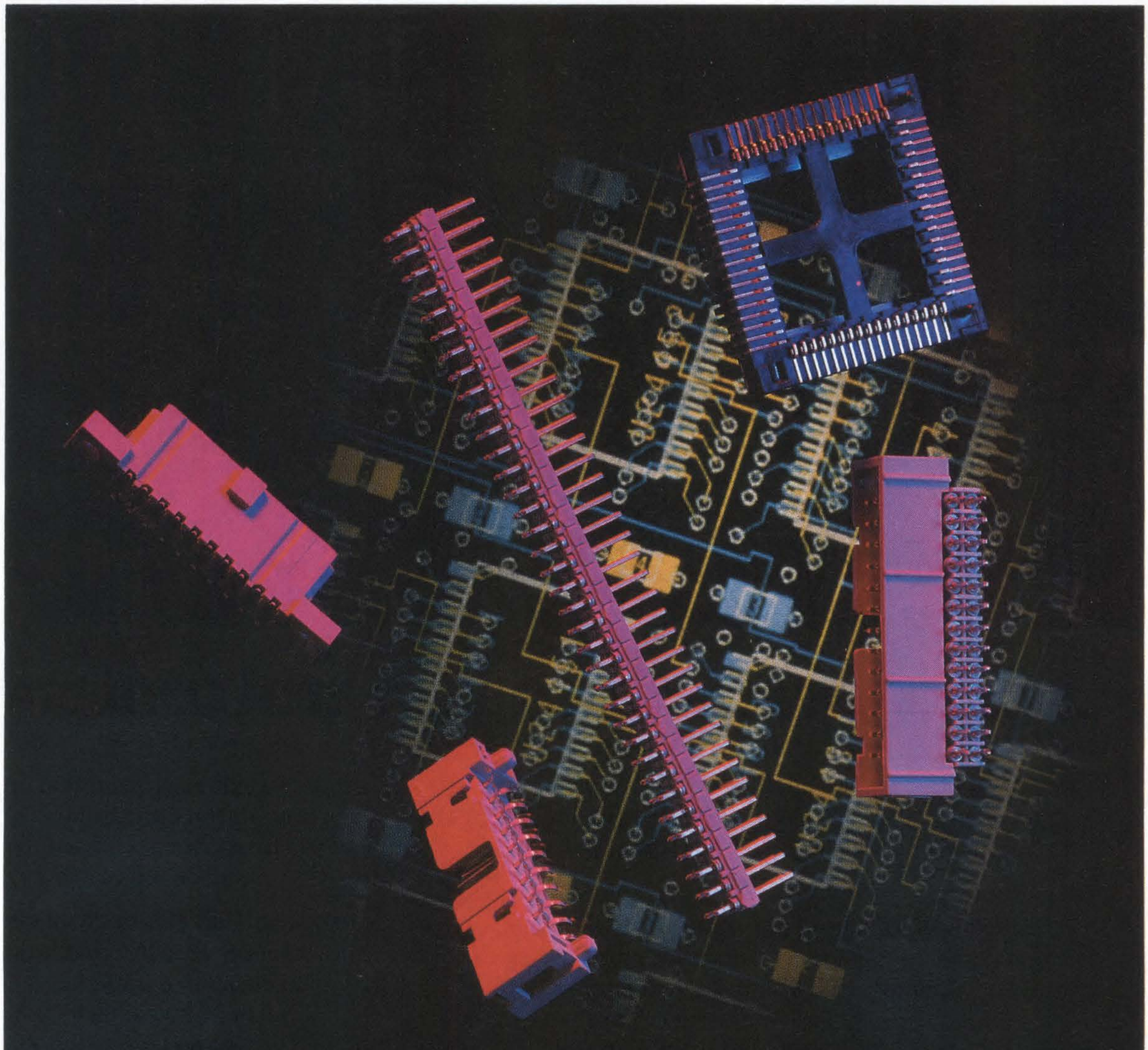
CIRCLE NO 60

Surface-mount connectors

SPECIAL REPORT



You can find a variety of surface-mount-technology (SMT) connectors for use in your pc-board designs. Manufacturers offer SMT versions of such parts as D-subminiature pin and socket headers, backplane and I/O connectors, and chip-carrier sockets. (Photo courtesy 3M Electronics Products Div)

SMT connectors can present you with a number of design considerations and tradeoffs that don't occur in through-hole designs. By understanding the different solder techniques and physical configurations of SMT connectors, you can choose the right SMT connectors to maximize the connections' reliability yet minimize space on your board.

KEEPING AMERICA COMPETITIVE

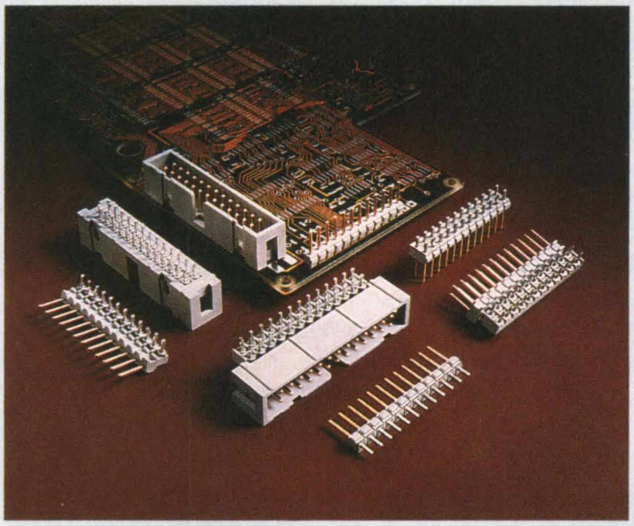
J D Mosley, *Regional Editor*

Converting your through-hole pc-board designs to surface-mount-technology (SMT) designs can give you a number of advantages. For one thing, it does away with the expense of creating plated through-holes in pc boards. The absence of these holes and the pads that would normally surround them increases the available surface area on both sides of the pc board and permits closer spacing of leads and components. You can often shrink the required board space for an SMT version of a circuit to less than half the area needed for a through-hole version.

Besides being smaller, SMT boards are easier to route, because they don't require you to dodge plated holes, and they let you wire their internal planes more densely. The increased density can result in fewer wiring layers. Your design may still require vias; however, vias are much smaller than plated through-holes—you can route as many as seven 0.005-in. traces between 0.020-in. vias on 0.100-in. centers.

With the advantages of SMT come a number of tradeoffs, however. For one thing, connectors are the most difficult components to adapt to surface-mount technology. Because they're deprived of leads that anchor and stabilize, connectors with surface-mount solder joints can withstand only a fraction of the mechanical and thermal stresses that through-hole connectors can tolerate **(Table 1)**. According to one estimate, a through-hole joint provides 15 to 20 times the mechanical strength of an SMT joint **(Ref 1)**. Further, when you convert your designs from through-hole pc boards, which usually have the standard 100-mil spacing, to surface-mount circuits, which often have tighter centers, the SMT boards' shorter leads and traces may significantly alter impedance and timing specs. To make matters worse, SMT connectors lack standards: Manufacturers offer contact centers on spacings of various sizes, such as 25, 33, 50, and 100 mils.

Furthermore, making the transition from through-hole to SMT connectors includes not only the expense of learning new design techniques, but also the cost of converting from a wave-soldering process to a reflow-soldering process. Although it's possible to wave-solder an SMT circuit, particularly in circuits that use both through-hole and SMT devices, the selection of SMT components that can withstand exposure to a 260°C wave of molten solder is limited.



Preformed solder inlays mounted around each pin *on these connectors from 3M allow the simultaneous reflow and bonding of the connectors' solder tails and surface-mount components during IR or vapor-phase reflow soldering. The vendor claims this scheme combines the speed and economy of reflow soldering with the bond strength of through-hole connector mounting.*

Connectors are particularly ill suited for such exposure. Female terminals tend to fill with solder, and many connectors are too tall to pass successfully through the solder wave on the bottom of a pc board. What's more, solder has a tendency to coat pins, ruining them for mating.

To solve these problems, you can use one of several reflow-soldering techniques. Vapor-phase reflow soldering, for example, limits the maximum solder temperature to 215°C, provides uniform heating, and employs a nonoxidizing atmosphere. However, the technique also exposes the entire component to this temperature for as long as two minutes. Conventional housing materials can't withstand such heat, so you have to use components made from special

Connectors with surface-mount solder joints can withstand only a fraction of the mechanical and thermal stresses that through-hole connectors can tolerate.

high-temperature plastics, which may exhibit brittleness. Further, vapor-phase equipment and materials are more costly than the equipment and materials used in other soldering processes.

Infrared (IR) reflow is less expensive than vapor-phase reflow, but it can cause uneven heating of the components and the board, both of which can absorb IR energy at varying rates. If you use IR reflow, therefore, you must develop temperature profiles for each device on the board.

The least expensive reflow process is conductive-belt reflow. To use this technique, you place a pc board (with components on only one side) onto a heat-conductive belt that passes over a hot plate. Conductive-belt reflow is slow and is limited to use with lightweight substrates; it's used primarily with ceramic substrates.

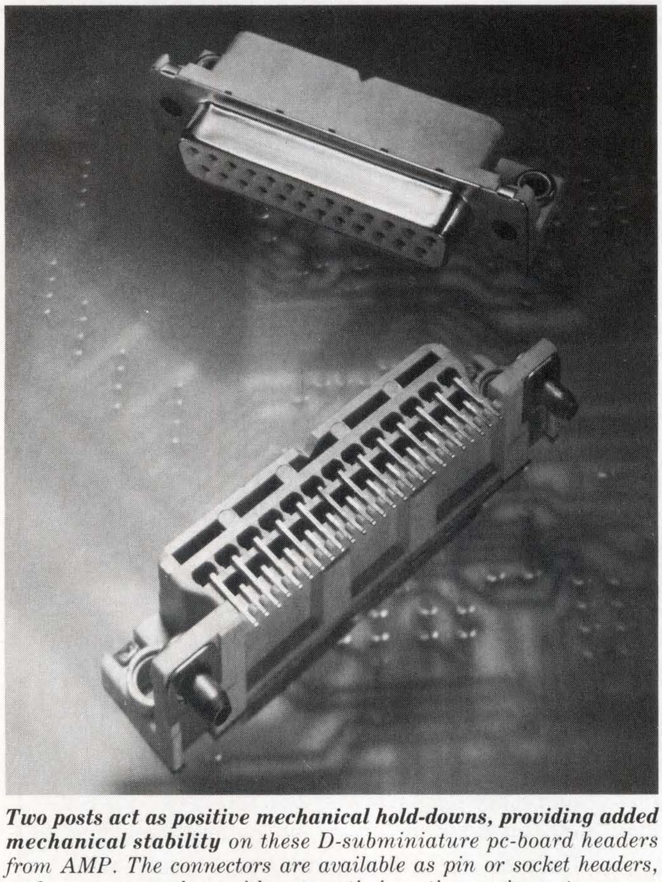
One significant benefit offered by the vapor-phase and IR reflow-solder techniques is that they let you use all six sides of a pc board—an important consideration when you're positioning connectors. Placing a connector on the edge of the pc board lets you eliminate the solder-joint damage caused by sideways forces against the connector.

TABLE 1—COMPARISON OF THROUGH-MOUNT AND SMT SOLDER JOINTS

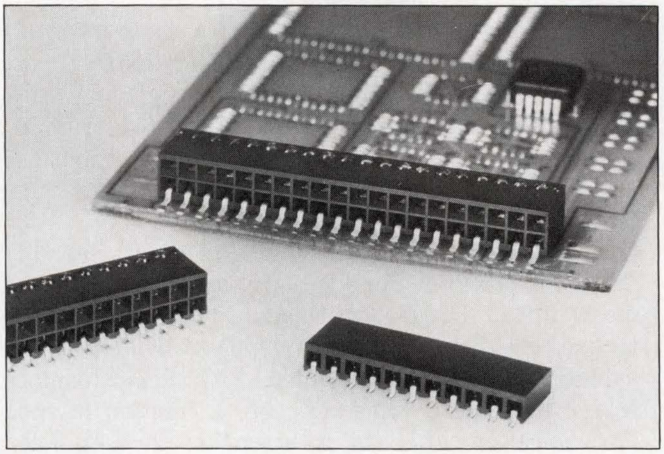
PARAMETER	THROUGH-MOUNT SOLDER JOINTS	SURFACE-MOUNT SOLDER JOINTS
SOLDER VOLUME	0.00038 IN.^{3}	0.00004 IN.^{3}
SOLDER-JOINT SURFACE AREA	0.040 IN.^{2}	0.0071 IN.^{2}
PULL STRENGTH	>20 LBS	4 TO 8 LBS

(COURTESY DU PONT CONNECTOR SYSTEMS)

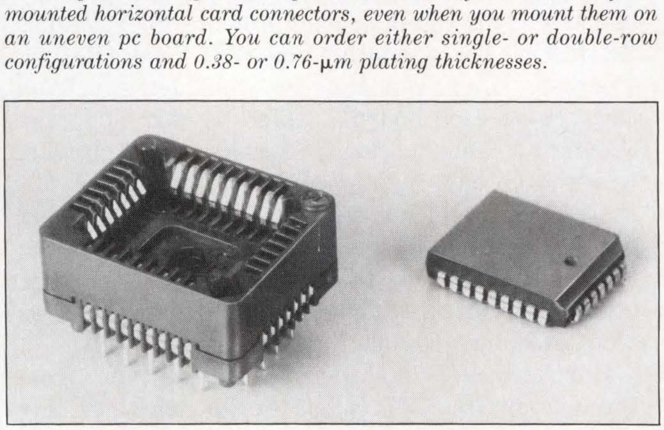
The soldering technique is only one of your design considerations. Your connector choice may also depend on the shape of the leads you're able to use. Generally speaking, you'll probably choose a J-shaped lead, a butt joint, or a gull- or L-shaped lead. Modified versions of



Two posts act as positive mechanical hold-downs, providing added mechanical stability *on these D-subminiature pc-board headers from AMP. The connectors are available as pin or socket headers, and you can use them with automatic-insertion equipment.*



Floating contact legs ensure positive contact *of Du Pont's surface-mounted horizontal card connectors, even when you mount them on an uneven pc board. You can order either single- or double-row configurations and 0.38- or 0.76-μm plating thicknesses.*



Many manufacturers offer leaded-chip-carrier sockets—*such as this modular 32-pin socket from Methode Electronics—in both through-hole and surface-mount styles.*

TABLE 2—FORCES ACTING ON INDIVIDUAL CONTACTS		
FORCE	GRAMS	OUNCES
INSERTION FORCE— PIN INTO TYPICAL RECEPTACLE	275 (MAX)	9.625 (MAX)
WITHDRAWAL FORCE— PIN FROM TYPICAL RECEPTACLE	200 (MAX)	7.000 (MAX)
FORCE TO PEEL OFF SOLDER TAIL— VERTICAL DIRECTION	900 (MIN)	31.50 (MIN)
FORCE TO SHEAR OFF CONTACT— HORIZONTAL DIRECTION	1800 (MIN)	63.00 (MIN)

(COURTESY DU PONT CONNECTOR SYSTEMS)

these basic shapes abound; manufacturers are testing a variety of shapes for pull strength and pliancy.

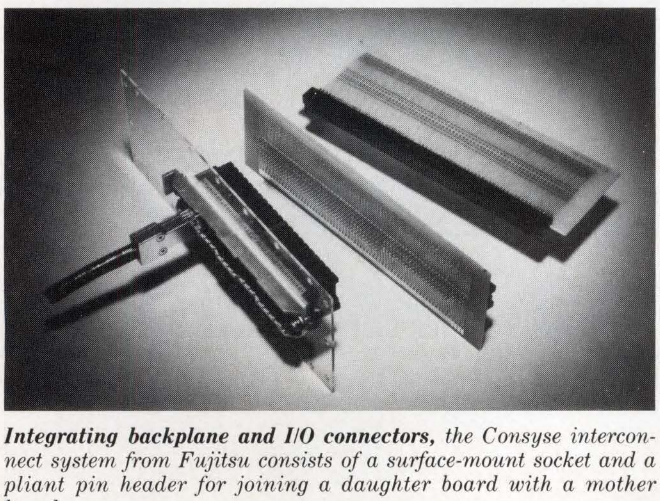
Oddly enough, butt joints present greater resistance to pulling force than do J- or L-shaped leads. In tests performed by AMP, a butt joint with two solder fillets withstood more than 5 lbs of pulling force. L-shaped leads withstood just over 4 lbs of vertical force, and J-shaped leads resisted 4 lbs. On the J leads, heel fillets provided virtually all the joint strength measured: With or without a toe fillet, the J-lead pulled free at 4 lbs of force.

Pliancy, however, is often more important than pull strength. Pliant leads ease the stress generated by thermal shock and mechanical forces. As long as a joint is strong enough to withstand the forces associated with mating and unmating (see **Table 2**), a low-strength joint with a pliant lead can tolerate more vibration and shock than can a higher-strength joint with a rigid lead. Butt joints are inherently less pliant than J- or L-shaped leads. The longer and more flexible the lead, the more pliancy it offers, and the smaller the chance that the solder joint will crack.

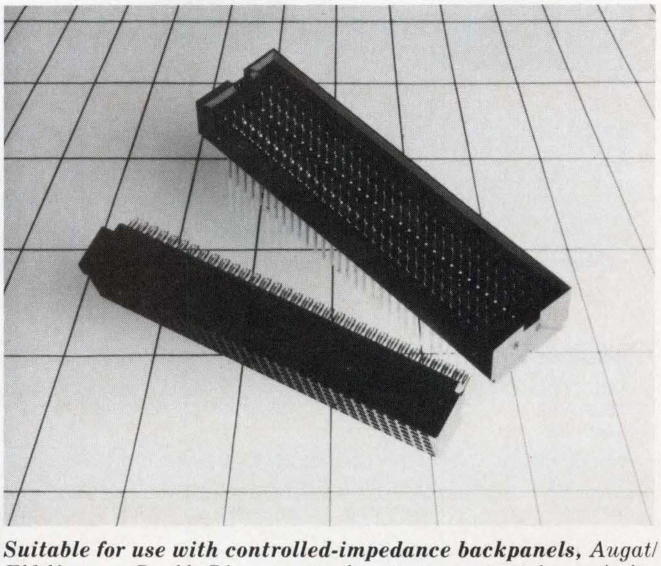
Solder-joint cracking is a key concern in SMT-board design. Vibration and thermal cycling can propagate tiny cracks along the lead, resulting in contact failure. One solution to this problem is to use floating terminals. Under circumstances that would normally result in cracking, floating terminals can increase the life of solder joints. For example, if you have to contend with a long connector or a flexible pc board, you can ensure the coplanarity of the leads by using a connector whose contacts float in the housing cavity. Leads with floating contacts maintain contact in spite of vibration, heat expansion, and board flexing; thus, they are preferable for board-to-board connections. Du Pont makes connectors with floating contact legs in single- or double-row configurations and 0.38- or 0.76-μm plating thicknesses.

SMT connectors that sandwich a card edge can provide I/O connections at lead densities reaching 40 leads/in. Teradyne's VHSICon line of high-density connectors includes such a model. Offered in configurations having 100 to 400 contacts on centers ranging from 50 to 25 mils, these connectors are suitable for use with flexible circuit modules that are 0.150 to 0.350 in. thick.

By placing connectors on both the front and back of a center plane or by using stacking connectors to stack the board in piggyback fashion, you can shorten com-



Integrating backplane and I/O connectors, the Consyse interconnect system from Fujitsu consists of a surface-mount socket and a pliant pin header for joining a daughter board with a mother board.



Suitable for use with controlled-impedance backpanels, Augat/Elfab's 6-row Double Din connector boasts a mere 0.070-in. variation in the length of its conductor paths. Offering a density of 60 contacts per linear inch, this connector provides 200 to 300 individually replaceable contacts that are available in a variety of lengths and plating options.

Although it's possible to wave-solder an SMT circuit, the selection of SMT components that can withstand a 260° C wave of molten solder is limited.

munication paths between boards, increase wiring efficiency, minimize the overall package, and lower costs. Teledyne Kinetics manufactures a line of surface-mount pc-board stacking connectors using what the company calls "pressure contacts," which deflect slightly, providing concentrated contact force to the pads on the surface of the pc board. These connectors use a screw fastener to hold down the device and secure the parallel boards.

Another way to increase the life of solder joints is to use a hold-down mechanism or strain relief. Such devices protect the solder joints by absorbing the forces associated with connector insertion and withdrawal. Furthermore, hold-downs can allow automatic-placement equipment to position the connector more accurately, and they keep the connector in place during the reflow process. They can also help overcome TCE (thermal coefficient of expansion) mismatch, which can occur in the solder joints of SMT connectors that are wave soldered. You can choose from a variety of devices for anchoring surface-mount connectors to the pc board **(Table 3)**.

Other devices can help connectors that mate two pc boards resist undesirable forces. For example, you can

REPRESENTATIVE SURFACE-MOUNT CONNECTORS

MANUFACTURER	MODEL	CONNECTOR TYPE	NUMBER OF CONTACTS	PWB CONTACT CENTERS (IN.)	CONTACT RESISTANCE (Ω)	INSERTION FORCE	WITHDRAWAL FORCE	CURRENT RATING (A)	PRICE
ADVANCED INTERCONNECTIONS	1586-XX	PLCC ADAPTER	20 TO 124	0.100	0.005	2.5 OZ	1.5 OZ	1	$15
AMP	MOD IV	VERTICAL RECEPTACLE	10 TO 64	0.100	0.012	9.0 OZ	1.5 OZ	1.5	$3.54 (25 MILLION)
	AMPLIMITE	D-SUBMIN-IATURE	9 TO 37	0.054	0.015	12 OZ (MAX)	0.75 OZ (MIN)	2	$3 (10 MILLION)
	HPT	PLCC SOCKET	20 TO 84	0.050	0.012	N/A	N/A	N/A	$2.24 (10,000)
	GOLD/GOLD	PLCC SOCKET	20 TO 84	0.050	0.025	N/A	N/A	N/A	$3.52 (10,000)
	MODULAR JACK	PC BOARD I/O	2 TO 8	0.050	0.020	2 LBS (MAX)	20 LBS (MIN)	1.9	$0.50 (100 MILLION)
	DIPLOMATE SL	DIP SOCKET	14 TO 40	0.100	0.020	N/A	N/A	1	$1.26 (28-CONTACT SIZE)
	MATE-N-LOK	HEADER	4	0.200	0.025	5 LBS (MAX)	1 LB (MIN)	5	$0.43 (25,000)
AUGAT/ELFAB	4-ROW BOX	BOARD TO BOARD	200 TO 300	0.050	0.015	1.8 OZ	1.0 OZ	3	$0.09/MATED PAIR
	DOUBLE-DIN	BOARD TO BOARD	200 TO 300	0.050	0.015	1.8 OZ	1.0 OZ	3	$0.17/MATED PAIR
FUJITSU	CONSYSE	BACKPLANE I/O	256	0.100	0.030	10 LBS (MAX)	6.6 LBS (MIN)	1	$0.35/ CONTACT
ITT CANNON	D-SUB	D-SUBMIN-IATURE	9 TO 25	0.104	0.050	12 OZ	18 OZ	3	$3.70 (25-LINE SIZE)
	G60	DIN EUROCARD	32 TO 96	0.100	0.015	5.5 OZ	2 OZ	3	$4.50 (96-LINE SIZE)
	LCS	PLCC SOCKET	44 TO 84	0.100	0.030	N/A	N/A	1	$4 (84-LINE SIZE)
METHODE	213 SERIES	PLCC SOCKET	28 TO 84	0.050	0.015	8 OZ (MAX)	2 OZ	3	$0.035/ CONTACT
	500/501	BOARD TO BOARD	25 TO 50	0.050 OR 0.100	0.005	0	0	2	$6 (OEM QTY)
NEPENTHE	IC61	SOCKET	32	0.050	30 (MAX)	4 LBS (MAX)	1.5 LBS (MIN)	N/A	$5.88 (250)
TELEDYNE KINETICS	SURFACE STACK	STACKING	10 TO 64	0.050 TO 0.100	0.050	0	0	4 (MAX)	$1.30 TO $34
TERADYNE	VHSICON	HIGH-DENSITY	100 TO 400	0.050	0.015	2.25 OZ (MAX)	3.5 OZ (MIN)	3	$70 TO $1509
3M	DHT 3500	LOW-PROFILE	2 TO 72	0.100	N/A	N/A	N/A	3	FROM $1.40 (1000)
	2-0068-05405	PLCC SOCKET	68	0.100	0.010	N/A	N/A	N/A	$6.78 (100)

NOTES:
N/A=NOT AVAILABLE
PLCC=PLASTIC LEADED CHIP CARRIER
PWB=PRINTED WIRING BOARD

Vapor-phase reflow soldering limits the maximum solder temperature to 215° C, provides uniform heating, and employs a nonoxidizing atmosphere.

obtain mechanical ejectors that release connectors with a minimum of force, mechanical card guides that ensure the planarity of boards joined at right angles, and tip-in mechanisms that ensure the accurate location of parallel-board connectors. You can also protect SMT connectors from force by using two connectors, one on each side of a parallel daughter board.

If you have a complex connector problem, you can use computer analysis to perform 2- and 3-dimensional finite-element modeling. Finite-element modeling programs (available from CAD vendors) let you precisely define the solder interconnections that best complement the connector geometries, lead/board interaction, lead platings, housing materials, and environmental factors that will affect your circuit.

Regardless of the soldering process or lead design you select, you must always make provisions for visual inspection of the joint. Although connector housings that rest squarely upon the pc board may greatly stabilize the connector against twisting loads, they may prove to be a disadvantage if they prevent you from easily identifying poor solder joints. L-shaped leads offer the best shape for solder-joint inspection and repair, and they also have greater pull strength. Gull-wing leads add increased pliancy to the benefits of the L shape. J-shaped leads, however, occupy less board space. **EDN**

Manufacturer's box begins on pg 150

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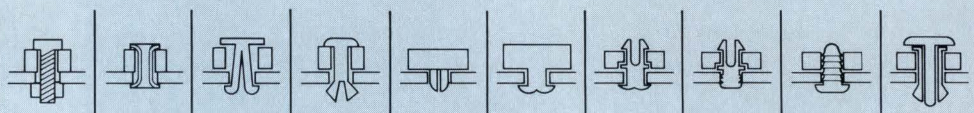
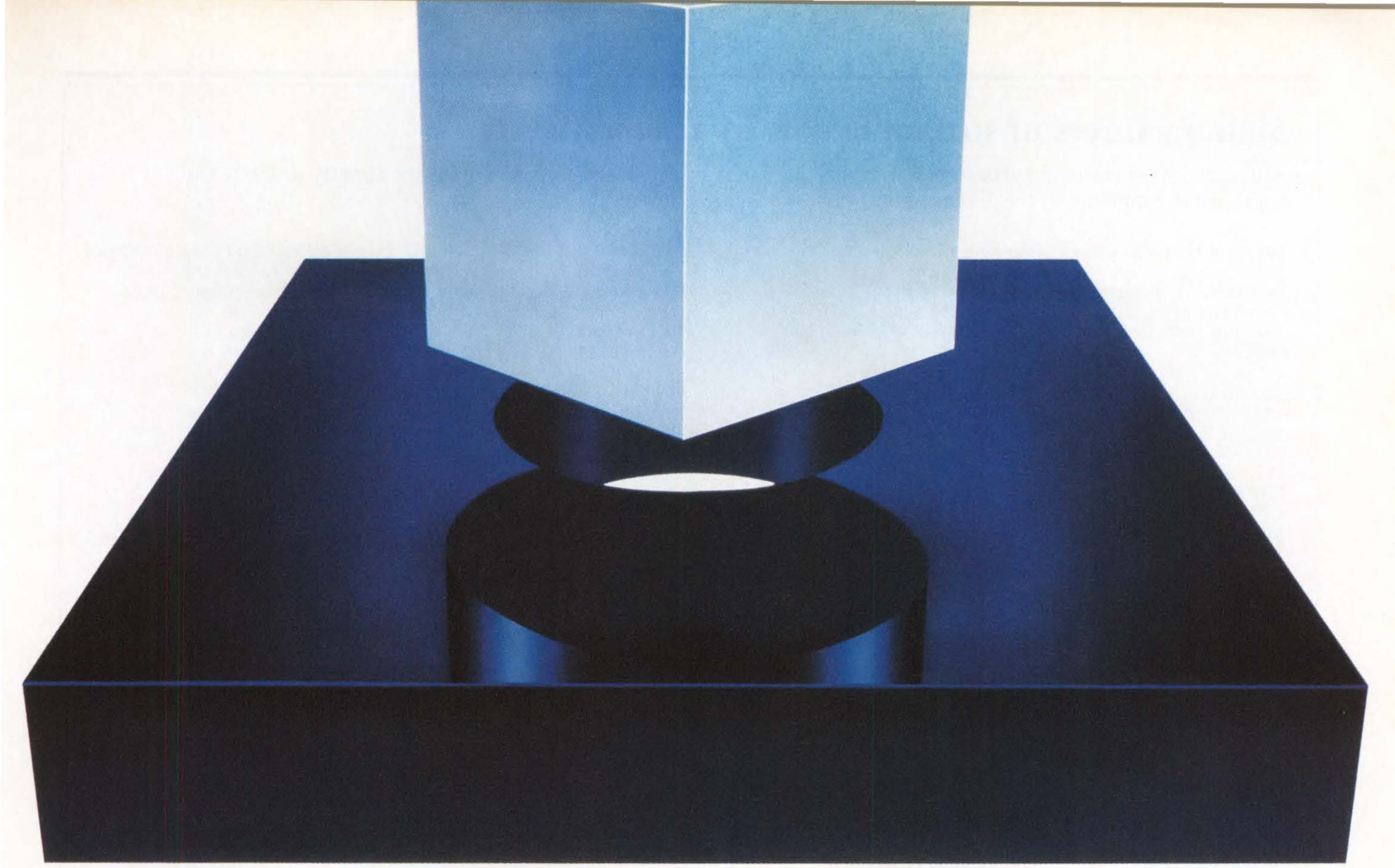
Article Interest Quotient (Circle One)
High 497 Medium 498 Low 499

TABLE 3—VARIOUS STRAIN RELIEFS FOR SMT BOARDS



	NUT AND BOLT	RIVET	METAL CLIP	PLASTIC CLIP	PRESS FIT	HEAT STAKE	HEAT-STAKE INSERT	PRESS-FIT INSERT	BOTTOM UP	TWO-PIECE
ALIGNMENT DURING ASSEMBLY					•	•	•	•	•	
COMPRESSES LEADS TO BOARD	•	•			•	•	•	•	•	•
PREVENTS BOARD BOW	•	•	•			•	•		•	•
PREVENTS ROCKING	•	•			•	•	•	•	•	•
PREVENTS UNMATING STRESS	•	•			•	•	•	•	•	•
PERMITS THERMAL EXPANSION	•		•	•			•	•	•	•
0.100±0.003-IN. HOLE	•	•	•	•	•	•	•	•	•	
MOUNTING EARS REQUIRED					•	•			•	
EASILY REPAIRABLE	•		•	•		•	•		•	•
WEAKENED BY HEAT	•	•	•							
NONINDUCTIVE				•	•	•	•	•	•	•
SUITABLE FOR HAND ASSEMBLY	•			•	•			•	•	•
AUTOMATION POTENTIAL		•			•	•	•	•	•	
ASSEMBLY TOOLING NEEDED					•			•		



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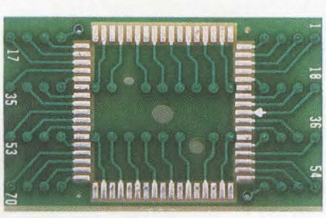

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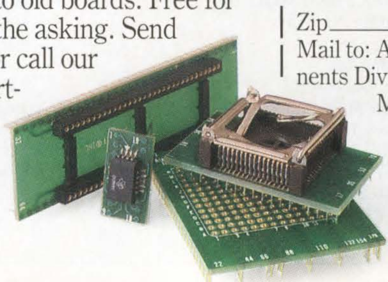

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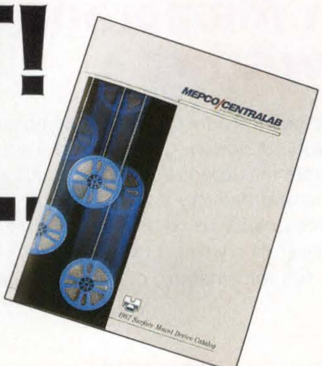

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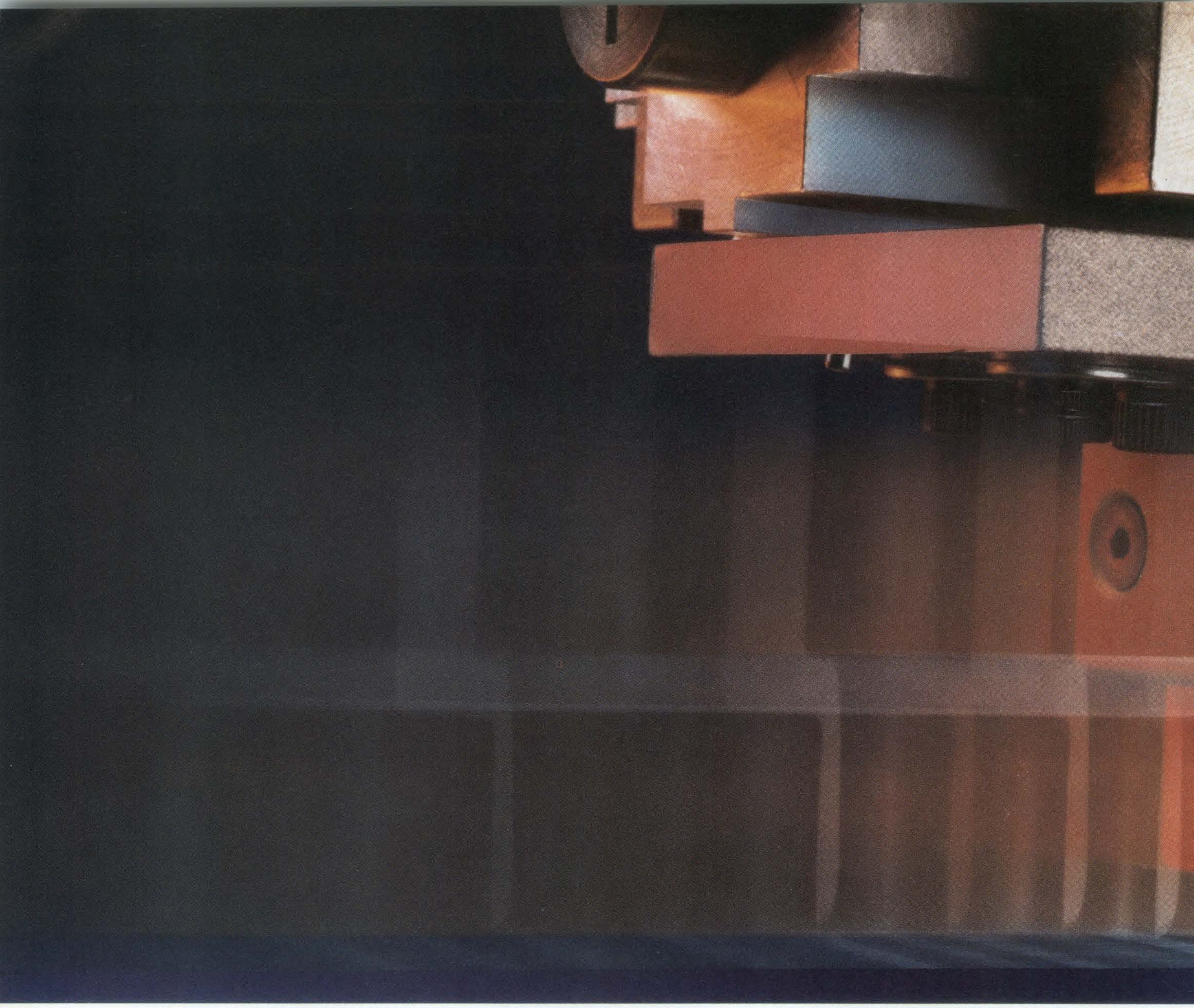

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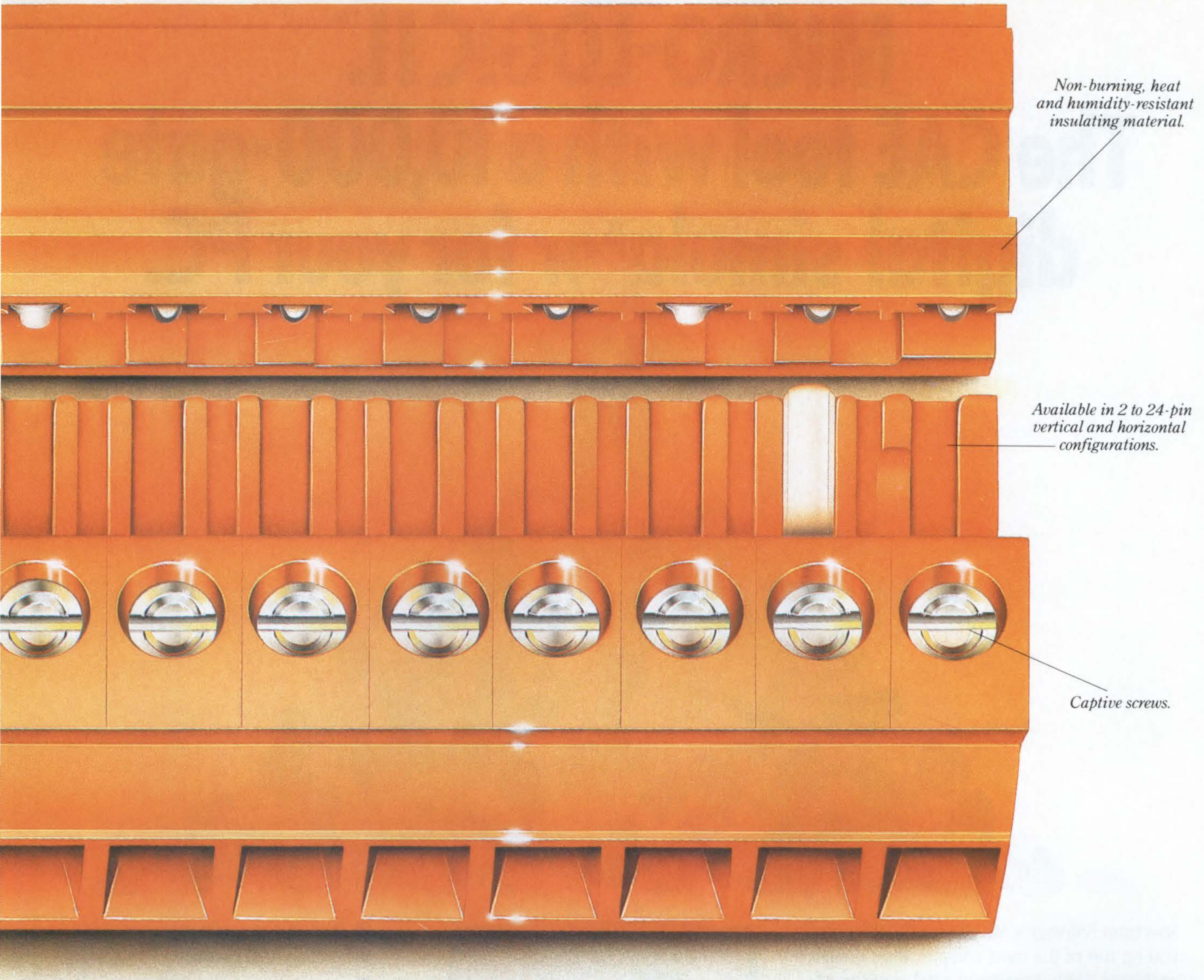

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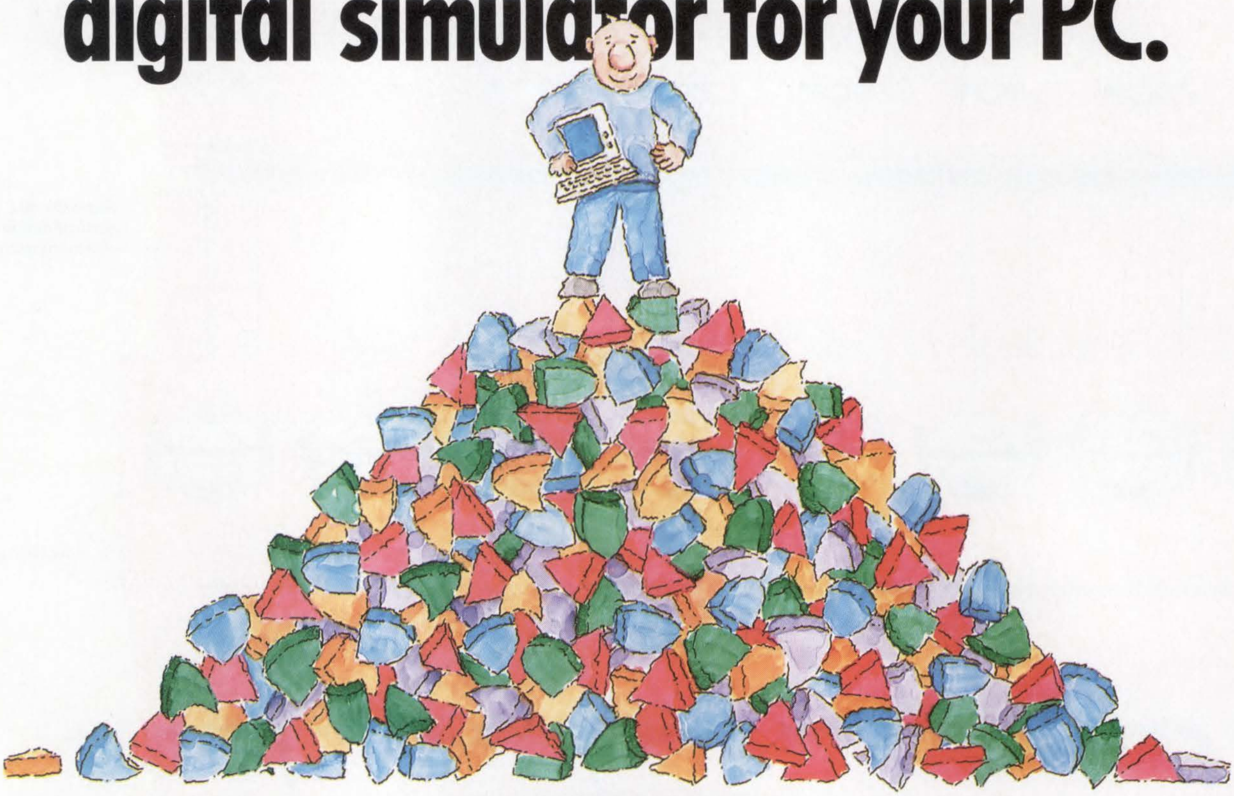

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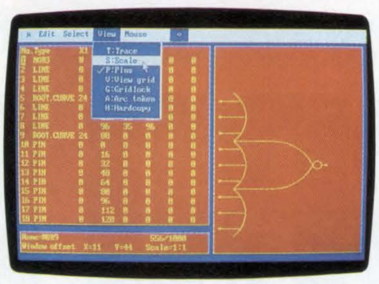

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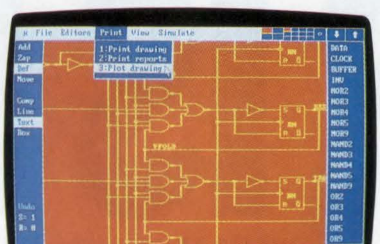

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Use of graphs eases transformer selection for linear supplies

Engineers generally use simple rules of thumb when selecting transformers for linear power supplies. These rules of thumb aren't universally applicable, however, and blindly using them may cause you to select a less-than-optimal transformer—and thus a less-than-optimal supply.

