JUNE 10, 1981

A CAHNERS PUBLICATION

EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

SPECIAL ISSUE: TEST & MEASUREMENT

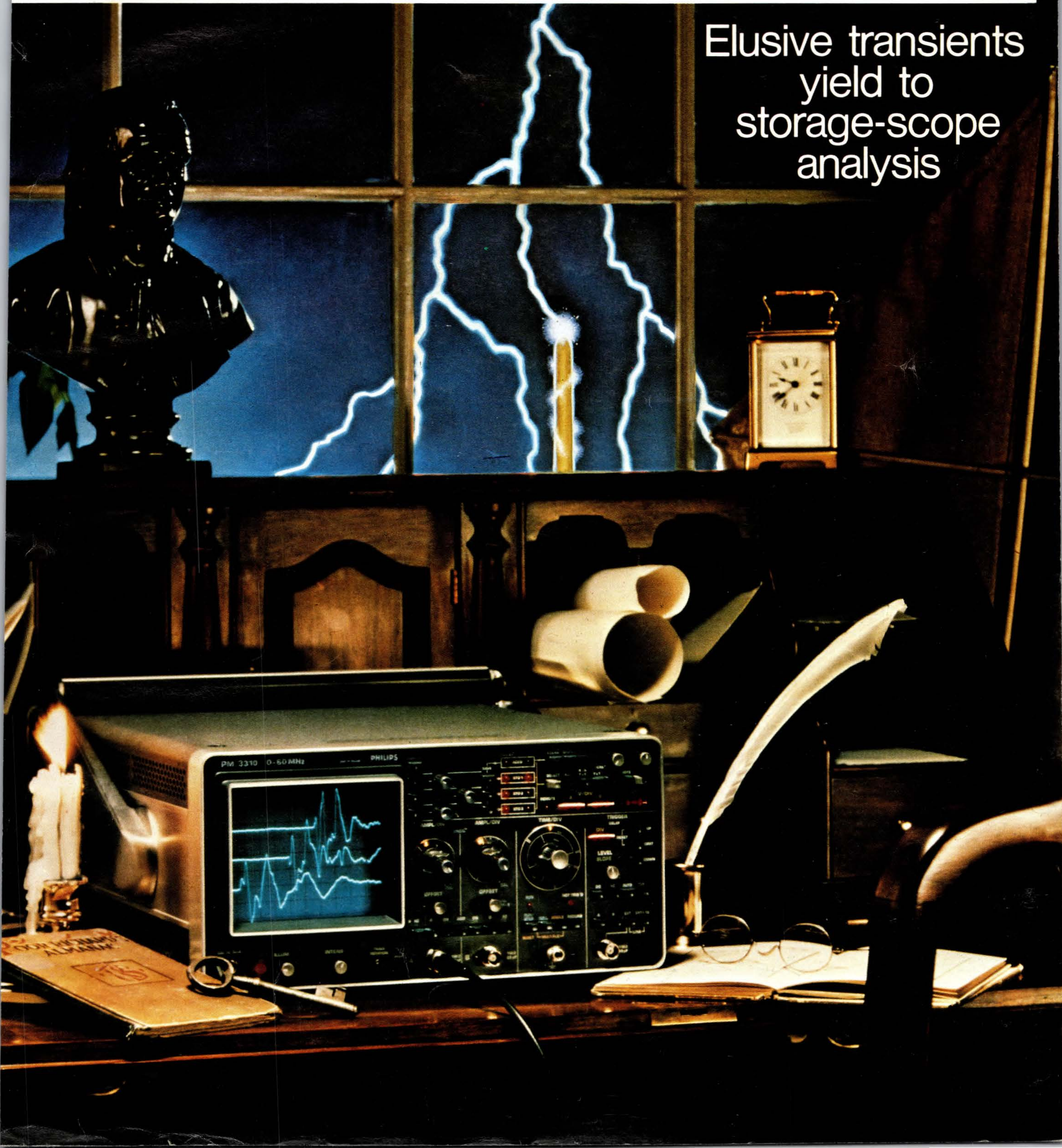
Phase-angle voltmeters

Emulation systems

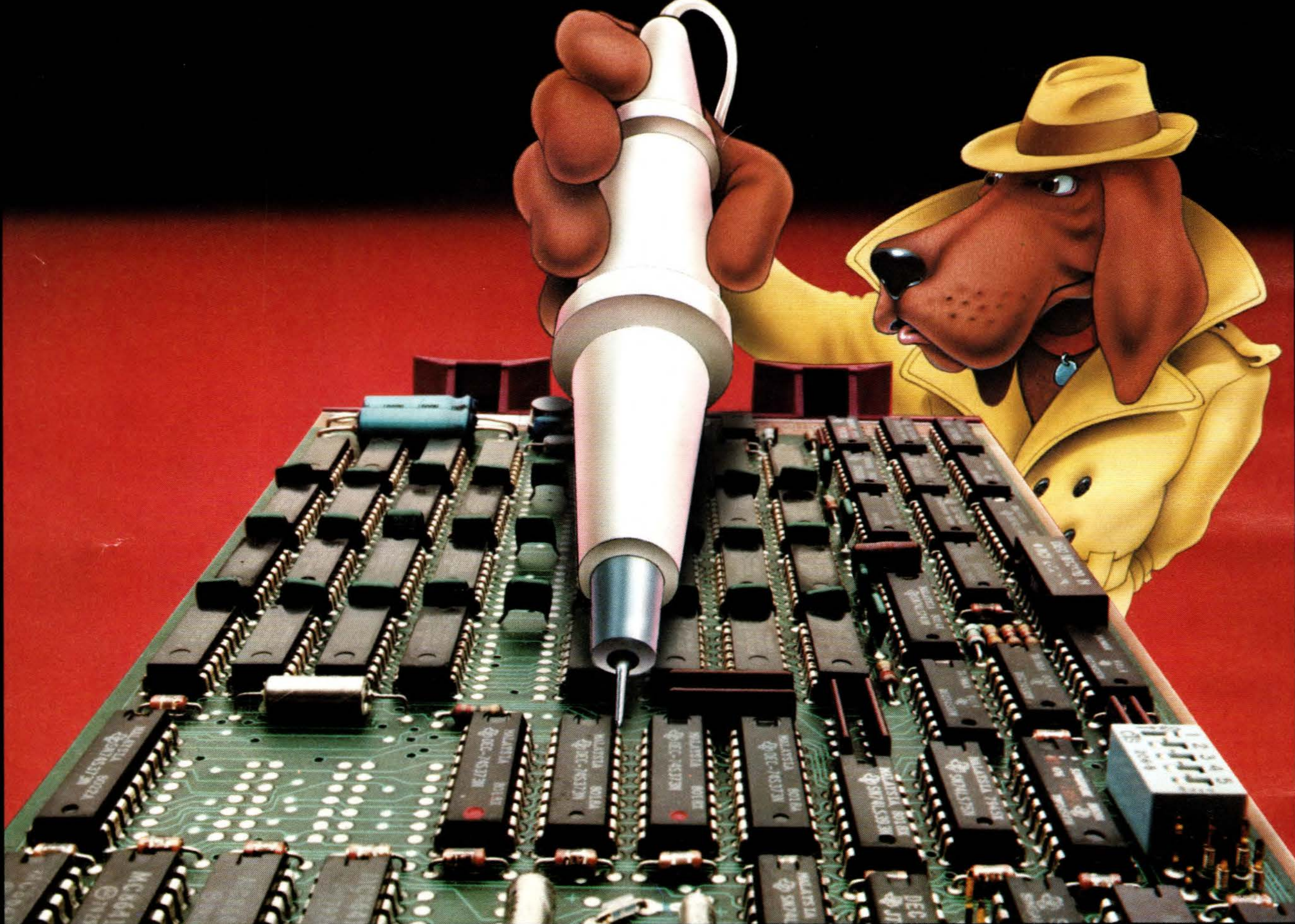
In-circuit testers

Development systems

Elusive transients yield to storage-scope analysis



PUT A BLOODHOUND ON THE CASE



For One-step Memory Board Testing.