Thomas G Lock, *Case Western Reserve University*

If you're designing a linear power supply that will use a transformer operating at full rated load with a load-regulation factor of 0.9, traditional rules of thumb for selecting the transformer will suffice. For other applications, these rules won't necessarily be sufficient. You can account for varying power-supply operating parameters for all operating conditions by expressing the equations in the **box**, "Circuit models yield design equations," in the form of easy-to-use graphs. These equations are derived from simple models of common power-supply topologies (**Fig 1**).

Modeling power supplies' behavior involves some simplifying assumptions. The models used to produce the graphs in this article assume that you can ignore the effects of temperature and mains-voltage variations; assume that diodes conduct abruptly, have a constant forward-voltage drop, and have a negligible series resistance; and assume that the filter capacitors have a negligible equivalent series resistance and such a large capacitance that the ripple voltage (the ac voltage

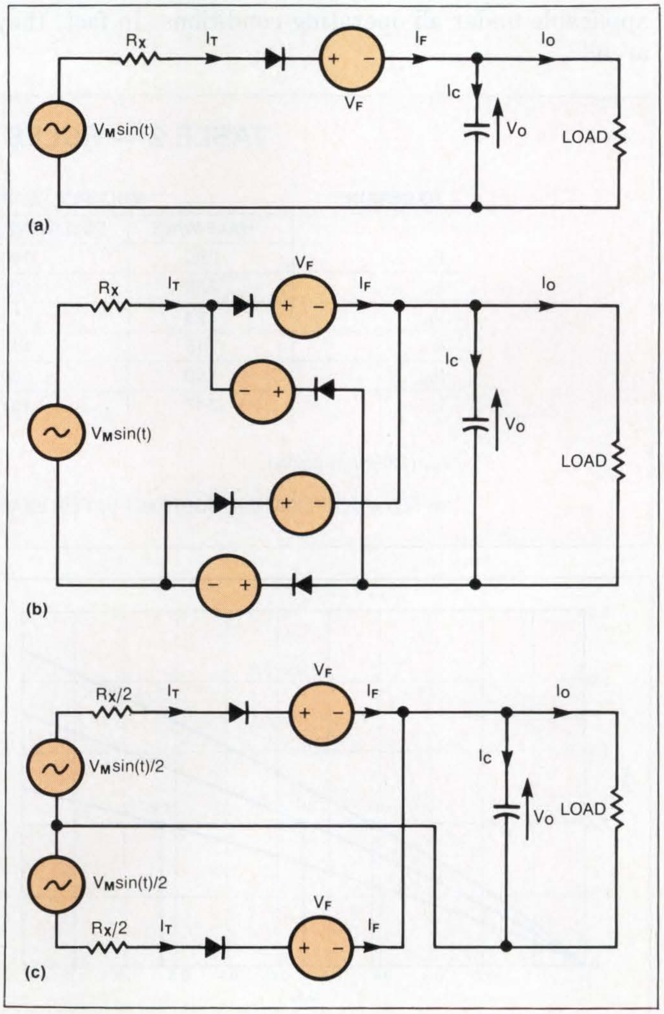


Fig 1—For each linear-power-supply topology*—half-wave* ***(a,)*** *full-wave bridge* ***(b,)*** *and full-wave center-tap* ***(c)****—you can use* ***Figs 2*** *through* ***6*** *to determine the important circuit parameters necessary for component selection.*

The transformer makers' rules don't state where the numbers come from or whether they are applicable to all operating conditions.

across the capacitor) is also negligible. The models don't ignore the internal impedance of the transformer, however, because it's too important.

Although this article uses many first-order approximations to describe power-supply operation, the design rules and graph derivations are accurate models of real power supplies and are much more accurate for a wide range of designs than are the rules of thumb. **Table 1** shows the transformer makers' simple rules of thumb for selecting a transformer for a 1A power supply with capacitive filtering. Depending on whether you're using a half-wave, full-wave bridge, or full-wave center-tap rectifier, you'll need a 2.4, 1.8, or 1.2A transformer. Although the numbers are right, the rules don't state where the numbers come from or whether they are applicable under all operating conditions. In fact, they aren't.

To understand why, you may at this point want to refer to the equations derived in the **box**. A transformer's specified voltage V_S, specified current I_S, and load-regulation factor F_X are all constant characteristics of the transformer. The conduction angle δ, dc output voltage V_O, dc output current I_O, peak diode forward current I_F, rms transformer current I_T, and rms capacitor current I_C are all variables that depend

TABLE 1—RULES OF THUMB FOR TRANSFORMER SELECTION

TRANSFORMER/RECTIFIER TYPE	FILTER TYPE	REQUIRED RMS SECONDARY RATING
HALF-WAVE	CAPACITOR	2.4×DC CURRENT
FULL-WAVE BRIDGE	CAPACITOR	1.8×DC CURRENT
FULL-WAVE CENTER-TAP	CAPACITOR	1.2×DC CURRENT

TABLE 2 — RULES OF THUMB VERIFIED

TO OBTAIN:	MULTIPLY TRANSFORMER-TYPE FACTOR:			BY:
	HALF-WAVE	FULL-WAVE BRIDGE	FULL-WAVE CENTER-TAP	
F_X	0.90	0.90	0.90	—
I_T	2.39	1.81	1.19	I_O
V_O	1.24	*	0.62	V_S**
I_F	7.16	4.12	3.58	I_O
I_O	1.00	1.00	1.00	I_O
I_C	2.17	1.51	1.31	I_O

*$V_O=(1.32\times V_S)-(2\times V_F)$

**AFTER MULTIPLICATION, SUBTRACT V_F FOR EXACT RESULT.

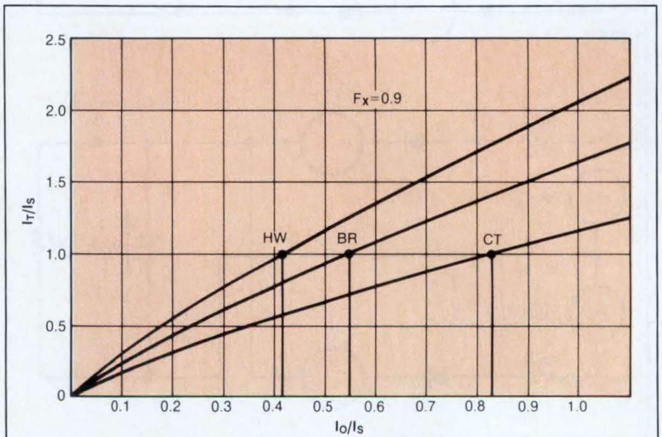


Fig 2—This graph of I_T/I_S vs I_O/I_S shows the points where each curve crosses the $I_T/I_S=1$ line. These points represent the maximum allowable transformer load.

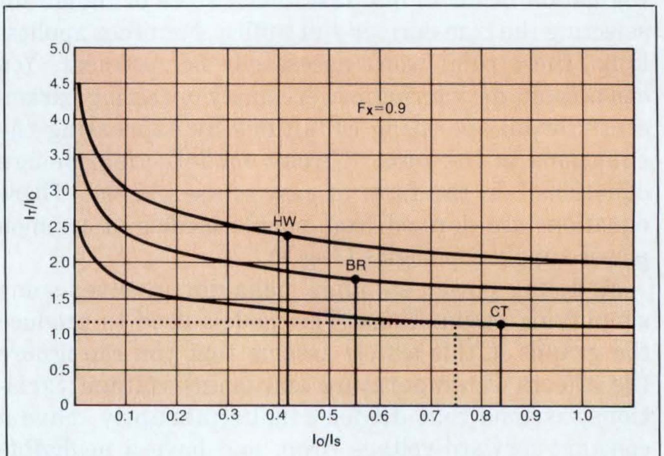


Fig 3—This graph aids in transformer selection. I_S is the transformer maker's maximum specified transformer current.

on how much power the supply actually delivers.

The maximum allowable power dissipation in the transformer occurs when $I_T = I_S$—when the transformer's rms current under load equals the manufacturer's rated maximum current. Plugging this condition into **Eqs 2, 4,** and **6** in the **box** generates **Table 2**'s list of relationships for a transformer dissipating its maximum allowable power. (**Table 2** expresses current in terms of I_O because engineers generally think of a power supply in terms of its output current.)

Rules verified in one instance

These results verify the transformer makers' rules of thumb: A 1A supply using a half-wave rectifier requires a 2.39A transformer; a 1A supply with a full-wave-bridge rectifier requires a 1.81A transformer; and a 1A supply with a full-wave center-tap rectifier requires a 1.19A transformer. As stated earlier, though, these results are only valid for the transformer under full load and with a load-regulation factor of 0.9.

Fig 2 plots I_T/I_S vs I_O/I_S for the three topologies; HW stands for half-wave, BR stands for full-wave bridge, and CT stands for full-wave center-tap. The graph shows the points where each curve crosses the $I_T/I_S = 1$ line. These points represent the maximum allowable transformer load. The X-axis coordinates of these maximum-load points are simply the reciprocals of the 2.39, 1.81, and 1.19 factors in **Table 1**. Operating to the right of these points would overload the transformer.

Figs 3 through **6** are similar graphs; they plot I_T, V_O, I_F, and I_C with respect to I_O/I_S. All the graphs assume that the transformer's load-regulation factor F_X is 0.9.

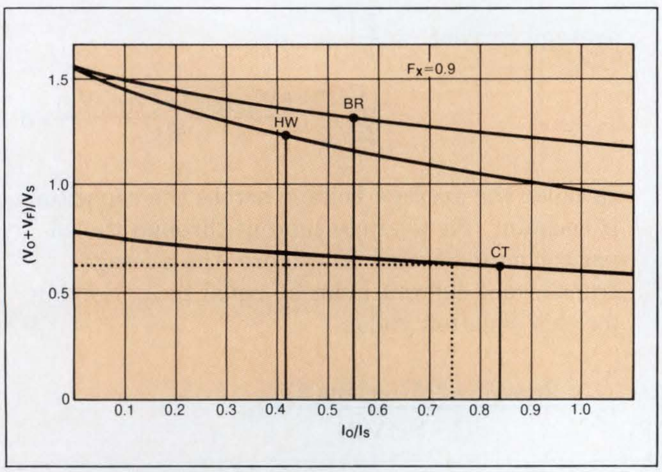


Fig 4—After selecting your transformer, *you can use this graph to predict your power supply's output voltage. (V_F is the rectifier's forward-voltage drop).*

For more precise results, use the exact value of F_X for the transformer you are using and replot the graphs from the equations in the **box**.

The graphs may indicate some unexpected results. A simple example will serve as an illustration. For a 1A power supply with a 10A transformer and a half-wave rectifier, $I_O/I_S = 0.1$. The graphs indicate that the capacitor rms current will be 2.875A, the transformer rms current will be 3.05A, and the diode peak forward current will be 11.6A. Assuming a diode forward-voltage drop of 1V, a 10V transformer will provide a dc output voltage of 13.5V.

To fully comprehend how to use the graphs, consider a more realistic example: a 3A, 20V power supply suitable for regulation to 15V. First, you have to decide

Text continued on pg 164

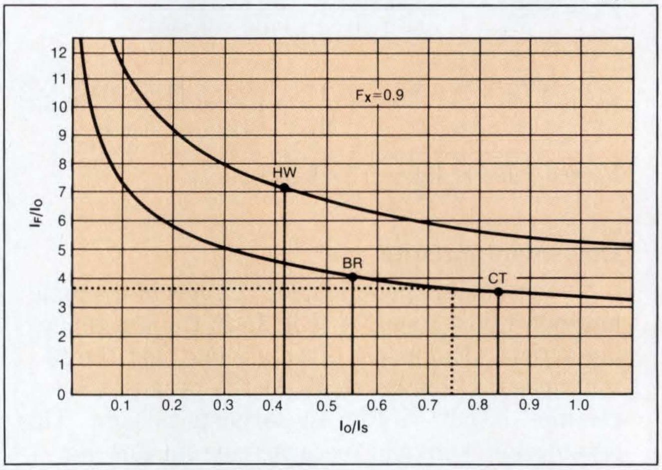


Fig 5—This graph predicts the forward current *that your rectifier diode will have to handle.*

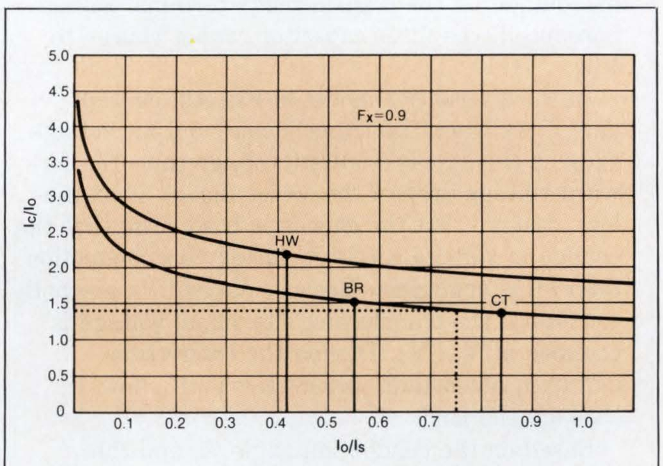


Fig 6—Using this graph will ensure *proper sizing of your power supply's output-filter capacitor.*

Circuit models yield design equations

To model a real transformer, you can use an ideal voltage source $V_M\sin(t)$ in series with an internal impedance R_X. In the case of a center-tap transformer, half of the voltage and half of the impedance appear on each half of the secondary winding. With the transformer connected to a load, the current flowing through R_X causes a voltage drop across R_X and reduces the transformer's terminal voltage.

Transformer makers specify a transformer's rms voltage (V_S) and rms current (I_S). The ratio of V_S to the open-circuit voltage, typically 0.8 to 0.9, is the transformer's load-regulation factor (F_X).

The transformer equations for F_X, R_X, and P_S (power) are

$$F_X = \frac{\sqrt{2}V_S}{V_M} = \frac{\text{specified rms voltage}}{\text{open-circuit rms voltage}}$$

$$R_X = \frac{(V_M/\sqrt{2})-V_S}{I_S} = \left(\frac{1}{F_X}-1\right)\frac{V_S}{I_S} = \frac{(1-F_X)V_M/\sqrt{2}}{I_S}$$

$$P_S = I_S^2\,R_X = \left(\frac{1}{F_X}-1\right)\times V_S\times I_S.$$

Equivalent circuits

Now consider the equivalent circuit of a simple half-wave power supply (**Fig 1a** in the accompanying article). Engineers often assume that the filter capacitor charges to V_M at the peak of the rectifier output, as **Fig Aa** purports to show. This assumption is invalid, because current flowing through the transformer produces a voltage drop across R_X, which reduces the transformer's terminal voltage. If the transformer's terminal voltage is reduced, the filter capacitor cannot charge to V_M.

In the alternative model in **Fig Ab,** current only flows when the transformer's output voltage exceeds the supply's output voltage (plus the forward-voltage drop of the series diode). Nonetheless, assume that the capacitor is so large that the change in voltage across it during this conduction interval is negligible. Because V_O and V_F are both constants, the transformer's terminal voltage is clamped at V_O+V_F. During the entire time $0<t<2\pi$, a constant current $I_O=V_O/R_L$ flows through the load.

Based on the conduction angle, δ, and the transformer's V_S, I_S, and F_X, you can calculate the following circuit parameters: the dc filter output voltage (V_O), the dc filter output current (I_O), the peak diode forward current (I_F), the rms transformer current (I_T), and the rms filter capacitor current (I_C). You can generally read the peak diode forward voltage V_F from the diode's data sheet if you know I_F.

First, the transformer voltage at which the rectifier begins to conduct is

$$V_M\sin(\delta) = V_O+V_F.$$

Or, in terms of the dc filter output voltage,

$$V_O = \frac{\sqrt{2}\sin(\delta)}{F_X}V_S-V_F.$$

The peak diode current occurs when the voltage across the transformer's internal impedance is at its maximum—which equals the maximum sinewave voltage minus the transformer's terminal voltage:

$$I_F = \frac{V_M-(V_O+V_F)}{R_X} = \frac{\sqrt{2}[1-\sin(\delta)]}{1-F_X}\times I_S. \quad (1)$$

The instantaneous transformer current, I_X, during conduction is

$$I_X = \frac{V_X}{R_X} = \frac{V_M\sin(t)-(V_O+V_F)}{R_X}.$$

Integrating the instantaneous current and dividing by the period yields the average transformer current:

$$\text{average current} = \frac{1}{T}\int_0^T I_X\times dt$$

$$= \frac{1}{2\pi}\int_\delta^{\pi-\delta}\frac{V_M\sin(t)-(V_O+V_F)}{R_X}\times dt.$$

Because the average voltage across the capacitor is constant, the average current through the capacitor must be zero. Therefore, the average transformer current must be equal to I_O. Solving for this equation yields

$$I_O = \frac{2\cos(\delta)+(2\delta-\pi)\sin(\delta)}{\pi(1-F_X)\sqrt{2}}\times I_S.$$

Plugging the instantaneous current into the standard rms integral equation gives

$$\text{rms current} = \sqrt{\frac{1}{T}\int_0^T I_X^2 \times dt}$$

$$= \sqrt{\frac{1}{2\pi}\int_{\delta}^{\pi-\delta}\left(\frac{V_M\sin(t)-(V_O+V_F)}{R_X}\right)^2 \times dt,}$$

which yields

$$I_T=\frac{1}{1-F_X}\sqrt{\frac{1}{\pi}[(\pi-2\delta)[\frac{1}{2}+\sin^2(\delta)]-\frac{3}{2}\sin(2\delta)] \times I_s}. \quad (2)$$

Although the average current through the filter capacitor is zero, the capacitor does charge and discharge. Its rms current is

$$I_C = \sqrt{I_T^2-I_O^2}.$$

The equations for full-wave bridge and full-wave center-tap rectifier circuits are simple extensions of the half-wave rectifier equations. Consider the full-wave bridge power-supply equivalent circuit first (**Fig 1b** in the accompanying article). There are two differences between the full-wave bridge and the half-wave circuits:

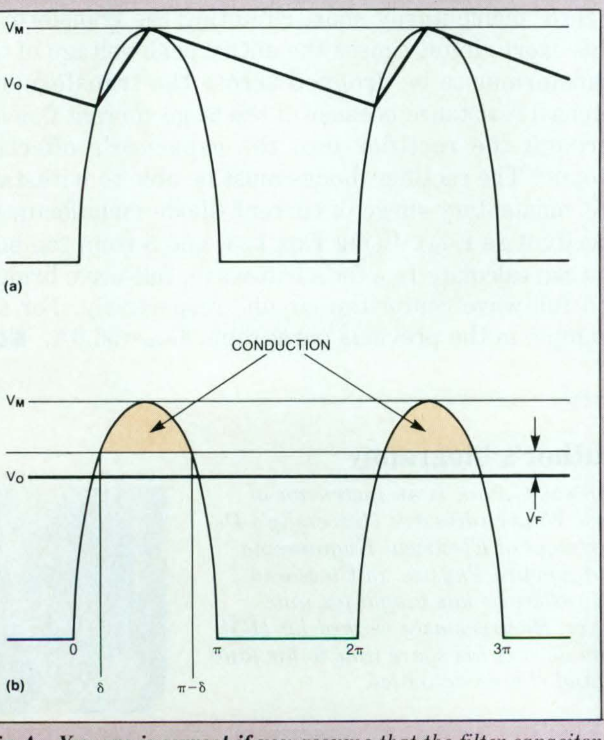


***Fig A—You are incorrect if you assume** that the filter capacitor charges to V_M at the peak of the rectifier output as **Aa** shows. **Ab's** correct model of filter-capacitor operation shows current flowing only when the transformer's output voltage exceeds the supply's output voltage (plus the forward-voltage drop of the series diode).*

The full-wave bridge supply can have two diode forward-voltage drops at any time, and the period of the transformer current is π instead of 2π.

These differences result in the following equations for the full-wave bridge rectifier circuit:

$$V_M\sin(\delta) = V_O+2V_F$$

$$V_O = \frac{\sqrt{2}\sin(\delta)}{F_X}V_S-2V_F$$

$$I_F = \frac{\sqrt{2}[1-\sin(\delta)]}{1-F_X}\times I_S \quad (3)$$

$$I_O = \frac{\sqrt{2}[2\cos(\delta)+(2\delta-\pi)\sin(\delta)]}{\pi(1-F_X)}\times I_S$$

$$I_T = \frac{1}{1-F_X}\sqrt{\frac{2}{\pi}[(\pi-2\delta)[\frac{1}{2}+\sin^2(\delta)]-\frac{3}{2}\sin(2\delta)] \times I_S} \quad (4)$$

$$I_C = \sqrt{I_T^2-I_O^2}.$$

Next, consider the equivalent circuit for a full-wave center-tap power supply (**Fig 1c** in the accompanying article). There are four differences between the full-wave center-tap and half-wave circuits: The peak transformer voltage is $V_M/2$, the transformer impedance in each leg is $R_X/2$, the period of the current charging the capacitor is π instead of 2π, and I_T is defined as the current flowing through one leg of the transformer, resulting in two paths of current through the rectifier diodes to the filter capacitor.

These differences result in the following equations for the full-wave center-tap rectifier circuit:

$$V_M\sin(\delta)/2 = V_O+V_F$$

$$V_O = \frac{\sin(\delta)}{F_X\sqrt{2}}V_S-V_F$$

$$I_F = \frac{\sqrt{2}[1-\sin(\delta)]}{1-F_X}\times I_S \quad (5)$$

$$I_O = \frac{\sqrt{2}[2\cos(\delta)+(2\delta-\pi)\sin(\delta)]}{\pi(1-F_X)}\times I_S$$

$$I_T = \frac{1}{1-F_X}\sqrt{\frac{1}{\pi}[(\pi-2\delta)[\frac{1}{2}+\sin^2(\delta)]-\frac{3}{2}\sin(2\delta)] \times I_S} \quad (6)$$

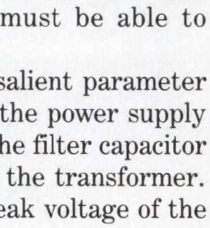
$$I_C = \sqrt{2I_T^2-I_O^2}.$$

which topology to use. Supposing you use a full-wave bridge rectifier, you can see by looking at **Fig 3** that you need at least a 5.4A transformer. **Fig 4** indicates that the transformer should be rated at about 16.7V (assuming 1V diode forward-voltage drops). If you use a full-wave center-tap rectifier, you need a 3.6A, 33.9V transformer.

In this case, the center-tap rectifier circuit is the topology of choice because of the availability of a stock 4A, 36V transformer (Stancor P-8673). Going back to the graphs armed with this transformer's parameters, you can see that $I_O/I_S=0.75$ (indicated by a dotted line in **Fig 3**). **Fig 3** also indicates that the transformer rms current will be 3.7A. **Fig 4** predicts a dc output voltage of 21.8V, resulting in the voltage regulator dissipating 20.4W. **Fig 5** shows that the diodes must be rated for a repetitive peak forward current of 11.1A, and **Fig 6** indicates that the filter capacitor must be able to withstand an rms current of 4.2A.

You should be aware of one other salient parameter when choosing a transformer. When the power supply is first turned on, the voltage across the filter capacitor is zero, momentarily short-circuiting the transformer. This short circuit causes the entire peak voltage of the transformer to be dropped across the transformer's internal resistance because of the large current flowing through the rectifier into the capacitor's effective ground. The rectifier diodes must be able to withstand this momentary surge of current (diode manufacturers specify it as I_{FSM}). Using **Eqs 1, 3,** and **5** from the **box,** you can calculate I_{FSM} for a half-wave, full-wave bridge, and full-wave center-tap circuit, respectively. For the example in the previous paragraph, $I_{FSM}=56.6A$. **EDN**

Author's biography



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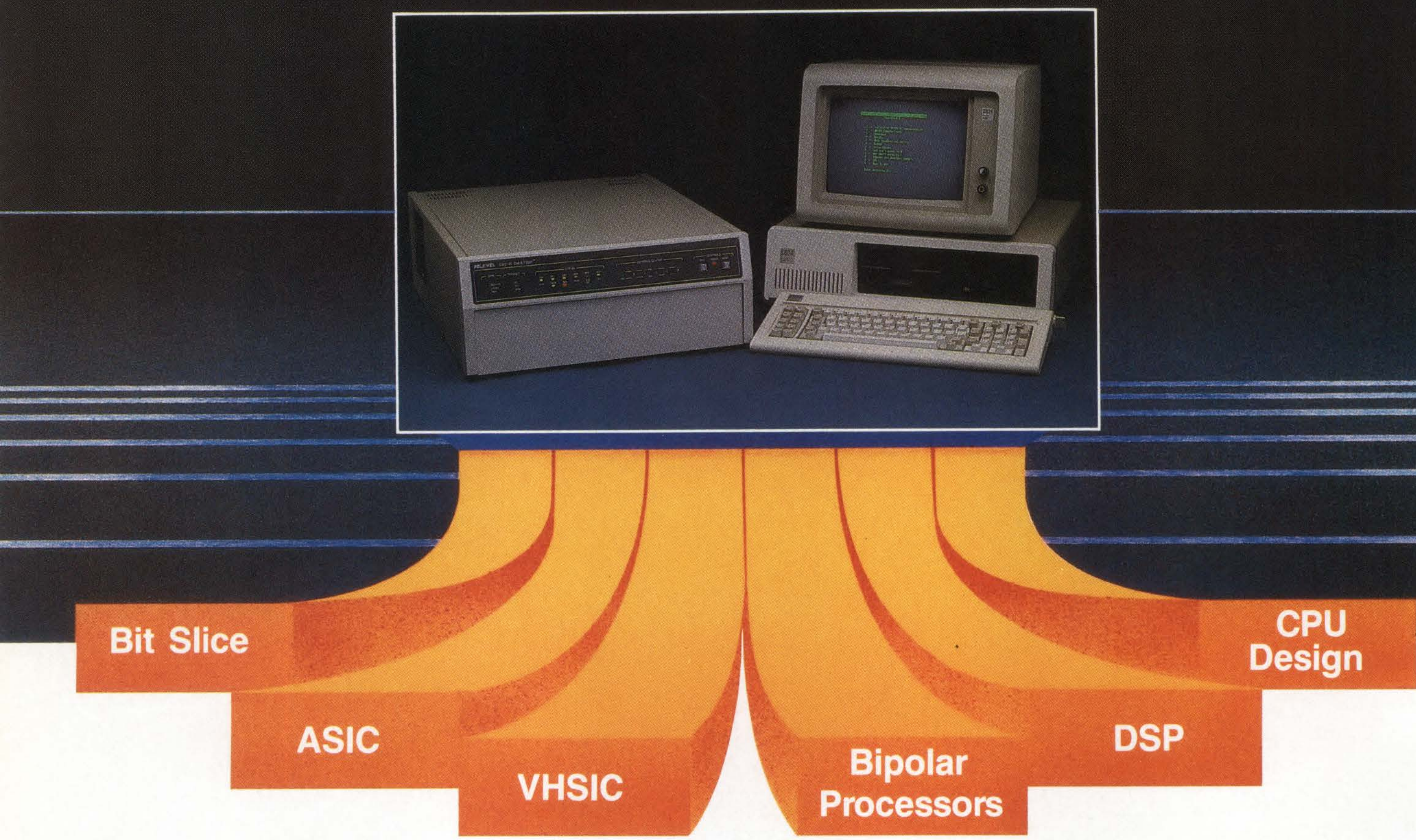

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Array-processing languages now suit personal-computer users

Array-processing languages have made many programming or calculating jobs easier on mainframes. The streamlined approach of these languages is now an option for PC users as well. And though some limitations exist, you'll find they can operate in general on a par with their mainframe cousins.

Avram Tetewsky, *Charles Stark Draper Lab Inc*

For some time, scientists, engineers, and programmers have enjoyed the simplicity and flexibility of array-processing languages such as Control-C on mainframe computers. For solving statistical, digital-signal-processing, classical-control, state-space-control, and estimation-related problems, these specialized languages are more suitable than the more traditional languages such as C, Pascal, Ada, and Fortran. Array-processing languages are now available for PC users as well. Matlab, from The Mathworks (Sherborn, MA), for example, performs as well as its mainframe equivalents with very few exceptions.

Although traditional languages can be very flexible, they burden users with mundane tasks when handling arrays. You must declare, allocate, and keep track of data pointers for each array used in a program. In addition, you must design DO or FOR loops when manipulating these data structures or when calling complex numerical and graphic subroutines. An array-processing language can relieve you of these tasks because they automatically recognize matrix expressions and let you manipulate matrices without having to write explicit loops.

A language for processing arrays should also allow you to write your own utilities. Some products give you precanned utilities and clever graphics but no means for inserting your own utilities or independently controlling program flow to solve problems. A good array-processing language, like Matlab, integrates general mathematics, special-purpose subroutine libraries, and graphics with the flexibility for writing your own routines. Matlab's array-processing syntax grew out of the public-domain language Moler-MATLAB. This syntax (such as "*, .*, etc . . .") has been expanded to include the extensive Linpack (Linear Algebra) and

The opinions in the article are the author's and don't necessarily reflect the views of Charles Stark Draper Lab Inc.

Although traditional languages are very flexible, the user is burdened with mundane tasks when handling arrays.

Eispack (Eigenvalue) subroutine libraries available to the public domain by the Department of Energy. Control theory, graphics, and I/O formatting packages have also been added. Other application libraries are currently being developed, and user-group libraries are now available.

Matlab combines a flexible set of scientific utilities, easy graphics, and good debugging capabilities with a readable syntax for solving complex problems. It is presently available to run on an IBM PC. Even though this computer is limited to 640k bytes of RAM by PC-DOS, the package can solve many nontrivial problems. For problems requiring more memory space, Matlab is now available for Sun and VAX computers and will be available for the Macintosh soon.

No loops needed

APL, Speakeasy, Minitab, IDL, Dataplot, SAS/IML, R/S 1, Asyst, MLAB, Gauss, Control-C, and Matlab are all array-processing languages. Basically, these languages can perform mathematical operations on matrices without doing loop-type manipulations. Thus they treat scalars and vectors as 1×1 and N×1 matrices, respectively.

Consider the simple problem of creating the sum of a 50-Hz and a 120-Hz sine wave. Let the summation occur within a time period from 0.0 to 5.0 sec, with intervals of 0.001 sec. Using a traditional language, you must first calculate the size of the array, (in this case, 1000 storage units are needed per second of simulation). Next, you have to design loops to access this data. Using Fortran 77 as an example:

```
C       . . . allocate arrays
        REAL  X(5000), T(5000), PI
        PARAMETER (PI=3.14159)
C       . . . set up loops to calculate data
        DO 100 I=1,5000
           T(I) = FLOAT(I-1)*0.001
           X(I) = SIN(2.0*PI*50.0*T(I)) +
     &            SIN(2.0*PI*120.0*T(I))
0100    CONTINUE
C       . . . call some plot routine and pass in the T
        and X vectors.
```

The Fortran code creates two arrays (X and T) that you can use in a routine to plot the required summation. The program requires laborious array allocation and dimensioning, along with a DO loop to fill the arrays with data. Although many languages, such as C, Ada, and Pascal, allow dynamic allocation of arrays and pointers, this feature doesn't relieve the basic tedium at all.

Now consider the same problem using an array-processing language such as Moler-Matlab, a public-domain precursor to Matlab, Gauss, Control-C, Matrix-X, and other commercial packages **(Ref 1).** The required code for the program is

```
t = 0:0.001:5;  % A vector of the appropriate size is
                % created and initialized from 0 to 5
                % in 0.001 increments.
x = sin(2*pi*50*t) + sin(2*pi*120*t);
                % x will be created as needed. Because
                % is a vector, x will be a vector and
                loop
                % operations are always implied when
                % ever vector or matrices are used.

plot(t,x),title(' a quick plot '),xtitle(' time '),
ytitle(' volts ');
                % quick and easy graphics.
                % Note that Matlab is case-sensitive,
                % thus you can have a mix of upper
                and
                % lowercase variable names.
```

The first statement creates an array that contains a vector spanning the 5-sec period in 0.001-sec intervals. The next statement uses this array and automatically creates another array containing the summation values at each interval. You then plot one array against the other by typing a simple plot statement.

But array-processing languages go even further. They can do matrix mathematics so that a "*" multiplies matrices and performs dot products. A "/" or a "¢" computes the left and right matrix inverses, respectively. That is, you can use a "/" to solve underdetermined interpolation problems where there are more equations than unknowns. Obversely you can use a "¢" to solve overdetermined smoothing problems (in a least-square sense), where there are fewer equations than unknowns. A " ' " performs transpose (or conjugate transpose) operations.

Linear algebra does not, however, define all the types of operation—for example, a spreadsheet operation, where the contents of one column (or vector) are multiplied by another column (element by element) and stored in a third column. The following Fortran program shows how you might use a traditional language to create two vectors of data and perform element-by-element multiplications, such as those found in the dot product.

```
        REAL      DX, MAXX, X1(1000), X2(1000)
        REAL      Y1, Y2(1000), Y3
        INTEGER N

        MAXX = 10
        DX     = 0.1
        N      = (MAXX/DX) + 1
C       . . . create some dummy data
        DO 1000 I = 1,N
              X1(I) = FLOAT(I-1)*DX
              X2(I) = FLOAT(I-1)*DX
1000    CONTINUE
        DO 2000 I = 1,N
C       . . . element by element operation
              Y2(I) = X1(I)*X2(I)
2000    CONTINUE
C       . . . initialize accumulator for
        dot product
        Y1 = 0
        DO 3000 I = 1,N
C       . . . dot product
              Y1 = Y1 + X1(I)*X2(I)
3000    CONTINUE
C       . . . store the 4th element of Y1 in Y3
        Y3 = Y1(4)
```

In Matlab, the same operation becomes

```
DX     = 0.1;
MAX_X= 10;
X1     = [0:DX:MAX_X];   %
X2     = [0:DX:MAX_X];   % two vectors with some dummy data.
Y1     = X1*X2;          % Y1 is a scalar equal to X1
                         % dot product X2
Y2     = X1.*X2;         % Y; 2 is a vector, each element is
                         % the element by element product of
                         % X1 and X2
Y3     = Y2(4);          % the 4th element of Y3.
```

Modern languages, such as Ada, include operator- and function-overloading options. Overloading allows operators (such as "+, −, * , or /") and subprograms (such as user-created functions or subroutines) to manipulate data differently depending on the number of arguments in the statement. Matlab also includes function- and operator-overloading options. For example,

```
plot(y)                   % plot y versus an integer subscript
plot(x,y)                 % plot y versus x
plot(x1,y1,x2,y2 . . . )  % plot y1 versus x1, y2 versus x2, etc.
```

With overloading, you can group functions with a common purpose under one name without having to create many special function names for each case.

The element-by-element as well as the matrix and vector capabilities of Matlab let you readily express any problem within the syntax of this array-processing language. Coupled with the technique of operator and function overloading, an array-processing language can make your code simple to create, simple to read, and fast.

Dynamic resizing simplifies processing

Some problems in digital signal processing require data arrays to be expanded or contracted. For example, when working with fast Fourier transforms (FFTs), vectors must be expanded out to be even powers of 2, and, in some cases, include zero padding to suppress time-domain aliasing. With Matlab, the expansion can be automatic, and it is also easy to reshrink the data after all processing is done. For example,

```
n = length(x);        % compute the size of x so that it can
                      % be restored to its original
                      % dimension.
x= FFT(x);            % the FFT is programmed to
                      % automatically increases x until it's
                      % length is a power of 2.

. . . other processing

x= IFFT(x);           % calculate inverse FFT.
                      % contract x.
x= [x(1:n), [ ] ];    % x is replaced by its first n
                      % elements and a zero length vector.
```

Matlab and Control-C (for VAX from Systems Control Technology, Palo Alto, CA) are very evenly matched. **Table 1** compares the instruction sets of the two programs. One significant difference between Control-C and Matlab is that Control-C can convert continuous functions to discrete data with a delay (c2dt); Matlab can do this but without a delay (c2d). However, Matlab has an another conditional operator (elseif) and includes find and search index functions, which Control-C doesn't.

Although you can write your own subprograms, most users want to build programs using off-the-shelf tools. Therefore, you may want to consider other array-processing languages, such as Gauss (for the PC and available from Aptech Systems Inc, Kent, WA), for your application. If you use complex variables, control theory, and digital signal processing extensively, or if you need to be able to move your program between different computer and operating systems, you might want to choose Matlab. On the other hand, you might choose Gauss if you don't need extensive, complex

Array-processing languages can perform mathematical operations on matrices without loop-type manipulations.

variable operations but do need advanced statistical software; the ability to handle large data sets (with fast I/O); and linkage with some Fortran, C, or assembly object modules. For problems that exceed the 640k-byte memory imposed by PC-DOS, you can buy Sun or VAX versions of Matlab.

If you are doing simulation problems that use ordinary differential equations, you must be able to express these equations in state-space form. Otherwise Matlab, Gauss, and Control-C cannot handle them. Also if you are doing nonlinear or multirate digital simulations, consider a PC or a mainframe version of ACSL (A Computer Simulation Language), Simnon (Simulate Non-Linear Systems), or Matrix-X. The PC and VAX versions of Matlab and Control-C offer links to ACSL.

EDN

Reference

1. Moler, Cleve, *Technical Report CS81-T*, Dept of Computer Science, College of Engineering, University of New Mexico, August 1980 and 1982.

Author's biography

Avram Tetewsky is a signal analyst at the Charles Stark Draper Lab Inc, where he analyzes detection and estimation systems and digital control systems. He received a BSEE from Renssalaer Polytehnic Institute in 1976, an MSEE from MIT in 1978, and an EEEE from MIT in 1980. Avram is a NY State EE Intern and a member of the Computer Society IBM PC Tech Group. He holds an FCC first-class license. In his spare time, he also enjoys swimming, biking, cats, guitar, and piano. He is also a member of the Computer Society IBM PC Tech Group.