"Sure," the Captain said, "a lot of people know about you – the MD-300 Macrodata Detective memory board tester, but not everybody knows how much of an edge our new Computer-guided Bloodhound Probe gives the user. The way this little guy sniffs out faults in the peripheral circuitry of memory boards puts any other probe system to shame.

"Nobody else can handle both synchronous and asynchronous memory board operations with the same quality of test. We're the ones who provide both a hard disk as well as a floppy disk for faster, increased storage. And that's just scratching the surface.

"Look at what else we can offer when we put our Computer-guided Bloodhound Probe to work with a Macrodata Detective MD-300: max-min programmable dual threshold input voltage levels of $\pm$10V... float detect... 10MHz operation ... 1 megohm input impedance ... an H-P compatible signature analysis probe... transition counting to isolate difficult faults... isolation of faults in clocked feedback loops... multiple strobe in same cycle for one-pass testing... and windowed transition counting. That's the kind of fault detection in memory boards that every user deserves!

"Everybody out there with a Macrodata memory board tester should retrofit it with this powerful new Computer-guided Bloodhound Probe. And anybody thinking about taking custody of a new memory board tester should think twice about buying one of those other systems that doesn't offer the fault detection capabilities of our Macrodata MD-300."

Contact us today for more information on the Macrodata line of memory board and system testers and our new Computer-guided Probe.

Eaton Corporation, Test Systems, 21135 Erwin Street, Woodland Hills, CA 91365. Phone (213) 887-5550. Telex 69-8489.

EATON
Semiconductor Equipment

CIRCLE NO 1

Pretty easy.
Taken at face value, our Model 3010 Signal Generator is simplicity itself. Just flip the lever/indicator switches to any frequency between 1 MHz and 1 GHz. No ranges to set, no counters to add, no need to reset output level.
Yet, behind that face is the most sophisticated instrument in its price range. Not only do you get synthesized signal generation with 0.001% accuracy and ±1.0 dB flatness, you get programming and modulation features for nearly any situation.
For ATE applications, Model 3010 has frequency programming as standard equipment; GPIB programmability is optional.
Four modulation frequencies can be used for complex or simultaneous modulation (AM on FM, FM on FM, AM on AM). Model 3010 makes modulation even simpler by letting you change center frequencies in AM and FM without readjusting modulation frequency or output level.
The price is easy too. Just $4,950.* Call us toll free today for a demonstration.
Wavetek Indiana, Inc., P.O. Box 190, 5808 Churchman, Beech Grove, IN 46107. Toll free 800-428-4424; in Indiana (317) 787-3332. TWX (810) 341-3226.

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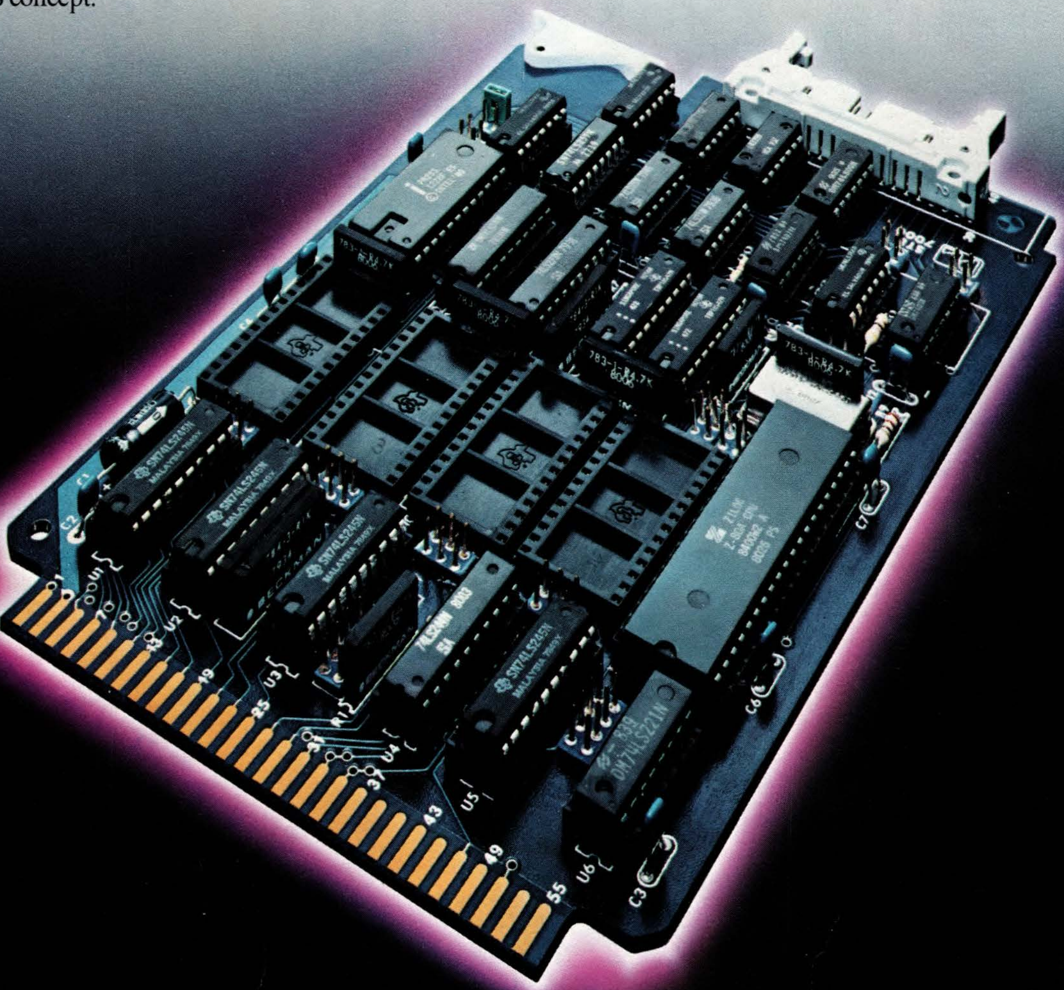
*U.S. price only

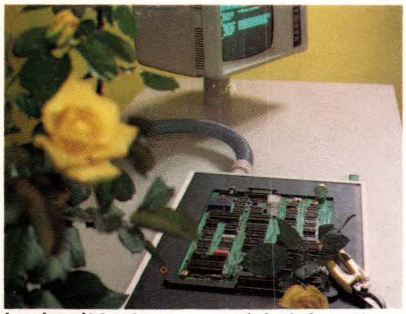
Circle no. 2 for literature

Circle no. 3 for demonstration

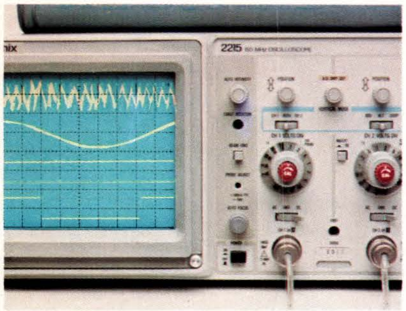


EDN

JUNE 10, 1981 • VOLUME 26, NUMBER 12 • EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS



In-circuit testers *expand their functions and repertoires, yet hold the line on cost and complexity (pg 39).*



Lightweight scopes *cost less than $1200, achieve 60-MHz bandwidths (pg 70).*

On the cover: *If Ben Franklin had had access to a digital-storage scope, one experimental run would have yielded data extensive enough to convince all skeptics. Turn to pg 76. (Photo courtesy Philips Test & Measuring Instruments)*

DESIGN FEATURES

TECHNOLOGY UPDATE

NEW PRODUCTS

DEPARTMENTS

CP BPA ABP

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Now: 45ns -

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55ns
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55ns

High Speed

1/2

CIRCLE NO 5

DON'T LET YOUR CLOCK GIVE YOU A BAD TIME.

You've really worked long and hard to make sure your new system has the highest throughput possible.

Don't blow it with a bum ticker.

Get AMD's Am2925.

The new Am2925 will boost the throughput of Am2900 and all high-performance systems up to 30%.

What's our secret? Microcode control of the cycle length.

Your system no longer has to run at the cycle of the slowest instruction. You can get down to as low as 100ns microcycles.

And, there are four different clock waveforms to choose from.

We even have a clock for the AmZ8000.

The AmZ8127 provides CPU clock drive to Vcc-.4 for the AmZ8000 and all MOS CPUs.

But that's not all.

The oscillator output is terrific for synchronizing dynamic RAM timing. And the AmZ8127 has synchronized slower clocks for slower peripheral functions.

Both the AmZ8127 and the Am2925 include an oscillator, single-step, run-halt and wait controls. Both replace a dozen MSI chips.

Bipolar LSI: The Simple Solution.

The Am2925 and AmZ8127 are two of the newest members of AMD's Bipolar LSI family. The family that makes designing any system easier, faster, simpler, cheaper.

Like all of AMD's parts, both our clocks meet or exceed INT•STD•123. We guarantee it.

The International Standard of Quality guarantees these electrical AQLs on all parameters over the operating temperature range: 0.1% on MOS RAMs & ROMs; 0.2% on Bipolar Logic & Interface; 0.3% on Linear, LSI Logic & other memories.

INT•STD•123

If you need a clock or any high performance part for your next design, call or write Advanced Micro Devices.

We've got some very timely solutions.

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You don't become the world's best selling in-circuit tester without selling some pretty tough customers.

The real test for any automatic test equipment is on-line, in the actual production test environment. It's here, and only here, that any test system demonstrates its real value.

To find out what sold the world's best selling in-circuit test system to three pretty tough customers, we went to the men who made the evaluation and the buying decision. Here's what they had to say about the system they chose.

"Northern Telecom found the 303 versatile enough to test more than 1500 board varieties in high volume applications."
John Jed,
Director of Manufacturing Quality.

"The Fairchild 303 has proven to

The Fairchild Series 30/303 In-circuit PCB Tester

be an extremely cost-effective test system in terms of capital expense, operator ease, software, system maintenance and reliability.

"While we've seen significantly improved yields in every 303 installation, with some of our high density, digital PCBs, the 303 test programs are so well developed that yields are as high as 98%. And this has meant a savings in cost and diagnostic time.

"We have close to thirty 303 systems on-line in both our U.S. and Canadian manufacturing facilities. The 303 has simplified our training, programming and service requirements."

"As a first time ATE user, Milton Bradley's major concerns were ease of use and total system capability. We got both with the 303."
John Scalia,
Electronics Manufacturing Engineering Manager.

"Before we made a final buying decision on any in-circuit test system, we had to be convinced of two things. One, would the ATE company provide the in-depth pro-

Dave Otto,
Test Engineer,
Sykes Datatronics Inc.

gramming support we needed initially; and two, could the system reliably test our complex PCBs? Fairchild and the 303 did both.

"Their training was both comprehensive and complete, and included everything from LSI programming to system maintenance.

"While our boards are small to medium in size, they contain analog components and digital ICs, including both commercial and custom LSI. With the 303, we're able to get extremely high yields on all our PCBs.

"In addition, the datalogging program has proved to be invaluable. Management uses the fault reports to pinpoint and remedy PCB manufacturing trouble spots, reducing our faults/board ratio and repair times. Even design anomalies are often isolated. Since installation, we've improved the efficiency of our manufacturing process—realizing dramatic cost reductions in troubleshooting and repair. Yields at final test have consistently been in excess of 90%."

"Back in 1978, Sykes Datatronics thought the best in-circuit system for isolating manufacturing faults was the 303. Today, we still think it's the best system."

Dave Otto,
Test Engineer, Sykes Datatronics Inc.

"Three years ago, we made the decision to go with ATE for the same reasons a lot of rapidly growing companies do: greater throughput, increased yields, and a generally more cost-effective manufacturing operation. We realized the best method for isolating manufacturing faults was in-circuit testing; and quite frankly, the 303 was the only proven system we found.

"Since 1978, we've doubled our growth every year and the 303 has been more than adequate in keeping pace with that growth. During this time, we've added only a minimum of PCB troubleshooters.

"The system has also been able to keep pace with the changing size and density of our boards. And it's given us the confidence to design boards of greater complexity, because we know the system can test them.

"Based on past performance, we've just placed an order for another 303."

To these three customers, Fairchild's 303 in-circuit test system has proven itself where it counts—on-line, in the production test environment. It will do the same for you. Whatever your product, Fairchild's 303 will help improve PCB yields, throughput and quality, and reduce overall testing costs.

After all, the dependable 303 has proven itself in more installations than any other in-circuit test system in the world. And it's backed by the largest service organization in the ATE industry.

For more information on the Fairchild 303, call or write: Fairchild Test Systems Group, 299 Old Niskayuna Rd., Latham, NY 12110; Tel. (518) 783-3600.

FAIRCHILD

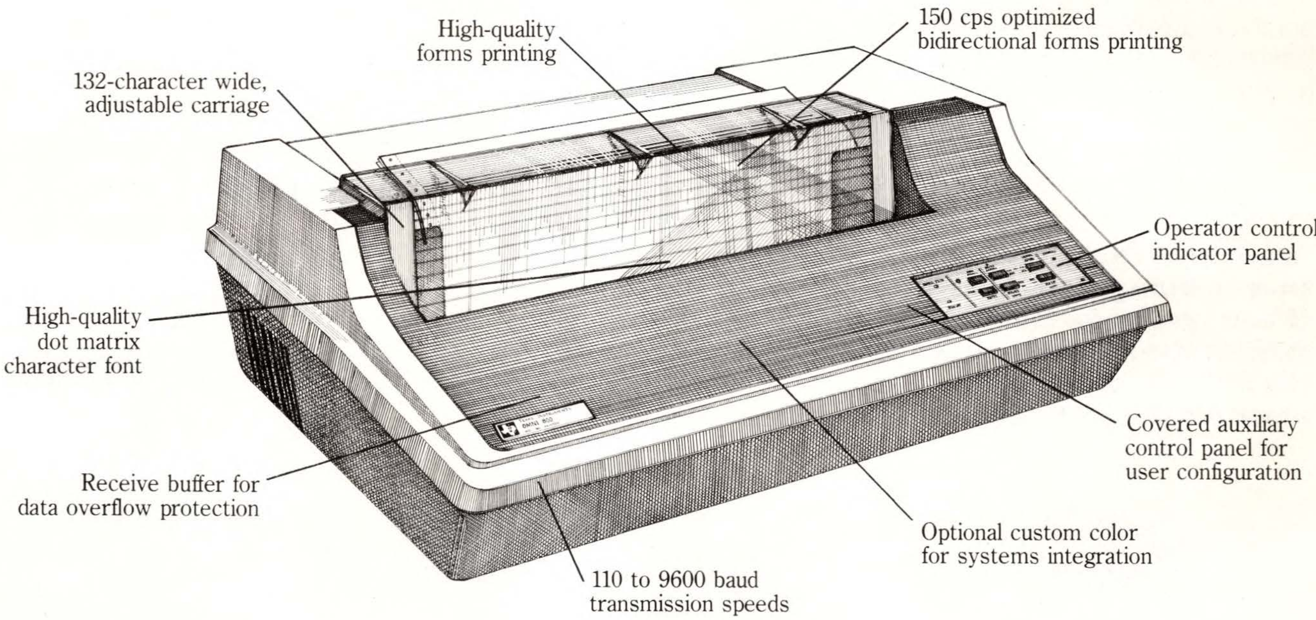
A Schlumberger Company

The First Family of ATE.