Article Interest Quotient (Circle One)
High 488 Medium 489 Low 490

TABLE 1—MATLAB ON PC VS CONTROL-C ON VAX

MATLAB—PC		CONTROL-C—VAX
FUNCTION	**DESCRIPTION**	**COMPARISON**
GENERAL:		
help	HELP FACILITY	y
casesen	ALLOW FOR VARIABLES WITH UPPER AND LOWER CASE NAMES BEING UNIQUE	n
who	LIST ALL VARIABLES IN USE	y
size	REPORT BACK THE ROW AND COLUMN DIMENSIONS	y
length	REPORT BACK THE LENGTH OF A VECTOR	y
^C	LOCAL ABORT	^Y
clear	CLEAR WORKSPACE	y
quit	TERMINATE PROGRAM	exit
MATRIX OPERATORS:		
+,−,*	MATRIX ADD, SUBTRACT, MULTIPILY	y
/,\	RIGHT AND LEFT INVERSE	y
^	MATRIX POWER	**
'	CONJUGATE TRANSPOSE	y
ARRAY OPERATORS:		
+,−	ADD, SUBTRACT	y

MATLAB—PC		CONTROL-C—VAX
FUNCTION	**DESCRIPTION**	**COMPARISON**
.*	ELEMENT BY ELEMENT MULTIPLICATION	y
./,.\	RIGHT AND LEFT DIVISION	y
.^	ELEMENT BY ELEMENT POWER	.**
.'	TRANSPOSE	y
RELATION AND LOGICAL OPERATORS:		
<,<=,>,>=		y
==, ~==	EQUALITY AND INEQUALITY	= <>
&, ¦, ~	AND,OR,NOT	no compounds
CONTROL FLOW:		
if,elseif,	CONDITIONALS	no elseif
else,end	CONDITIONALS	y
for,while,	LOOP CONTROL	y
break	EXIT LOOP	exit
return	SUBPROGRAM RETURN	y
pause		y
SPECIAL SYMBOLS:		
=	ASSIGNMENT	y
[]	FORM VECTOR OR MATRIX	y
()	ARITHMATIC PRECEDENCE	y

TABLE 1—MATLAB ON PC VS CONTROL-C ON VAX *(Continued)*

MATLAB—PC		CONTROL-C—VAX
FUNCTION	**DESCRIPTION**	**COMPARISON**
.	DECIMAL POINT	y
. .	CONTINUE STATEMENT TO NEXT LINE	y
,	SEPARATE ARGUMENTS	y
;	SUPPRESS OUTPUT, OR END ROWS	y
%	COMMENTS	//
:	SUBSCRIPTING, VECTOR GENERATION	y
!	EXECUTE AN OPERATING SYSTEM COMMAND	$
MATRIX CONDITIONING:		
cond	CONDITION NUMBERS 2-NORM	y
det	DETERMINANT	y
norm	[1,2,F AND INF NORMS	y
rcond	CONDITION ESTIMATE	y
DECOMPOSITIONS AND FACTORIZATIONS:		
chol	CHOLESKY FACTORIZATION	y
eig	GENERALIZED EIGEN-VALUES AND VECTORS	y
hess	HESSENBERG FORM	y
inv	INVERSE	y
lu	GAUSS FACTORS	y
null	NULL SPACE	y
orth	ORTHOGONALIZATION	y
pinv	PSEUDO INVERSE	y
qr	ORTHOGONAL-TRIANGULAR DECOMPOSITION	y
qz	QZ ALGORITHM	y
rref	REDUCED ROW ECHELON FORM	y
schur	SCHUR DECOMPOSITION	y
svd	SINGULAR VALUE DECOMP	y
MISC MATRIX FUNCTIONS:		
expm	MATRIX EXPONENTIAL	y
logm	MATRIX LOG	y
sqrtm	MATRIX SQUARE ROOT	y
funm	ARBITRARY MATRIX FUNCTIONS	y
poly	CHARACTERISTIC POLYNOMIAL	y
kron	KRONECKER TENSOR PRODUCT	y
POLYNOMIALS:		
roots		y
polyval	POLYNOMINAL EVALUATION	y
conv	MULTIPLICATION OF POLY	y
SIGNAL PROCESSING:		
conv	CONVOLUTION	y
cov	COVARIANCE	y
dft	DISCRETE FOURIER TRANSFORM	y
fft,fft2,	1 AND 2D FFTs	y
ifft,ifft2	1 AND 2D FFTs	
fdesign	DESIGN FILTER	y
filter	DIRECT FILTER IMPLEMENTATION	y
freq	FREQUENCY RESPONSE	y
xcorr	CROSS CORRELATION FUNCTION	y
COLUMN-WISE DATA ANALYSIS:		
max,min	MAX AND MIN OF MATRICES	y
mean,std	MEAN AND STANDARD DEVIATION	y
sort		y
sum		y
prod		y
cumsum		y
cumprod		y
diff		y
hist		y
table1		y
any		n
all		n
find	EXTRACT INDEX BASED ON LOGICAL EXPRESSIONS .	n
SPECIAL VALUES:		
eps	FLOATING POINT PRECISION	y
ans	LAST TEMPORARY RESULT	y
pi,inf		y
NaN	NOT A NUMBER	n
clock	WALL CLOCK TIME	y
nargin, nargout	# OF INPUT OUTPUT ARGUMENTS	y
I/O:		
format	SET FORMAT PRECISION	y
fprintf	C ROUTINE FPRINTF (LIKE A FORTRAN FORMAT)	SAVE -options
sprintf	C ROUTINE NUMBER TO STRING	n
input	GET NUMBER FROM KEYBOARD	y
keyboard	VERSION OF INPUT FOR SUBPROGRAM	y

Listing continued on pg 172

TABLE 1—MATLAB ON PC VS CONTROL-C ON VAX *(Continued)*

MATLAB—PC		CONTROL-C—VAX
FUNCTION	**DESCRIPTION**	**COMPARISON**
PROGRAMMING:		
.m	FILE EXTENSION FOR USER WRITTEN SUBPROGRAMS.	.ctrl
global	LIKE FORTRAN COMMON	y
exist	CHECK IF VARIABLE EXITS	y
eval	ALLOW FUNCTIONS TO BE PASSED AS ARGUMENTS	y
GRAPHICS:		
plot		y
loglog		y
semilogx,semilogy		Y
polar		y
mesh	3D SURFACE	y
meshdom	CREATE THE XY DOMAIN FOR 3D PLOT	y
grid	ADD GRID LINES	y
title,xlabel,ylabel		Y
axis	ALLOW AUTO OF FIXED SCALE.	y
hold	HOLD SCREEN ON PLOT	y
shg	RESHOW GRAPHICS SCREEN	y
cla,clg	CLEAR TEXT, CLEAR GRAPHICS	y
home	HOME CURSOR	y
print	GET HARDCOPY	y
gpp	GENERIC PRINT VIA DRIVERS	y
misc	GREEK, SYMBOLS, AND LARGE FONTS	y
PROGRAM INTERFACE:		
Save,Load	SAVE AND LOAD DATA TO DISK FILES	y
diary	DIARY OF SESSION	y
edit	INVOKE YOUR FAVORITE EDITOR	y
ACLS	LINK TO A COMPUTER SIMULATION LANGUAGE	y
ELEMENTARY MATH FUNCTIONS:		
abs		y
sqrt		y
real		y
imag		y
conj		y
round		y
fix		y
floor		y
cell		y
sign		y
rem		y
sin,cos,tan		y
asin,acos,atan,atan2		Y
sinh,cosh,tanh		Y
exp,log,log10		y
bessel		y
rat	RATIONAL APPROXIMATION	y

MATLAB—PC		CONTROL-C—VAX
FUNCTION	**DESCRIPTION**	**COMPARISON**
UTILITY MATRICES:		
diag	DIAGONAL MATRICES	y
eye	IDENTITY MATRICES	y
ones	CONSTANT MATRICES	y
rand	RANDOM MATRIX	y
logspace	LOG SPACED VECTORS	y
magic	MAGIC SQUARE	y
tril,triu	LOWER AND UPPER TRIANGULAR PARTITION	y
toeplitz	TOEPLITZ MATRIX	y
rsf2csf	REAL-SCHUR TO COMPLEX	y
CONTROL THEORY:		
ss2tf,tf2ss	STATE-SPACE TO TRANSFER FUNCTION	y
ss2zp,stf2zp	STATE-SPACE TO POLES AND ZEROS	y
zp2tf,zp2ss	POLE-ZERO TO TRANSFER FUNCTION OR STATE-SPACE	y
c2d,d2c	CONVERT BETWEEN CONTINUOUS AND DISCRETE WITH ZERO-ORDER-HOLD	y
append,connect, parallel,series	SPLICE BLOCK DIAGRAMS	y
impulse,setp	IMPULSE AND STEP RESPONSE	y
lsim	CONTINUOUS SIMULATION TO ARBITRARY INPUTS	y
dimpulse,dstep		y
dlsim	DISCRETE SIMULATIONS	y
filter	SINGLE-INPUT-SINGLE-OUTPUT Z-TRANSFORM SIMULATION	y
bode,Nyquist, dbode,freq	PLOTTING	y
lqr,lqre	LINEAR QUADRATIC GAUSSIAN REGULATORS AND ESTIMATORS	y
dlqr,dlqre	DISCRETE LQR AND LQRE	y
place	POLE PLACEMENT	y
rlocus	ROOT-LOCUS	y
damp	DAMPING FACTORS AND RESONANCE	y
margin	GAIN AND PHASE MARGINS	y
ctrb,obsv	CONTROL AND OBSERVABILITY	y
tzero	TRANSMISSION ZEROS	y
fixphase	UNWRAP PHASE FOR BODE PLOTS.	y
ord2	GENERATE A,B,C,D FOR 2ND ORDER SYSTEM	y
rlc	CONTINUOUS RICATTI RESIDUALS	y
dric	DISCRETE RICATTI RESIDUALS	y
abcdcheck	CHECK CONSISTENCY	y
nargcheck	CHECK NUMBER OF .m FILE ARGUMENTS	y

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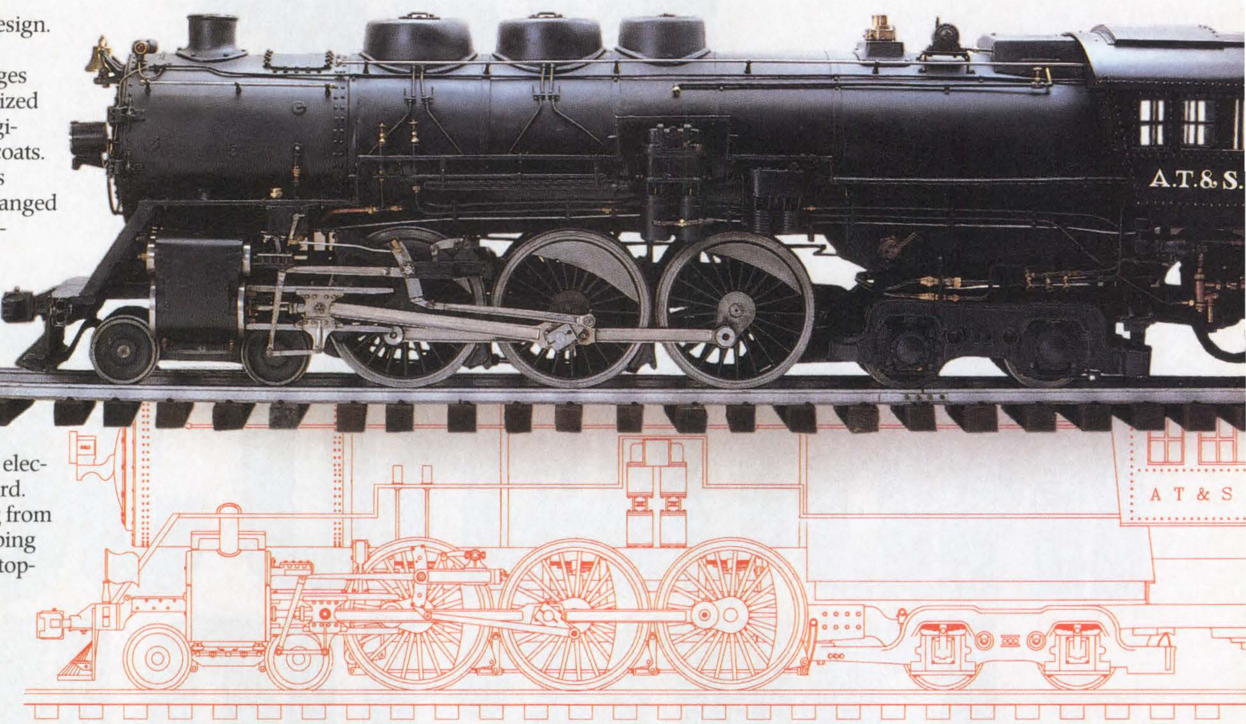

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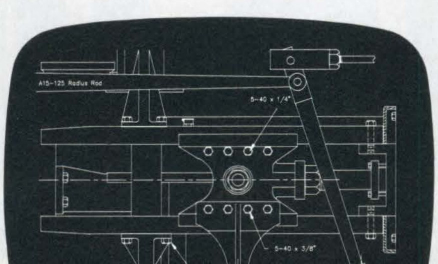

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CIRCLE NO 107

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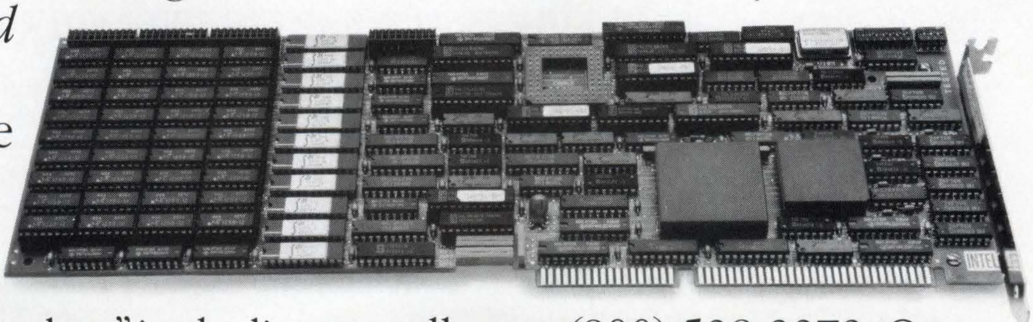

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CIRCLE NO 122

Digital potentiometer brings μP-based control to audio systems

From rotary volume and tone controls to the sliders on an equalizer, the control of most audio systems is still primarily mechanical. But this situation is changing as μP-based systems employing digitally controlled potentiometers find increasing use in audio designs.

Jeff Randall, *Xicor Inc*

Designs incorporating mechanical potentiometers are still found in the majority of audio applications. For example, at the heart of most volume and tone controls on car stereos is a rotary potentiometer. Digitally controlled potentiometers, however, now offer a more reliable alternative together with the option for programming various settings. Although automated control of potentiometers can be a challenge, it's clear that the μP-type control of audio functions is, in many applications, desirable.

Typical volume controls generally contain a simple potentiometer and resistor circuits **(Fig 1)**. In this design, the potentiometer controls the signal to a fixed-gain amplifier section. Because the human ear's sensitivity to changes in volume is logarithmic in nature, a potentiometer used as a volume control is likely to have a logarithmic taper. Tone controls can vary from simple potentiometer and capacitor circuits to complex active filters. The Baxandall filter network has been the workhorse of the audio industry for years. This design **(Fig 2)** utilizes two linear-taper potentiometers to control the gain of an active filter. The potentiometers replace a portion of the input resistance and the feedback resistance. By moving the position of the wipers, you can vary the amount of boost and cut for both the bass and treble frequencies.

Graphic equalizers, which typically contain a group of seven bandpass filters, are one of the fastest growing modes of audio control. Each filter has a potentiometer that controls the gain to a particular bandpass section. The potentiometers generally appear as sliders on the face of the equalizer. **Fig 3** shows a typical graphic-equalizer schematic. Equalizers compensate for the imperfections of a listening environment by boosting or cutting the audio gain at specific frequencies.

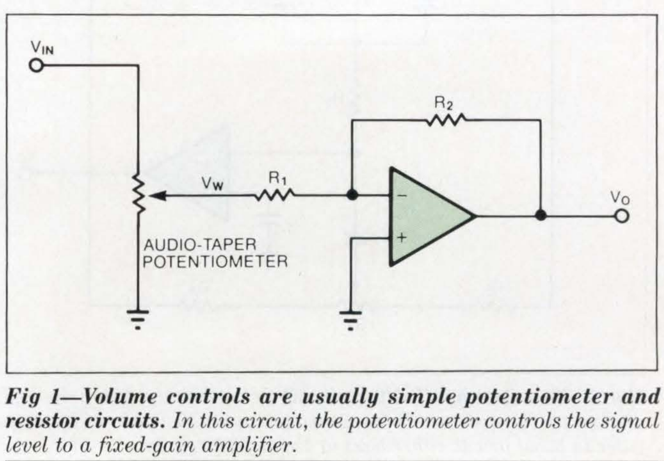


Fig 1—Volume controls are usually simple potentiometer and resistor circuits. *In this circuit, the potentiometer controls the signal level to a fixed-gain amplifier.*

Although a challenge, microprocessor control of audio functions is more desirable in many applications than mechanical potentiometers.

By using a spectrum analyzer and a pink-noise generator, you can customize the response of an audio system for a particular room or concert hall. You do this by feeding a desired response to the system—a pink-noise signal—that is generally flat across the audio band, with some attenuation at higher frequencies. You then adjust the equalizer until the system output closely matches the pink-noise input as displayed on the spectrum analyzer.

This process of matching a system to a room is often referred to as environmental calibration. It requires the listener to read the display of the spectrum analyzer and manually adjust the potentiometers (sliders) of the equalizer.

Primarily used for industrial-control applications, motorized potentiometers offer a relatively straightforward approach to building simple audio control circuits. In these devices, a dc reference voltage or a digital signal, either of which represents the position of the motor, is introduced into a small motor that is linked to a rotary potentiometer. The numerous drawbacks to this type of system include noise caused by the motor assembly and the increased space and power requirements of placing a motor on an audio pc board.

At the cost of greater complexity, you can use D/A converters to control and manipulate analog-circuit functions. These converters are frequently the choice for high-fidelity digital audio controls because of their precision, but for the analog-circuit designer, they can be a little intimidating. One method (**Fig 4**) uses first an A/D converter to sample the input signal, then a microprocessor to further manipulate the signal, and lastly a D/A converter. Although the results can be good, it's a complex and somewhat unfamiliar approach for the analog designer.

An array of resistors with a wiper tap that is digitally selectable offers many advantages of the microprocessor world without the complexity of D/A conversion. Such circuits are referred to as digitally controlled potentiometers. Logic circuits, counters, and memory circuits are often combined with resistor arrays to accomplish an approximation of potentiometer control. Recently, a few manufacturers have introduced devices that incorporate many of these functions in a single circuit. Some examples are Xicor's X9MME, Toshiba's TC9169AP, and National's LMC835. The Toshiba and National parts incorporate features that lend themselves well to audio designs, but are not specifically intended for general-purpose potentiometer replacement.

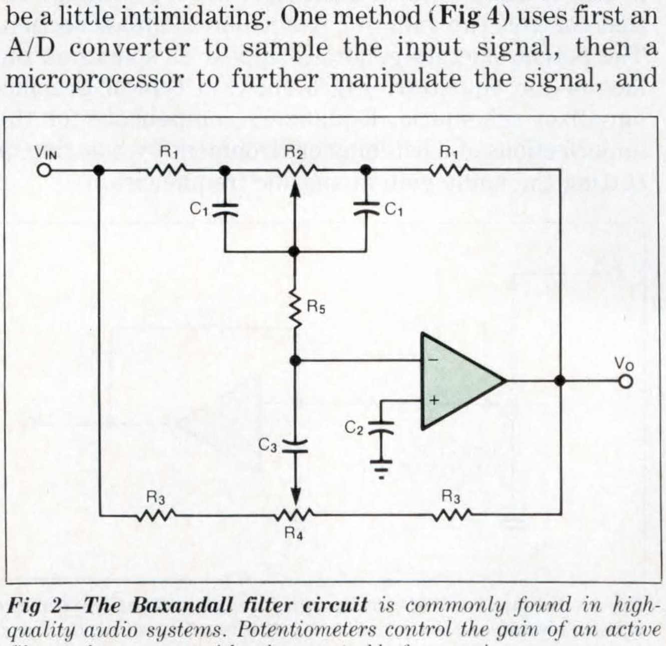


Fig 2—The Baxandall filter circuit *is commonly found in high-quality audio systems. Potentiometers control the gain of an active filter to boost or cut either bass or treble frequencies.*

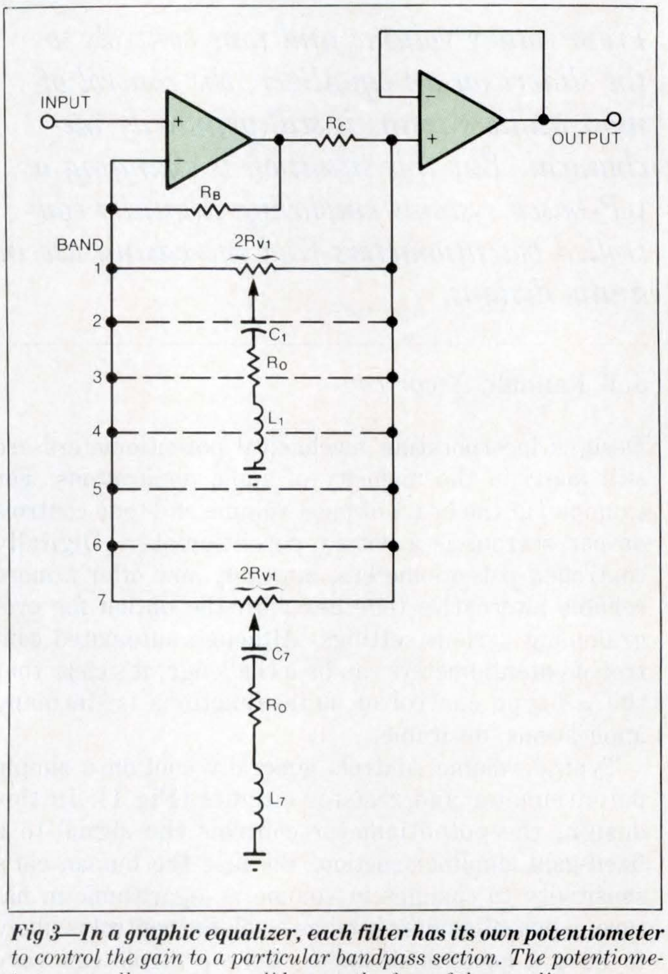


Fig 3—In a graphic equalizer, each filter has its own potentiometer *to control the gain to a particular bandpass section. The potentiometers normally appear as sliders on the face of the equalizer.*

Xicor's X9MME (**Fig 5**), on the other hand, combines a single 99-position potentiometer with 3-line digital control. In addition to the internal counter circuitry for wiper positioning, the device incorporates nonvolatile memory to retain the wiper position. The X9MME is a digitally controlled replacement for a mechanical potentiometer. Because of its conventional 3-terminal potentiometer design, it integrates easily into existing analog designs.

Circuit illustrates digital control

The Baxandall tone-control circuit commonly used in high-quality audio systems provides a good example of how to use digitally controlled potentiometers. In this circuit, the Xicor X9MME replaces the conventional mechanical potentiometers normally used for adjusting the bass and treble frequencies.

The tone-control circuit, its frequency response, and the equations for gain and filter frequencies are shown in **Fig 6**. This circuit uses digital potentiometers to control the gain of two active filters. The low-frequency (bass) filter includes resistors R_1 and R_2 and capacitors C_1s. The maximum gain of this section is at low frequencies, where the capacitors are essentially open circuits.

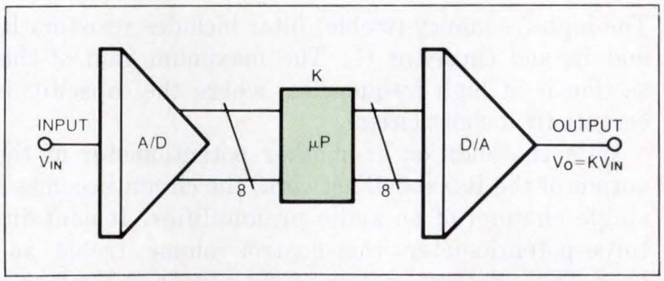


Fig 4—One method of controlling analog-circuit functions *is with A/D and D/A converters using a microprocessor interface. Although it's effective, this method is complex and costly.*

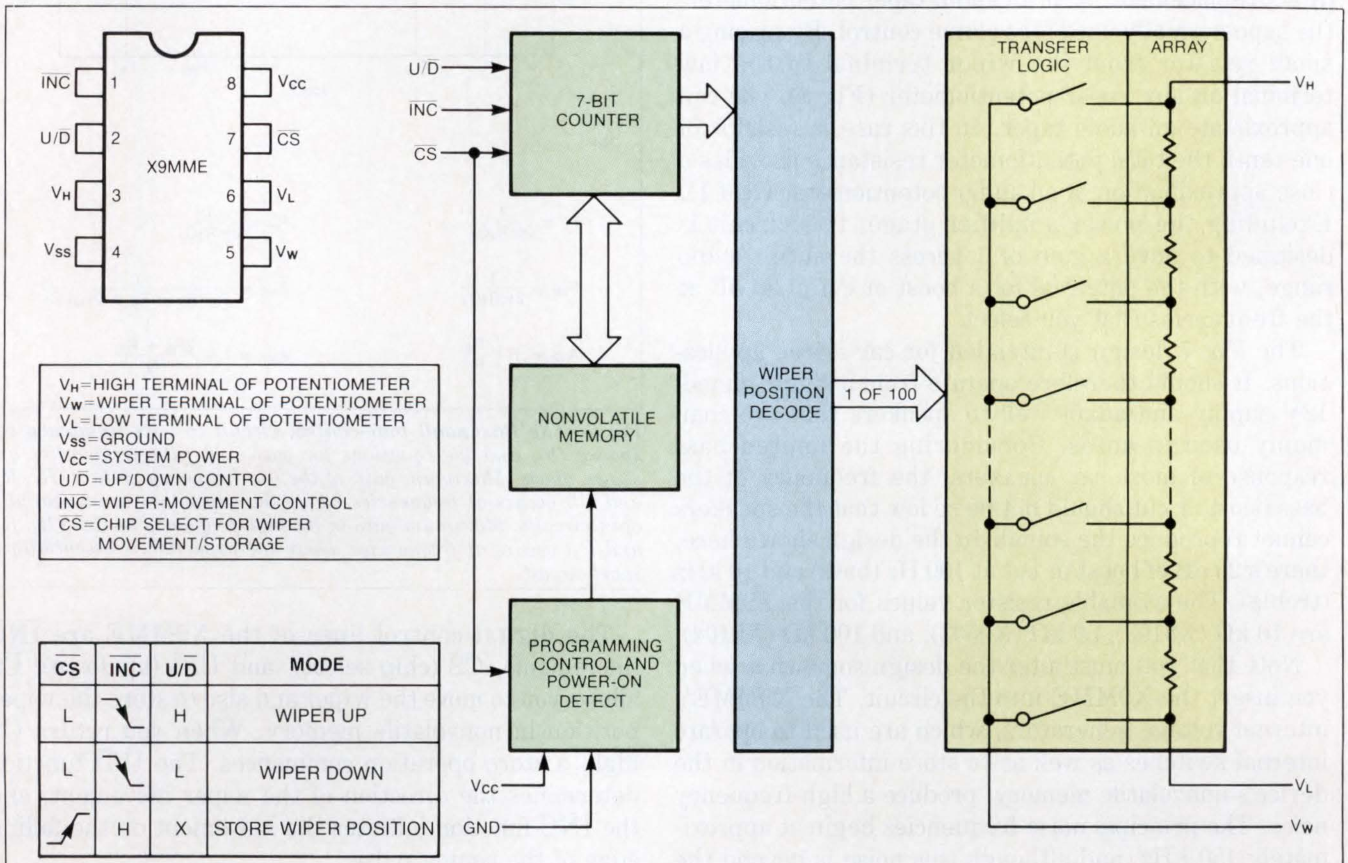


Fig 5—Digitally controlled potentiometers, *such as the X9MME from Xicor, offer an alternative solution for microprocessor control of signal levels without the need for A/D and D/A converters. The X9MME combines a 99-position potentiometer with internal counter circuitry for wiper position control, and a nonvolatile memory that retains the wiper's position. It provides a conventional 3-terminal design that easily integrates into conventional designs.*

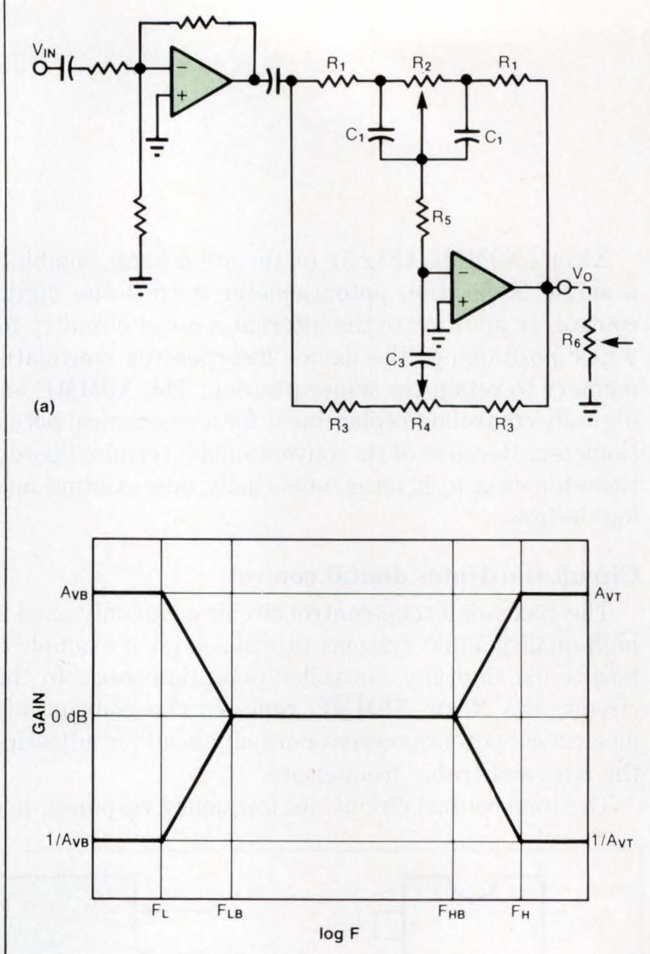
The high-frequency (treble) filter includes resistors R_3 and R_4 and capacitor C_3. The maximum gain of this section is at high frequencies, where the capacitor is essentially a short circuit.

With the addition of another potentiometer at the output of the Baxandall network, the circuit becomes a single channel of an audio preamplifier. It contains three potentiometers that control volume, treble, and bass. These potentiometers might appear on the face of a home or car stereo, for example, as knobs that the operator would adjust by hand to control and shape the sound reaching the amplifier and speakers.

Except for the digital control lines and the 5V power for the X9MME, the complete circuit is shown in **Fig 7**. X9MMEs replace R_2, R_4, and R_6. Note that this replacement does not alter the analog design considerations. Because R_2 and R_4 are both linear-taper pots, the X9MME, which is also a linear-taper pot, provides a direct replacement. R_6 is an audio-taper potentiometer, the type normally used for volume control. By placing a small resistor from the wiper terminal to the low terminal on any linear potentiometer **(Fig 8)**, you can approximate an audio taper. In this case, a resistor of one-tenth the total potentiometer resistance provides a close approximation of an audio potentiometer **(Ref 1)**. Excluding the power-amplifier stage, this circuit is designed to have a gain of 1 across the entire audio range, with the potential for a boost or cut of 20 dB at the frequencies that you select.

The **Fig 7** design is intended for car-stereo applications. It should therefore operate from a single-ended, 12V supply and adapt well to speakers that are commonly used in autos. Considering the limited bass response of most car speakers, the frequency of the bass boost or cut should not be so low that the speakers cannot reproduce the sound. In the design shown here, there's 20 dB of boost or cut at 100 Hz (bass) and 10 kHz (treble). The available resistor values for the X9MME are 10 kΩ (X9103), 50 kΩ (X9503), and 100 kΩ (X9104).

Note that you must alter the design somewhat when you insert the X9MME into the circuit. The X9MME's internal voltage generators, which are used to operate internal switches as well as to store information in the device's nonvolatile memory, produce a high-frequency noise. The principal noise frequencies begin at approximately 150 kHz, and although this noise is beyond the audio range, it can still be a source of problems in the circuit. For this reason, the design incorporates capacitors around the X9MME to filter out any noise that might interfere with the circuit's operation.



$$F_L = \frac{1}{2\pi R_2 C_1} \qquad F_H = \frac{1}{2\pi R_3 C_3}$$

$$F_{LB} = \frac{1}{2\pi R_1 C_1} \qquad F_{HB} = \frac{1}{2\pi\,(R_1 + R_3 + 2R_5)\,C_3}$$

$$A_{VB} = 1 + \frac{R_2}{R_1} \qquad A_{VT} = 1 + \frac{2R_5 + R_1}{R_3}$$

Fig 6—The Baxandall tone-control circuit (a), its frequency response (b), *and the equations for gain and filter-frequencies are shown above. Maximum gain of the low-frequency section (R_1, R_2, and C_1) occurs at frequencies where the capacitors are essentially open circuits. Maximum gain of the high-frequency section (R_3, R_4, and C_3) occurs at frequencies where the capacitor is essentially a short circuit.*

The digital control lines of the X9MME are $\overline{\text{INC}}$ (increment), $\overline{\text{CS}}$ (chip select), and U/$\overline{\text{D}}$ (up/down). $\overline{\text{CS}}$ allows you to move the wiper and also to store the wiper position in nonvolatile memory. When you return $\overline{\text{CS}}$ high, a store operation commences. The U/$\overline{\text{D}}$ function determines the direction of the wiper movement, and the $\overline{\text{INC}}$ function initiates the movement on the falling edge of the timing pulse.

When initially designing with the X9MME, it may be helpful to assemble a simple switch system for controlling the devices. In **Fig 9**'s circuit, a 555 timer supplies a slow clock pulse to the increment pin of each X9MME

An array of digitally selectable resistors offers many advantages of the µP world without the complexity of D/A conversion.

through a momentary switch. Pull-up resistors connect to each digital line, and grounding switches connect to the U/$\overline{D}$ and $\overline{CS}$ pins. To move the wiper up, you set the $\overline{CS}$ pin to ground, the U/$\overline{D}$ pin at 5V, and pulse the $\overline{INC}$ pin with the clock. Each step of the clock produces a 1% change in the wiper position.

This initial procedure lets you separate the analog portion of the design from the digital. Once the circuit is functioning adequately, with the switch network controlling the X9MMEs, the microprocessor interface is relatively simple to implement.

Simplifying the µP interface

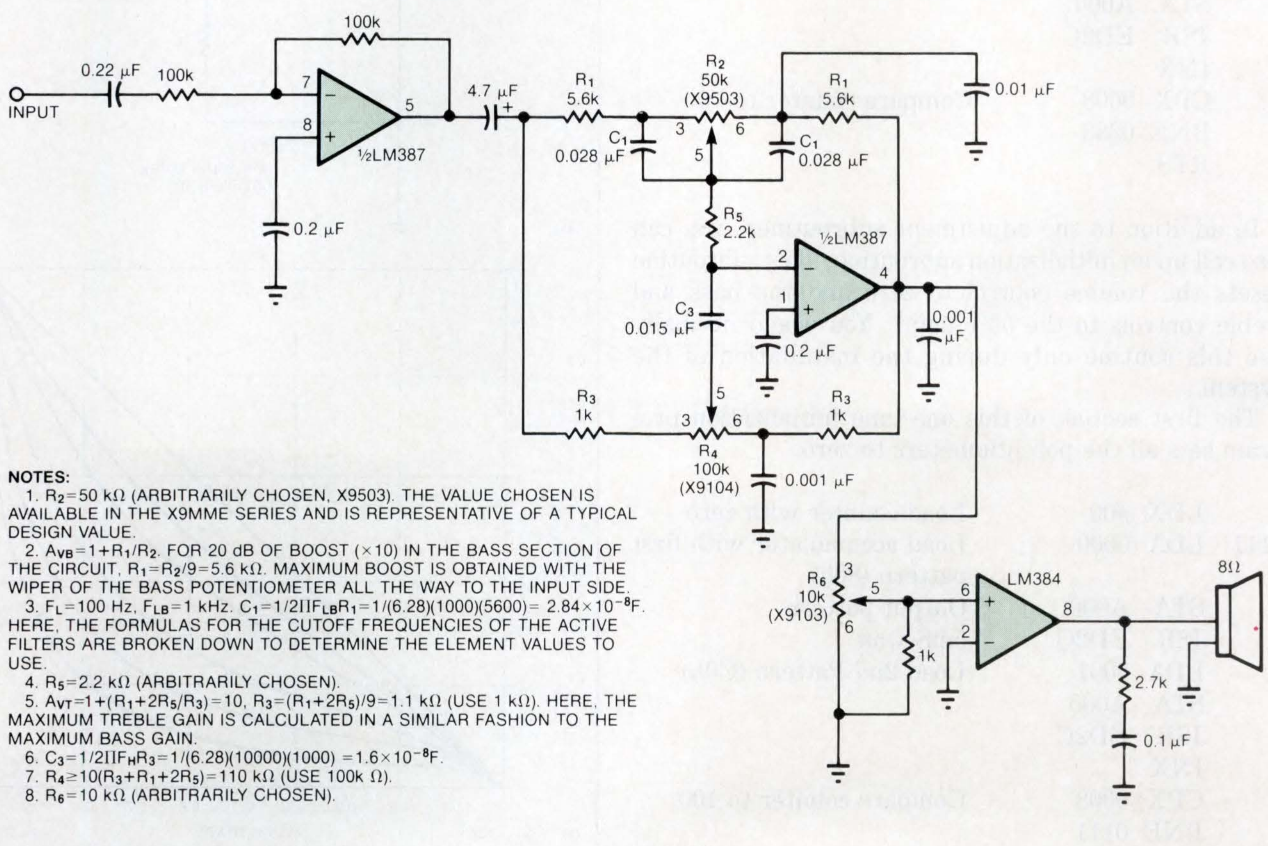
With three devices on the board, the system requires nine control lines. To simplify the interface to an 8-bit microprocessor, you should connect the $\overline{INC}$ lines for all three devices to the same pin. The pin configuration for interface with the 6502 microprocessor system is

A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
N/C	$\overline{INC}$	$\overline{CS_1}$	$U/\overline{D_1}$	$\overline{CS_2}$	$U/\overline{D_2}$	$\overline{CS_3}$	$U/\overline{D_3}$

#1 = Volume
#2 = Bass
#3 = Treble

To move the wiper of a given potentiometer, you should bring that potentiometer's $\overline{CS}$ pin low, force the U/$\overline{D}$ pin for the appropriate potentiometer either high or low (depending on the direction of wiper movement), and then toggle the $\overline{INC}$ pin. For example, to increase the volume you should alternate the following two patterns to the port connected to the control lines of the preamplifier circuit:

N/C	$\overline{INC}$	$\overline{CS_1}$	$U/\overline{D_1}$	$\overline{CS_2}$	$U/\overline{D_2}$	$\overline{CS_3}$	$U/\overline{D3}$
1	0	0	1	1	1	1	1
1	1	0	1	1	1	1	1



NOTES:

1. R_2=50 kΩ (ARBITRARILY CHOSEN, X9503). THE VALUE CHOSEN IS AVAILABLE IN THE X9MME SERIES AND IS REPRESENTATIVE OF A TYPICAL DESIGN VALUE.
2. $A_{VB}=1+R_1/R_2$. FOR 20 dB OF BOOST (×10) IN THE BASS SECTION OF THE CIRCUIT, $R_1=R_2/9=5.6$ kΩ. MAXIMUM BOOST IS OBTAINED WITH THE WIPER OF THE BASS POTENTIOMETER ALL THE WAY TO THE INPUT SIDE.
3. F_L=100 Hz, F_{LB}=1 kHz. $C_1=1/2\Pi F_{LB}R_1=1/(6.28)(1000)(5600)= 2.84\times10^{-8}$F. HERE, THE FORMULAS FOR THE CUTOFF FREQUENCIES OF THE ACTIVE FILTERS ARE BROKEN DOWN TO DETERMINE THE ELEMENT VALUES TO USE.
4. R_5=2.2 kΩ (ARBITRARILY CHOSEN).
5. $A_{VT}=1+(R_1+2R_5/R_3)=10$, $R_3=(R_1+2R_5)/9=1.1$ kΩ (USE 1 kΩ). HERE, THE MAXIMUM TREBLE GAIN IS CALCULATED IN A SIMILAR FASHION TO THE MAXIMUM BASS GAIN.
6. $C_3=1/2\Pi F_H R_3=1/(6.28)(10000)(1000) =1.6\times10^{-8}$F.
7. $R_4\geq10(R_3+R_1+2R_5)$=110 kΩ (USE 100k Ω).
8. R_6=10 kΩ (ARBITRARILY CHOSEN).

***Fig 7—In this circuit,** X9MMEs replace the conventional potentiometers (R_2, R_4, and R_6) of **Fig 6** without any alteration of the analog design considerations. Because R_2 and R_4 are both linear-taper potentiometers, the X9MME provides a direct replacement. The volume control (R_6) requires a 1-kΩ shunt resistor from its wiper to ground to simulate an audio taper.*

A 3-terminal potentiometer that provides 99 positions, 3-line digital control, and an internal counter integrates easily into existing designs.

Note that at this point you have selected $\overline{CS}$, set U/$\overline{D}$ to 1, and toggled $\overline{INC}$ to increase the volume. You can alter the bass and treble settings in a similar manner.

The microprocessor system used in this design consists of a 6502-based keyboard monitor. The controlling program scans the keyboard for the ASCII character that transfers control to the specified subroutine. For a given input, the subroutine selects the appropriate potentiometer and toggles the $\overline{INC}$ pin 10 times before returning to the controlling program.

An example program for adjusting the volume, bass, or treble is

```
      LDX  #00     Load counter with zero
0333  LDA  0006    Load accumulator with first
                   pattern.
      STA  A000    Output pattern.
      JSR  ED2C    5mS wait
      LDA  0007    Load 2nd Pattern
      STA  A000
      JSR  ED2C
      INX
      CPX  0008    Compare counter to 10
      BNE  0333
      RTS
```

In addition to the adjustment subroutines, you can also call up an initialization subroutine. This subroutine resets the volume control to zero and the bass and treble controls to the 50% point. You would normally use this routine only during the installation of the system.

The first section of this one-time initialization program sets all the potentiometers to zero.

```
      LDX  #00     Load counter with zero
0111  LDA  0000    Load accumulator with first
                   pattern (80h)
      STA  A000    Output pattern.
      JSR  ED2C    5mS wait
      LDA  0001    Load 2nd Pattern (C0h)
      STA  A000
      JSR  ED2C
      INX
      CPX  0008    Compare counter to 100
      BNE  0111
```

The next section of the program sets the bass and treble potentiometers to 50% and returns control to the controlling routine.

```
      LDX  #00     Load counter with zero
012C  LDA  0003    Load accumulator with first
                   pattern (B5h)
      STA  A000    Output pattern.
      JSR  ED2C    5mS wait
      LDA  0004    Load 2nd Pattern (F5h)
      STA  A000
      JSR  ED2C
      INX
      CPX  0005    Compare counter to 50
      BNE  0333
      RTS
```

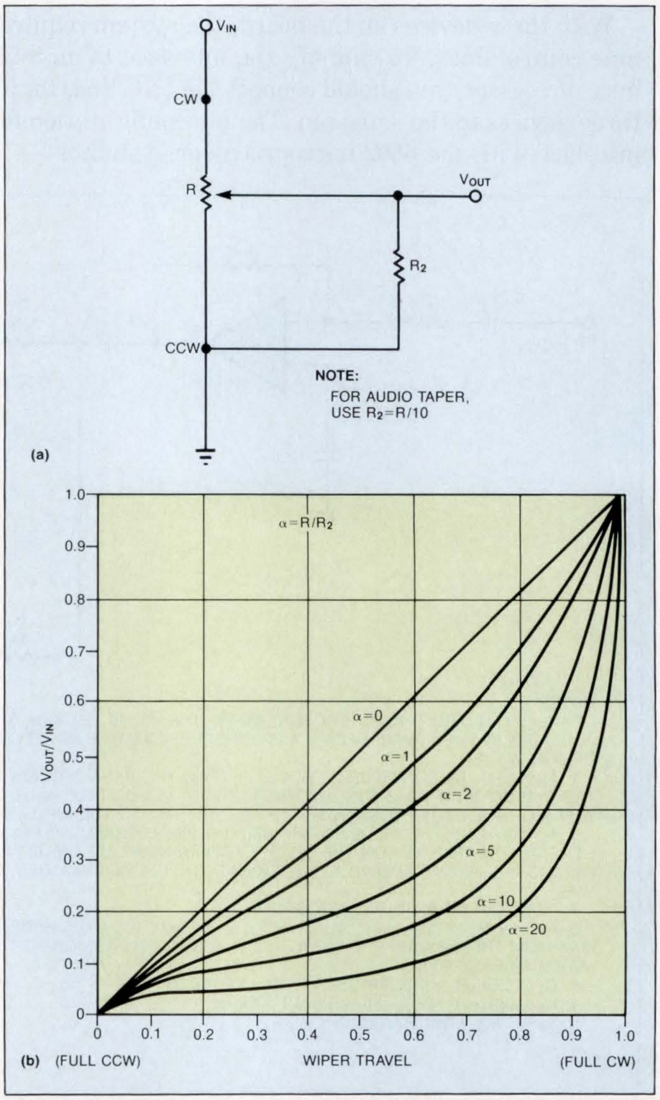


Fig 8—A shunt-resistor from the wiper of the potentiometer to ground (a) *can simulate various logarithmic tapers when used with a linear pot. The graph* ***(b)*** *plots the resulting curves as a function of the resistor ratios.*

CIRCLE NO 106

With digitally controlled potentiometers, the gain or frequency response of a circuit is quickly alterable via microprocessor commands.

The **Fig 9** circuit using the X9MME digital potentiometers operates much like many sophisticated home stereo systems, except that all controls are digital switches—in this case, a keyboard. The only moving parts are in the switches, and the entire system is relatively free from the problems of vibration or jarring—potential hazards in all mechanical potentiometer systems.

Keys 1 through 6 on the keyboard represent the up/down controls for the circuit. By depressing Key 1, the volume increases by 10 steps. Key 2 decreases the volume in the same manner. Similarly, Key 3 is treble up, Key 4 is treble down, Key 5 is bass up, and Key 6 is bass down. The key for the letter I calls the initialization routine. Keep in mind that beyond allowing control of step size, and the auto-zero or initialize function, this

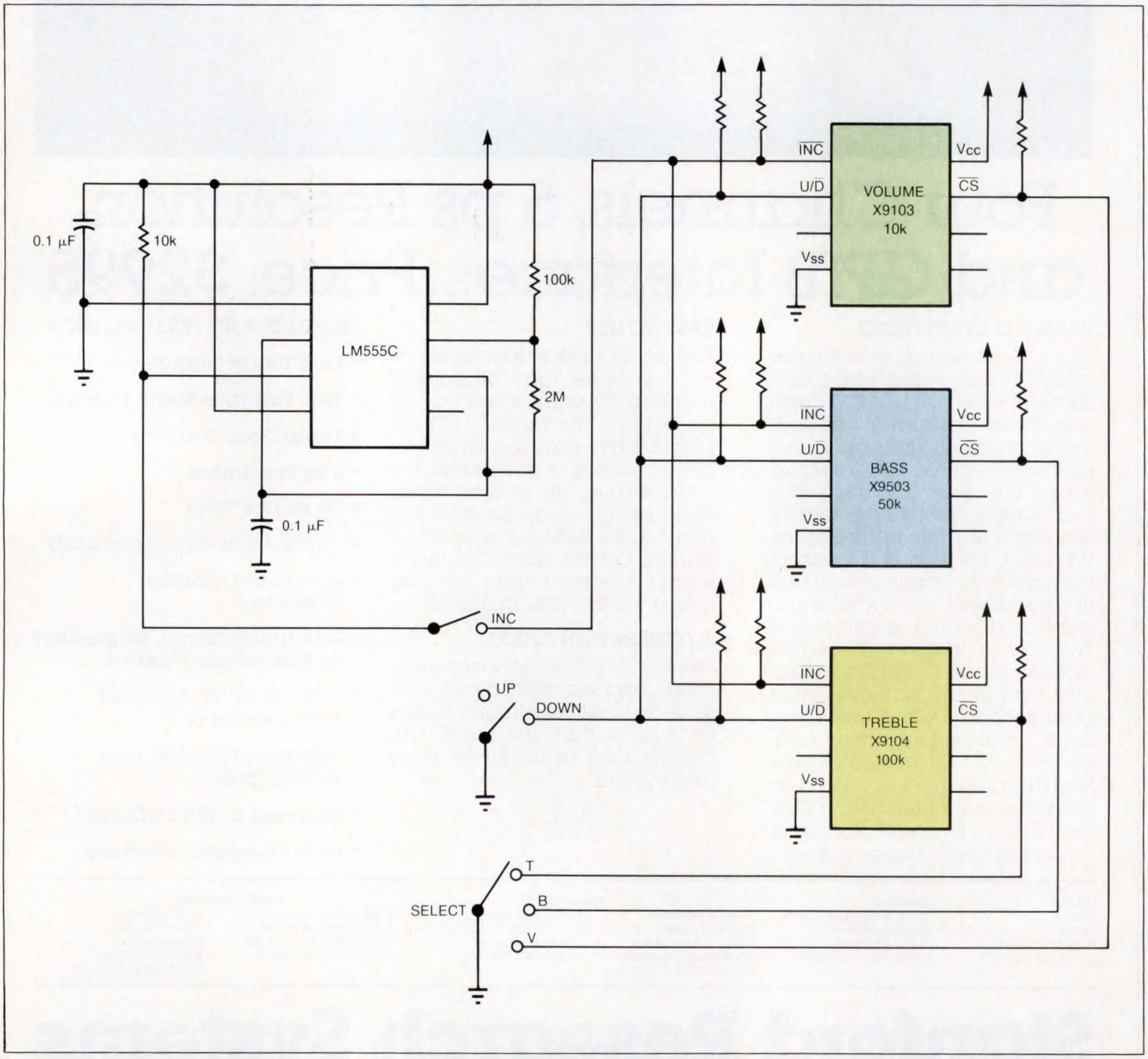


Fig 9—This breadboard circuit *uses a 555 timer to supply a slow clock-pulse to the increment pin of each X9MME through a momentary switch. Pull-up resistors connect to each digital line, and grounding switches connect to the up/down and chip-select pins. Each step of the clock produces a 1% change in the wiper position.*

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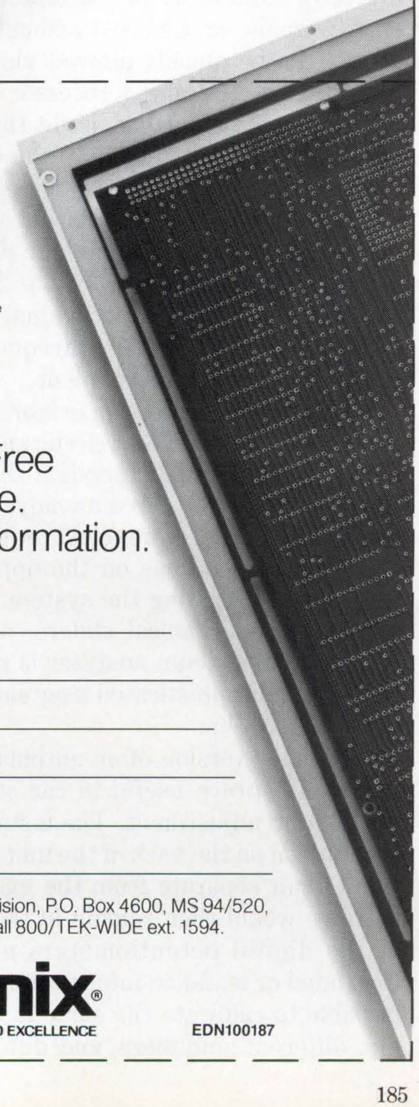

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Nonvolatile memory can be important in once-only-calibration circuits.

system really does not take advantage of the versatility of microprocessor control.

The system performs nearly identically to the same circuit with mechanical potentiometers. The X9MME is quiet to −65 dB below a 1V signal, which is considered a fair performance for normal audio-quality devices. For audiophile quality, this number should be closer to −120 dB, but in car-stereo or communications-equipment applications, the device works adequately.

Aside from the obvious advantage of a lack of moving parts, the most useful additional feature of this design is probably the choice of step size in the adjustment of the controls. The 10 steps per adjustment is an easy value with which to work.

Advanced circuit design and digital control are simply extensions of these design principles. By using digitally controlled potentiometers, the gain of the entire circuit, or the boost and cut of a given frequency range, can be quickly altered via microprocessor commands. Once the microprocessor assumes control, any parameter of the analog circuit that is controllable by a potentiometer is available to the programmer.

For example, with microprocessor control, you can easily automate the combination of the graphic equalizer and the spectrum analyzer discussed earlier. By controlling the position of the potentiometers that control the gain of the individual equalizer bands, you can calibrate the system's frequency response to any room or listening environment.

In one scenario, the operator presses a calibration button on the equalizing circuit, activating a pink-noise generator that in turn sends a short burst of sound to the system. The spectrum analyzer in the system then decides which frequencies require adjustment and changes the positions on the appropriate potentiometers, thus calibrating the system. It's not necessary to adjust any mechanical sliders, and no separate (and expensive) spectrum analyzer is required. Moreover, a relatively unsophisticated user can now accurately calibrate the system.

A simpler version of an automatic-calibration circuit might also prove useful in car stereos as a once-only installation adjustment. The installer pushes a calibration button on the back of the unit to adjust a compensation circuit separate from the main tone controls. The settings would then remain in the nonvolatile memory of the digital potentiometers until the system was upgraded or installed into another car. Thus it would be possible to calibrate the same unit for different speakers, different amplifiers, and different auto interiors.

The Xicor X9MME is a general-purpose device. Although well suited for audio applications, it may be even better for other analog applications. Its 99-step resolution across its range exceeds any normal requirements in most audio applications. For auto-zero and balancing circuits, however, this resolution is invaluable.

The device's nonvolatile memory, although of limited interest in applications where the user may not want to retain the previous potentiometer settings, could be quite important in a once-only calibration circuit where it is desirable to retain the factory settings. In a TV cable decoder, for example, mechanical potentiometers abound. In that application, the use of nonvolatile digital potentiometers could eliminate the constant headaches of having to make adjustments because of jarred equipment or tampering. **EDN**

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1. Rumreich, Mark, "Resistors Provide Nonlinear Pot Tapers," *EDN*, November 13, 1986, pgs 292-293.
2. Giles, Martin, et al, *Audio/Radio Handbook*, Santa Clara, CA: National Semiconductor, 1980.
3. Gray, Paul R and Robert G Meyer, *Analysis and Design of Analog Integrated Circuits*, Toronto, Ontario, Canada, John Wiley and Sons, 1984, pgs 635-700.
4. National Semiconductor Corp, Product Data Sheet, LMC835, April 1984.
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6. Toshiba Corp, Product Data Sheet, TC9169AP-TC9170AP, June 1985.

Author's biography

Jeff Randall is a field-applications engineer with Xicor Inc. He is responsible for customer applications support, technical presentations for all Xicor E² products plus additional analog circuit assistance to customers in the central US. Jeff has a BSEE from Washington State University. Prior to joining Xicor, he worked as an instrumentation and controls engineer, at Chevron Engineering. Jeff's hobbies include playing bass and singing in jazz and pop-music bands, radio-control auto racing, and home brewing.

Article Interest Quotient (Circle One)
High 491 Medium 492 Low 493

DESIGN IDEAS

EDITED BY TARLTON FLEMING

Synchronous divider replaces 1× clock line

Mike J Shah
Webcrafters Inc, Madison, WI

A serial-transmission data link based on a 1× clock can obviously transmit a higher data rate than one using a 16× clock. Both types of systems, however, must synchronize the clock and data signals, which may require a clock line separate from the data line. The **Fig 1** circuit eliminates the clock line and yet provides the USART with a 1× clock signal synchronized to the data stream.

Positive transitions in the 57.6-kHz clock signal (output of IC_{3D}) enable IC_1 to sample each data bit at its midpoint. To generate and synchronize this clock signal to the data input, XOR gates IC_{3A}, IC_{3B}, and IC_{3C} form an edge detector that produces a positive pulse following each positive or negative transition of the data signal (waveform A). These pulses repeatedly clear counter IC_{4A} to zero, and the local oscillator (f_{OSC}) continually clocks the counter. Because the oscillator frequency (921.6 kHz) is 16× the data's baud rate, the counter's $1Q_D$ output (a count-of-8 event) occurs at the midpoint of each data bit.

This approach to clock recovery at the data link's receive end has the advantages of simplicity and instantaneous response compared with the use of PLLs or phase-encoding schemes like biphase, FM, or modified FM. Most data transmitters and receivers include a crystal-controlled clock generator, from which you can usually derive f_{OSC}. Because such generators offer 0.1% or better accuracy and stability, the **Fig 1** circuit need only provide phase synchronization.

The line receiver (IC_2) should have hysteresis so that its output (waveform A) can provide the sharp transitions needed by the edge-detector circuit. The detector circuit's output pulse widths t_D and $t_{D'}$ should be less than the period of f_{OSC}, but wider than the minimum required by the counter's Clear input.

As shown, counters IC_{4A} and IC_{4B} enable data reception and transmission by dividing the data period by 16. (This division factor results in a midbit quantization jitter of ±½ the f_{OSC} period, or 1/16 of a data bit.) Division by 8 is the minimum recommended. **EDN**

To Vote For This Design, Circle No 748

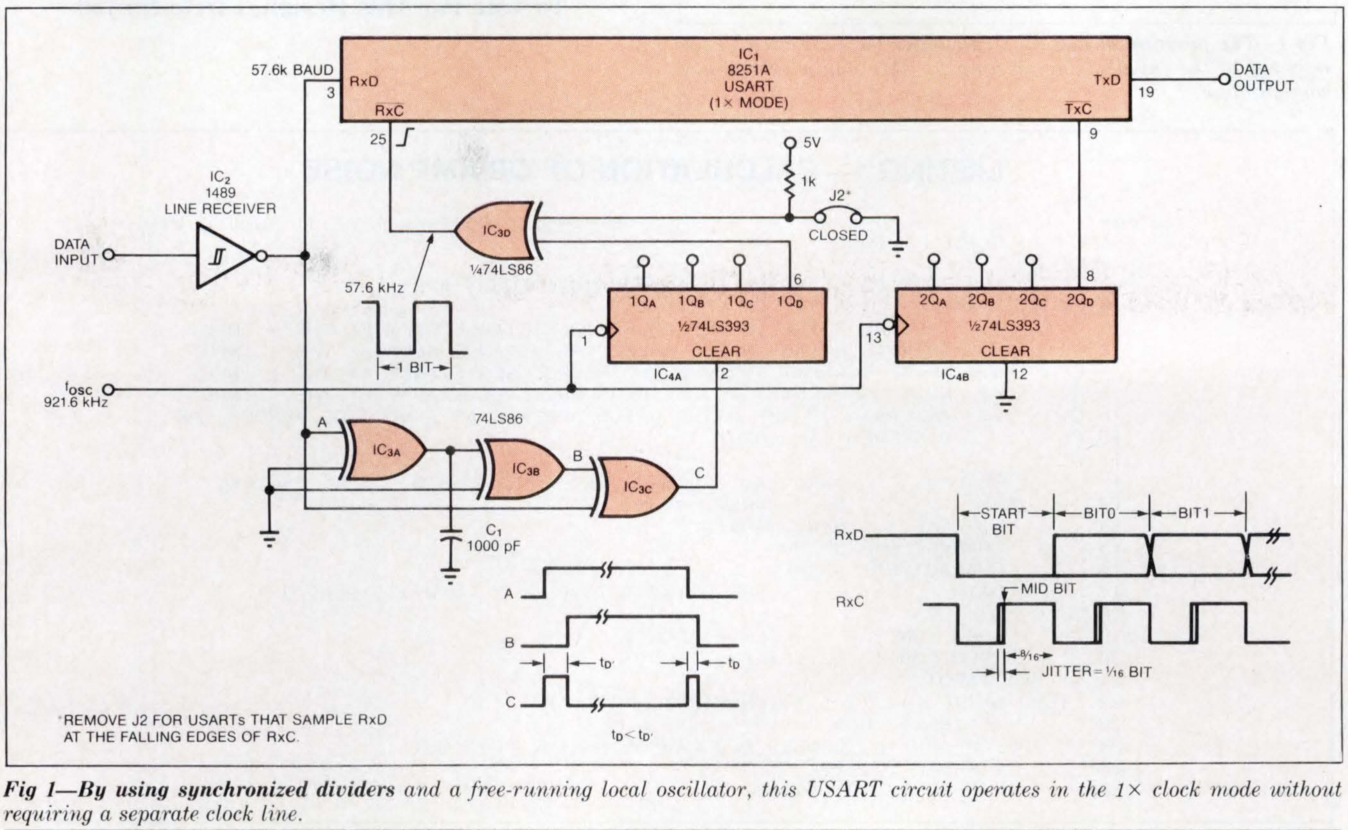


*Fig 1—**By using synchronized dividers** and a free-running local oscillator, this USART circuit operates in the 1× clock mode without requiring a separate clock line.*

Fortran program calculates op-amp noise

James S Taylor
James S Taylor & Associates, Fairborn, OH

Calculating the input-referred noise of an op-amp circuit isn't difficult, but making this calculation for several different op amps, over different bandwidths and for different circuit configurations, can become a chore. **Listing 1** is a Microsoft Fortran program that simplifies this task. It computes the total input-referred noise for an op-amp circuit (based on the test circuit of **Fig 1**), is flexible enough to handle a range of options, and runs on IBM PCs and compatibles.

The program prompts you for the external resistor values and such op-amp noise parameters as noise-voltage and noise-current densities (**Listing 2**). (For those parameters, use a frequency well above the op amp's noise-corner frequency—1 kHz, for example.)

Listing 2 also includes an example of **Listing 1**'s output for the OP-27A op amp. The program presents the data inputs and the output on your CRT screen for verification before printing. Boltzmann's constant and the absolute temperature are listed in separate data statements, so you can easily modify the program to calculate the resistor's thermal noise at different temperatures. **EDN**

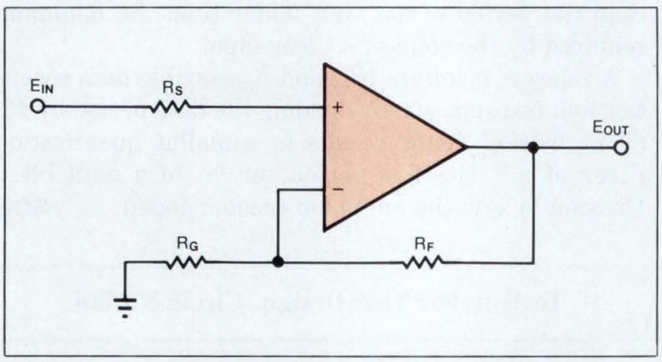


Fig 1—The program of Listing 1 calculates *the total circuit noise referred to the input of the op amp for this noninverting-gain configuration.*

References

1. Precision Monolithics Inc, *Application Note AN-15, Minimization of noise in operational amplifier applications,* Santa Clara, CA.

2. National Semiconductor Corp, *Application Note AN-104, Noise specs confusing?* Santa Clara, CA.

3. Signetics Corp, *Application Note AN-104, Explanation of noise,* Sunnyvale, CA.

To Vote For This Design, Circle No 750

LISTING 1—CALCULATION OF OP-AMP NOISE

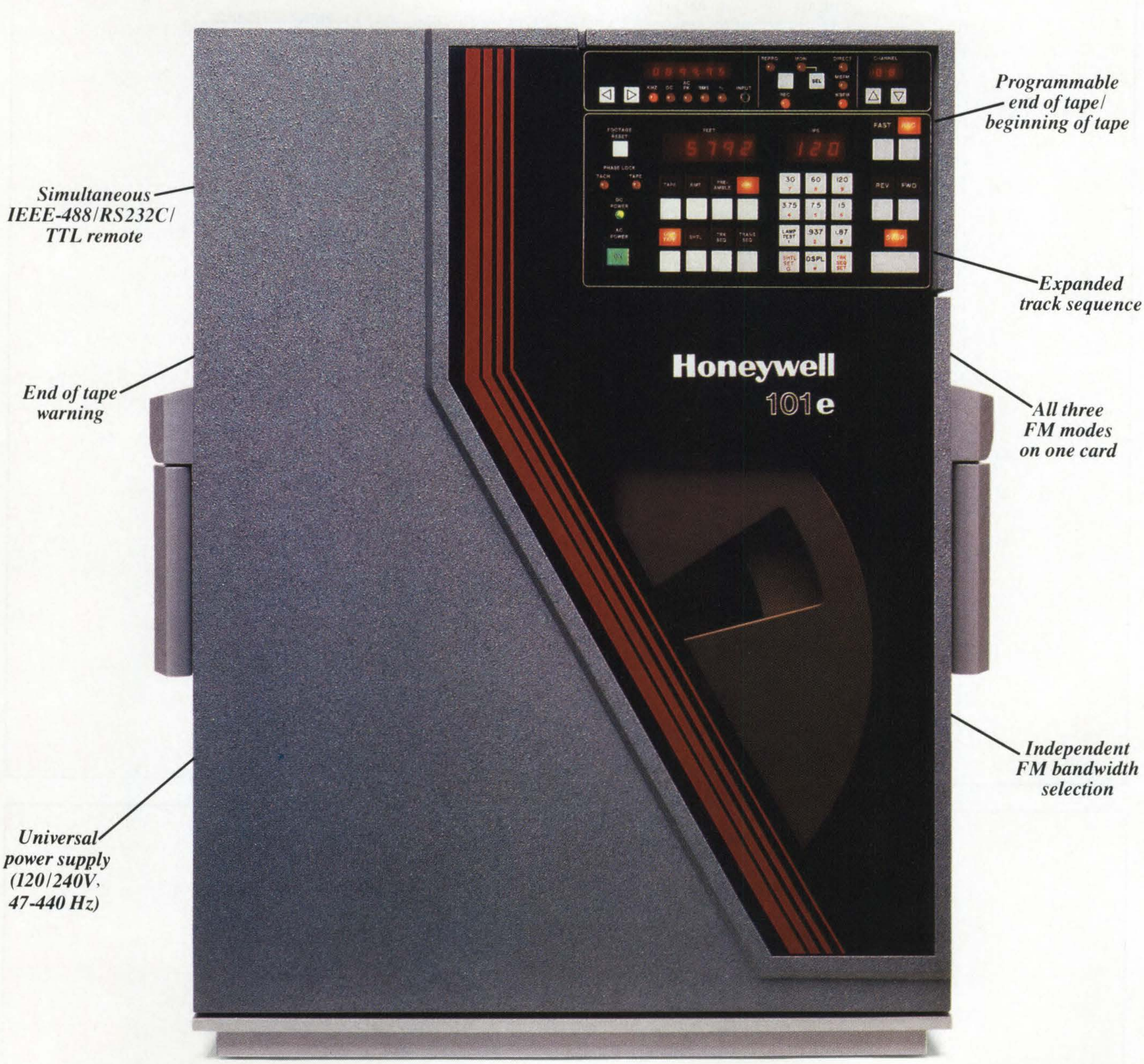
```
D Line# 1       7                             Microsoft FORTRAN77 V3.31 August 1985
      C         NOISE    .FOR
      C
      C         THE SOURCES OF NOISE IN AN OP-AMP CIRCUIT ARE:
      C
      C         1.  THERMAL NOISE IN THE SOURCE RESISTANCE SEEN BY THE + INPUT
      C         2.  THERMAL NOISE IN THE SOURCE RESISTANCE SEEN BY THE - INPUT
      C         3.  NOISE CURRENT THROUGH THE SOURCE RESISTANCE AT THE + INPUT
      C         4.  NOISE CURRENT THROUGH THE SOURCE RESISTANCE AT THE - INPUT
      C         5.  INTERNAL OP-AMP NOISE WHICH APPEARS AS A VOLTAGE ACROSS THE
      C             DIFFERENTIAL INPUT
      C
                REAL*4       IWN,  K,    LBW,  NE,   NI,   NIN,  NIP,  NOISE,
              &              N6,   NRSP, NRSN
                LOGICAL      NEW,  AGAIN
                CHARACTER*8 OPAMP
                CHARACTER*1 ANSWER
                DATA         K / 1.38E-23 /, T / 300.0 /, NEW / .TRUE. /
      C   OPEN FILES
                OPEN (UNIT = 1, FILE = 'CON')
                OPEN (UNIT = 2, FILE = 'CON')
      C   GET INPUT
          1000 WRITE (1, 1) ' ', CHAR(27), '[', '2', 'J'
                  IF (NEW) THEN
      C   THE OP-AMP ID IS USED FOR LABELLING THE PRINTOUT
                     WRITE (1, 2)
                     READ (2, 3) OPAMP
```

LISTING 1—CALCULATION OF OP-AMP NOISE *(Continued)*

```
D Line# 1      7                                Microsoft FORTRAN77 V3.31 August 1985
C   FCE = VOLTAGE NOISE CORNER FREQUENCY
          WRITE (1, 4)
          READ (2, 5) FCE
C   FCI = CURRENT NOISE CORNER FREQUENCY
          WRITE (1, 6)
          READ (2, 5) FCI
C   EWN = NOISE VOLTAGE DENSITY, F >> FCE
          WRITE (1, 7)
          READ (2, 5) EWN
          EWN = EWN
C   IWN = NOISE CURRENT DENSITY, F >> FCI
          WRITE (1, 8)
          READ (2, 5) IWN
C   THE NEXT LINE CORRECTS FOR A TRADITIONAL ERROR IN THE WAY
C   NOISE CURRENT DENSITY IS SPECIFIED
          IWN = IWN * SQRT(2.)
          NEW = .FALSE.
        ENDIF
C   RSP = SOURCE RESISTANCE AT THE POSITIVE INPUT
        WRITE (1, 9)
        READ (2, 5) RSP
C   RG = RESISTANCE TO GROUND AT THE NEGATIVE INPUT
        WRITE (1, 10)
        READ (2, 5) RG
C   RF = FEEDBACK RESISTANCE TO Eout AT THE NEGATIVE INPUT
        WRITE (1, 11)
        READ (2, 5) RF
C   RSN = EQUIVALENT SOURCE RESISTANCE AT THE NEGATIVE INPUT
        RSN = RG * RF / (RG + RF)
C   FL = LOWEST FREQUENCY OF INTEREST
        WRITE (1, 12)
        READ (2, 5) FL
C   FH = HIGHEST FREQUENCY OF INTEREST
        WRITE (1, 13)
        READ (2, 5) FH
        BW = FH - FL
        LBW = LOG(FH / FL)
C   CALCULATE INDIVIDUAL NOISE COMPONENTS
        NRSP = SQRT(4.0 * K * T * RSP * BW) * 1.0E9
        NRSN = SQRT(4.0 * K * T * RSN * BW) * 1.0E9
        NE = EWN * SQRT(FCE * LBW + BW)
        NI = IWN * SQRT(FCI * LBW + BW)
        NIP = RSP * NI / 1000.
        NIN = RSN * NI / 1000.
C   CALCULATE THE TOTAL NOISE, ROUNDED TO THE NEAREST NANOVOLT
        NOISE = INT(SQRT(NRSP**2 + NRSN**2 + NIP**2 + NIN**2 + NE**2))
        N6 = NOISE * 6.0
C   DISPLAY THE RESULTS
        WRITE (1, 14) OPAMP, FCE, FCI, EWN, IWN
        WRITE (1, 15) NRSP
        WRITE (1, 16) NRSN
        WRITE (1, 17) NE
        WRITE (1, 18) NI
        WRITE (1, 19) NIP
        WRITE (1, 20) NIN
        WRITE (1, 21) NOISE, N6
C   PRINT THE RESULTS, IF REQUESTED
        WRITE (1, 22)
        READ (2, 1) ANSWER
        IF ((ANSWER .EQ. 'Y') .OR. (ANSWER .EQ. 'y')) THEN
          OPEN (UNIT = 3, FILE = 'PRN')
          WRITE (3, 14) OPAMP, FCE, FCI, EWN, IWN
          WRITE (3, 15) NRSP
          WRITE (3, 16) NRSN
          WRITE (3, 17) NE
          WRITE (3, 18) NI
          WRITE (3, 19) NIP
          WRITE (3, 20) NIN
          WRITE (3, 21) NOISE, N6
          CLOSE (3)
        ENDIF
C   ASK IF ANOTHER CALCULATION IS REQUIRED
        WRITE (1, 23)
        READ (2, 1) ANSWER
        IF ((ANSWER .EQ. 'Y') .OR. (ANSWER .EQ. 'y')) THEN
          AGAIN = .TRUE.
```

Listing continued on pg 192

WHAT'S NEW.



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CIRCLE NO 126

LISTING 1—CALCULATION OF OP-AMP NOISE *(Continued)*

```
D Line# 1     7                                Microsoft FORTRAN77 V3.31 August 1985
          WRITE (1, 24)
          READ (2, *) ANSWER
          IF ((ANSWER .EQ. 'Y') .OR. (ANSWER .EQ. 'y')) NEW = .TRUE.
        ELSE
          AGAIN = .FALSE.
        ENDIF
        IF (AGAIN) GO TO 1000
C     CLOSE UP AND CLEAR OUT
        WRITE (1, 1)
        CLOSE (1)
        CLOSE (2)
C     FORMAT STATEMENTS
    1 FORMAT (5A1\)
    2 FORMAT (' ENTER THE OP AMP TYPE:  '\)
    3 FORMAT (A8)
    4 FORMAT (' ENTER THE VOLTAGE NOISE CORNER FREQUENCY, Hz:  '\)
    5 FORMAT (F8.4)
    6 FORMAT (' ENTER THE CURRENT NOISE CORNER FREQUENCY, Hz:  '\)
    7 FORMAT (' ENTER THE NOISE VOLTAGE DENSITY, nV / sqrt(Hz):  '\)
    8 FORMAT (' ENTER THE NOISE CURRENT DENSITY, pA / sqrt(Hz):  '\)
    9 FORMAT (' ENTER SOURCE RESISTANCE AT THE + INPUT, ohms:  '\)
   10 FORMAT (' ENTER RESISTANCE TO GROUND AT THE - INPUT, ohms:  '\)
   11 FORMAT (' ENTER RESISTANCE TO Eout AT THE - INPUT, ohms:  '\)
   12 FORMAT (' ENTER THE LOW FREQUENCY LIMIT, Hz:  '\)
   13 FORMAT (' ENTER THE HIGH FREQUENCY LIMIT, Hz:  '\)
   14 FORMAT (/' Op-Amp type:   ', A8/
     &        ' Voltage noise corner frequency:', F7.2, ' Hz'/
     &        ' Current noise corner frequency:', F7.2, ' Hz'/
     &        ' Noise voltage density: ', F17.4, ' nV / sqrt(Hz)'/
     &        ' Noise current density: ', F17.4, ' pA / sqrt(Hz)'/)
   15 FORMAT (' Thermal noise from Rs(+) = ', F11.2, ' nV')
   16 FORMAT (' Thermal noise from Rs(-) = ', F11.2, ' nV')
   17 FORMAT (' Op-Amp noise voltage = ', F15.2, ' nV')
   18 FORMAT (' Op-Amp noise current = ', F15.2, ' pA')
   19 FORMAT (' Noise current * Rs(+) = ', F14.2, ' nV')
   20 FORMAT (' Noise current * Rs(-) = ', F14.2, ' nV'/)
   21 FORMAT (' TOTAL NOISE =', F8.2, ' nV RMS,', F9.2, ' nV P-P'/)
   22 FORMAT (' PRINT THESE RESULTS?  '\)
   23 FORMAT (' WOULD YOU LIKE TO CALCULATE NOISE AGAIN?  '\)
   24 FORMAT (' WOULD YOU LIKE TO SPECIFY A DIFFERENT OP AMP?  '\)
C
          END
```

LISTING 2—INPUT PROMPTS AND SAMPLE OUTPUT

```
 ENTER THE OP AMP TYPE:  OP-27A
 ENTER THE VOLTAGE NOISE CORNER FREQUENCY, Hz:  2.7
 ENTER THE CURRENT NOISE CORNER FREQUENCY, Hz:  140.0
 ENTER THE NOISE VOLTAGE DENSITY, nV / sqrt(Hz):  3.0
 ENTER THE NOISE CURRENT DENSITY, pA / sqrt(Hz):  0.4
 ENTER SOURCE RESISTANCE AT THE + INPUT, ohms:  10000.0
 ENTER RESISTANCE TO GROUND AT THE - INPUT, ohms:  1000.0
 ENTER RESISTANCE TO Eout AT THE - INPUT, ohms:  9000.0
 ENTER THE LOW FREQUENCY LIMIT, Hz:  0.0001
 ENTER THE HIGH FREQUENCY LIMIT, Hz:  100.0

Op-Amp type:   OP-27A
Voltage noise corner frequency:   2.70 Hz
Current noise corner frequency: 140.00 Hz
Noise voltage density:               3.0000 nV / sqrt(Hz)
Noise current density:                .5657 pA / sqrt(Hz)

Thermal noise from Rs(+) =       128.69 nV
Thermal noise from Rs(-) =        38.61 nV
Op-Amp noise voltage =            35.15 nV
Op-Amp noise current =            25.51 pA
Noise current * Rs(+) =          255.13 nV
Noise current * Rs(-) =           22.96 nV

TOTAL NOISE =  291.00 nV RMS,  1746.00 nV P-P

PRINT THESE RESULTS?  Y
 WOULD YOU LIKE TO CALCULATE NOISE AGAIN?  Y
 WOULD YOU LIKE TO SPECIFY A DIFFERENT OP AMP?  N
```

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*Rev. C, Paragraph 1.2.2

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V /I converter has zero I_B error

Roberto Burani and Giovanni Stocchino
FATME SpA, Rome, Italy

In a conventional (simplified) voltage-to-current converter (**Fig 1**), $I_E=V_{IN}/R_P$, and $I_C=I_E-I_B$. Because $I_B=I_E/(1+\beta)$, the output current is affected by changes in β, which varies with I_E, V_{OUT}, and temperature. The voltage-controlled current source of **Fig 2** overcomes this drawback by eliminating the output transistor's base current as a source of error. (For earlier voltage-to-current circuits, see *EDN*, September 15, 1983, pg 227, and January 10, 1985, pg 290).

Notice that the output device in **Fig 2** (a composite of Q_2 and the optocoupler's output phototransistor) has only two dc terminals, so I_C and I_E are identical at low frequencies. Output current, then, is proportional to current flowing in the optocoupler's LED. The output device contributes only a negligible error due to current leakage (about 1 pA/V), which is caused by finite isolation resistance in the package.

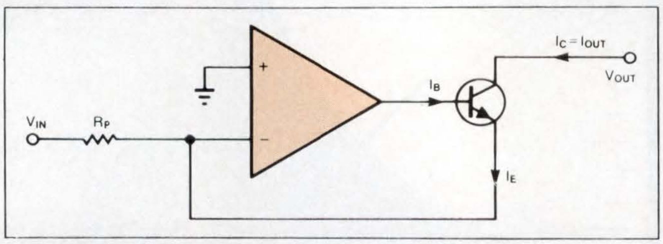


Fig 1—In this simplified V/I converter, *I_{OUT} equals V_{IN}/R_P minus I_B, which varies with I_E, V_{OUT}, and temperature.*

To identify potential sources of error, consider the expression for output current:

$$I_C \equiv I_E = \frac{V_{IN} \pm V_{OS}}{R_P} \pm \frac{I_B + 2I_{OS}}{2} \geq I_{DARK} + I_{OFF},$$

where V_{OS} is the op amp's input offset voltage, I_B and I_{OS} are the op amp's respective input bias and offset currents, I_{DARK} is the optocoupler's dark current, and I_{OFF} is the cutoff current for transistor Q_2. Resistors R_5 and R_6 extend the output-current range by reducing I_{DARK} and I_{OFF} to a few nanoamperes.

The maximum deviation *(d)* of output current from the ideal (V_{IN}/R_P) is

$$d = \left| I_C - \frac{V_{IN}}{R_P} \right| = \frac{V_{OS}}{R_P} + \frac{I_B}{2} + I_{OS}.$$

You can control the major sources of error (V_{OS} and dV_{OS}/dT) by selecting a suitable op amp. (As intended, the quantity d contains no error contributions from the output device.)