CIRCLE NO 7

The Industry Standard.

810 RO
Receive-Only Printer



The OMNI 800* Model 810 RO, with its reputation for outstanding reliability, sets the standards that other printers in the industry are measured against. And with good reason. Great for applications like report generation, invoicing and ticket printing, the 810 RO's field-proven performance handles heavy workloads with ease.

TI is dedicated to producing quality, innovative products like the Model 810 RO. And TI's hundreds of thousands of data terminals shipped worldwide are backed by the technology and reliability that come from 50 years of experience.

For more information on the Model 810 RO, contact the TI sales office nearest you, or write Texas Instruments Incorporated, P.O. Box 202145, Dallas, Texas 75220, or phone (713) 373-1050.

We put computing within everyone's reach.

CIRCLE NO 8

TEXAS INSTRUMENTS
INCORPORATED

In Canada, write Texas Instruments Incorporated, 41 Shelley Rd., Richmond Hill, Ontario L4C 5G4, (416) 884-9181. In Europe, write Texas Instruments, M/S 74, B.P. 5, Villeneuve-Loubet, 06270, France, (93) 20 01 01. In Asia Pacific, write Texas Instruments Asia Ltd., 990 Bendeemer Rd., Singapore 1233. Telex RS 21399, or phone 2581122.

News Breaks

A CHIP FOR ALL ARCHITECTURES

You'll be able to take a painless approach to upgrading your 8-bit hardware to 16 bits when production quantities of Zilog's (Cupertino, CA) Z800 become available in the second quarter of 1982. The chip will feature 16-bit internal architecture, 8- or 16-bit external structure and 100% compatibility with Z80 code. It will also contain two new instructions (multiply and divide) along with all the old ones. Expected to cost $10 (OEM), the Z800 will include an on-board memory map that directly addresses 4M bytes of RAM; you'll be able to order 40-pin versions with multiplexed data buses or nonmultiplexed 64-pin versions. A buffered instruction set and 12-MHz clock will furnish three to five times the performance of the Z80A with the same code.—ET

16-BIT A/D CONVERTER SPECS ±0.003% MAX LINEARITY ERROR

Priced at $199, the ADC1140 16-bit A/D converter features a 35-μsec max conversion time and a guaranteed ±0.003% of full-scale range max linearity error (without requiring any external components). Manufacturer Analog Devices (Norwood, MA) claims that the unit, housed in a 2×2×0.4-in. package, is the lowest cost device in its accuracy or resolution category. It provides pin-selectable input-voltage ranges, operates over 0 to 70°C and has a typical power consumption of 1.2W.—TO

UNIX SOFTWARE DIRECTORY AVAILABLE BY SUBSCRIPTION

An industry-wide directory of UNIX and C products is available on a subscription basis from InfoPro Systems. Covering a wide range of software and hardware products, the UNIX Software List gives full where-to-get-it information. Listings include UNIX operating-system suppliers, user groups, C compilers and interpreters, software tools, database-management systems and more.

A yearly subscription to the directory costs $18 in North America; $24 for foreign airmail. For more information, contact InfoPro Systems, Box 33, East Hanover, NJ 07936; phone (201) 625-2925.—JM

DIGITAL PATTERN GENERATOR EXTENDS TESTER'S CAPABILITY

Addition of Model DX89 digital pattern generator to Model MTS77 ATE system permits testing of mixed-technology devices such as flash converters and analog I/O μPs on one tester. From LTX Corp (Westwood, MA), the DX89/MTS77 combination features 12.5-MHz pattern-generation capability and can test devices with 24 input and 24 output pins. A 4k×4-bit memory on each channel lets you specify input ONE, ZERO or high-impedance conditions and output ONE, ZERO or don't-care conditions. Moreover, output channels feature 4k×1-bit data-recording channels that let the tester "learn" such conditions as the digital response of an A/D converter to a sine-wave input.

Other features include 32k-bit channels for data-send and -receive operations that facilitate telecomm-circuit testing. Furthermore, the system can simultaneously but independently test the encode and decode sections of codecs. It can generate digital patterns algorithmically, "learn" them from good devices, assemble them from CAD or other data files or synthesize them through matrix operations such as FFTs. Typical system prices range from $350,000 to $400,000.—RN

SPEAKING OF VOICE I/O . . .

When Speech Systems Inc opens up for business, it will act as a speech-system integrator, putting existing technology to work in systems. To be located in Encino, CA, the firm will be headed by William Meisel, formerly with Technology Service Corp.

News Breaks

. . . At NCC last month, Digital Pathways Inc (Mt View, CA) demonstrated yet another application for voice synthesis. Its Serial Line Controller uses Texas Instruments' TMS5200 speech chip to initiate voice messages whenever it recognizes certain messages passing between a computer and a terminal. The unit acts as a telephone-based computer-terminal operator that works around the clock. Priced at $1975, it can alert a person by telephone whenever an abnormal condition exists.—ET

N-CHANNEL POWER MOSFETs AIMED AT GENERAL-PURPOSE APPLICATIONS

Two power-MOSFET families for broad-based general-purpose applications will be fabricated with hexagonal multicell, vertical-DMOS structures. From RCA Solid State Div (Somerville, NJ), the medium-power TA9196/9213 devices will sport drain-to-source breakdown ratings of 80 to 120V and a 1.5A drain current. The TA9192/9212 MOSFETs will provide higher power options with 100 and 150V breakdowns and 6A current-handling abilities. The medium-power units will come in TO-39 and TO-220AB packages, while the high-power chips will reside in either TO-204MA (the old TO-3) or plastic TO-220AB packages.