For the circuit of **Fig 2**, a single programming resistor (identified as R_P) provides an output-current range of about six decades. (Note that this resistor's TC is also a potential source of error; it dissipates 125 mW when V_{IN}=5V.) The maximum deviation is typically 50 nA—that is, 0.0002% of full scale. **EDN**

To Vote For This Design, Circle No 746

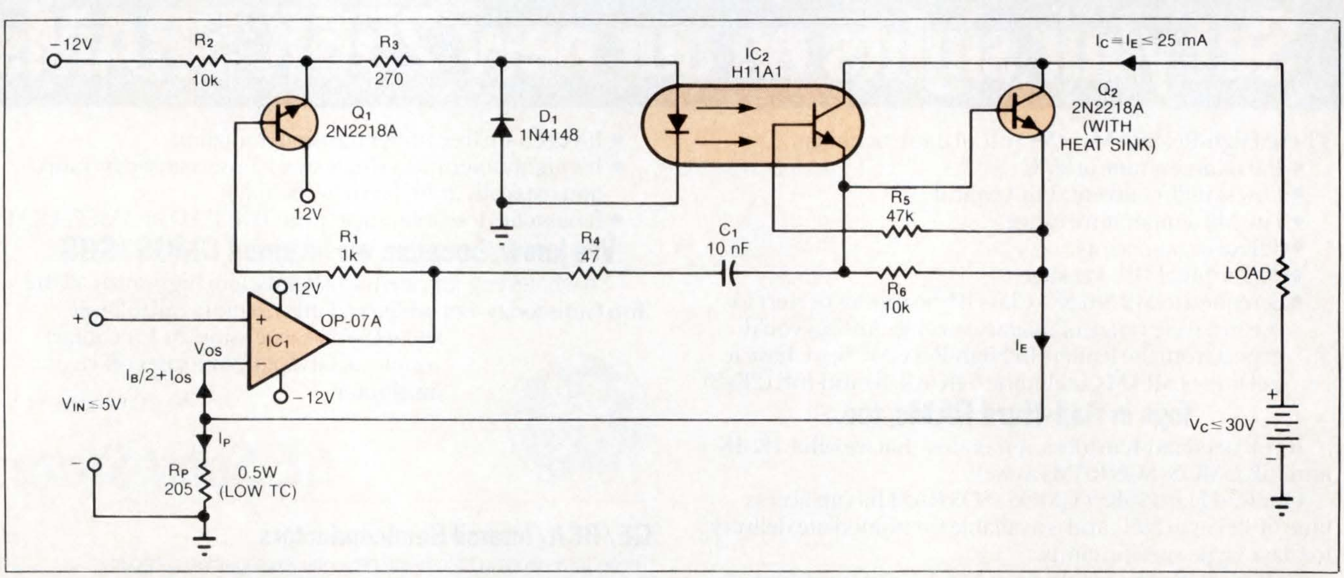
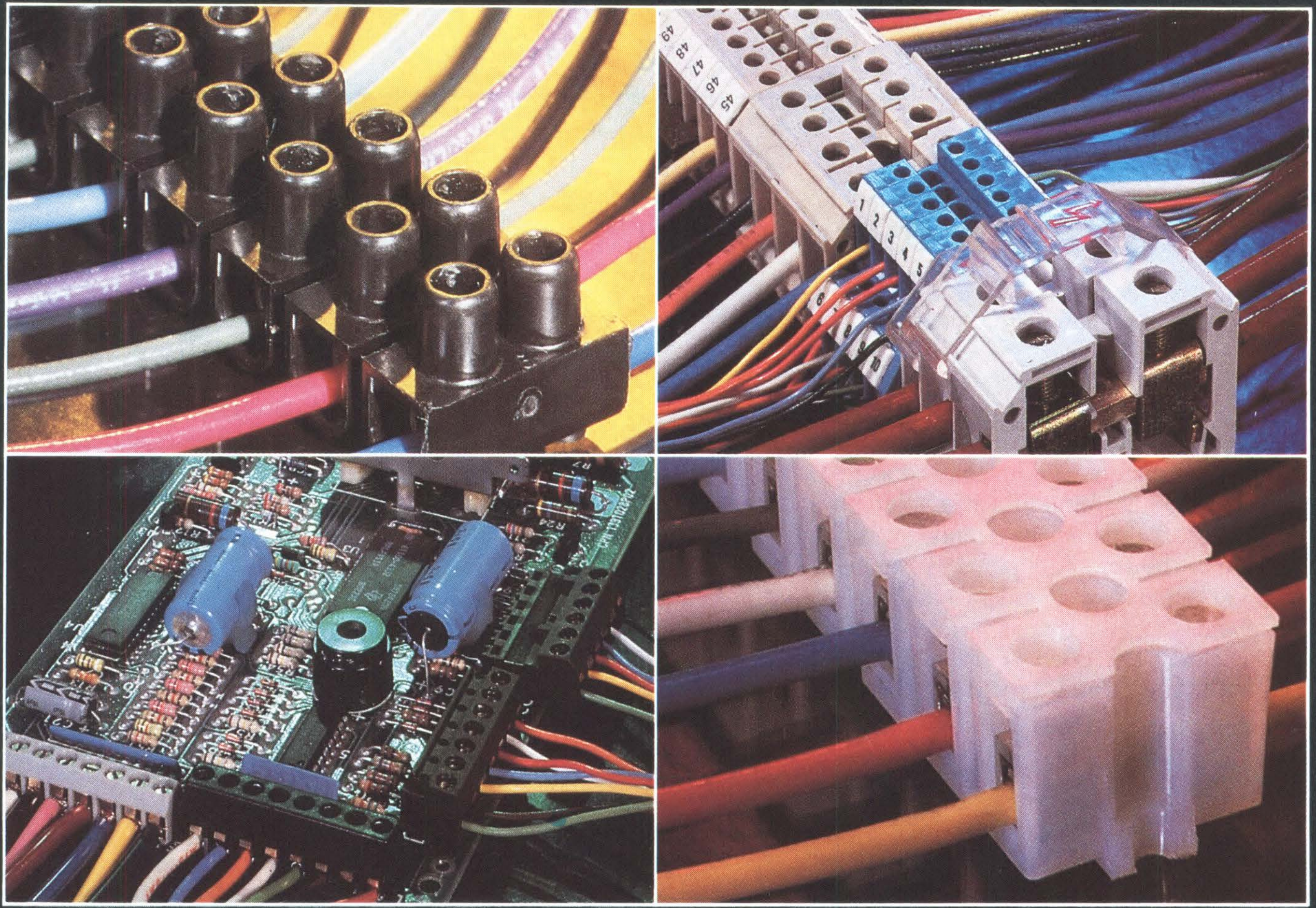


Fig 2—This voltage-controlled current source *uses an optocoupler (IC_2) to eliminate an error found in more conventional circuits and which is caused by the output transistor's base current.*



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CIRCLE NO 127

Circuit monitors system's power supply

David Wilson
Fairchild Industrial Products,
Winston-Salem, NC

Industrial systems that include μPs or μCs are increasingly prone to immobilization due to a low-voltage condition, a glitch in the supply voltage, or an outright failure of the power supply. **Fig 1**'s circuit, unlike most voltage-supervisor ICs, can handle all three of these problems.

Following detection of an aberration in the supply voltage, the circuit salvages program execution by activating the $\overline{\text{Reset}}$ line. IC_1 handles the conditions of power-up and low supply voltage, and the circuit's external components enable detection of abnormal operation by the CPU. Software problems and thermal effects, for example, can affect the CPU.

During power-up, IC_1 asserts the active Reset and $\overline{\text{Reset}}$ signals until the supply voltage attains its nominal value. An internal current source and capacitor C_4 provide a time delay ($t_D=1.3\times10^4\times C_4$), which ensures a proper reset before the reset lines become inactive. (For this circuit, t_D=28 msec.) Similarly, if the supply voltage dips low during normal operation, the reset

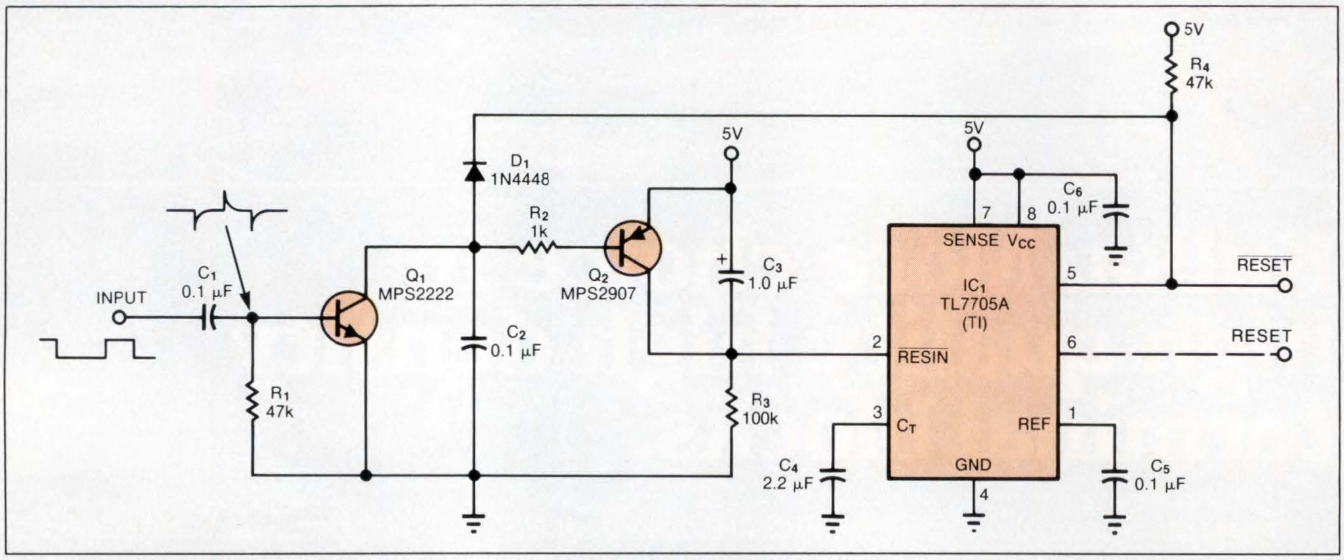

Fig 1—Combining a supply-supervisor chip (IC_1) *with an external watchdog circuit provides protection for a μP system. The circuit issues a system reset in response to a CPU malfunction, a glitch, a low-voltage condition, or a failure of the power supply.*

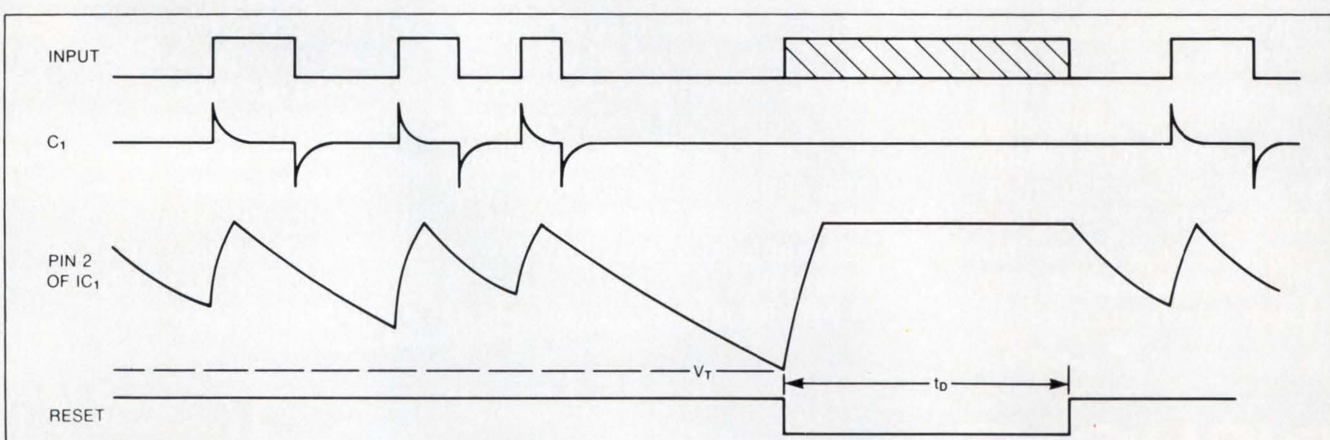

Fig 2—The waveforms of Fig 1's watchdog circuit *show that a signal from the CPU (connected to the Input) prevents a system reset by repeatedly jerking the pin 2 voltage away from IC_1's V_T switching threshold. A malfunctioning CPU will allow the voltage to reach the threshold, producing a reset.*

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Los Angeles, CA 90045 (213) 216-7611 FAX: (213) 216-7646

lines become active until the voltage returns to normal and the delay time expires.

In addition, the circuit includes a watchdog function that activates a reset condition when the CPU exhibits abnormal operation. Once you connect a selectable CPU signal to the circuit's Input, C_1 differentiates the signal, producing alternate negative and positive pulses. Each positive pulse causes transistor Q_1 to turn on and discharge C_2, which turns on transistor Q_2.

Capacitor C_3 discharges as Q_2 turns on, pulling pin 2 of IC_1 high. The R_2C_2 time constant ensures that C_3 discharges completely before Q_2 turns off. C_3 immediately begins to recharge, driving the voltage at pin 2 toward the IC's internal switching threshold V_T **(Fig 2)**. Unless the CPU signal toggles in time (within an interval defined by the R_3C_3 time constant), the pin 2 voltage activates a reset by crossing the V_T threshold. (Diode D_1 helps hold Q_2 on while the reset signal is active.) Thus, the minimum frequency *f* for the Input signal is

$$f = -\frac{1}{R_3C_3\ln\left(\frac{V_T}{V_{CC}}\right)}.$$

Because V_T isn't a tightly controlled parameter and can range from 0.6 to 2V, f can vary from 4.7 to 11 Hz (when V_{CC}=5V). You must ensure, then, that the selected CPU signal exceeds 11 Hz. (You can choose a signal that comes from a CPU output and that toggles with each execution of a particular subroutine, for example.) The duty cycle is unimportant.

IC_1 senses the pin 7 supply voltage at a threshold of 4.55V typ. Other ICs have different thresholds: TL7709A, 7.6V; TL7712A, 10.8V; and TL7715A, 13.5V. **EDN**

To Vote For This Design, Circle No 747

Low-power circuit splits supply voltage

John A Haase
Colorado State University, Fort Collins, CO

The simple circuit of **Fig 1a** can convert a single supply voltage (a battery, for example) into a bipolar supply. Sense resistors R_1 and R_2 establish relative magnitudes for the resulting positive and negative voltages. Their rail-to-rail value, of course, equals V_{SUPPLY}. R_4 and R_5 represent the load impedances.

For example, equal-value sense resistors produce $\frac{1}{2}V_{SUPPLY}$ across each of the load resistors R_4 and R_5. The op amp maintains these equal voltages by sinking or sourcing current through R_3; the op amp's action is equivalent to that of variable conductances G_1 and G_2 in shunt with each load resistor **(Fig 1b)**.

Choose a value for R_3 such that the largest voltage across it (the greatest load-current mismatch) won't exceed the op amp's output-voltage capability for the application. You can add a buffer amplifier at the op amp's output to provide greater load currents. If you need bypass capacitors across the load resistors as well, connect a capacitor (dashed lines) to ensure that the amplifier remains stable. **EDN**

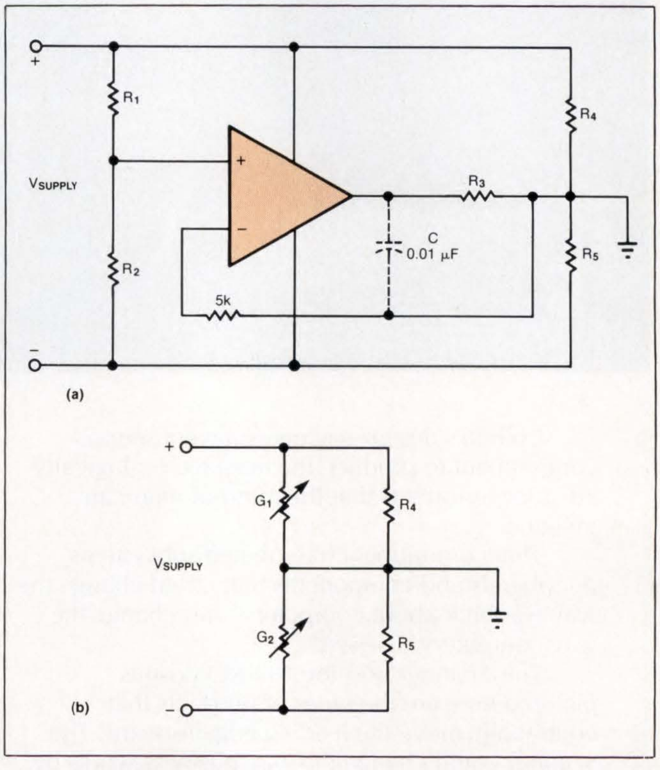

***Fig 1—This circuit (a) splits a single supply** into a bipolar supply and regulates the resulting voltages according to the relative magnitudes of R_1 and R_2. The action of the op amp is equivalent to that of the variable conductances across each load resistor **(b)**.*

To Vote For This Design, Circle No 749

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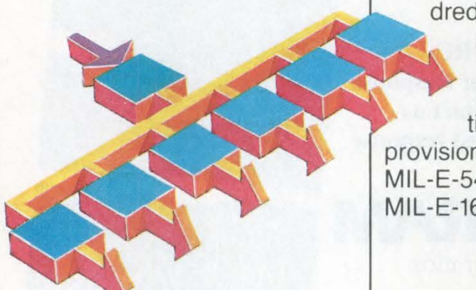

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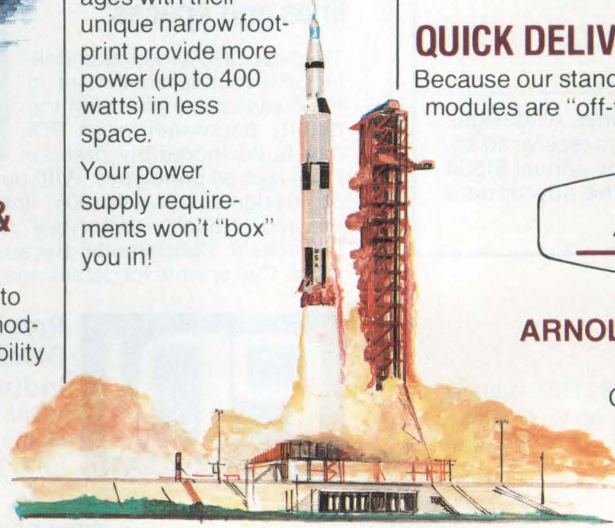

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DESIGN IDEAS

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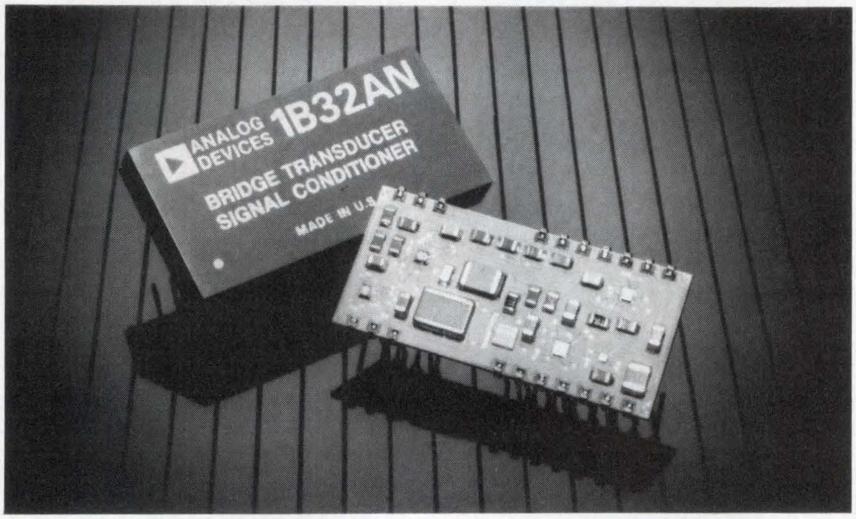
ISSUE WINNER

The winning Design Idea for the July 9, 1987, issue is entitled "Square-wave oscillator spans dc to 20 MHz," submitted by Michael Jachowski of Precision Monolithics Inc (Santa Clara, CA).

NEW PRODUCTS

COMPONENTS & POWER SUPPLIES



SIGNAL CONDITIONER

- *Features direct transducer interface*
- *±0.005% max nonlinearity*

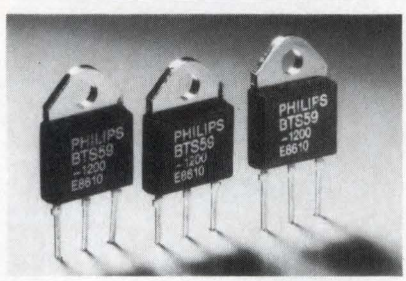
The 1B32 hybrid signal conditioner offers offset voltage and gain drifts of ±2 μV and ±6 ppm/°C max, respectively. It also features a nonlinearity of ±0.005% max and a common-mode rejection of 140 dB min. The unit consists of a lowpass filter, an adjustable transducer excitation source, and a chopper-based amplifier. Pin-strappable standard gains of 333.3V/V and 500V/V for 2 mV/V and 3 mV/V, respectively, are available. The integral 3-pole filter offers a 60-dB/decade roll-off higher than 4 Hz. The input noise (0.1 to 10 Hz) equals 1 μV p-p. The operating range equals −25 to +85°C. $52 (100). Delivery, four to six weeks ARO.

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 461-3643.

Circle No 351

THYRISTORS

- *Handle nonrepetitive peak currents to 100A*
- *Optimized for ac motor control, resonant converters*



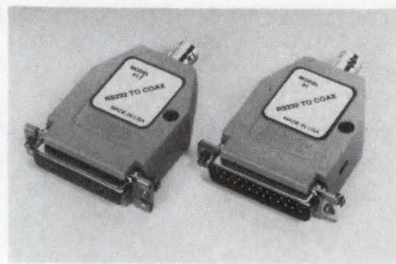
The BTS59 and BTR59 Series 15A GTO thyristors handle peak nonrepetitive currents as high as 100A. The BTS59 devices are optimized for ac motor-control applications operating at frequencies as high as 2.5 kHz; the BTR59 devices are designed for use in resonant converters operating above 20 kHz. The BTS59 Series comprises three devices with voltage ratings of 850, 1000, and 1200V; all these devices have a fall time of 250 nsec. The BTR59 Series currently comprises two devices with voltage ratings of 800 and 1300V; both have a circuit commutation turn-off time of 1 μsec. Both series have a maximum controllable anode current of 50A. The thyristors are packaged in SOT-93 encapsulations. Around $5.

Philips, Elcoma Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757005. TLX 51573.

Circle No 352

Amperex Electronic Corp, George Washington Hwy, Smithfield, RI 02917. Phone (401) 232-0500.

Circle No 353



DATA CONVERTER

- *Full-duplex communications on a single cable*
- *Requires no external power source*

By altering the standard data signals, the Model 61 RS-232C-to-coax converter provides full-duplex communication on a single coaxial cable. It is packaged in a DB-25 cover and requires no external power source. The device provides full-duplex operation for Transmit Data and Receive Data at rates ranging to 9600 baud over distances of 2500 ft. It has a DTE/DCE (data-terminal equipment/data-communications equipment) switch that allows you to reverse pins 2 and 3 of the interface, as required, by the host port. The Model 61 comes equipped with a standard BNC connector for the coaxial cable and a male or female DB-25 RS-232C connector. $60 (100).

Telebyte Technology Inc, 270 E Pulaski Rd, Greenlawn, NY 11740. Phone (800) 835-3298; in NY, (516) 423-3232.

Circle No 354

LINEAR TECHNOLOGY DESIGN NOTES

Number 2 in a series from Linear Technology Corporation October, 1987

Sampling of Signals for Digital Filtering and Gated Measurements

William Rempfer

Introduction

For many signal processing applications a sample and hold function is required in a data acquisition system. It is often critical for the processing system to know the exact value of an analog input at an exact time. In DSP applications such as digital filters the usable bandwidth of the system is limited by the Nyquist frequency and the sample and hold bandwidth need only be, and is often intentionally limited to, one half the sampling rate. However, another area of application requires infrequently capturing instantaneous values of relatively fast signals, sometimes referred to as gated measurements. In the extreme case of pulse height measurements, only one sample point is required. Here, the sample and hold bandwidth should be as high as possible even though the sampling rate is very low.

The LTC1090 excels in both environments. This note shows how the LTC1090 sample and hold can be synchronized to an external event and gives two simple applications: an 8 channel data acquisition system with digital filtering, and the gated measurement of a 1MHz sine wave.

The LTC1090 Sample and Hold

The LTC1090 provides a sample and hold which is fast, accurate and can be synchronized to an external event. Although the sampling rate is limited (by the A/D conversion and data transfer rate) to about 30kHz, the signal bandwidth of the sample and hold exceeds 1MHz. The acquisition time is less than 1μs to 0.1% (1LSB). Accuracy is so good, in fact, that it is possible to include all the sample and hold's error contributions (offset, gain, hold step, droop rate, etc.) into the converter specification and still maintain overall system accuracy of ±0.05% (±0.5LSB) over temperature.

Sampling occurs on the falling edge of the last data transfer clock pulse as described in the LTC1090 data sheet. Figure 1 shows a typical application which includes circuitry to synchronize sampling to an external sample clock, f_S.

8-Channel Data Acquisition System with Digital Filter

The circuit of Figure 1 contains an LTC1090 providing multiplexing, sample and hold, A/D conversion and data transfer to the microcontroller (MCU). An MC68HC05C4 is used as the

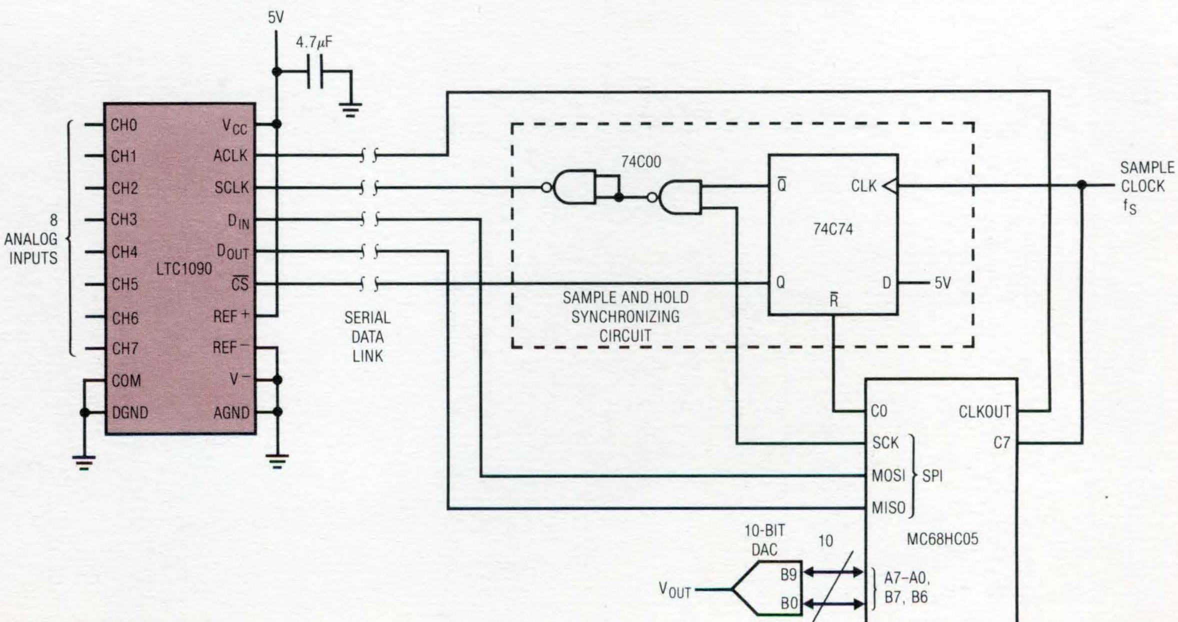


Figure 1. 8 Channel Data Acquisition System Showing Sample and Hold Synchronizing Circuitry

controller (much higher filter performance may be achieved with a dedicated DSP processor). The MCU communicates with the LTC1090 over the serial peripheral interface (SPI), performs the digital filtering algorithm and provides the filtered data on its output port. The DAC provides reconstruction of the filtered waveform for viewing on an oscilloscope or spectrum analyzer. The 74C74 and 74C00 synchronize the sampling of the LTC1090 to the externally applied sample clock, f_S.

In Figure 1, the MCU initiates a two byte serial data exchange with the LTC1090. This configures the LTC1090 for the next conversion, simultaneously reads back the previous conversion result and resets the 74C74. The LTC1090 will sample the analog input when the last shift clock (SCLK) pulse falls, so the MCU must end the data transfer by leaving the SCLK in a high state. This inhibits sampling of the selected analog input. When the sample clock, f_S, rises, it clocks the 74C74 which raises the $\overline{CS}$ and drops the SCLK. This falling SCLK causes the sample to be taken and starts the conversion. After the MCU senses the rising sample clock it waits for the conversion to be completed (44 ACLK cycles) and then initiates another data exchange, preparing the LTC1090 for the next sample. This cycle repeats.

4th Order Elliptic Filter

Using the circuit of Figure 1, a 4th order elliptic digital filter was implemented. 10 bit input and output data words and 14 bit coefficients were used with the same coefficients being used for each channel. A direct form II IIR filter was implemented according the following equations:

$$D(n) = [7203 \times D(n-1) - 19209 \times D(n-2) + 6324 \times D(n-3) - 4383 \times D(n-4)] \times 2^{-14} + X(n)$$

$$Y(n) = [3069 \times D(n) + 5505 \times D(n-1) + 7824 \times D(n-2) + 5504 \times D(n-3) + 3066 \times D(n-4)] \times 2^{-14}$$

where: $X(n)$ = filter input value
$Y(n)$ = filter output value
$D(n)$ = delay node value

The filter frequency response is shown in Figure 2. The cutoff frequency is 175Hz, one fourth the sample frequency of 700Hz. The cutoff frequency of the filter can be tuned by varying the frequency of the sample clock.

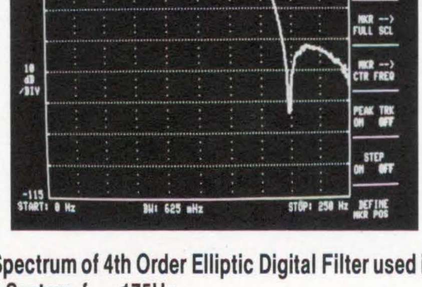


Figure 2. Spectrum of 4th Order Elliptic Digital Filter used in the Data Acquisition System, $f_C = 175Hz$

Because of 68HC05 speed and instruction set limitations, sample rate is limited by the MCU's ability to perform the DSP algorithm. Maximum sample rate was determined to be 700Hz for a single channel filter and 90Hz for eight channels. Using a high performance DSP would allow sample rates approaching the limit of 30kHz for one channel and 3.7kHz for all eight set by the LTC1090. Hopefully, this simple example will encourage the reader to pursue higher order, higher performance applications.

If large amplitude, unwanted AC signals are present on the inputs, a linear filter such as the LTC1062 can be used to remove them and prevent reduction in the dynamic range of the system.

Gated Measurements of Fast Signals

As an example of gated measurements, the circuit of Figure 1 was used with no filtering to repetitively sample a 5Vp-p 1MHz sine wave. The waveform was sampled at 15kHz (approximately one sample every 67 cycles of the 1MHz waveform). A 20ns pulse, triggered off the sample clock, was applied to the z-axis input of a storage scope to illuminate one dot on the CRT per sample. Samples were allowed to accumulate on the storage scope as shown in Figure 3. The upper waveform is the sampled input to the LTC1090 and the lower waveform is the sampled output of the DAC. (Remember that the waveforms are not real time: one dot was illuminated only every 67 cycles of the 1MHz sine wave.) With this technique the signal bandwidth of the LTC1090 sample and hold was determined to be 2MHz.

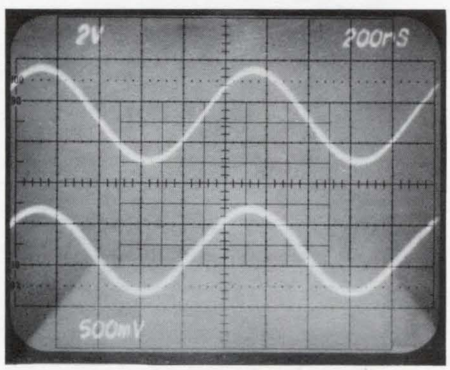


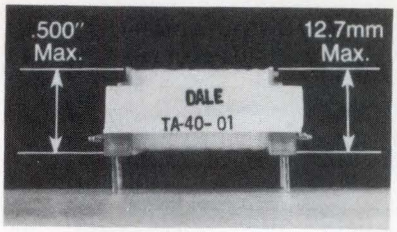
Figure 3. Input and Output Sample Points of a 1MHz Sine Wave Accumulated on a Storage Scope

Using the LTC1090 sample and hold, high speed circuits such as a 1MHz bandwidth AC to DC converter are possible. Because the acquisition time is less than 1µs it is also possible to make a gated measurement of the height of a pulse as narrow as 1µs to 0.1% accuracy.

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

Linear Technology Corporation
1630 McCarthy Boulevard
Milpitas, CA 95035-7487

LINEAR TECHNOLOGY



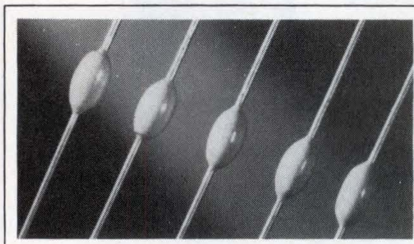
TRANSFORMER

- *Meets FCC Part 68 requirements*
- *Return loss equals 14 dB min*

Produced to meet the requirements of FCC Part 68, the TA-40-01 telephone-coupling transformer is suitable for data/voice applications. It handles as much as 90 mA of unbalanced dc current and has operating levels of −45 to +10 dBm. Using the level at 1.8 kHz as a reference, it has a frequency response of +0.2 to −1 dB from 500 to 3500 Hz, and +0.2 to −2 dB from 300 to 3500 Hz. Over a 500- to 1800-Hz range, the primary impedance match equals 600Ω±20%. The minimum return loss is 14 dB. $3.70 (100).

Dale Electronics Inc, 2064 12th Ave, Columbus NE 68601. Phone (602) 665-9301.

Circle No 355



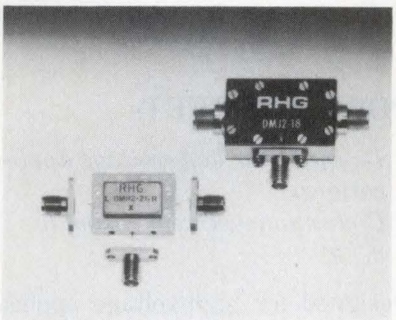
CAPACITOR

- *Accommodates bypass and coupling applications*
- *10-pF to 1-μF capacitance-value range*

The Mono-Axial capacitor is available in industry dielectrics of Class I (COG or NPO), Class II (X7R), and Class III (Z5U). The latter two are typically used for bypass and coupling applications. The capacitance value ranges from 10 pF to 1 μF in standard tolerances of ±5% (COG), ±10% (X7R), and ±20% (Z5U). The working voltages span 50 to 200V dc. The lead material is 24-AWG tinned copper-clad steel. The unit comes taped and reeled, per EIA RS-296E, to accommodate automatic-insertion equipment. $0.028 (1000) in production volume quantities. Delivery, 10 weeks ARO.

Mepco/Centralab Inc, 7158 Merchant Ave, El Paso, TX 79915. Phone (915) 779-3961.

Circle No 356



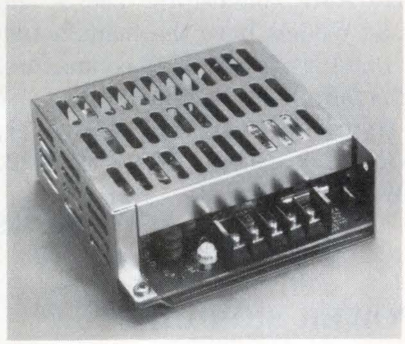
MIXERS

- *Designed for stripline assemblies*
- *2- to 26-GHz bandwidths*

The DMR and DMRH double-balanced mixers are housed in packages designed to drop into stripline microwave assemblies. They are also available with removable SMA connectors that simplify testing. The DMR units cover octave and multioctave LO/RF (local oscillator/radio frequency) bandwidths as wide as 2 to 26 GHz, having IF ranges of dc to 500 MHz. The DMRH mixers feature a 1- to 10-GHz IF range and offer LO/RF coverage of 4 to 18 GHz. Option H, which requires 13- to 16-dBm LO injection rather than the standard 10 dBm, is available on a total of nine mixer models. $575 to $1075 with option H. Delivery, 90 days ARO.

RHG Electronics Laboratory Inc, 161 E Industry Ct, Deer Park, NY 11729. Phone (516) 242-1100. TWX 510-227-6083.

Circle No 357



POWER SUPPLIES

- *Feature an input EMI filter*
- *Have 20-msec holdup time*

The Pony Series switching power supplies come in 14 models that deliver 15 to 30W. The supplies are enclosed units and are UL recognized and CSA certified. All models feature an input EMI filter, a 115V ac input voltage rating, built-in overvoltage protection, and a typical efficiency of 65%. The line regulation, from low to high line, is 0.4%; the load regulation (from no load to full load) is 1%. All models provide a minimum holdup time of 20 msec. $24.90 (1000).

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

Circle No 358

BACKPLANES

- *Feature multilayer construction*
- *Offer various power options*

These VSB (VME subsystem bus) backplanes are available in 3-, 4-, 5-, and 6-slot versions. They feature a multilayer, rigid laminated construction (with full ground and power planes) that minimizes signal interference. They connect to the J2 32-bit extension backplane via a lateral-coupling technique. The lateral coupler maintains the integrity of the connectors' center row of contacts across the VSB and J2 backplane interface. The backplanes are available with various power-input options. The 3- and 4-slot versions have AMP connectors. The 5- and 6-slot models have the manufacturer's 50A studs and AMP connectors. $238 for a 6-slot version.

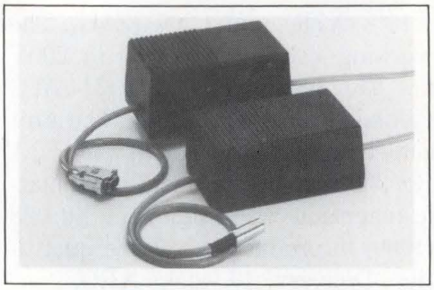
Hybricon Corp, Box 149, Ayer, MA 01432. Phone (617) 772-5422. TWX 710-347-0654.

Circle No 359

POWER SUPPLIES

- *25W power outputs*
- *1500V dielectric strength*

The X and Y desktop linear power supplies provide 25W of output power and are available in single- and multiple-output versions. The standard values are 5, 12, and 24V dc. The supplies offer input voltage ranges of 105 to 130V ac and 220 to 240V ac. Their dielectric strength is 1500V, and they operate over 0 to 40°C. The output regulation is 5%. The supplies are designed to UL, CSA, and VDE standards and feature short-circuit protection. The housings are made of durable fire-retardant plastic. $40 (100).

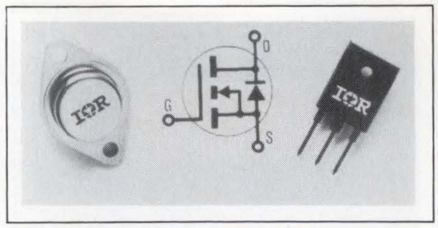


Jerome Industries Corp, 730 Division St, Elizabeth, NJ 07201. Phone (201) 353-5700. TLX 132001.

Circle No 360

POWER MOSFETs

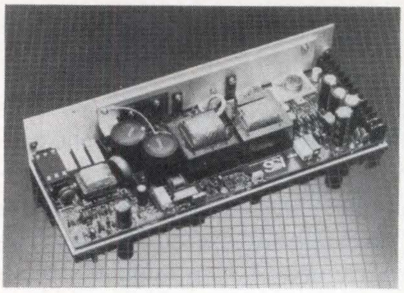
- *Designed for high-voltage applications*
- *Continuous current rating to 8.1A*



Designed for high-voltage applications, these power MOSFETs are available in two package styles. The IRFAE50, IRFAF50, and IRFAG50 are housed in the TO-3 packages and are rated at 800, 900, and 1000V, respectively. The similarly rated IRFPE50, IRFPF50, and IRFPG50 are housed in plastic TO-3P packages. On-resistance measures 1.2, 1.6, and 2Ω for the 800, 900, and 1000V units, respectively. Continuous-current ratings range from 5.25 to 8.1A for the TO-3 packages and 5.75 to 8.1A for the TO-3P-packaged units. $11 to $14 (1000). Delivery, 10 weeks ARO.

International Rectifier, 233 Kansas St, El Segundo, CA 90245. Phone (213) 607-8837.

Circle No 361



POWER SUPPLY

- *Designed specifically for hard-disk drives*
- *Features 50W main-output rating*

Designed specifically for hard-disk-drive applications, the quad-output SQV350 350W switching supply provides power for two 8-in. drives or as many as eight 5¼-in. drives. The unit features a 5V main-output rating of 10A. One of the three auxiliary outputs is rated for 12 or 24V at 16A pk to accommodate initial turn-on/spin-up loads. The remaining two outputs are rated at 5A each with 7A peak loads. The supply features built-in overload and overvoltage protection and remote sense capability. $251 (100). Delivery, three to six weeks ARO.

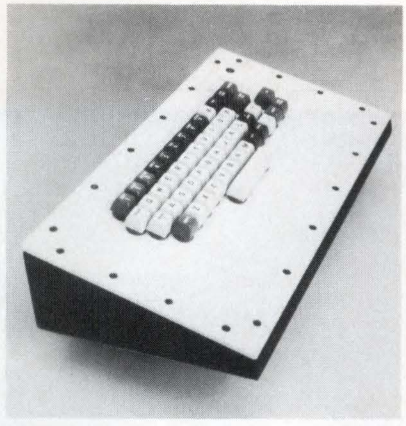
Switching Systems International, 500 Porter Way, Placentia, CA 92670. Phone (714) 996-0909.

Circle No 362

KEYBOARDS

- *Combine full-travel and snap-action keys*
- *Virtually impervious to EMI*

Using no adhesives of any kind, these custom military keyboards combine full-travel typewriter-style keys and snap-action function keys in a single housing. The units can be radiation hardened and are totally submersible and Tempest compatible. Both the individual key components are sealed and shielded so

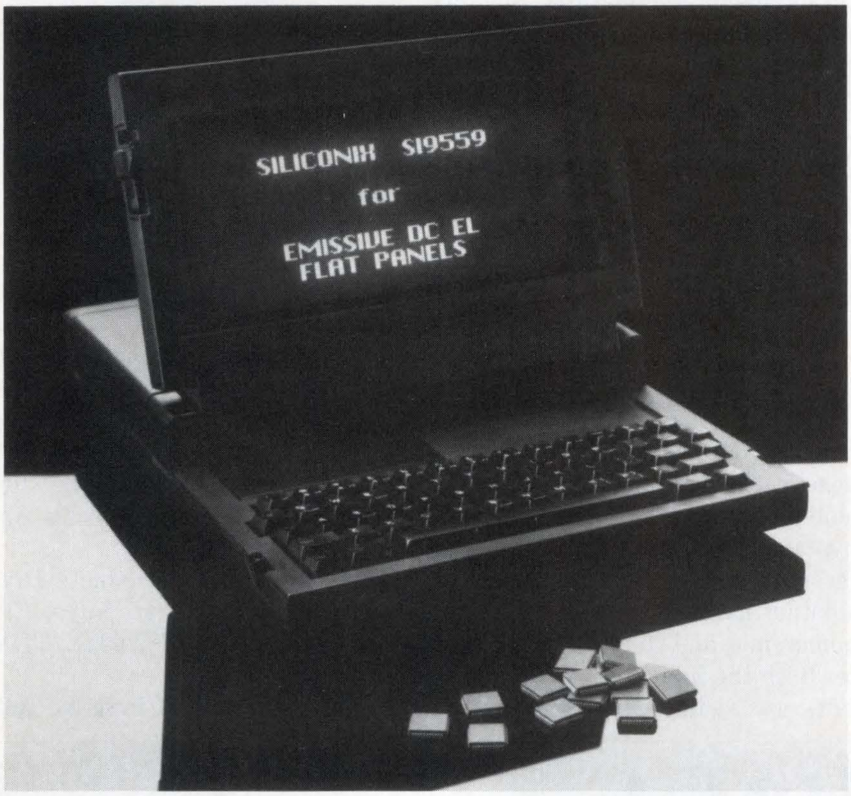


that they're virtually impervious to moisture, dust, and EMI. The keyboards are available with or without interface electronics, enclosures, bezels, faceplates, trackballs, joy sticks, displays, and other I/O options. From $1000 (100).

IEE Inc, Planar Products Div, 7740 Lemona Ave, Van Nuys, CA 91405. Phone (818) 787-0311. TLX 4720556.

Circle No 363

INTEGRATED CIRCUITS



DISPLAY DRIVER

- *90V-output capability*
- *0.1- to 1-mA constant-current outputs*

The Si9559 column driver suits dc, flat-panel displays such as the electroluminescent (EL) and gas-plasma types. Like the company's ac-display drivers, the Si9559 has 90V push-pull outputs. In addition, each output features a constant-current pullup that you can adjust from 0.1 to 1.0 mA. These pullups help control power dissipation and maintain uniform luminance in the display. The 32-channel device offers guaranteed operation and ±10% constant-current matching over the 40 to 90V supply range; thus, the chip remains compatible with an aging EL panel as the panel's light-emission-threshold voltage increases. The device also includes a pin that controls data flow through the shift register (left or right). This feature lets you install the chip for use on either side of the display panel. The device comes in a 44-pin plastic, J-lead, surface-mount package. $10.95 (100). Delivery, eight to 10 weeks ARO.

Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (800) 554-5565, ext 1400.

Circle No 364

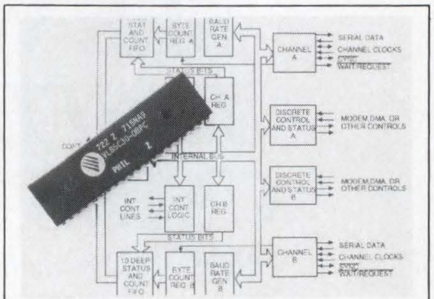
RAM CONTROLLER

- *Addresses 64M bytes*
- *Has adjustable control-signal pulse widths*

The DP8522 video RAM controller/driver can address and drive a 4M-bit video RAM array as large as 64M bytes. The video RAM controller, which is part of the company's advanced-graphics chip set, lets you choose memory components that best fit your system's requirements. The CMOS chip's control signals have adjustable pulse widths. This feature allows you to adjust the controller/processor interface to accommodate clock signals that span a wide range and exceed 20 MHz. The programmable chip supports dual-port video RAMs, and it allows dual access to the same memory bank by a second graphics controller, a CPU, a LAN, or a DMA controller. Additional features that enhance speed include programmable t_{RAH} (row-address hold) and t_{CAS} (column-address setup), and support of memory interleaving, which eliminates RAS (row-address strobe) recharge time. The DP8522 comes in a 68- or 84-pin plastic chip carrier. $28 (1000).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 749-7431. TLX 346353.

Circle No 365



CMOS CONTROLLER

- *Two independent full-duplex channels*
- *Supports direct memory access*

The VL85C30 is a CMOS serial-communications controller suitable for use with nonmultiplexed buses. Compatible with the industry-standard NMOS 8530, the chip includes two independent full-duplex channels, as well as a 14-bit byte counter and 19-bit-wide FIFO array that permit operation with a DMA controller. The device has facilities for modem controls in both channels. Further, it handles asynchronous formats, synchronous byte-oriented

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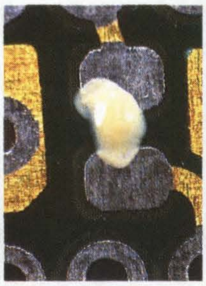
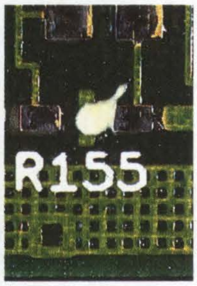


Won't migrate when heated. Assures good soldering results.



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protocols such as IBM Bisync, and synchronous bit-oriented protocols such as IBM HDLC (high-level data-link control) and IBM SDLC (synchronous data-link control). It supports DMA and serial-data-transfer applications, such as those on cassette, diskette, and tape drives. The device is housed in a 40-pin plastic or ceramic DIP, or a 44-pin plastic leaded chip carrier. In an 8- or 10-MHz version, $19 (500).

VLSI Technology, 10220 S 51st St, Phoenix, AZ 85044. Phone (602) 893-8574.

Circle No 368

MOTOR DRIVER

- *Drives bipolar stepper motors with currents to 1.5A*
- *Works with unstabilized motor-supply voltages to 45V*

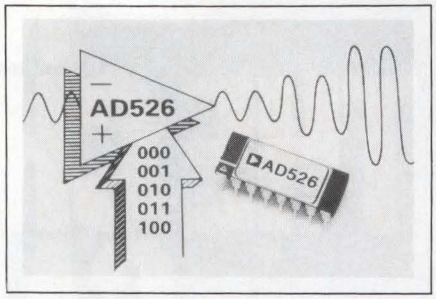
The TEA3718 stepper-motor driver IC controls the current in one winding of a bipolar stepper motor. The device provides facilities for half and full stepping, and it can control the motor-winding current over 5 mA to 1.5A from 10 to 45V supplies. It's suitable for use with unstabilized motor supplies. You can select the output current level in steps, or you can vary it continuously. Output-protection diodes are integrated in the output stage, and the driver has thermal-overload protection and an alarm output. Its control input is LS TTL compatible. The device is available in a DIP or a Powerpack package. The Powerpack device has a maximum output current of 1.5A; from a 40V supply, it dissipates 1.2W when delivering 0.5A, 1.5W when delivering 0.8A. $2.10 (1000).

Thomson Semiconducteurs, 45 Ave de l'Europe, 78140 Velizy, France. Phone (1) 39469719. TLX 204780.

Circle No 366

Thomson Components-Mostek Corp, 1310 Electronics Dr, Carrollton, TX 75006. Phone (214) 466-6000. TLX 730643.

Circle No 367



MONOLITHIC IA

- *Software-programmable gains*
- *0.01% max linearity error*

The AD526 is a single-ended, monolithic, programmable-gain instrumentation amplifier (IA) that provides gains of 1, 2, 4, 8, and 16. You can obtain additional gains of 32, 64, and 128 by cascading two AD526s. No external components are required. The FET-input stage provides a 150-pA max input bias current; the max input V_{OS} is as low as 0.25 mV (C grade). Laser trimming provides 0.01% gain error for gains 1, 2, and 4, and 0.02% gain error for gains 8 and 16. The linearity error is 0.01% max for all gains across the operating temperature range. The slew rate is 4V/μsec at low gains or 18V/μsec at higher gains. The settling time to within 0.01% is 2.1 to 4.1 μsec, depending on gain. The device is available in a 16-pin plastic or side-brazed ceramic DIP. Plastic J and K grades, $5.25 and $7.05, respectively, (100).

Analog Devices Inc, Box 9106, Norwood, MA 02062. Phone (617) 329-4700. TWX 710-394-6577.

Circle No 369

16-BIT μP

- *Multiple register banks ease bottleneck*
- *Register and memory storage in a 1k-byte RAM*

Suitable for application in industrial equipment control and office automation, the HD641016 16-bit μP has a RAM-based architecture that joins register and memory storage in a 1k-byte array. The chip's multiple programmable register banks

(sixteen 32-bit registers) alleviate the context-switch bottleneck encountered during subroutine jumps and during switching between interrupts. In response to an interrupt, the μP can execute a bank-switch instruction in less than 1 μsec. It also features a 1k-byte RAM that's used for general-purpose CPU registers and for high-speed data memory; a 4-channel DMA controller; a 16-bit, 2-channel timer; a 2-channel ASCI interface; an interrupt controller with 22 internal interrupt sources; a memory-access controller; and a clock generator. Intended for running C-language programs, the HD641016 is supported by a real-time in-circuit emulator and a complete development and debug system. It comes in an 84-pin PLCC or plastic pin-grid array. $75 for a sample. The IC will be available in the first quarter of 1988.

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

Circle No 370

ANALOG I/O PORT

- *Monolithic CMOS chip*
- *Contains a T/H amp, ADC, DAC, V_{REF}, and buffer*

The AD7569 combines an 8-bit A/D converter, an 8-bit D/A converter, a track/hold amplifier, a buffer amplifier, and a 1.25V bandgap reference on a monolithic chip that combines CMOS and bipolar transistors. The A/D converter converts in 2 μsec max with ±½LSB accuracy; the D/A converter's voltage output settles within ±½LSB in 1 μsec max. The device's data sheet specifies all ac and dc parameters. These parameters include a total unadjusted error of ±2 LSB max, a min 44-dB S/N ratio, and a typical intermodulation distortion of 55 dB (D/A) and 60 dB (A/D). A single command generates the S/H signal and initiates the conversion. The bus-access time is 75 nsec; the write pulse width is less than 80 nsec. The device consumes less than 60 mW and operates on a 5V supply (or, to handle bipolar signals, it can operate on ±5V supplies). Specified for the commercial, industrial, and military temperature ranges, the chip comes in a 24-pin plastic or ceramic DIP or a 28-pin LCC or PLCC. From $6 (100).

Analog Devices Inc, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565. TWX 710-394-6577.

Circle No 371

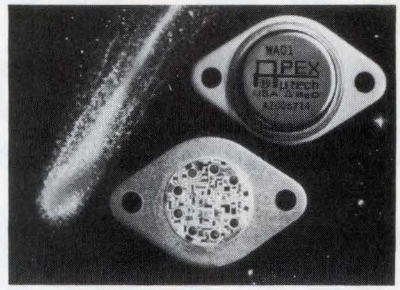
DUAL-PORT RAM

- *2k-byte×8-bit CMOS device*
- *55-nsec access time*

The V61C32 is a CMOS, dual-port static RAM that can provide asynchronous, simultaneous access to different memory locations without wait states. The device allows independent, asynchronous access to a common memory by two μPs, or access by a μP and a data bus to a common cache or buffer memory. Its power-down standby mode reduces the supply current to 100 μA max, and a battery-backup mode allows the chip to retain data when the power supply is as low as 2V. Different versions of the product are graded for 55-nsec, 70-nsec, and 90-nsec access times and for operation over the commercial, industrial, and military temperature ranges. The device comes in a 48-pin plastic or ceramic DIP or a 52-pin PLCC. From $18.90 (100).

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

Circle No 372



WIDEBAND AMPLIFIER

- *4000V/μsec slew rate*
- *150-MHz full-power bandwidth*

The WA01 is a hybrid transimpedance amplifier that comes in an 8-pin TO-3 package. The amplifier is suitable for use as a video amplifier, flash-converter buffer, or sample/hold stage. Its 400-mA output current allows the amplifier to drive a 100-pF load at 4000V/μsec. Its full-power bandwidth is 150 MHz. The device includes a 1.5-kΩ feedback resistor that sets the internal transimpedance gain at 1.5V/mA. In addition, the premium-grade version (the WA01A) specs a 5-mV V_{OS}, 25-μV/°C V_{OS} drift, and a 10-μA noninverting input bias current. WA01, $107.20; WA01A, $139.40 (100). Delivery, eight weeks ARO (100).

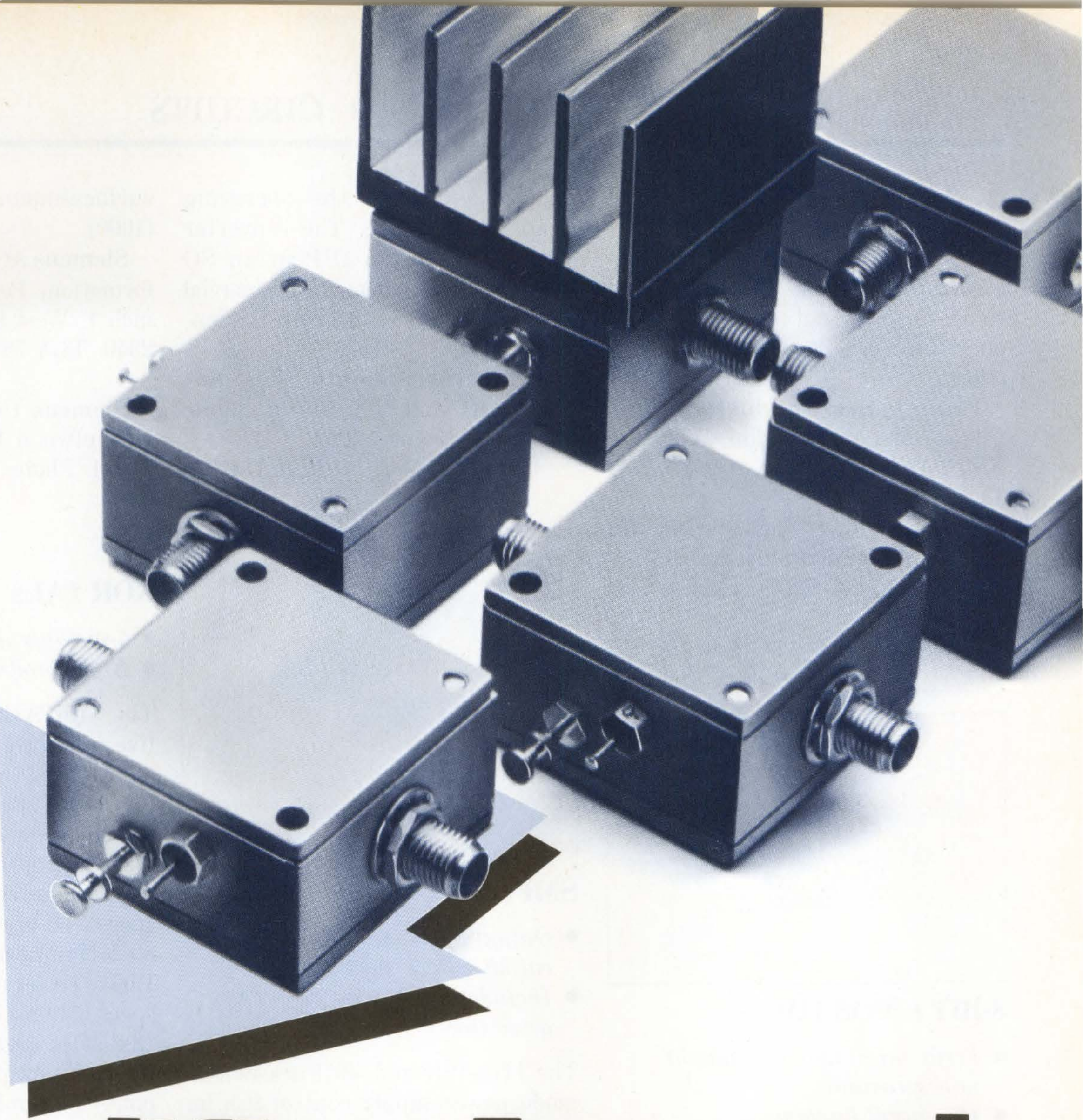
Apex Microtechnology Corp, 5980 N Shannon Rd, Tucson, AZ 85741. Phone (800) 421-1865.

Circle No 373

FLASH CONVERTER

- *Has a guaranteed clock frequency of 30 MHz*
- *Consumes less than 600 mW of power*

The SP97308E is an 8-bit flash A/D converter optimized for use in low-power, high-quality video systems, such as studio equipment and direct-broadcast satellite or high-resolution TV systems. The converter has a guaranteed clock frequency of 30 MHz, yet consumes less than 600 mW. Its typical differential and integral linearity is ±1/2 LSB, and the device maintains full accuracy to



Amplifier Arsenal

50KHz—2000MHz, Low Noise 100mW output Gain Controlled from $69.95

Our ZFL-2000 miniature wideband amplifier hit a bulls-eye when we introduced it last year. Now we've added more models to offer you a competitive edge in the continuing battle for systems improvement.

The ZFL-2000, flat from 10 to 2000MHz, delivers +17dBm output and is priced at only $219.

Need more output? Our ZFL-1000H, flat from 10 to 1000MHz, delivers +20dBm output.

Is low noise a critical factor: Our ZFL-500LN and 1000LN boast a 2.9dB NF.

Variable gain important? Our ZFL-1000G, flat from 10 to 1000MHz, delivers +3dBm output with 30dB gain control while maintaining constant input/output impedance.

Searching for a high-quality, low-cost amplifier? Our ZFL-500 flat from 50KHz to 500MHz, delivers +10dBm output for the unbelievable low price of only $69.95. Need to go higher in frequency? Consider the ZFL-750, from 0.2 to 750MHz, for only $74.95. Or the $79.95 ZFL-1000, spanning 0.1 to 1000 MHz.

One week delivery...one year guarantee.

SPECIFICATIONS

MODEL	FREQUENCY MHz	GAIN, dB (min.)	MAX. POWER OUTPUT dBm(typ)	NF dB(typ)	PRICE $ Ea.	Qty.
ZFL-500	0.05-500	20	+9	5.3	69.95	1-24
ZFL-500LN	0.1-500	24	+5	2.9	79.95	1-24
ZFL-750	0.2-750	18	+9	6.0	74.95	1-24
ZFL-1000	0.1-1000	17	+9	6.0	79.95	1-24
ZFL-1000G*	10-1000	17	+3	12.0	199.00	1-9
ZFL-1000H	10-1000	28	+20	5.0	219.00	1-9
ZFL-1000LN	0.1-1000	20	+3	2.9	89.95	1-24
ZFL-2000	10-2000	20	+17**	7.0	219.00	1-9

* 30dB gain control **+15dBm below 1000MHz

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C101 REV.C

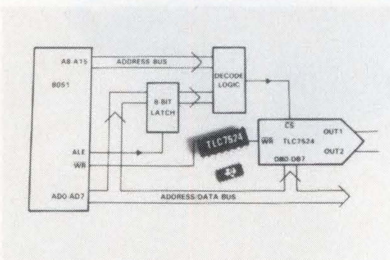
its Nyquist frequency limit. The converter features latched ECL-compatible outputs and an on-chip bandgap reference. The SP97308E comes in an 18-lead ceramic DIP and operates over −40 to +85°C. £25.26 (1000).

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

Circle No 374

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

Circle No 375



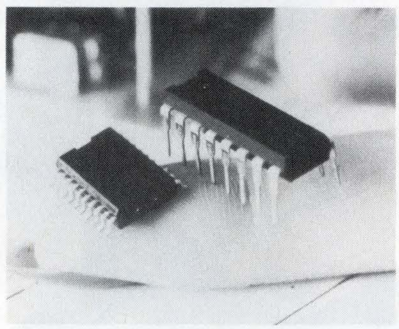
8-BIT CMOS DAC

- *Performs 2- and 4-quadrant multiplication*
- *Has input latches*

The TLC7524 8-bit CMOS D/A converter is pin compatible with similar products from Analog Devices, PMI, and Micro Power Systems, but can respond directly to fast control signals from the TMS320 family of DSP chips. The device includes an inverted R-2R ladder, analog switches, and input latches. For most applications, you must add an external op amp and a voltage reference. The device can perform 2- and 4-quadrant multiplication, which is useful for gain-setting and signal-control applications. Precision fabrication gives the converter a max linearity error of ½ LSB without the need for thin-film resistors or laser trimming. The converter's settling time is 100 nsec and its propagation delay is 80 nsec. It also features single-supply operation (5 to 15V), TTL and CMOS compatibility when used with a 5V supply, and monotonicity over the operating temperature range. The converter comes in a 16-pin DIP or an SO (small outline) package. Commercial version, \$3.26; industrial version, \$3.75 (100).

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

Circle No 376



SMPS IC

- *Output optimized for symmetrical MOSFET switching*
- *Includes an on-chip frequency generator*

The TDA-4918 and -4919 are switch-mode power-supply control ICs for push-pull and single-ended driver outputs, respectively. Their output stages are optimized for driving MOSFET power transistors, sinking a current of 1A to turn the MOSFET off, and sourcing 300 mA to turn it on. This asymmetrical drive current helps to match the turn-off and turn-on times of the MOSFET, so that the MOSFET switching is symmetrical, even at clock frequencies as high as 200 kHz. The ICs have an integral frequency generator that operates to frequencies as high as 300 kHz. In addition, the ICs have three on-chip comparators that monitor the supply's output for overvoltage and undervoltage conditions and provide dynamic current limiting. The ICs also provide soft-start facilities. The maximum supply current to the devices in standby mode is 2 mA. The TDA4918 comes in an 18-pin DIP; the TDA4919 is housed in a SO-20L surface-mount package. \$2.50 (1000).

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

Circle No 377

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

Circle No 378

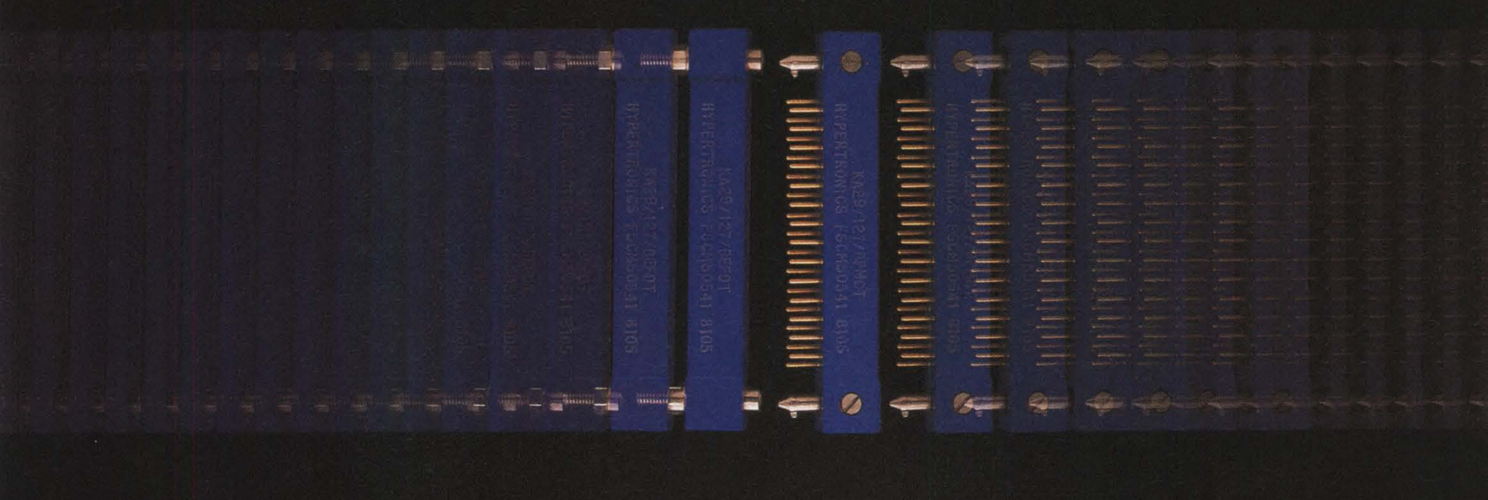
XOR PALs

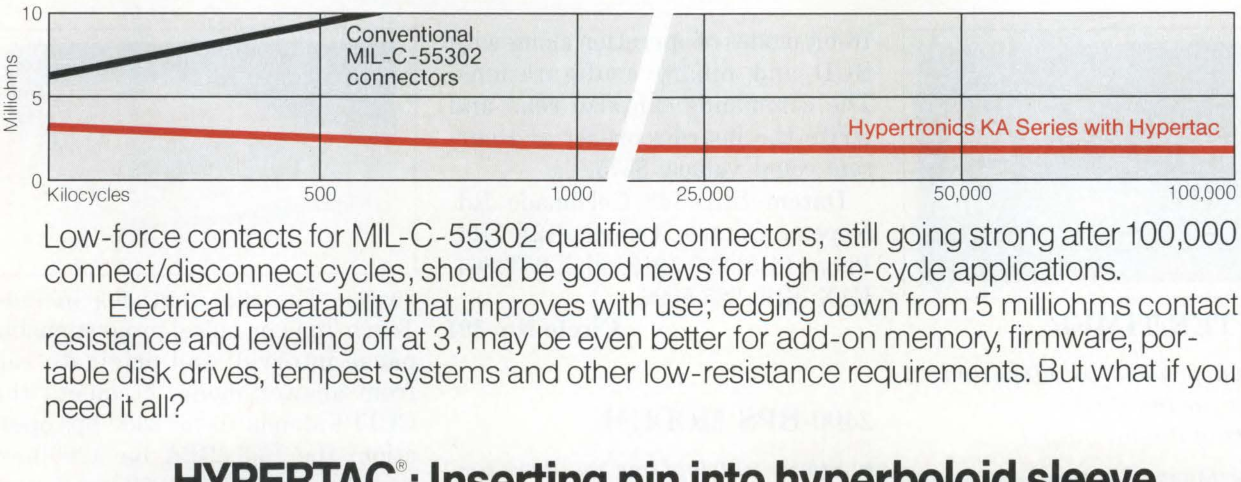
- *5-member family*
- *Eight product terms per output*

The AmPAL20XRPXX family of five exclusive-OR (XOR) programmable-array logic (PAL) devices offers more speed and power options than do comparable 24-pin industry-standard products. Among the AmPAL devices are a part that specs a 20-nsec propagation delay, a 30-MHz operating frequency, and 1.05W power dissipation; a part that specs a 30-nsec propagation delay, a 22.2-MHz operating frequency, and 900-mW power dissipation; and half-power (450 mW) versions that spec 30- and 40-nsec propagation delays. The parts can execute counter, comparator, and parity-checking functions in computers and peripheral systems. The output combinations include four registered and six combinatorial, six registered and four combinatorial, eight registered and two combinatorial, and 10 registered outputs. Each device features programmable polarity and eight product terms per output; one device has 22 inputs. Software support for the devices includes the ABEL, CUPL, and AmCUPL programs. The 24-pin devices come in plastic, ceramic, and surface-mount packages. In plastic packages, the 20-nsec version sells for \$9 and the 30-nsec version costs \$7 (100).

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

Circle No 415

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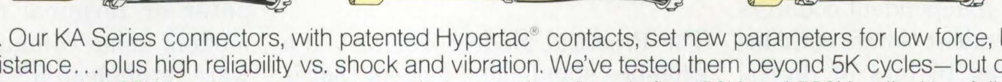
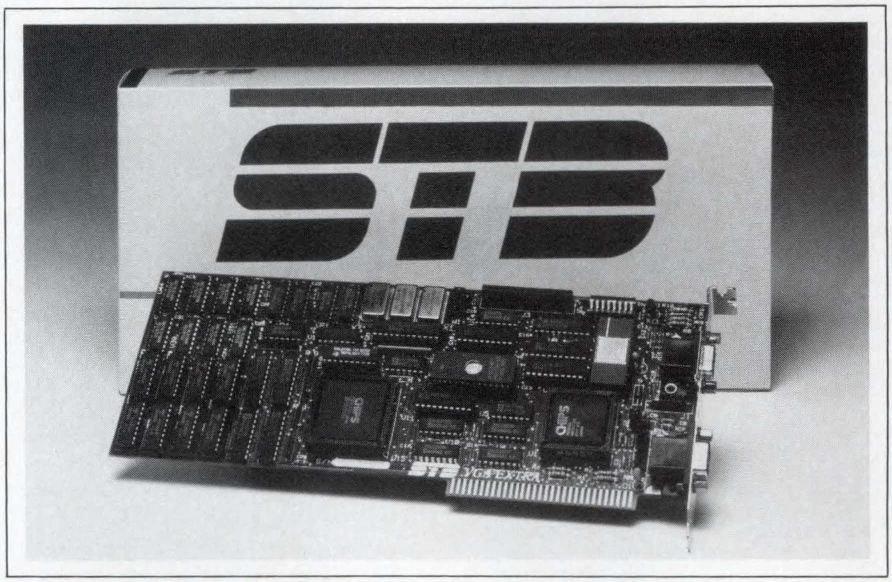


COMPUTERS & PERIPHERALS

GRAPHICS ADAPTER

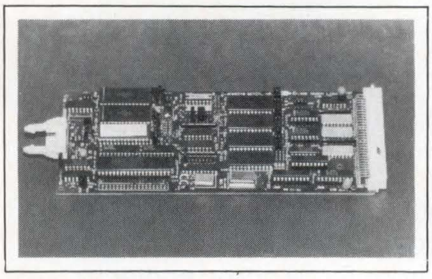
- *640×480-pixel resolution with two and 16 colors*
- *Compatible with EGA, CGA, MDA, and Hercules*



The VGA Extra is a plug-in board for the IBM PS/2 Model 30, as well as the IBM PC, PC/XT, and PC/AT. The adapter is compatible with all modes of IBM's Video Graphics ARRAY (VGA) standard. It provides VGA resolutions of 320×200 pixels with 256 simultaneous colors, as well as 640×480 pixels with two and 16 colors. All colors are available from a palette of more than 256,000 colors. The board also offers 640×480 pixels in 16 shades of gray; 320×200 pixels in 64 shades of gray; and high-quality 720×400 pixels (a 9×16 character cell). Besides being fully compatible with the EGA, the CGA, the MDA, and Hercules Graphics, the device provides a 132-column display with high-quality text (an 8×14 character cell) in spreadsheet and terminal-emulation applications. $495.

STB Systems Inc, 1651 N Glenville, Suite 210, Richardson, TX 75081. Phone (214) 234-8750.

Circle No 390



COUNTER/TIMER

- *Six independent counters and timers for the BitBus*
- *16 bits of digital output*

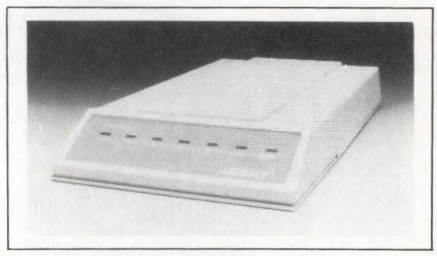
The dDCM345 is a Bitbus-compatible board for control applications requiring a counter/timer module. Each of its six independent counters and six independent timers contains 16 bits. It has 16 bits of digital output organized as 2 bytes and 24 bits of digital input organized as 3 bytes that provide bit and byte accesses to the I/O channel. Three independent 28-pin JEDEC sockets can support as many as 96k bytes of RAM or EPROM. The timer/counter commands can control 8- and 16-bit modes of operation along with BCD and binary configurations. The commands can also read and write the board's preset and current count values. $575.

Datem Ltd, 148 Colonnade Rd, Nepean, Ontario, Canada K2E 7R4. Phone (613) 225-5919. TLX 0533864. FAX (613) 225-5996.

Circle No 391

2400-BPS MODEM

- *Stores 10 telephone numbers for automatic dialing*
- *Has automatic answer and is Hayes compatible*



The Practical Modem 2400 SA is a 2400-bps stand-alone modem that is fully Hayes compatible. It can store as many as 10 telephone numbers for automatic dialing and has features such as an automatic answer mode, echoplexer, speaker volume, and half- or full-duplex operation. You select the number of times the phones rings before the modem answers. The dial features include Touch Tone or pulse; programmable pause interval; and originate call from answer mode. It meets the CCITT standards for 2400-bps operation, the Bell 212A for 1200-bps, and the Bell 103 for 300-bps operation. It operates with the Hayes command set, which allows a computer or terminal to control the modem using communication software through an RS-232C interface. The modem measures 10.5×5.5×1.3 in. and is designed to fit under a telephone. $239.

Practical Peripherals, 31245 La Baya Dr, Westlake Village, CA 91362. Phone (818) 991-8200. TWX 910-336-5431.

Circle No 392

"EDN NEWS DRIVES RIGHT TO THE HEART OF OUR MARKET."

Denise Piscitello
Advertising Manager
Industrial Electronic Engineers, Inc.

Denny Piscitello handles advertising for IEE's growing number of display products. Back in May 1986, she advertised in EDN News for the first time.

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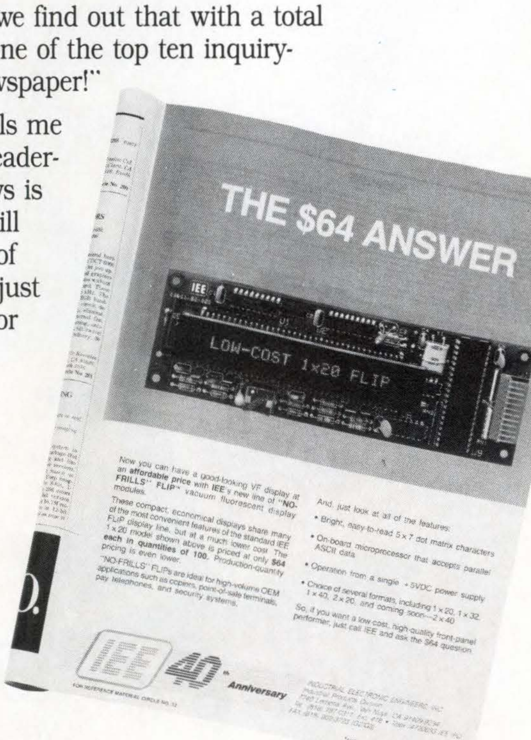
Says Piscitello, "This tells me that the all-important readership factor for EDN News is very high. EDN News will remain a valuable part of IEE's advertising team, just as EDN magazine has for more than 25 years."



Advertising in EDN News works for Industrial Electronic Engineers. It can work for you.

EDN NEWS

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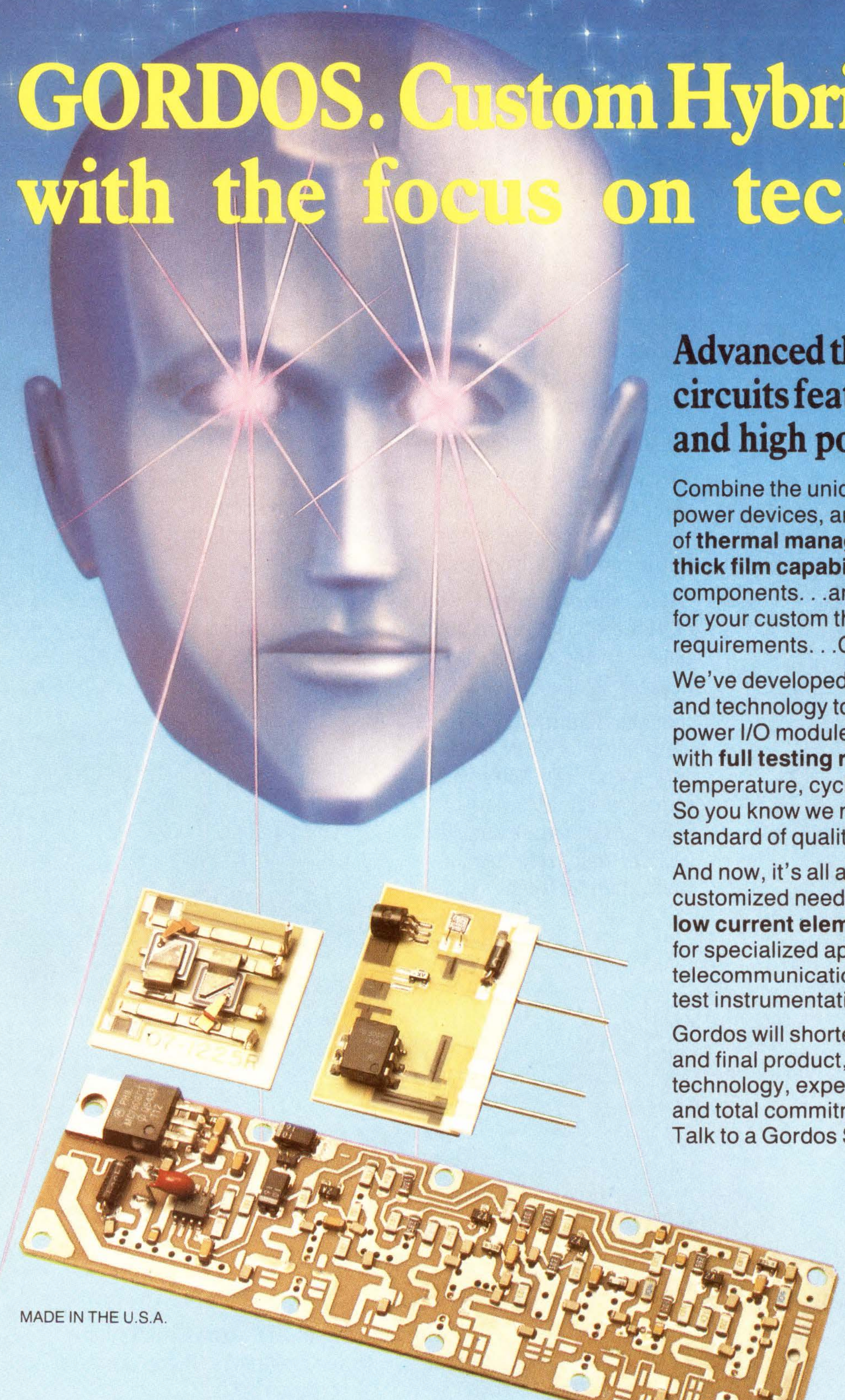
GORDOS. Custom Hybrid Circuits with the focus on technology.



Advanced thick film power hybrid circuits feature SM components and high power density.

Combine the unique experience in high current power devices, and the thorough understanding of **thermal management with total in-house thick film capability,** featuring surface mount components. . .and you have a superior source for your custom thick film hybrid circuit requirements. . .GORDOS!

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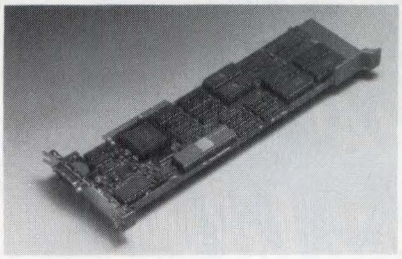
CIRCLE NO 75



ETHERNET ADAPTER

- *Links the IBM PS/2 50, 60, and 80 to a LAN*
- *Network control performed in a custom ASIC chip*

The NICps/2 is a card designed for the microchannel architecture used in the IBM PS/2 Models 50, 60, and 80 computers. It allows these computers to use an Ethernet LAN. The network interface controller uses an ASIC chip developed to fully exploit the computer architecture. The chip uses shared memory to maximize the speed of data transfers between the card's onboard RAM and the computer. No manual switches are needed because you can set port settings, memory locations, and interrupt levels by using the IBM programmable option select (POS) software and the software on the card. The board has a registered ID number from IBM. $495.

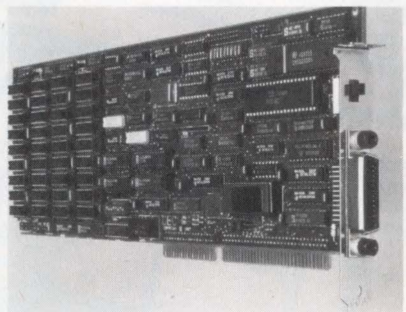
Ungermann-Bass Inc, 3900 Freedom Circle, Santa Clara, CA 95052. Phone (408) 496-0111.