Production quantities should be available in September for approximately $1.85 (1000) for the TA9196/9213 and $4.45 (1000) for the TA9192/9212.—GH

100-MHz 6-TRACE SCOPE COSTS $2595

Kikusui International Corp (Carson, CA) has put a $2595 price tag on its 100-MHz Model 6100 (EDN, March 18, pg 37). The scope can simultaneously display Channel 1, Channel 2, Channel 3, Trigger A, Trigger B and the sum or difference of Channels 1 and 2. Warranty is 2 yrs on the scope, 1 yr on the CRT.—RN

LESS-THAN-$600 DOT-MATRIX PRINTER FEATURES FULL-SIZED CARRIAGE

Accepting paper up to 15½ in. wide and printing 136-character columns, the $595 (1000) MX-100 dot-matrix printer from Epson America (Torrance, CA) employs a dual print font (9 × 9 or 18 × 18) to achieve near-letter-quality output. It supports a bit-image graphics function of 60 dots/in. in Standard mode and 120 dots/in. in Double Density mode. The printer, which will be available by mid-year, comes standard with a Centronics-compatible 8-bit parallel port and a 1-line buffer. Options include RS-232 and IEEE-488 interfaces and a 2k-byte buffer.—CW

DATA SEPARATOR INCREASES DISK-DRIVE CAPACITY BY 50%

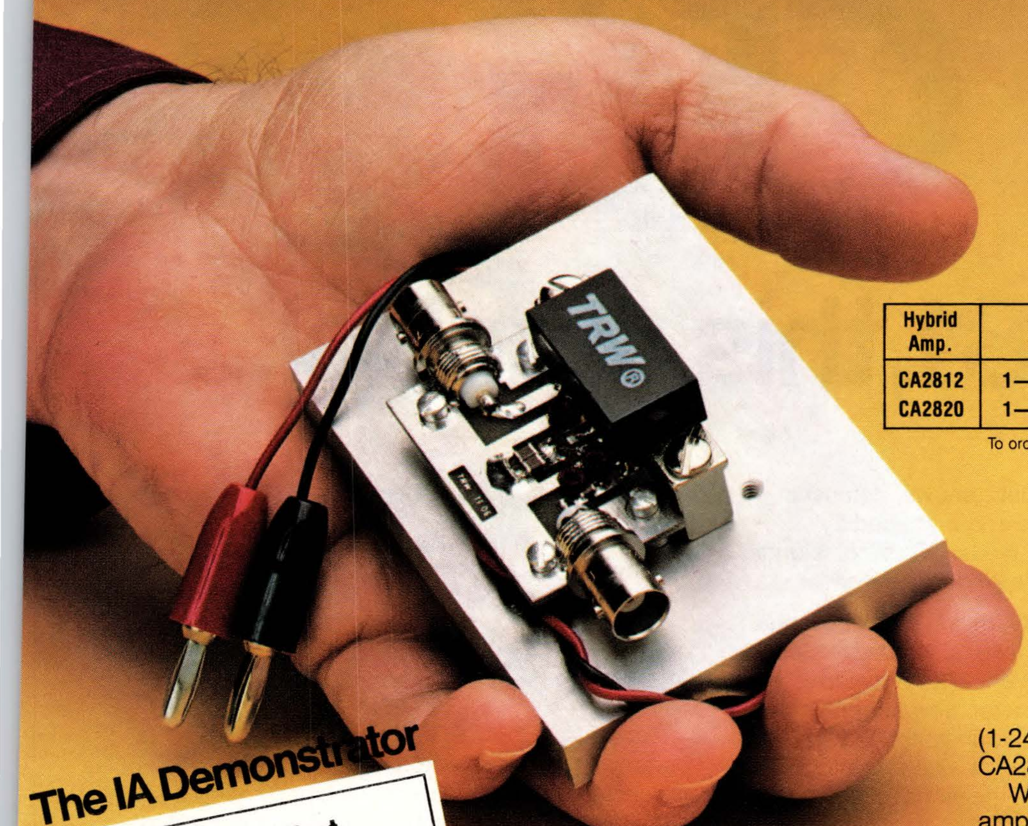
The Data Express II ($250) from Rotating Memory Systems Inc (Sunnyvale, CA) supports run-length-limited code to allow recording of as much as 50% more disk-drive data per track. This capability increases the capacity of the firm's Model RMS 503 drive from 3.18M to 4.5M bytes; RMS 506, from 6.38M to 9M bytes; and RMS 512, from 12.72M to 18M bytes. Two custom VLSI encoder/decoder ICs minimize required circuitry.

The $197 Data Express I separator handles MFM coding at 5 MHz and supports only standard capacities. Both units support two 5¼-in. Winchester drives via SA1000-type interfaces and mount within the drive or controller enclosure. They require 5 ± 0.25V dc at 1.5A max, 1.1A typ, and 50-mV p-p max ripple.—AR

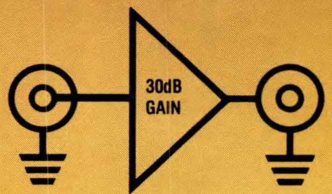
DIAL-UP DIRECTORY DESCRIBES 100-COMPUTER NATIONAL NETWORK

If you own a computer, modem and terminal, you can gain access to a national computer network of more than 100 small computers, maintained by user groups, schools, publishers, commercial businesses and hobbyists. Novation (Oxnard, CA) provides a 24-hr dial-up directory of the network; call (213) 881-6880 and type CAT followed by a Carriage Return or Enter to gain access to it.—JB

Special instrumentation amplifier offer!



MATCHED FOR 50Ω SYSTEMS



Hybrid Amp.	Freq. (range)	V_{CC} (nominal)	P_0	I_{TO}
CA2812	1—520MHz	12V	0.3W	34dBm
CA2820	1—520MHz	24V	0.5W	37dBm

To order test fixture and amplifier specify IACA part #

The IA Demonstrator

Evaluation Test Fixture and Hybrid Amplifier
A $142.00 VALUE
ONLY $62 COMPLETE.
(Limit one to a customer)

We want to show you that TRW's hybrid amplifiers are ideal for all sorts of analog and digital applications. Our Demonstrator will prove it to you. Instantly.

Whatever type of instrument or system you're working on — chances are you'll have to boost an RF signal somewhere, and with minimum distortion. Before you spend hours or days designing and debugging a high-performance discrete component amplifier, order the IA Demonstrator that meets your requirements and save all that time and trouble. Because all you do is plug in the IA Demonstrator to see how well a TRW hybrid will perform in your application.

Each IA Demonstrator includes an evaluation test fixture (worth $100) and the amplifier of your choice. For this special offer, you get both for only $20 over the normal price of the amplifier. And to amplify your thinking, we'll include our new 100-page RF Linear Hybrid Design Guide with complete data sheets, specs and the very latest applications notes.

These TRW hybrids feature wide bandwidth, 1 to 520 MHz; 3rd order intercept to 37 dBm; operation from 8V to 28 VDC, and power output to 500 mW. They're unconditionally stable into all load impedances, and available in hermetic packages; we also offer Hi-Rel performance. You can use them to simplify and speed up design time schedules, save PCB space and slash costs with our low, low OEM prices* (1-24 quantity: CA2812, $42.00; CA2820, $42.00).

What's more, if our wide band amplifier isn't demonstrably superior for your application, return your IA Demonstrator for a full refund, no questions asked. They're in stock — order now from one of the following TRW distributors:

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*OEM prices will vary slightly due to gold adder price fluctuation.