Circle No 393

IEEE BOARD

- *Connects the IBM PC to the IEEE-488 bus*
- *Addresses 4M bytes of memory on one card*

The 4×488 board plugs into the IBM PC, PC/XT, PC/AT, or compatibles and has an RS-232C port, a parallel port, and an IEEE-488 interface. The board has a user-configurable space for 256k-bytes or 1M-byte of dynamic RAM, expandable to 4M bytes of onboard memory. Further memory extensions of 4M, 8M, 12M, or 16M bytes are possible with other boards, breaking the 640k-byte DOS barrier. The RS-232C port is user-configurable for DTE (data terminal equipment) or DCE (data communications equipment) operation, and the parallel port is an IBM-compatible Centronics-type port. The board features no-switch installation, configuration, and testing. The software assigns conventional or extended memory in 128k-byte increments. Memory-management software implements the Lotus/Intel/Microsoft expanded-memory specification. The board can also emulate Tektronix and Hewlett-Packard controllers. With no memory, $795; with 1M bytes of memory, $995.



Capitol Equipment Corp, 99 S Bedford St #107, Burlington, MA 01803. Phone (617) 273-1818.

Circle No 394

VME BUS BOARD

- *Software support of the IBM PC/AT on the VME Bus*
- *PC/AT bus is accessible through the P2 connector*

The VME-0286AT is a single dual-high Eurocard for the VME Bus that is software compatible with the IBM PC/AT. It runs MS-DOS while providing access to VME Bus resident boards. It has standard serial, parallel, and keyboard ports and can accept an optional daughter board

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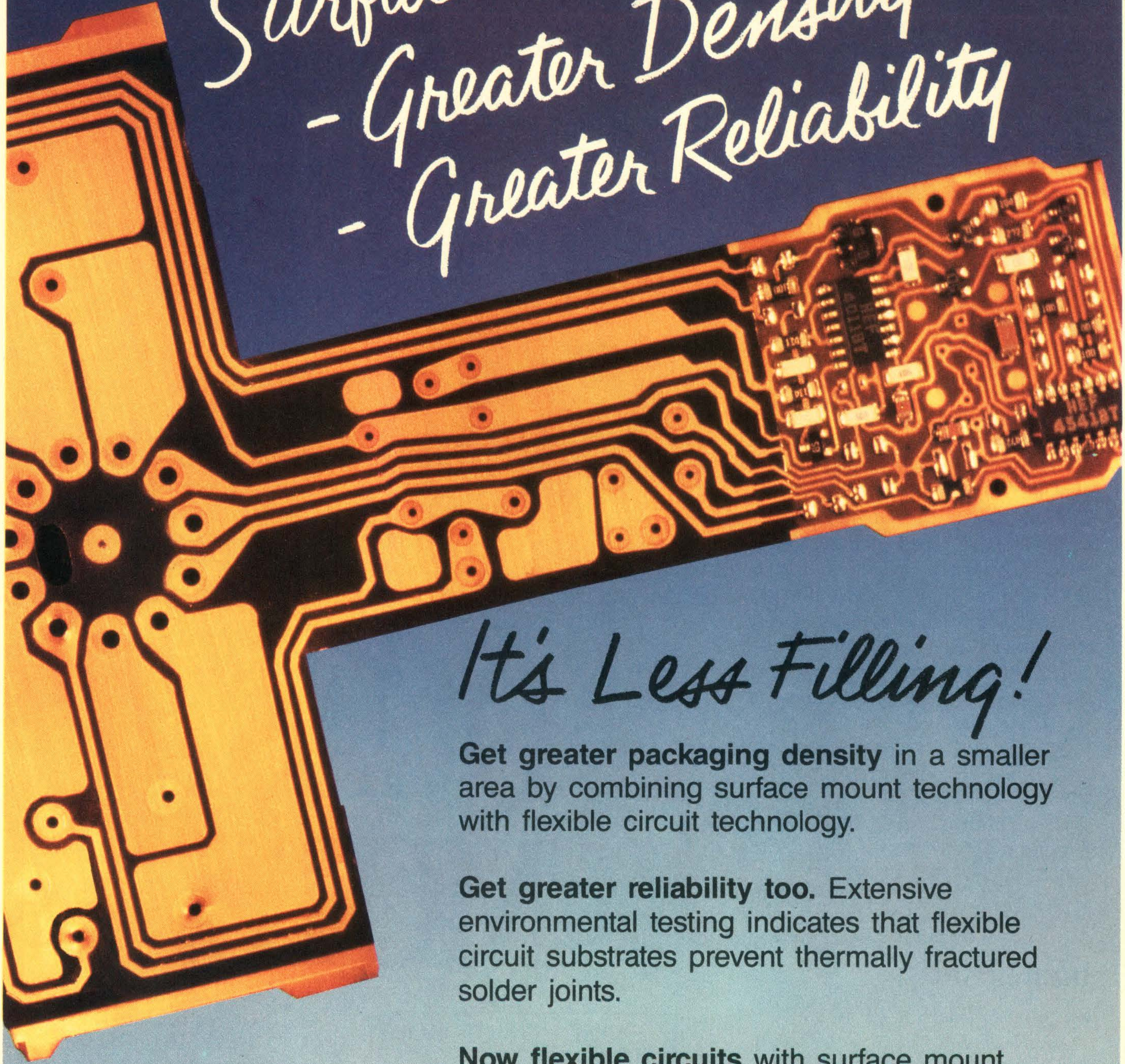

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Cirpack Design
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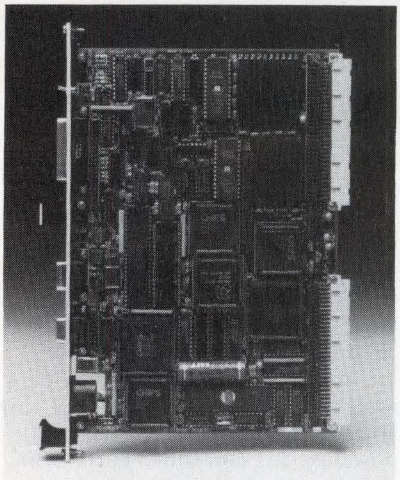
714/660-0541 • TWX: 310-371-7556

CIRCLE NO 76



for enhanced color and monochrome graphics. The board contains the following features: a P1 VME Bus Interface, A24/D16; a P2 IBM PC/AT bus interface; a 10-MHz 80286 μP; an 80287 coprocessor socket; a 1M-byte dynamic RAM dual-ported between the VME Bus and the 80286; and a socketed ROM BIOS (basic I/O system). By making the PC/AT bus accessible through the 96-pin P2 connector, a series of compatible support functions can be used. $2200.

Logical Design Group Inc, 6301 Chapel Hill Rd, Raleigh, NC 27607. Phone (919) 851-1101.

Circle No 395

DIGITAL READOUT

- *Stackable readouts operate with linear shaft encoders*
- *Functions and values selected with a joystick*

The Model LU10 digital readout is a stackable unit designed for use with Sony's Magnescale linear shaft encoders. It includes an amplifier for the encoder's magnetic head. When used to measure the multiaxis table displacement of metal-working machines, a primary unit serves as a power master, which distributes power to the auxiliary units stacked on top. The unit's μP has three days' battery back-up that prevents loss of displayed and preset values. You use a joystick to preset values. By pressing the joystick in four different directions, one of the seven segment digits can be erased, selected, incremented, or decremented. When all seven digits are preset, the values are stored in memory. The resolution is switch-selectable from 0.0005 mm to 0.01 mm in four steps. The unit is equipped with four audible alarms. Primary unit, $816; each auxiliary unit, $262.

National Machine Systems, 137 Bristol Lane, Orange, CA 92665. Phone (714) 921-0630.

Circle No 396

RAM DISK

- *As many as 512k bytes of portable mass storage*
- *Compatible with HP-IL controllers*

The HP-IL RAM disk is a portable mass-storage device available in sizes of 128k, 256k, and 512k bytes. The RAM disk measures 1.2×3.8×5.7 in. and stores data electronically without any moving parts. Powered by a 9V battery, it is

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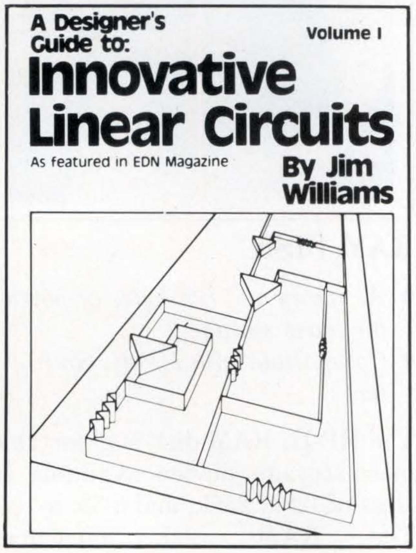

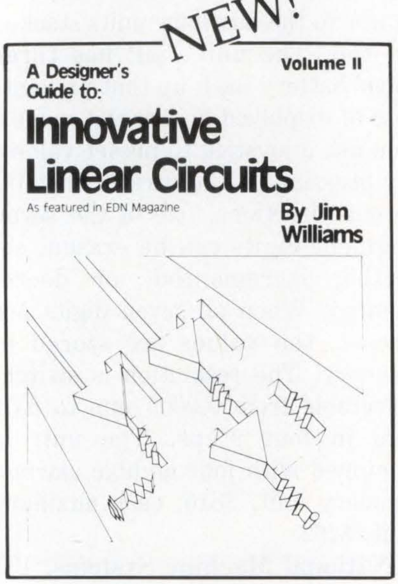

A Designer's Guide to Linear Circuits—VOLUME I
This original, 186-page collection by Jim Williams offers a wealth of analog design information. It includes practical and efficient ways to use op amps, comparators, data converters, and other analog ICs, and discusses the theories behind all the design techniques presented.

A Designer's Guide to Innovative Linear Circuits—VOLUME II
The reader response to Volume I was so positive, that we're offering Jim Williams' latest analog design articles —from 1983 to 1986—in an all-new Volume II. An even bigger collection than before, Volume II is still written in the language of working engineers, but now covers the newest and more complex circuits and systems *you* asked for! 266 pages.

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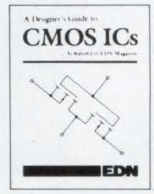

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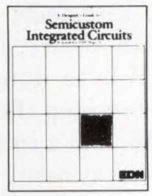

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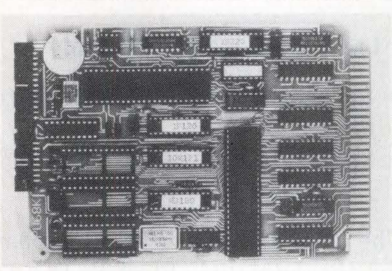
compatible with the following HP-IL controllers: HP-41, HP-71, HP-75, HP-110, HP Portable Plus, and an IBM PC or compatible with an HP-IL card installed. Multiple RAM disks (as many as 30 drives) can be used on the HP-IL Loop. The command set is compatible with the HP 82161A digital cassette drive. An optional RS-232C interface uses a DB-9 connector to emulate the HP 82164A HP-IL/RS-232C interface. It can transfer data at rates as high as 19.2k baud and supports XON/XOFF and ENQ/ACK transfers. From $345 (128k-bytes) to $895 (512k-bytes).

Corvallis MicroTechnology Inc, 895 NW Grant Ave, Corvallis, OR 97330. Phone (503) 752-5456.

Circle No 397



PROCESSOR BOARD

- *Provides 16-bit features for STD Bus*
- *Operates with OS-9/68K operating system*

The CPU-69K8 is a processor board that gives you a 16-bit upgrade on the STD Bus. The board operates with the OS/968K real-time operating system from Microware (Des Moines, IA). It features a 10-MHz 68008 μP with a 1 M-byte linear addressing space and a 68901 multifunction peripheral chip. The board has a programmable serial port, an 8-bit parallel port, two multimode timers, and a battery-backed real-time clock. Three sockets provide space for as many as 192k-bytes of onboard memory. You can obtain battery backing for the static RAM as an option. The board can handle both polled and vectored interrupts. The OS-9/68K real-time operating system is available for software development. CPU-68K8, $371 (100); OS-9 software package (including a C compiler), $600.

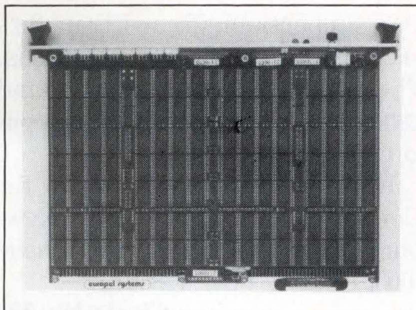
XYZ Electronics Inc, Box 322, Indianapolis, IN 46236. Phone (317) 335-2128.

Circle No 398

RAM BOARD

- *16M bytes of CMOS static RAM*
- *Can be formatted as single or paged memory blocks*

The COSMOS-16 is a double-Eurocard VME Bus memory board that provides as much as 16M bytes of CMOS static RAM with battery backup. To achieve this memory capacity, the board uses extensive surface-mount technology, and a piggybacked board assembly. It still only occupies one VME Bus slot width. The board's read access time (specified from the VME bus ad-



dress setup time) is 100 nsec. You can configure the board as a contiguous 16M-byte memory block on any 16M-byte address boundary, or as sixteen 1M-byte pages on 1M-byte boundaries. In addition, you can protect individual blocks from write access, supervisor access, or all bus accesses, by using front panel switches, hardwire jumpers on the board's P2 connector, or software programmable control registers. The board's VME Bus (Rev C) interface supports 16- or 32-bit data transfers, and 16-, 24-, or 32-bit addressing. The VME Bus interface also supports unaligned transfers and address pipelining operations. The 16M-byte board costs around £8000. It is also available depopulated to 2M or 9M bytes.

Europel Systems Ltd, 5 Vo-Tec Centre, Hambridge Lane, Newbury, Berks RG14 5TN, UK. Phone (0635) 31074. TLX 848507.

Circle No 399

TEXT CONVERTER

- *Converts text to speech*
- *Works on software that sends ASCII code to printer*

The Smart Speaker is a text-to-speech converter that connects to any computer having a standard parallel or serial port. It works with any software that puts out ASCII code to drive a printer. Because it can share the printer port via a built-in switch, it doesn't require an additional I/O port. The product converts ASCII text to speech and speaks it out through a built-in speaker. Numbers and text separated by spaces or periods are spelled out. The text-to-speech algorithm accepts data in formats that printers accept so that no special software is required. The converter can drive an external amplifier, VCR, audio tape recorder, or phone answering system. An external speaker can also be connected. It is available with a parallel-printer cable and power supply for $229.95.

Swisscomp Inc, 5312 56th St, Tampa, FL 33610. Phone (813) 628-0906. TLX 517399.

Circle No 400

CONTROLLER BOARD

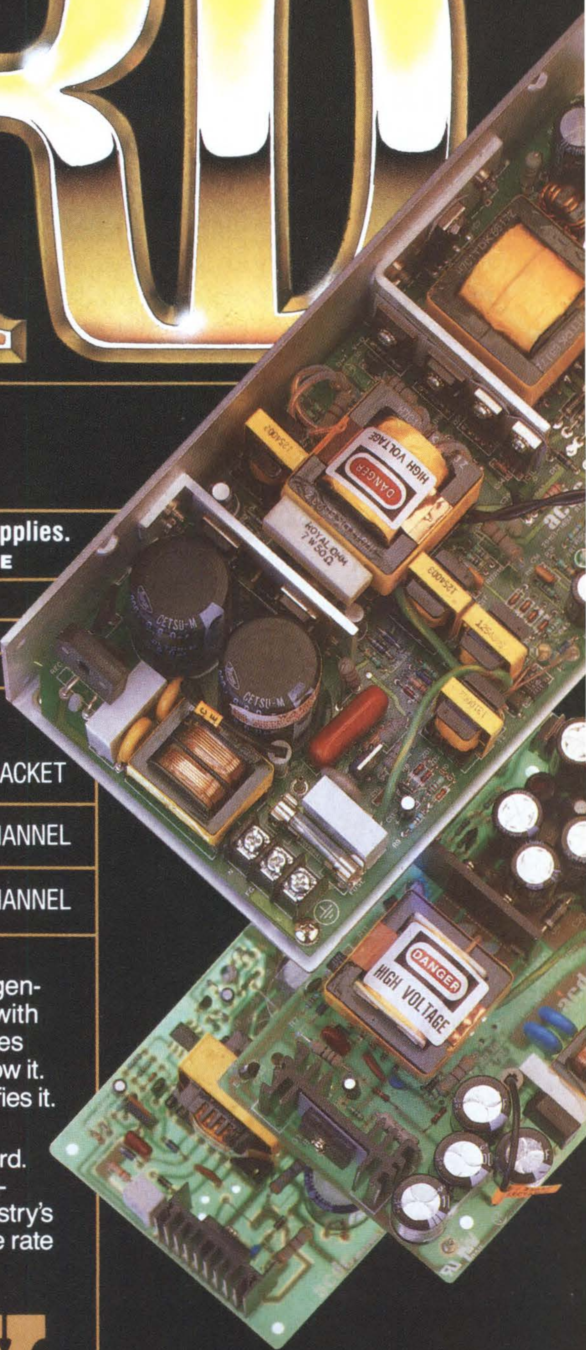
- *Provides IBM PC-compatibility for Superplot 80*
- *Supports software for Houston Instrument plotters*

The TAC-385 is a controller board for the IBM PC, PC/XT, PC/AT, and compatibles that provides turnkey operation of the company's Superplot 80 thermal printer/plotter. It is a full-length board that provides a bridge between existing graphics software and the Superplot 80. It supports software for Houston Instrument or HPGL plotters. The board can do vector-to-raster graphics and can store graphics data on a first-in, first-out basis. It can print multipage plots as long as 163 in. Controller board and Superplot 80 printer/plotter, $2400.

Gulton Industries Inc, Graphic Instruments Div, Gulton Industrial Park, East Greenwich, RI 02818. Phone (800) 332-3202; in RI, (401) 884-6800. TWX 710-387-1500.

Circle No 408

HARD



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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	L BRACKET
135	+5V/15A	+15V/3.2A	−15V/0.7A	−5V/0.7A	RBQ 132	L BRACKET
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

HARD TO BEAT

- UL, CSA, IEC 380/VDE 0806
- Replaceable Internal Fuse
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- 115/230 VAC Selectable Input
- Full power convection cooled

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CIRCLE NO 91

NEW PRODUCTS

TEST & MEASUREMENT INSTRUMENTS

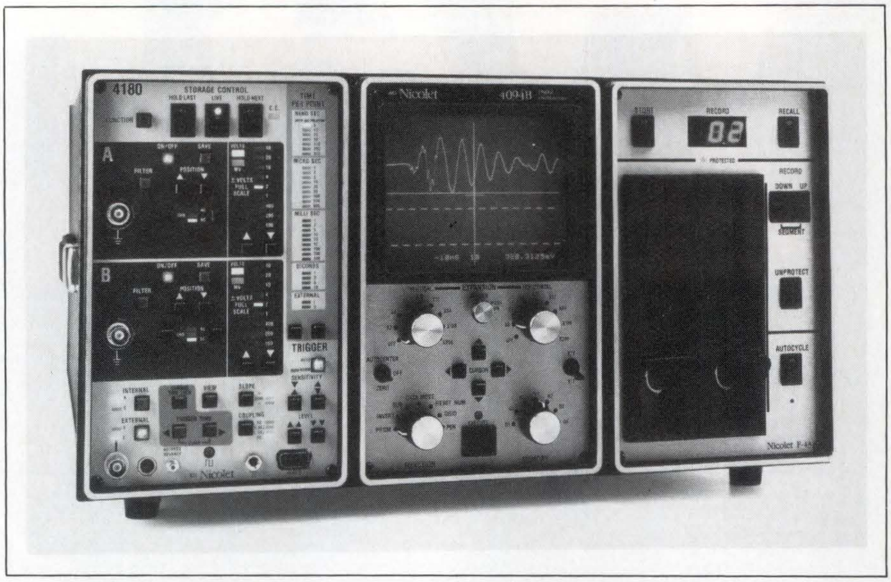
DIGITIZING PLUG-IN

- *Digitizes at 200M samples/sec*
- *Performs waveform analysis*

The 4180 digitizing plug-in for the vendor's 4094 digital oscilloscope provides simultaneous 8-bit digitizing at 200M samples/sec. You can install two 4180s in a 4094 mainframe; the plug-ins feed a 16k-sample/channel max sample memory. The digitizer can perform waveform analysis, including FFTs. Delivery, four months. $7900.

Nicolet, Test Instruments Div, Box 4288, Madison, WI 53711. Phone (608) 273-5008.

Circle No 379



HANDHELD SCOPE

- *Functions as digital oscilloscope, DMM, and counter*
- *Is autoranging in all modes*

The Scout SC01 is a handheld, multipurpose instrument. As a scope, it has two input channels with 20M-sample/sec, 7-bit digitizers backed by 256-byte sample memories. The 25-oz, battery-powered instrument measures 10×4×1.5 in., and its 3×3-in. LCD has a 128×128-pixel resolution. It also works as a 7-MHz frequency counter and as a dual-channel DMM. The device is autoranging in all measurement modes and can perform simple waveform analysis on captured traces. $1995.

Dolch American Instruments Inc, 2029 O'Toole Ave, San Jose, CA 95131. Phone (408) 435-1881.

Circle No 380

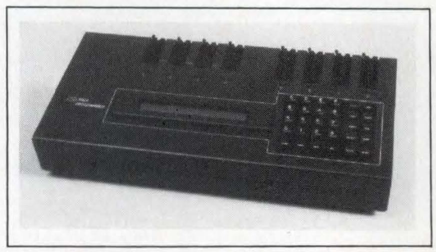
MULTIBUS II DEVELOPER

- *Development systems handle six to 12 users*
- *Comes with real-time operating system*

Two models of a Multibus II development/execution system called the Multibus II Modules Development Platform use 80386 µPs and come with the vendor's iRMX 286 real-time operating system. Model I supports six users and comes with one CPU board, 4M bytes of onboard RAM, an 80M-byte Winchester drive, a 60M-byte streaming tape drive, a 1.2M-byte floppy-disk drive, and a 6-port terminal controller. Model II supports six additional users and provides a second CPU board, hard disk, and terminal controller. Similar versions are available that run Unix V.3. System software includes the 80286 assembler, an editor, system-builder utilities, and the firm's proprietary high-level language, PL/M 286. Model I, $37,000; Model II, $45,000.

Intel Corp, Literature Dept W385, Box 58065, Santa Clara, CA 95052. Phone (800) 548-4725.

Circle No 381



GANG PROGRAMMER

- *Accommodates 8M-bit EPROMs/EEPROMs in set, gang mode*
- *Can be upgraded to program PLDs, biploar devices*

The Model 8606 EPROM/EEPROM programmer has eight sockets and accommodates byte-wide and 16-bit word-wide devices. It can program in gang or set mode and handles devices with 1k- to 8M-bit capacities. You can use the programmer as a stand-alone unit or operate it by remote control. Internal data RAM

is 4M bits and is battery backed. You can upgrade the device to a Model 8608 PLD and bipolar-device programmer. The vendor provides free software updates for three years. $2500.

Sherman Pirkle Inc, 782 Massachusetts Ave, Lexington, MA 02173. Phone (617) 861-6688.

Circle No 382

PROGRAMMER/ADAPTER

- *PLD-programmer adapter handles EPROMs*
- *Replaces PLD adapter*

An EPROM adapter for the Model 60A PLD programmer enables the unit to accommodate 120 EPROM types. It supports 28-pin EPROMs. The plug-in adapter replaces whichever PLD adapter you have installed in your programmer. You can make EPROM updates by changing PROMs in the unit. Model 60A with EPROM adapter, $2495. The adapter is also available separately.

Data I/O Corp, Box 97046, Redmond, WA 98073. Phone (206) 881-6444. TLX 152167.

Circle No 383

64180 μP EMULATOR

- *Has 4k-sample trace buffer*
- *Runs at clock speeds to 8 MHz with no wait states*

The Ice-Engine/m-64180 emulates the 64180 μP, an enchanced Z80-like single-chip μP. The emulator runs at clock speeds to 8 MHz with no wait states and features a pair of 32k-byte RAM banks that are mappable over the chip's 1M-byte address space. It has a 4k-sample trace buffer, 99 breakpoints, and one range breakpoint. $3495.

Ziltek Corp, 1651 E Edinger Ave, Santa Ana, CA 92705. Phone (714) 541-2931.

Circle No 384

NETWORK ANALYZER

- *Covers the 10-MHz to 40-GHz frequency range*
- *Prints out test results without controller*

The 561 network analyzer measures the transmission, return loss, and power of RF and microwave components over a frequency range from 10 MHz to 18 GHz, 26.5 GHz, or 40 GHz (depending on the model) without a controller. Its dynamic range is −55 to +16 dBm, and its noise floor is −62 dBm typ. The measurement resolution is 0.005 dB. The analyzer has a buffer memory that allows tests to proceed while previously taken data prints out. You need to normalize the instrument only once for a given setup. The unit can average repeated measurements, and it provides seven on-screen cursors. $7900. Delivery, 90 days ARO.

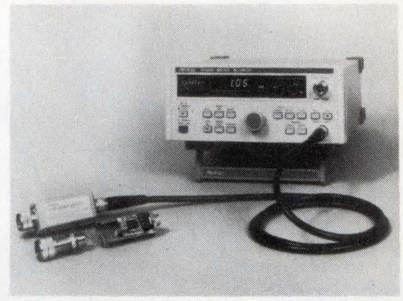
Wiltron Co, 490 Jarvis Dr, Morgan Hill, CA 95037. Phone (408) 778-2000.

Circle No 385

POWER METER

- *Covers the 50-MHz to 26.5-GHz frequency range*
- *Requires only one sensor*

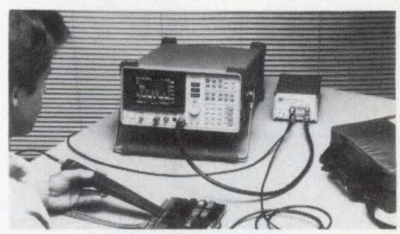
The ML4803A microwave power meter covers the frequency range from 50 MHz to 26.5 GHz and has a



dynamic range of −70 to −20 dBm. You need only one sensor diode for these ranges. The instrument reads out in W, dBm, or dB in absolute or differential modes. The front panel features both an LED display and an analog meter. The instrument has a built-in, 50-MHz calibration source. An IEEE-488 interface is standard. ML4803A, $2825. Sensors: amorphous, $550 to $1200; diode, $840 to $1315; millimeter waveband, $1900 to $6600.

Anritsu America Inc, 15 Thornton Rd, Oakland, NJ 07436. Phone (800) 255-7234; in NJ, (201) 337-1111.

Circle No 386



EMI FINDER

- *Analyzer and near-field probe combo find EMI hot spots*
- *Probes alone suit any RF analyzer*

The HP 8590A option H51 RF spectrum analyzer and the HP 11945A close-field probe set help engineers find EMI hot spots during EMC testing. The optional analyzer displays magnetic-field strength in dBμA/m. The analyzer compensates for the probe's antenna factors. You can store as many as three traces in the analyzer's memory to see if you are decreasing the EMI of the unit under test. The probe set comprises

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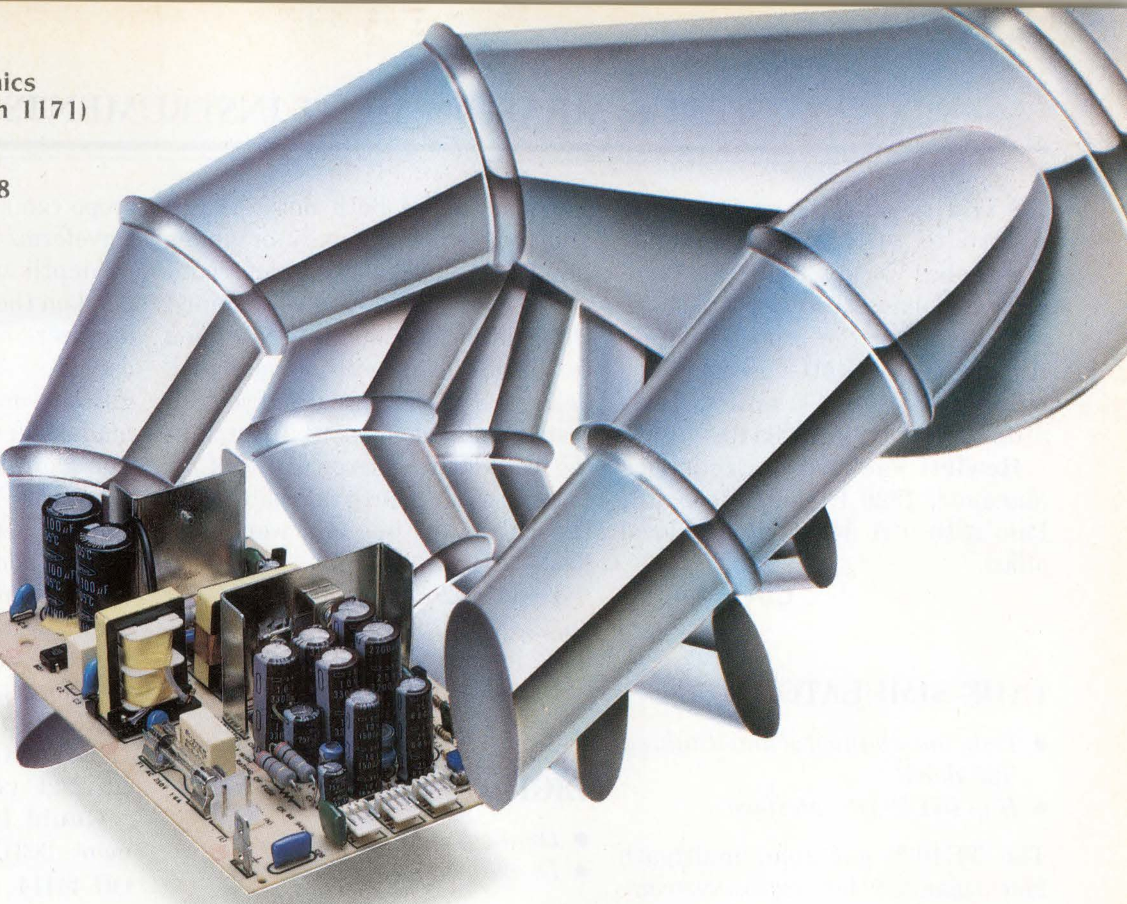

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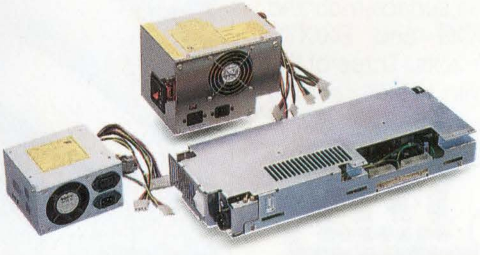
Our R&D customizes a standard model or generates a 100% original design in a lead time worth switching for!



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Taiwan Liton Electronic Co., Ltd.
12th Fl., 25 Tunhwa S. Rd Taipei, Taiwan, ROC
Tel: (02) 771-4321/8 Fax: 886-2-751-1962
Tlx: 24514/20211 TWLITON

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a 9-kHz to 30-MHz probe and a 30-MHz to 1-GHz probe. The passive probes work with any RF analyzer and have type-N connectors. You can power the probes from an RF source for EMI susceptability testing. HP 8509A option H51, $10,250; HP 11945A, $1110.

Hewlett-Packard Co, Inquiries Manager, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 387

FADE SIMULATOR

- *Tests one channel without taking link down*
- *Has IEEE-488 interface*

The TE1000 portable, multipath fade simulator for microwave-communications testing checks digital radios for multipath-distortion effects. It injects this distortion into the IF section of the receiver. You can manipulate both notch depth and frequency manually or under program control, and you can record these values once you've attained the appropriate bit-error rate. You can plot results with an interpath delay as long as 25 nsec, and you can test specific channels without taking the entire microwave link off line. The unit is programmable over the IEEE-488 bus and weighs 45 lbs. $32,500.

Tekelec, 26540 Agoura Rd, Calabasas, CA 91302. Phone (800) 835-3532; in CA and AK, (818) 880-5656.

Circle No 388

DIGITAL SCOPE

- *Digitizes input signals*
- *Displays analog waveforms*

The 1604 4-channel hybrid analog/digital oscilloscope has two 20M-sample/sec digitizers that feed individual 10k-sample memories. The scope can also show 20-MHz analog waveforms in real time. The memory depth and digitizing speed depend on the number of channels the digitizers have to service. A glitch-capture feature logs 50-nsec glitches, and the instrument's maximum time resolution is 50 nsec/div. You can delay triggering until as many as 16k events have been counted. An optional keypad and plug-in nonvolatile memory enable the instrument to perform elementary signal processing. Plug-in memories can store as many as 50 waveforms. The scope has an automatic-setup button, as well as an IEEE-488 interface bus and two RS-232C ports. $5590.

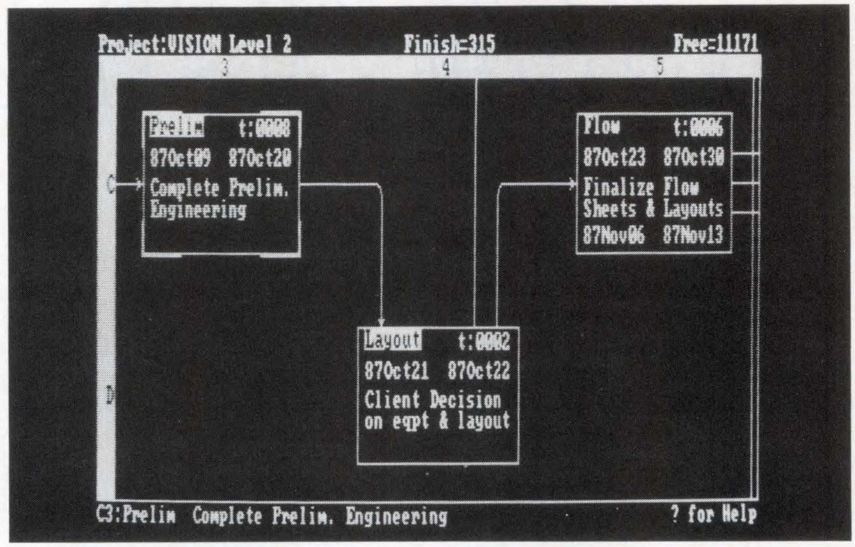
Gould Inc, Test and Measurement, 3631 Perkins Ave, Cleveland, OH 44114. Phone (216) 361-3315.

Circle No 389

CAE & SOFTWARE DEVELOPMENT TOOLS

PROJECT PLANNER

- *Generates critical-path and Gantt charts*
- *Calculates cost breakdowns*



Project:Vision Level 2 is an enhanced version of the vendor's project-planning software package, which runs on IBM PCs and compatible computers. This package's resource- and cost-scheduling capabilities complement the time and activity functions of the earlier version. Using a spreadsheet-style interface, you can allocate resources (people, equipment, and materials) to all of the simultaneous or sequential tasks that constitute a complete project. You can assign precedence to each task and specify the relationships between tasks. The program identifies tasks that, if delayed, would slow down the whole project, as well as tasks whose start and finish dates are more flexible. Five levels of scrutiny allow you to survey the overall situation or to focus on two or three individual tasks. You can display a Gantt chart showing how your time, material, and money use varies with each task; a built-in text editor lets you document each activity in detail. You can also export project information to other spreadsheet and database programs for further processing. To run the program, you need an IBM PC or compatible computer with at least 256k bytes of RAM, a Hercules or IBM graphics adapter (CGA or EGA), and an Epson FX-80, FX-100, or equivalent printer. $349.

Inmax Corp, 200 W Thomas, Suite 110, Seattle, WA 98119. Phone (800) 922-7774; in WA, (800) 648-7775.

Circle No 409

C CODE GENERATOR

- *Translates applications from database language to C*
- *Lets you search multiple databases*

Quic-PRO 5 is a software-development package that provides a fourth-generation database language, an applications generator, a query language, a report generator, a C translator, a C compiler, and a file handler. You develop your database applications with the aid of the event-driven interpretive database language and the applications generator; these modules include more than 100 high-level commands and a screen painter. The query language lets you access multiple databases in any relation. It also provides logical selection of items to be matched and retrieved; provides totals and subtotals of selected items; gives highest, lowest, and average values of selected items; and lets you format and print mailing labels. The report generator provides extensive sorting and formatting capabilities for special reports and has 255 accumulators that you can use for totals and subtotals. The C translator converts 100% of the development-language code to C source code and creates a batch file that permits compiling and linking of complete application programs without operator intervention. The C compiler provides all Kernighan and Ritchie features of the language, as well as the extensions specified by the proposed ANSI standard. The single-user version operates on any hard-disk system that has at at least 512k bytes of RAM and that runs PC-DOS, MS-DOS, or Concurrent PC-DOS. The multiuser version operates on systems that run Novell Netware, IBM PC Network, Concurrent PC-DOS, or MUCDOS. Single-user version, $199.95; multiuser version, $600.

QNE International, 136 Granite Hill Ct, Langhorne, PA 19047. Phone (215) 968-5966.

Circle No 410

IMAGING SOFTWARE

- *Processes color images at 768×575-pixel resolution*
- *Operates in a VME Bus environment*

In conjunction with the company's range of VME Bus frame-grabber/frame-store boards, you can use the VCS software package to develop programs for image processing. You can use the software in two modes: You can either enter simple 3-letter mnemonics that execute image-processing algorithms, or you can develop a program from the library of image-processing functions supplied with the package. The library currently contains over 150 image-processing functions, including edge detection, object and character recognition, filtering and convolution, and histogramming. You can either incorporate your own routines in the library or call them as external routines. £3000.

Primagraphics Ltd, Melbourn Science Park, Melbourn, Royston, Herts SG8 6EJ, UK. Phone (0763) 62041. TLX 817932.

Circle No 411

REAL-TIME OS

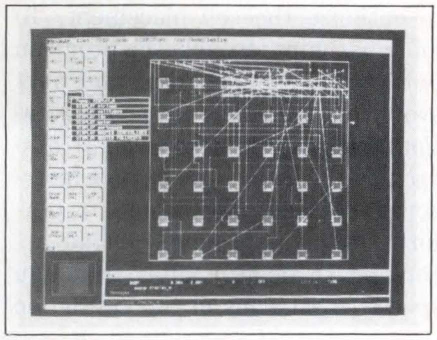
- *Can run 100 application tasks*
- *Offers as many as 4095 envelopes for message passing*

Version 2.0 of the AMX Multitasking Executive is a real-time, multitasking operating system for systems based on the 8086, 80186, and 80286 µPs. Its message-passing facility provides each task with four mailboxes in which the task receives messages from other tasks. A task does not have to issue a system call in order to receive a message. With the wait/wake feature, you can suspend a task until another task, timer procedure, or interrupt handler issues a request to wake the task again. Using the event manager, you can suspend a task to wait for a combination of events signaled by flags. The operating system provides 127 flag groups, each of which contains 16 flags, and you can define the events of interest in a group. The resource manager allocates system resources to tasks and ensures that only the task that currently owns a resource can release it. The semaphore manager provides a general-purpose counting semaphore with priority queuing and timeout. The buffer manager allows you to allocate multiple pools of fixed-size buffers; the number of pools is limited only by the amount of memory available. The memory manager controls the dynamic allocation of blocks of memory to particular tasks. The PC supervisor provides an interface to the I/O devices of the host PC, PC/XT, PC/AT, or compatible machine.

You can configure the operating system in several ways: as a linked system, which provides the smallest size and fastest execution; as a position-independent ROM image that you can place anywhere in your memory map; and as a resident system module in which all system modules are linked with the set of application tasks that the system will serve. $2195.

Kadak Products Ltd, 206-1847 W Broadway, Vancouver, British Columbia V6J 1Y5, Canada. Phone (604) 734-2796. TLX 0455670.

Circle No 412



IC DESIGN TOOL

- *Lets you design IC architecture*
- *Automatically compacts chip*

ValidCompose is the first tool in the vendor's product line to be entirely driven by design rules. It runs on Sun 3 workstations and on DEC's VAXstation. You begin the design process by creating a functional schematic in which the cells to be used appear as boxes that define the cells' relative shapes and sizes and their connection points. You then use the program's editing features to optimize the cell placement. To minimize wire lengths, the program performs automatic pair and port swapping, as well as automatic rotation and mirroring of cells. It also provides both automatic and interactive routing. The program performs placement and routing according to design rules that you specify, by means of the editor, on the original schematic. You can identify critical paths and specify wider widths for individual wires than the design rules call for. During floor planning, the program groups cells with critical interconnections and alerts you to the occurrence of critical paths that are too long. Once the program has performed the initial cell placement, it automatically compacts the chip into the smallest possible space, while observing the design rules. $20,000.

Valid Logic Systems, 2820 Orchard Parkway, San Jose, CA 95134. Phone (408) 432-9400. TLX 3719004.