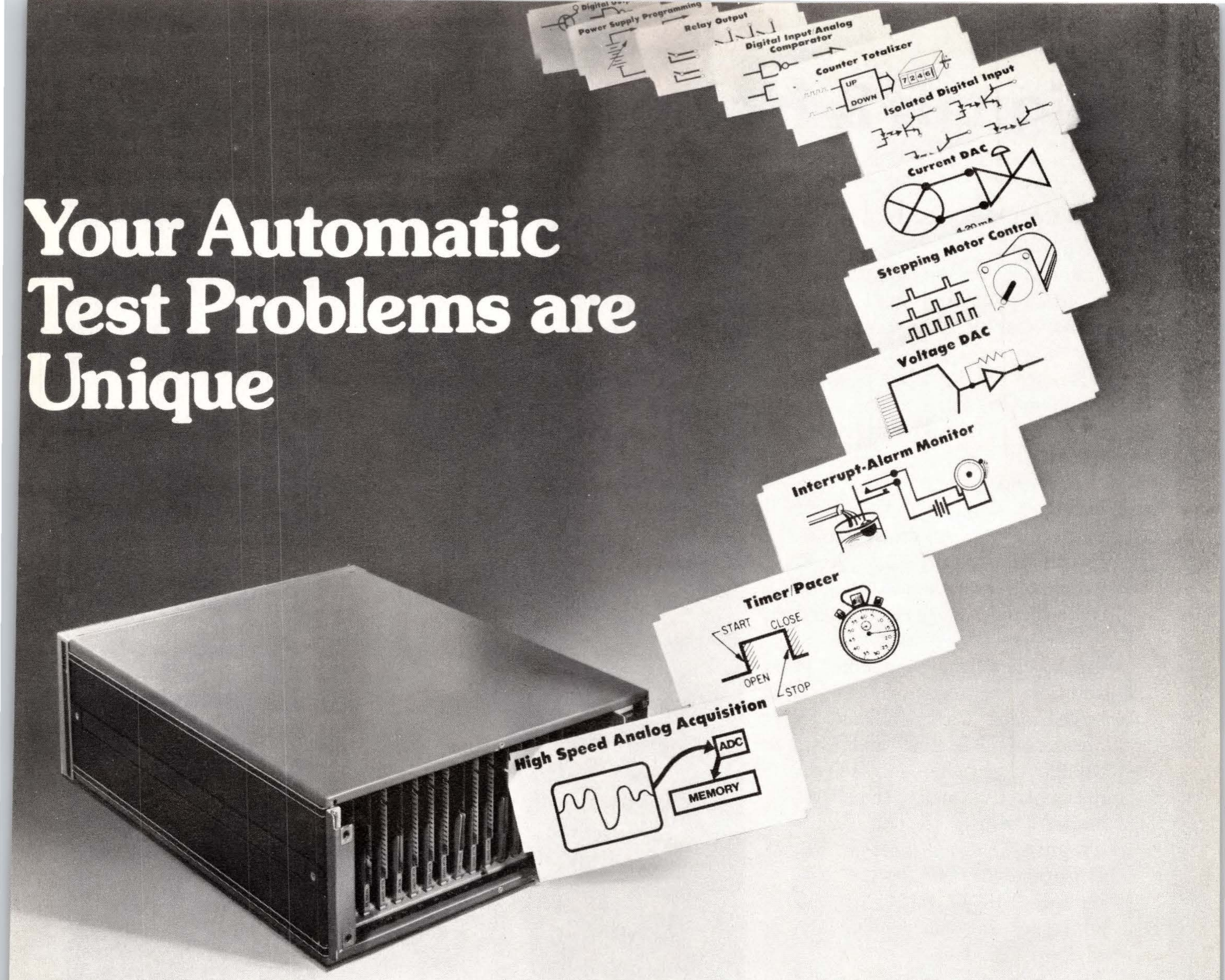
SPECIAL OFFER
THE IA DEMONSTRATOR

ORDER PART NO.	SPECIAL U.S. PRICE SAVE $80.00	REG. PRICE
IACA2812	**$62.00**	$142.00
IACA2820	**$62.00**	$142.00

TRW RF SEMICONDUCTORS
An Electronic Components Division of TRW Inc.

CIRCLE NO 9

Your Automatic Test Problems are Unique



The Multiprogrammer is the Answer

HP's 6942A Multiprogrammer is the vital link between your every changing automatic test problems and their fast, easy and economical solution. The microprocessor-controlled Multiprogrammer has an HP-IB interface, built-in self-test, a real time clock, and memory to store instruction sequences and data.

Extraordinary versatility is achieved through a selection of 19 different functional plug-in I/O cards used as building blocks to meet your specific applications. Now, Memory I/O cards can perform high-speed multiple-channel data acquisition, while other I/O cards simultaneously stimulate the device under test. This allows off-line subsystems to be conveniently assembled.

Other capabilities include programming power supplies with outputs of up to 250 volts or 1000 amps, and controlling stepping motors used as precision mechanical actuators. These functions are accomplished with simple-to-use mnemonic instructions and easily interfaced I/O cards.

A *User's Guide,* containing sample programs for each I/O card, speeds the task of writing software. The result is a shorter time from concept to solution. The Multiprogrammer combined with any of the popular HP controllers is a powerful answer to your automatic test problem.

For more information on how you can benefit from the 6942A Multiprogrammer, write to Hewlett-Packard, 1507 Page Mill Road, Palo Alto, CA 94304. Or call the HP regional office nearest you: East (201) 265-5000, West (213) 970-7500, Midwest (312) 255-9800, South (404) 955-1500, Canada (416) 678-9430.

HEWLETT PACKARD

21103

CIRCLE NO 10

Signals & Noise

You can learn to write

Dear Editor:
Thank you for sending me a copy of your "Writing for EDN" author's guide. I'm disappointed, however, that it doesn't reference the best book I have found on writing: *The Technique of Clear Writing*, by Robert Gunning.

This book provides a no-nonsense definition of the 10 principles of clear writing, lavishly illustrating each one. It even includes a chapter dedicated to technical writing. Finally, it presents a yardstick you can use to check the readability of your own writing.

The book was published by McGraw-Hill in 1968 and costs $12.95. If you want to receive a discount for more than five copies, write to the firm's warehouse at Princeton Rd, Hightstown, NJ 08520 and include billing and shipping addresses and the book's code, ISBN07-025206-8.

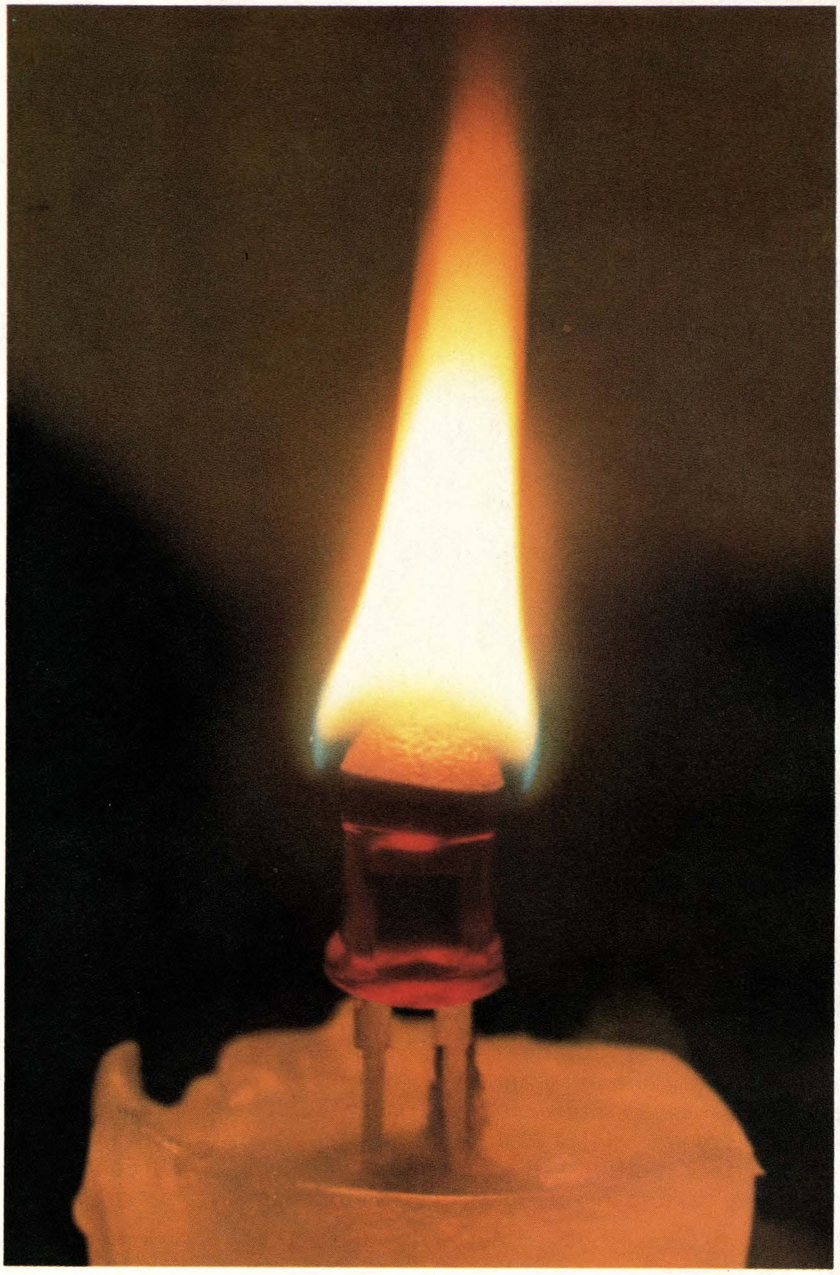
Sincerely,
Raymond Kostanty
Wood-Ridge, NJ

That's one cool chip

Dear Editor:
Tim Regan's brilliant Design Idea in EDN's April 1 issue (pg 81) describing that new hot chip, the F/C-102, contains a minor error. I believe he misquoted the -L version's temperature range as −32°F to 0°C. According to the spec sheet, the temp spec is 32°F to 0°C.

By the way, a MIL-spec version of the F/C-102 will be sampled in last quarter of this year. Temp spec is 0°F to 460°R.

Sincerely,
Tony Rea
Boylston Electronics Corp
Boston, MA



Nothing holds a candle to the new FED

Dear Editor:
The LM196 featured on the cover of EDN's April 1 special supplement is the ideal driver for the new flame-emitting diode (FED). The FED comes in two styles—regular and phosphorus doped—with output guaranteed to 1 candlepower. Other features include a self-extinguishing action when reverse polarity is applied and a constant color temperature. It's an excellent emitter of both infrared and visible light **(photo)**. Unlike the LED, the FED requires no series-limiting resistor.

Incidentally, what's the leakage spec on the LM196?

Sincerely yours,
Jeffrey A Small
Eastman Kodak Co
Rochester, NY

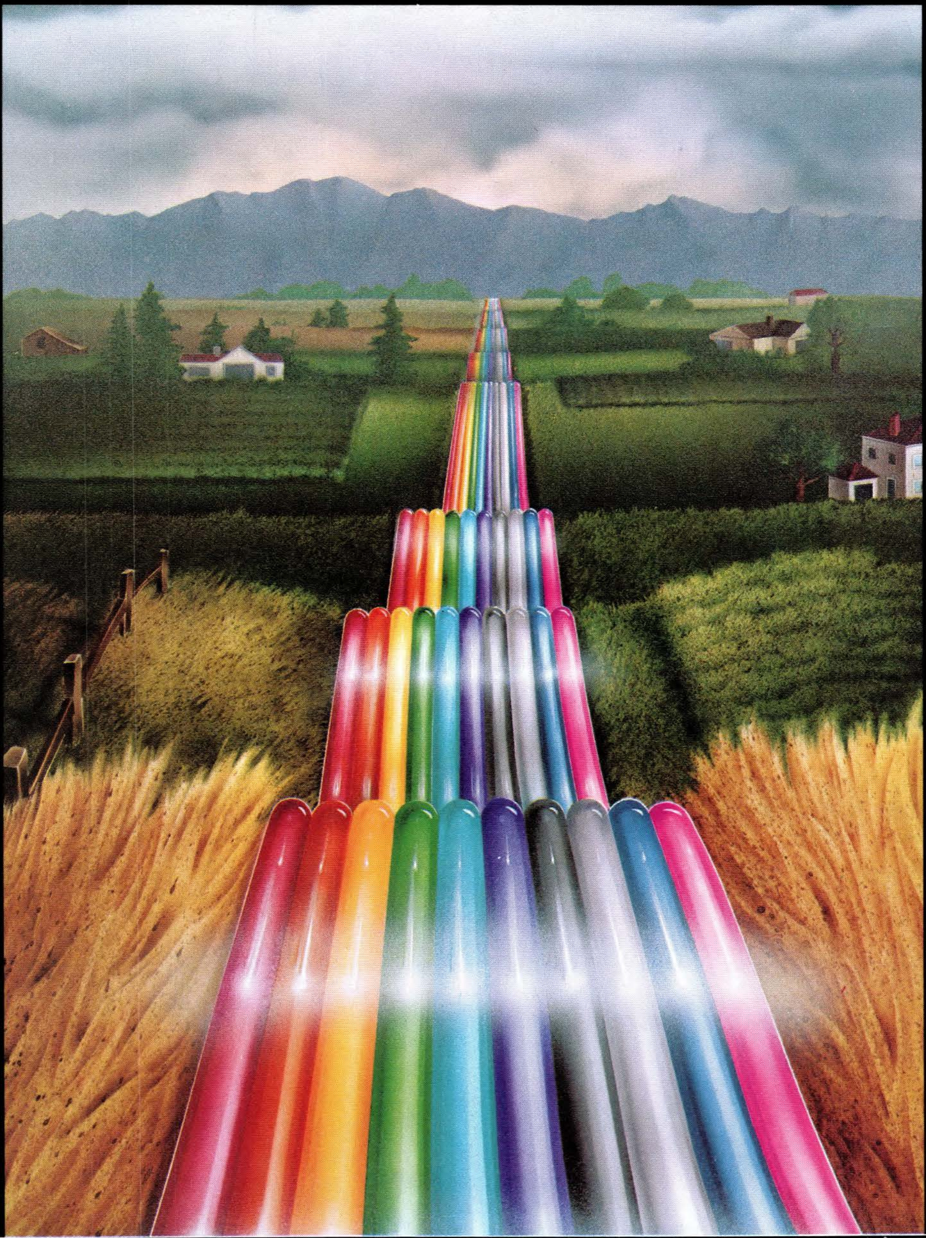
Continued on pg 27

NATIONAL ANTHEM®

SEMICONDUCTOR NEWS FROM THE PRACTICAL WIZARDS OF SILICON VALLEY.

Bringing integrity to long distance busing.

NEW DS3662 TRAPEZOIDAL BUS TRANSCEIVER VIRTUALLY ELIMINATES CROSSTALK OVER LONGER BUSES THAN EVER BEFORE.



- Reliable 16K bipolar PROMs
- Low cost bubble memory boards
- The 10 Amp MOOSE™ adjustable voltage regulator
- Reliable Mil/Aero PROMS
- The J-FET solution
- The leading edge in power op amps
- The SuperChip™ 8488 controller board
- μP-compatible DACs
- Self-contained precision instrumentation amp
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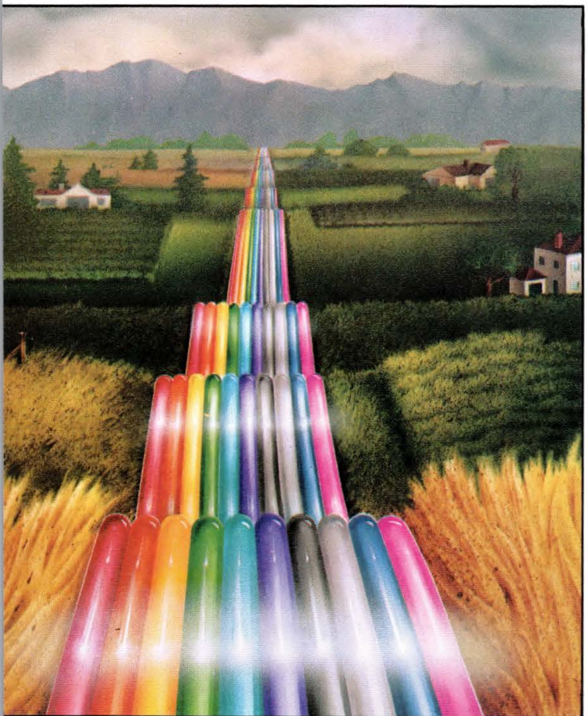
Digitalker COPS Data Acquisition Logic Transistors Hybrids Linear Interface Bubble Memory RAMs/ROMs/PROMs Transducers Displays Custom Circuits Optoelectronics Memory Boards Microprocessors Development Systems Microcomputers Modules Mil/Aero

The trapezoidal DS3662 puts quiet transmission on the bus.