Circle No 413

EGA/VGA BIOS

- *Offers full VGA compatibility on an IBM PS/2 system*
- *With an EGA chip set, provides most VGA features*

The vendor offers three versions of the EGA/VGA BIOS. The EGA+Autoemulation version, in combination with the 82C435/436 EGA chip set from Chips and Technologies (Milpitas, CA), provides 100% hardware and software compatibility with the IBM EGA card, but operates at twice the speed. The autoemulation feature adjusts automatically to the display modes required by applications software. The second version adds VGA-resolution graphics modes, which include 640×480 pixels in 2 or 16 colors; 360×400 pixels in 16-color alphanumeric mode; and 720×400 pixels alphanumeric in both 16-color and monochrome mode. This version also has a 16×8-pixel character set with a 16×9-pixel update set, and some VGA BIOS-compatible calls. It can operate with an NEC multisync and compatible monitor and can generate an IBM Enhanced Color Display, an IBM Color Display, an IBM Monochrome Display, or similar displays. The third version is a fully compatible VGA BIOS that you can load into RAM to run the video system of an IBM PS/2-50 machine; when new chip sets are available for VGA, this BIOS is designed to work with them. OEM license, from $10,000.

Interlink Business Network Corp, 2700 E Imperial Hwy, Building A, Brea, CA 92621. Phone (714) 579-0693. TLX 753197.

Circle No 414

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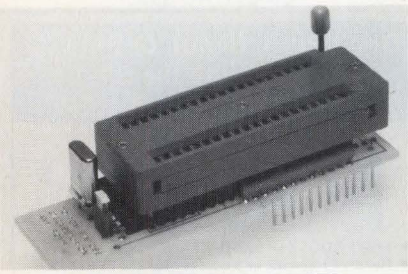
Please circle Reader Service number for additional information from manufacturers.



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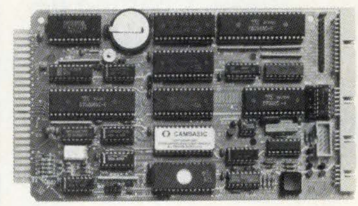
CMOS CONTROL COMPUTER



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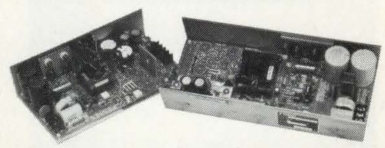

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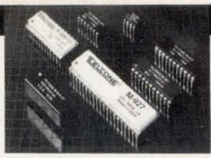

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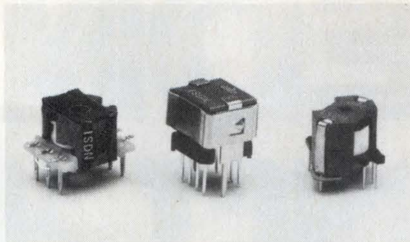

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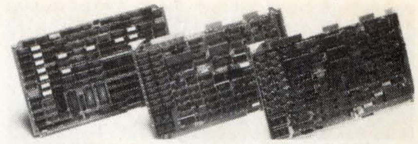

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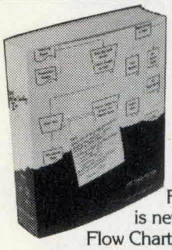

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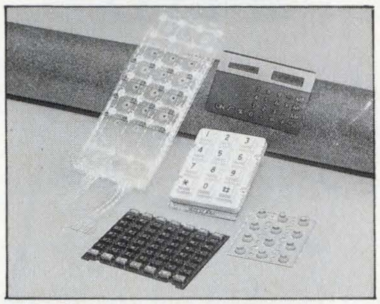

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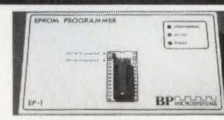

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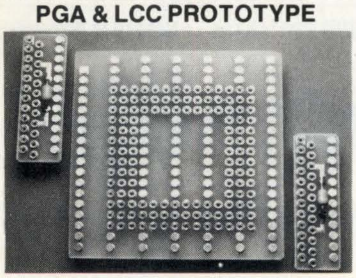

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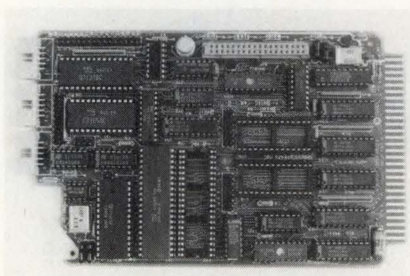

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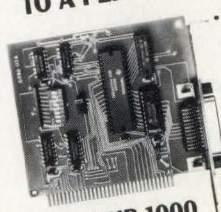

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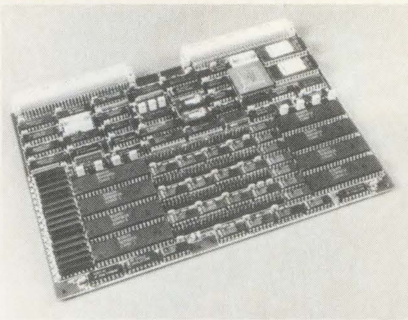

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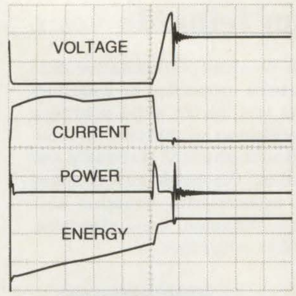

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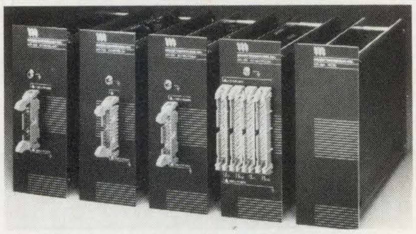

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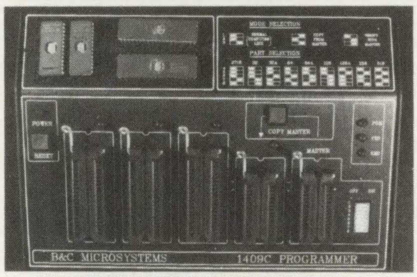

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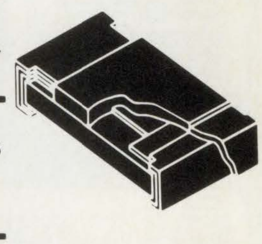

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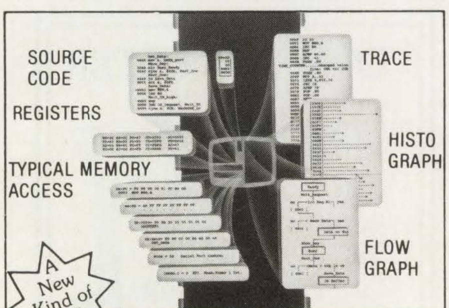

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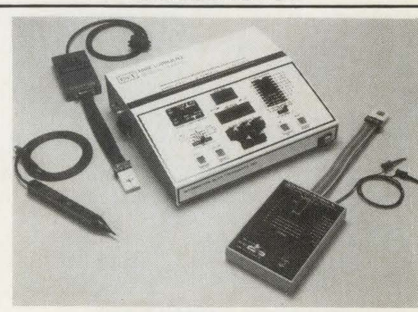

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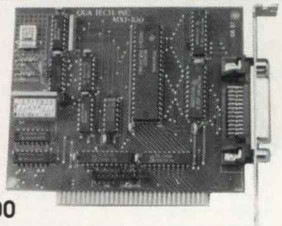

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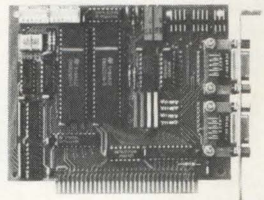

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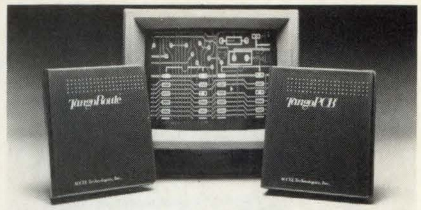

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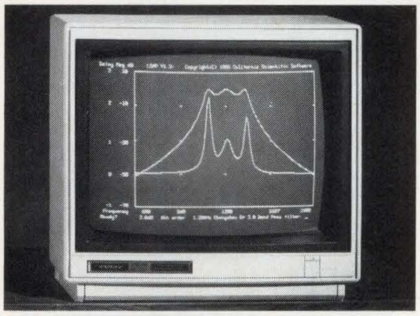

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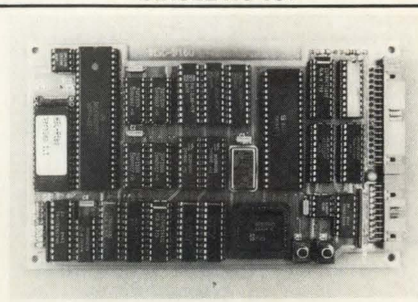

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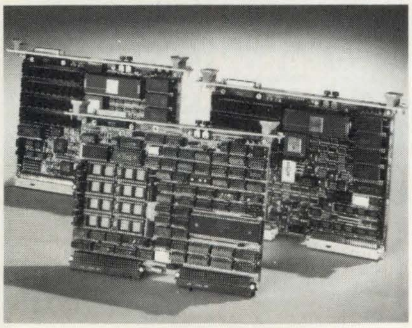

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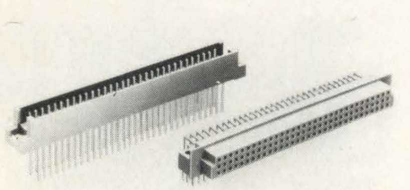

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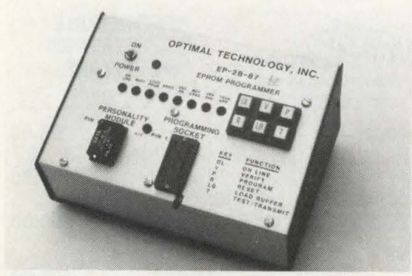

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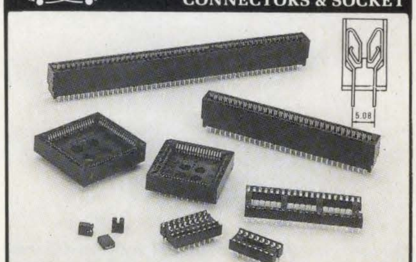

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App notes discuss waveform digitizing

Application notes AN-2017, *Principles of Digital Waveform Recording* and AN-2018, *Digital Signal Processing*, provide an overview of waveform digitizing and analysis. The two papers fill 28 pages of text, diagrams, and illustrations. They address such topics as fundamentals of ADC technology, understanding digitizer specifications, digitizer applications, digital signal processing, and computer-aided-test system design.

LeCroy, 700 S Main St, Spring Valley, NY 10977.

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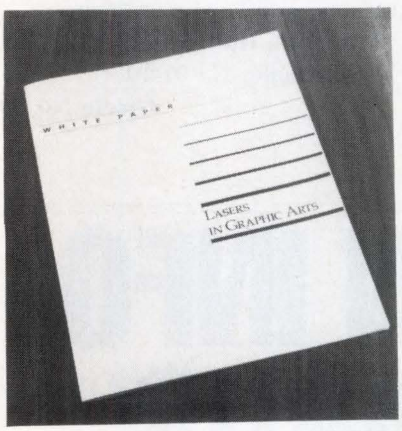

Report addresses use of laser for graphics

The 8-pg white paper, *Lasers in Graphic Arts,* discusses laser technology as a bridge between typographic output, and hardware and software used for publishing. The report deals with three graphics-arts applications: image setting, scanning, and printing.

Compugraphic Corp, Literature Div, 65 Industrial Way, Wilmington, MA 01887.

Circle No 402

Brochure discusses traveling-wave tubes

This brochure covers the vendor's line of microwave tubes and amplifiers for manufacturers of communications and military products. It describes products for military electronic counter measures (ECM) and radar, for stationary and mobile transmitters, for transmitter amplifiers in up-link ground stations of satellite TV and direct broadcasting systems, and for point-to-point satellite transmission of business data. The 20-pg booklet includes a section on product safety.

Stantel Components Inc, 636 Remington Rd, Schaumburg, IL 60173.

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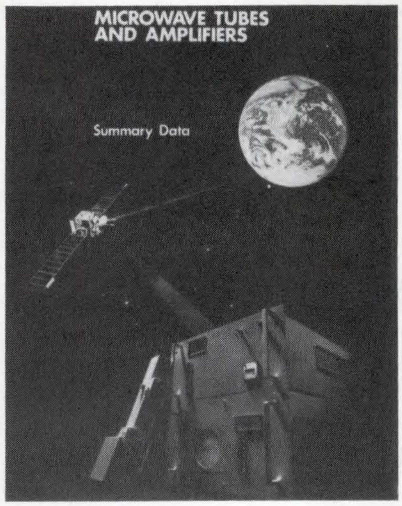

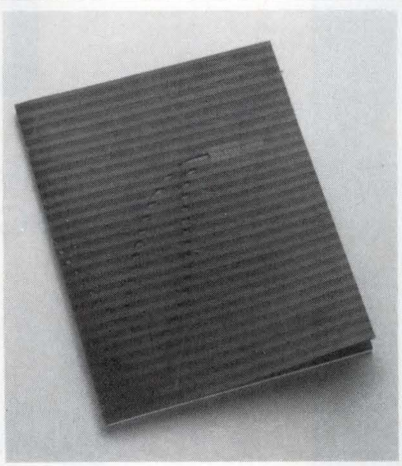

Booklet presents high-reliability products

Meeting the Challenge of Hi-Rel, a 38-pg brochure for the military market, contains an extensive QPL (quality products list), a compilation of high-reliability process offerings, and a glossary. Other sections include die and wafer ordering information and a summary of application notes.

Intersil Inc, 10600 Ridgeview Ct, Cupertino, CA 95014.

Circle No 404

Guide lists graphics hardware

The *TMS34010 Third Party Guide* provides information about products using the TMS34010 graphics system processor. More than 50 companies describe their TMS34010-based products, which include IBM PC add-in boards, electronic publishing systems, and image-processing systems. The book serves as a resource for high-performance graphics hardware and identifies software developers that have operating environments, development tools, and applications for the TMS34010.

Texas Instruments, Semiconductor Group (SC-754), Box 809066, Dallas, TX 75380.

Circle No 405

Data sheet for surface-mount repair

A 2-pg data sheet describes the vendor's SRM-100 surface-mount rework and repair system. The publication details how the system works and how it utilizes the proprietary programmable matrix heater. It also highlights the system's features and benefits, which include eliminating the need for expensive tooling to handle different surface-mount-device configurations. The data sheet's reverse side lists general, control-system, vision-system, utility, and physical specifications of the product.

SRTechnologies Inc, Pond Lane, Concord, MA 01742.

Circle No 406

Newsletter contains CAD/CAM information

Published continuously since 1981, the *Computer Aided Design Report* newsletter covers computer-aided design and manufacturing topics. The May and June issues provide a comparison of personal-computer CAD software from three Fortune 500 firms and software from two smaller companies. The results shows that buying software from major manufacturers won't necessarily be the best solution for your particular needs. Copies of both issues are available for $23. An annual subscription costs $138.

CAD/CAM Publishing Inc, 841 Turquoise St, Suite D, San Diego, CA 92109.

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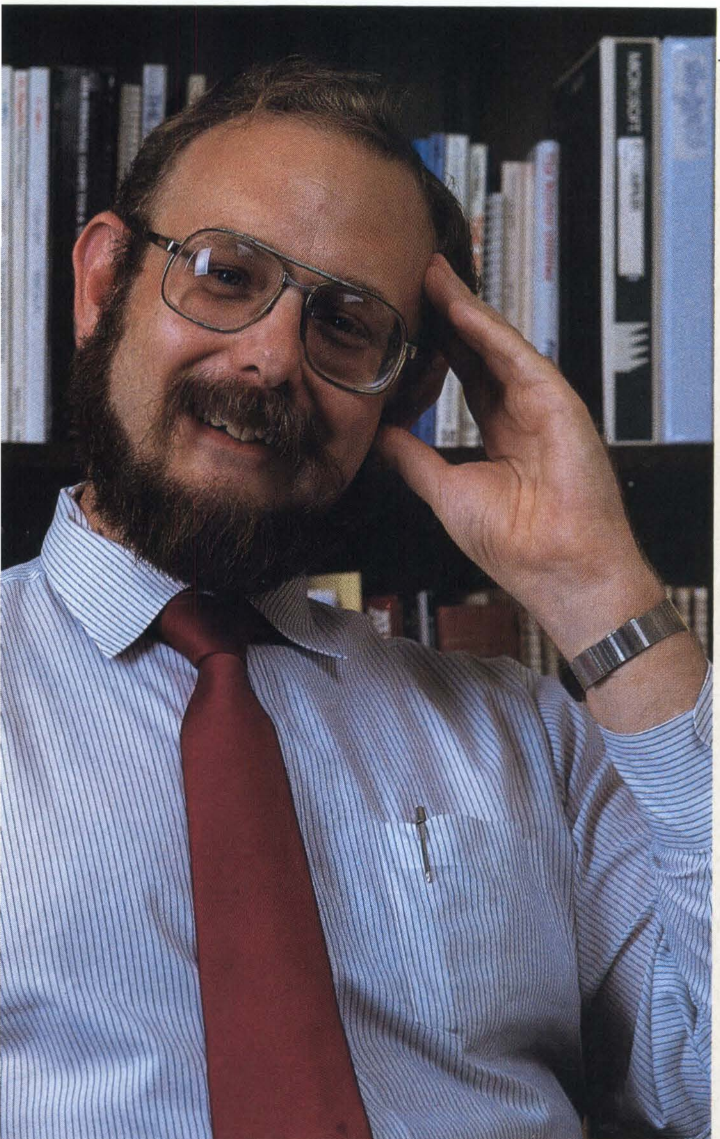
App note deals with signal measurement

Application Note No 59 describes channel-associated signaling measurements on pulse-code-modulation (PCM) systems. It covers primary- and secondary-order PCM systems operating at 2048k and 2448k bps, and it includes making measurements in traffic and detecting errors in the line code and in 2048k-bps frame-alignment words. A diagram illustrates the frame and multiframe structure of a 2048k-bps digital stream according to CCITT recommendation G704. Other subjects include signaling on PCM systems, the 2388A measurements channel number and signaling state, measurement configurations with illustrations, and local monitoring.

Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401.

Circle No 407



Tim Davis

Paul Hughett of Hughett Research (Palo Alto, CA): *Consulting takes a lot of assertiveness.*

The frustrating and fine art of independent consulting

Deborah Asbrand, *Associate Editor*

Paul Hughett's consulting business started out well enough. He found a client company that needed his computer-graphics expertise, and he signed a one-year contract that provided him with full-time work. At the year's end, the client still needed him, so Hughett stayed on. The one-year pact eventually stretched into two and a half years.

When the job finally ended, Hughett began a campaign to drum up new business for his consulting practice. He made cold sales calls on potential clients and offered his services to companies that had run newspaper advertisements for engineers. Six months later, he hadn't obtained enough contracts to support himself financially. "What I was doing wasn't working, despite the fact that I had all these technical skills," Hughett remembers. "I was having a good deal of trouble getting meetings with people, never mind getting business from them."

Hughett had come up against a hard fact of consulting: Technical skills don't sell themselves. Many engineers go into consulting expecting the opportunity to at last design in a hassle-free environment. Instead, what they find is that design is often the easy part of maintaining a consulting practice. The hard part—and the part that occupies the greatest portion of their time—is acquiring the business acumen and salesmanship needed to manage a small, client-oriented business.

There are no statistics on the number of engineers in private consulting. Membership in two organizations, the Professional and Technical Consultants Association and the American Consulting Engineers Council, remains steady. The Independent Computer Consultants Association, however, grew rapidly earlier this year, jumping from 1800 members in December 1986 to 2400 in July. Executive director Jack Christensen attributes the increase to a new tax law that changes the criteria by which independent technical consultants qualify for tax benefits, and consultants' resulting need to belong to an organization that can convey information on the new laws.

Consulting appeals to engineers for many reasons. Some engineers long to escape the multiple layers of management and the endless procedures that prevail in large companies. "The amount of bureaucratic procedure and the time I spent coping with the bureaucratic requests were an annoyance," says Nathan Sokal, a consultant since 1965. "Some people can let those things roll off their backs, but it wasn't as easy for me."

Others want more varied work than most permanent jobs allow. "I wanted to choose what I could do and to work with a variety of projects—things one typically can't do as an employee," says Guy Scharf, owner of Software Architects in Mountain View, CA, which specializes in office automation and software development. Scharf spent many years debating whether to open his own business before finally deciding to do so in 1981. "I either had to go out and do it, or give up the dream," he recalls.

Other engineers give consulting less forethought, deciding to give it a try when the opportunity presents itself. When a local company offered her a consulting job, Lynn Silberman of JL Software Systems in Portola Valley, CA, wasn't sure that she wanted to give up the security of corporate employment. She turned down the offer, but when a second opportunity arose, it piqued her curiosity and she accepted it.

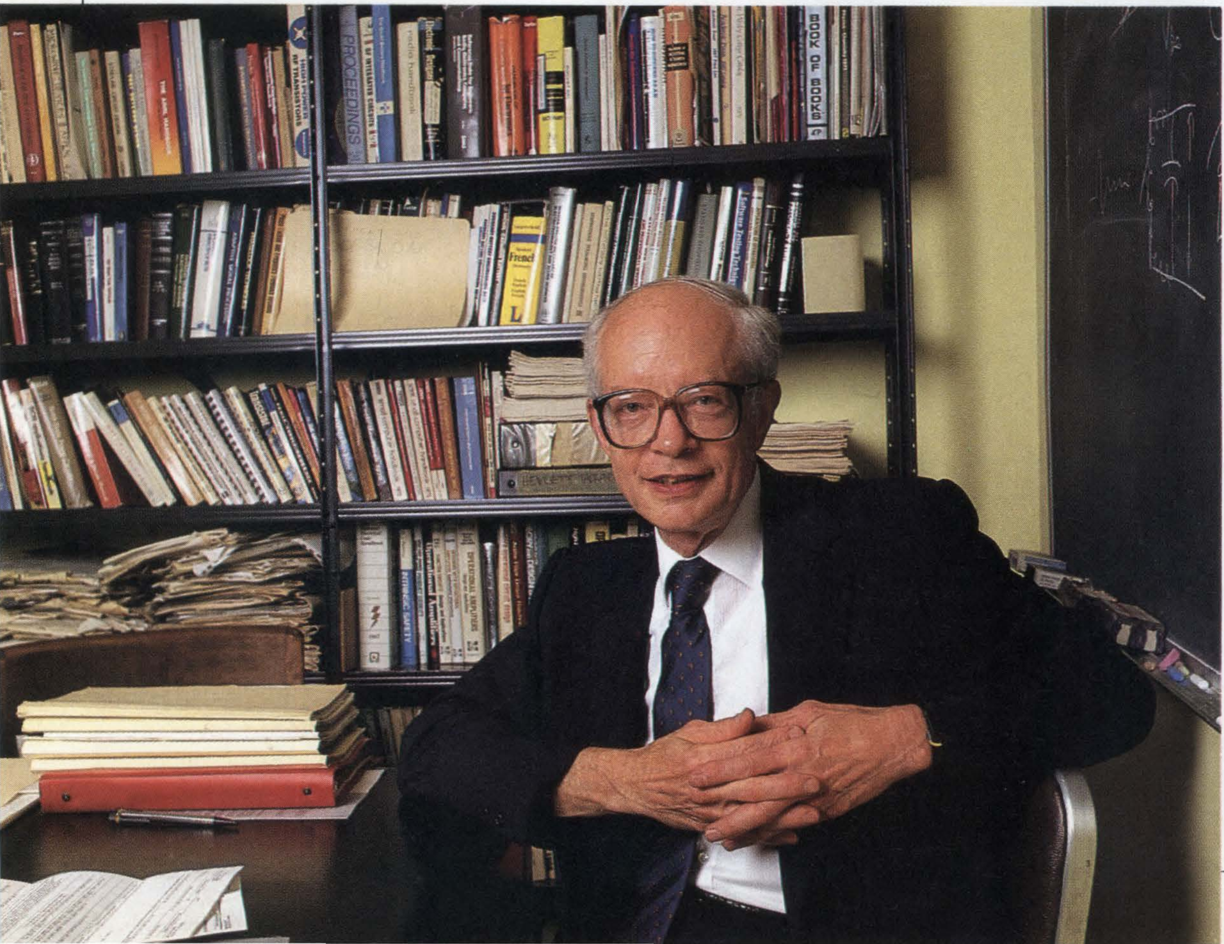
The skills that consultants need most are not necessarily the ones they developed working in engineering environments.

Despite their varied reasons for hanging out a shingle, engineers' perceptions of consulting are remarkably uniform. They describe consulting as fraught with frustrations, financial insecurity, and long hours. Moreover, the skills that they need most in consulting—salesmanship, marketing savvy, and general business know-how—are not necessarily the ones they develop working in engineering environments.

First on any consultant's list of things to do is cultivate clients, and doing so requires many engineers to undo the problem-solving skills that they were taught. "Engineering thinking is mainly analytical," says Arlen Burger, formerly a salesman and sales consultant and now a senior consultant with Robert Blake Associates (Santa Clara, CA), an out-placement company. "But when you're persuading someone to buy your product or your expertise, there are a lot of intangibles. The intangible, emotional characteristics of decision-making drive engineers crazy."

Burger estimates that as many as 40% of the engineers he counsels consider becoming consultants. Eighty percent of the engineers who enter consulting return to permanent corporate employment, Burger estimates, and he cites poor salesmanship as the reason.

Building a practice requires an active sales and marketing effort. For example, few companies advertise for consultants. And consultants who run advertisements in the hopes of attracting potential clients usually come up empty-handed.



Martha Everson

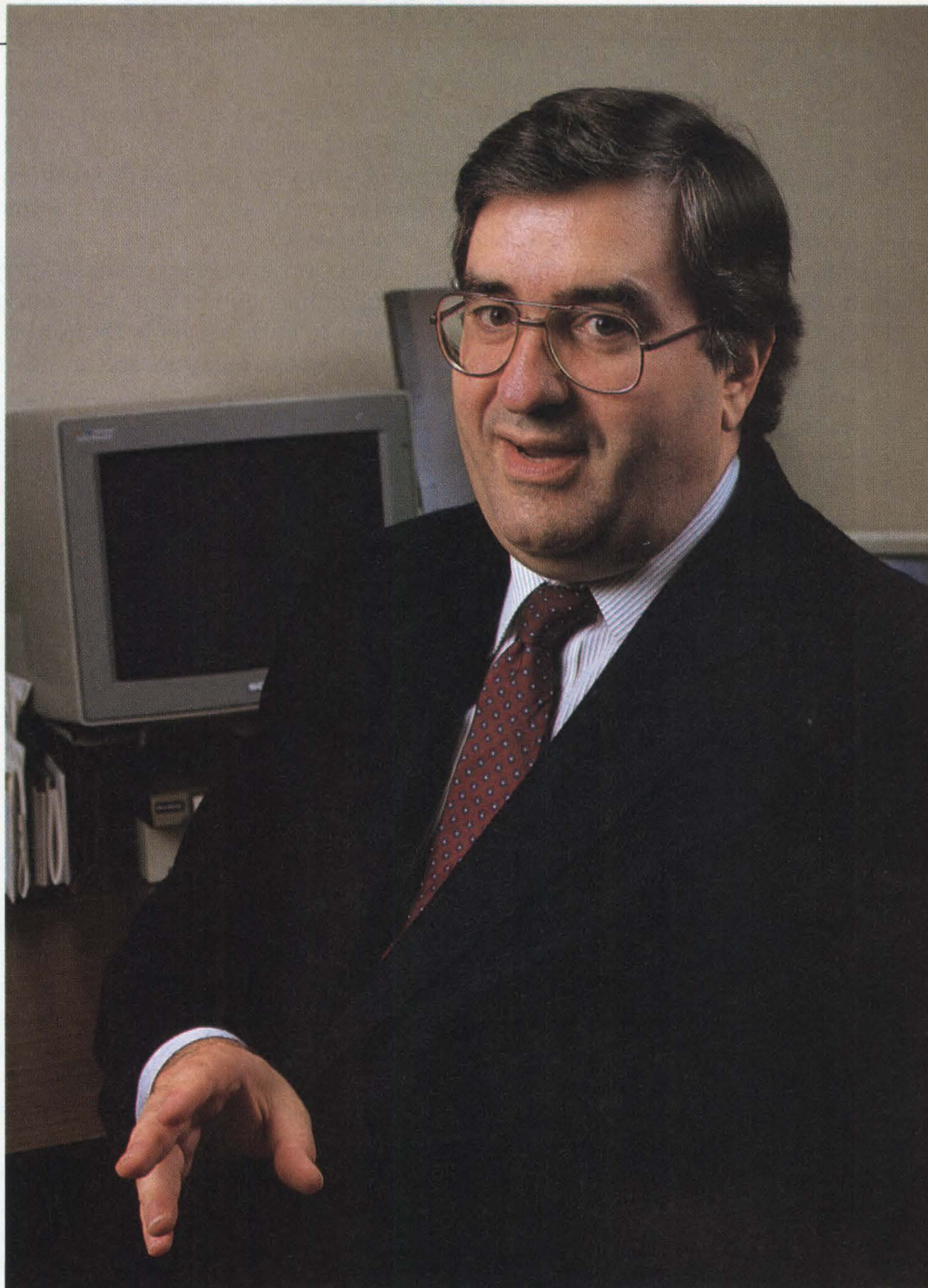
Nathan Sokal of Design Automation: *Repeat clients are the crux of a consulting practice.*

"The only response I got was from another consultant who wanted to know if I'd gotten any response," says Dennis Paull of Paull Associates in Los Altos, CA.

Like Hughett, other consultants have unsuccessfully tried to offer their consulting services to companies that ran help-wanted ads for permanent, full-time engineers. "If they run a help-wanted ad, they don't really want someone part-time," says Hughett. Promoting his services to personnel departments proved to be another "worthless" undertaking, he says.

The best way to create a profitable business, consultants maintain, is to use industry contacts. In rare cases, a word-of-mouth campaign is enough to acquire business. But most consultants point to cold sales calls as an equally important—if dreaded—method for building a practice.

"You don't have to learn to love selling, but you do have to be able to do it and not be unhappy about it," says Sokal. Joel Becker, an independent consultant specializing in antenna design, agrees with Sokal. Becker says that after nine years of consulting, he still isn't used to sales. "I don't think I ever will be," he adds. "Basically, you have to learn to take a rebuff and not take it personally."



Guy Scharf of Software Architects: "I either had to go out and do it, or give up the dream."

Tim Davis

Selling yourself

Making cold calls, says Marty McGrath, "was about the hardest thing I ever did. After you get a few turn downs, you start feeling that maybe you don't have anything to offer." Maintaining self-confidence is crucial for a newcomer to consulting, says McGrath, who credits the sales experience he gained in an earlier real-estate job with helping him to get his consulting practice started in 1981.

Through trial and error, though, most consultants are able to formulate a sales pitch that meets with some measure of success. "I ask potential clients what they're looking for and then figure out how to fill those needs," says Hughett, who sought to refine his selling techniques by hiring Burger as a sales consultant. "Then I say 'When do we start working on this?' It takes a lot of assertiveness."

McGrath tailors his sales strategy to appeal to the needs of companies in Silicon Valley, where he's operated his consulting practice, McGrath Technical Services, for the past six years. "In Silicon Valley, the average engineering turnover is two years. An engineer who leaves after two years often has just two weeks to document the work he's been doing. Usually, it just doesn't get done. I point out that I know I'll be gone in six months, so I'll have the documentation done."

In addition to sales calls, consultants find lots of other innovative ways to market themselves. Hughett, for example, attends conferences to stay up to date technically and "to stand around and talk to people at the coffee break. I get more useful information that way than by listening to the papers."

Scharf recently began distributing a 10-pg newsletter to about 100 clients and potential clients. The newsletter, which includes technical information on Scharf's office-automation and software-development specialties, costs $150 to produce each month. Yet Scharf considers the money well spent: The two issues that he's published to date have already produced two business leads.

Role playing

Securing a contract, though, is just the beginning of a consultant's work. In many cases, technical consultants perform a variety of roles for their clients: technical expert, mediator, and nursemaid. "There's a wide spectrum of personalities working for your clients," says Sokal. "You have to work with these people without offending them or making them feel anxious about the presence of a consultant. You have to be able to tell them something that might be unpleasant news, but present it to them in such a way that they get the technical content, without the emotional load."

What's more, consultants often must practice diplomacy in a variety of uncomfortable situations. They might carry the burden of being hired to solve a problem that has stymied the client's engineers. A consultant might also find himself hired to substitute for an engineer who's quit suddenly or been fired. One consultant remembers having been hired to replace a chief engineer who had died unexpectedly. Without the assistance of the engineer who worked on the product, the consultant takes on the additional role of detective as he tries to retrace the project's progression.

All of these circumstances lead to tense working environments. "You walk into the situation, and people are under a lot of stress; they've been having a lot of problems," says McGrath. "You have to prove yourself every time. You walk out of one job and you might be a hero. You walk into a new job, and they say 'So you're a consultant, huh? See if you can solve this.'"

Indeed, the ability to handle very demanding jobs and to work smoothly with people is critical because repeat business and positive references are the crux of a consulting practice. "You can't afford to be in business if you have to sell every job individually," advises Sokal, who now has six engineers working for his practice, Design Automation Inc, in Lexington, MA. Consultants say that most of their work is done for clients they've worked for previously, or for companies that clients have referred to them.

"You have to work with people without offending them or making them feel anxious about the presence of a consultant."

No matter how well-developed a consultant's network of contacts is, he or she is still vulnerable to the boom-and-bust cycle that is part of independent work. Dips in the economy produce soft consulting markets, but, ironically, consultants can also encounter lean times as a result of success: If business projects occupy all their time, they have no chance to seek new business.

Most seek to avoid the business roller coaster as much as possible by splitting their time between seeking new projects and working actively on existing ones. Most consultants bill 20 to 25 hours each week to their clients and devote the rest of their time to maintaining the practice through sales and marketing efforts, bookkeeping, and general paperwork.

Financial and other rewards

Consulting salaries vary. Most say consulting isn't a financial windfall, but allows them to equal or better the income they had as employees. "You have to enjoy doing it and have to feel it's better than working for someone else," says Hughett. "It takes too much grunt work and running around and taking risks. Money alone can't motivate people to do that." Scharf's advice is more stern. "Unless you feel irresistibly drawn to running your own business, don't bother starting a practice."

Lean times prompt some consultants to toy with the idea of returning to regular corporate employment, which would provide them with some protection against economic fluctuations. "There was a time last year when I was very low

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in money and had had a contract fall out from under me," Hughett says. "I had to think: Did I want to stay a consultant and be poor, or go back to industry and have less fun but make more money? I decided I enjoyed consulting enough to stick with it."

In addition to the security of permanent work, some consultants also miss the ready supply of colleagues with whom to swap ideas. "If you're working with other engineers, you can kick ideas around. That type of discussion is useful in problem solving," says McGrath. "In consulting, you don't have colleagues just down the hall." McGrath has a foolproof, if costly, solution to this problem: "I call people that I know and ask them if I can buy them lunch. I get a 100% response."

So with all of the drawbacks to consulting, why does anyone stay in the field? For one thing, consultants choose the engineering projects they work on, so the work tends to be more interesting than what they were assigned as corporate employees. "I've never attempted to peg a real specialty in the way that's generally advised," says Scharf, who prefers to work on a variety of technologies.

The learning curve for consultants is high. "I thought you had to be an expert and know it all, but that's not the case," says Silberman. "As long as you know something about the application, you can learn the rest of it."

Some consultants say they'd never return to corporate employment. "I'd never consider anything other than being in business for myself," says Becker. "I like being my own boss. I know why I do things; I was mystified by the decisions of some of the larger companies I worked for." **EDN**

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Oct. 29	Oct. 8	Computers & Peripherals; ICs & Semiconductors; Wescon '87 Product Preview	Closing: Oct. 15 Mailing: Nov. 5
Nov. 12	Oct. 22	Wescon '87 Show Issue; ICs; Computers & Peripherals	Closing: Oct. 29 Mailing: Nov. 19
Nov. 26	Nov. 5	Microprocessor Technology Report & Directory; Analog ICs; Sensors & Transducers	Closing: Nov. 12 Mailing: Dec. 3
Dec. 10	Nov. 19	Product Showcase-Volume I; ICs and Semiconductors; Software	Closing: Nov. 26 Mailing: Dec. 17
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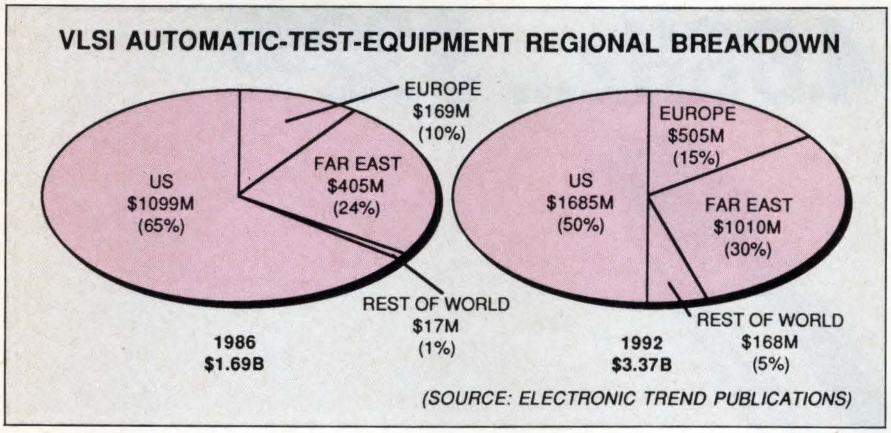

VLSI ATE becomes a critical issue

The cost of testing is exploding, according to Electronic Trend Publications (Saratoga, CA). The expanding use of VLSI devices and board-level products is pushing the cost contribution of testing, which historically has ranged from 5 to 10% of total device cost, to 45% of that cost and beyond. ETP concludes that design-to-test and built-in test techniques will be a crucial concern for the remainder of the decade.

Nearly $1.7 billion went into device and pc-board automatic test equipment in 1986. This considerable sum can be attributed to the growing volume and complexity of the components themselves. By 1992, forecasters suggest, the market for automatic test equipment worldwide will reach $3.37 billion. In 1986, 58% of VLSI ATE expenses was devoted to device testing, whereas the remaining 42% went to board testing.

To stay competitive, electronic-equipment manufacturers must develop relevant strategies for component and board testing. This revamping is important not only to reduce the individual testing costs and problems but to carve out longer-term integrated factory-automation programs.

In addition to higher speeds and increased device complexity (and consequently increased board and system complexity), built-in tests at the device level are becoming a more important consideration. A tighter linking among CAD, CAE, and CAT is also a noteworthy trend, as is a shift from the traditional shared-resource tester architecture to a structure centered on the tester-per-pin technique. ETP also emphasizes how new fixturing techniques at the pc-board level, which are designed to accommodate surface-mount devices and reduced lead spacing, are changing automatic-testing strategies. The use of hardware device models at the pc-board test level is another factor worth considering.

Other trends that equipment manufacturers should keep in mind include the increasing number of built-in pc-board, product, and service-level tests, as well as board, product, and system-level testability interfaces. Furthermore, remote troubleshooting in the field and the use of machine vision at the product-test stage have both increased. The use of free-flowing production methods is becoming extensive as well.

The market-research firm has developed some guidelines for formulating a strategy that encompasses these trends and changes. First, it's important to select and use automatic test equipment that yields better productivity, ensures high product quality, and incurs the lowest possible test costs. Achieving a workable balance among these factors is, of course, the greatest challenge. Second, it's important to remember that technological and economic tradeoffs should be made during product design rather than later. Third, manufacturers must consider the impact of CAD, CAE, and CAM strategies on ATE.

Signal-generator market to top $775M by 1993

The market for signal generators, which in 1983 totaled $232.5 million, should exceed $362 milllion this year, according to the Market Intelligence Research Co (Mountain View, CA). Moreover, the research organization forecasts that by 1993 the total will more than double to reach $777.5 million.

For its study, MIRC defined signal generators as all primary sources—analog or digital—for test signals. Used primarily by the military, the communications industry, and the computer and semiconductor industry, they are prevalent both at production sites and in design and development labs. Their applications include the testing of communications receivers, the testing of components in the communications industry, simulations for testing electronic warfare, and logic testing of digital components and products.

MIRC observes that, with more than 200 vendors selling signal generators, the products in general continue to be upgraded and improved. Although the signal-generator market experienced the effects of the overall slowdown in test-and-measurement purchases over the past few years, this market has outperformed other test-and-measurement segments because of its large base in the communications industry.

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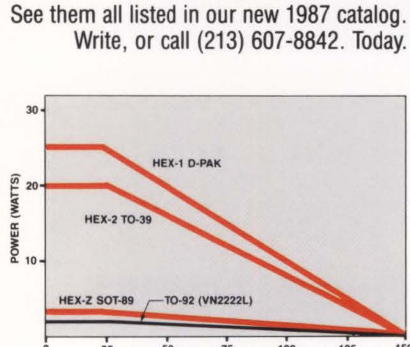

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