The industry's first trapezoidal transceiver allows higher data rates with lower distortion over longer distances.

The DS3662, National's new quad high speed trapezoidal bus transceiver, represents a major step forward in transmission integrity and overall system dependability.

Precise trapezoidal bus waveforms reduce noise coupling, without sacrificing the maximum data rate. The receivers use low pass filters to further enhance noise immunity.

The result is at least an order of magnitude increase in allowable bus lengths than ever before possible.

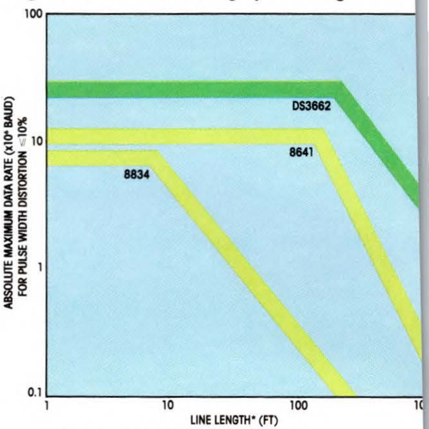
AC specs guaranteed. The DS3662—a pin-for-pin functional replacement for the standard 8641 transceiver—offers guaranteed AC specifications over the entire temperature and supply voltage range.

It also features glitch-free power up/down protection on the driver outputs. So entire cards can be brought on-line or off-line without adding any noise to the system bus.

Greater transmission integrity. The DS3662 is actually immune to noise pulses up to 20ns. So this new trapezoidal device does a great deal toward enhancing overall system performance even when used with conventional bus transceivers.

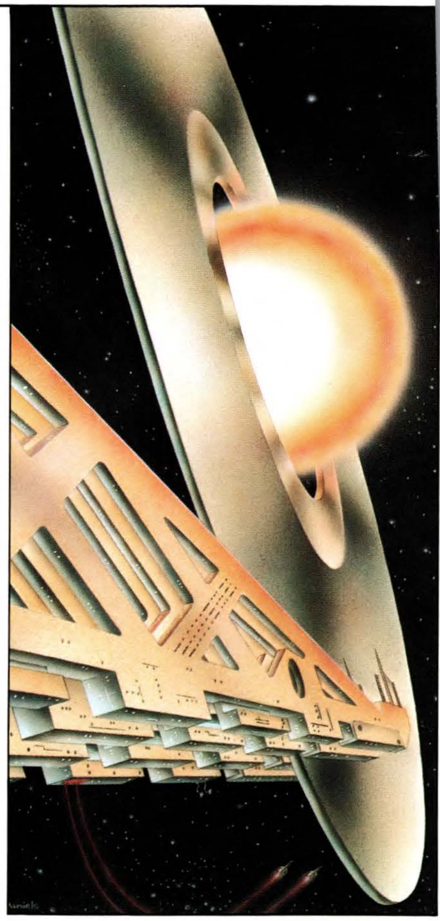
For a data sheet and application information, check box 082 on this Anthem's coupon.

Higher data rates and integrity over longer lines.



*Twisted pair cable (22 AWG stranded), terminated 180 / / 390 Ω, 50% duty cycle.

Solving servo problems with the fastest, cleanest power op amp ever.



The linear leader redefines the "leading edge" in power op amp design with their new LH0101.

National's new LH0101 series op amps are the fastest, cleanest power op amps now available. Others can match the 2A continuous or 5A peak output current, but no one comes close in any other major parameter.

To begin with, its 10V/μsec slew rate is four times faster than the nearest competition, National's own LH0021. And its 300KHz full power bandwidth is fifteen times wider than the rest.

Plus, by using a BI-FET™ input stage, the LH0101's 300pA input bias current is 100 times less than any other comparable amp on the market. And if this isn't enough, the LH0101 also offers extremely low distortion specs: 0.008% with undetectable cross-over distortion.

So the LH0101 is ideal for such demanding tasks as head positioning servos for hard disks.

An endless list of applications. With this kind of performance plus good availability in both commercial and military versions, applications are endless.

In addition to head positioning servos, the LH0101 is perfectly suited for inertial guidance platforms, synchro drivers, CRT deflections yoke drivers for graphic displays, power DACs for Automatic Test Equipment, motor drivers, and super-fidelity audio systems. And these are just a few applications to consider.

For the data sheet and application information on these high performance power op amps, check box 080 on this issue's National Archives coupon.

The LH0101. Tomorrow's reality today from the Practical Wizards of Silicon Valley.

BI-FET is a trademark of National Semiconductor Corporation.

National blitzes the Mil/Aero market with reliable PROMs.

An entire fleet of bipolar PROMs guarantees an extra measure of reliability in mil-spec applications.

The Practical Wizards are taking the Mil/Aero PROM market by storm with 15 hi-rel devices to choose from.

And all 15 have survived the rigors of National's 883B/RETS™ program, the same totally compliant Class B screening offered on their 1100 other Mil/Aero products.

Practicality prevails. National's technical expertise puts them out in front with significant bipolar advances that make practical sense.

Their DM77S190 and DM77S191, both state-of-the-art 16K bipolar PROMS, are perfect examples. They're as fast and as large as any in the industry. And their titanium-tungsten fusing and high volume Schottky production process gives them rock-solid reliability.

These full mil-temp high-speed PROMs are Schottky-clamped for a typical address access of 40 ns and a typical enable access of 20 ns. In addition, they use PNP inputs to reduce input loading. And they incorporate TRI-SAFE™ for low voltage programming.

Fuses that last. National's titanium-tungsten fuses are made of a very stable and reproducible metal combination which resists oxidation.

National uses an on-chip Darlington programming circuit that "pulse shapes" the programmer's input and sends a very fast, high energy current pulse to the selected fuse.

This minimizes local heating and produces a wide gap in the fuse link, one free of residual conductors and without deteriorating hermeticity. The result is the industry's most reliable PROM.

Additionally, the titanium-tungsten fusing allows a low 10.5V programming voltage. And that eliminates the need for guard rings and wide spacings.

Reliable PROMs from proven processes. As an additional measure of practical reliability, this family of PROMs uses titanium-tungsten as a buffer between the aluminum interconnect and the platinum-silicide "barrier."

National can fill any socket by offering a full line of TRI-STATE® or open collector devices, ranging from 256 to 16K bits.

Their tight quality control and practical innovation pay off in highly reliable, high volume products. In the TRI-STATE PROMs, for example, only 11 failures have been observed in 2.7 million hours of testing. Not one of the failures was fuse-related.

Full support for PROM programming. The Practical Wizards not only supply the PROMs, but all the tools necessary to program them.

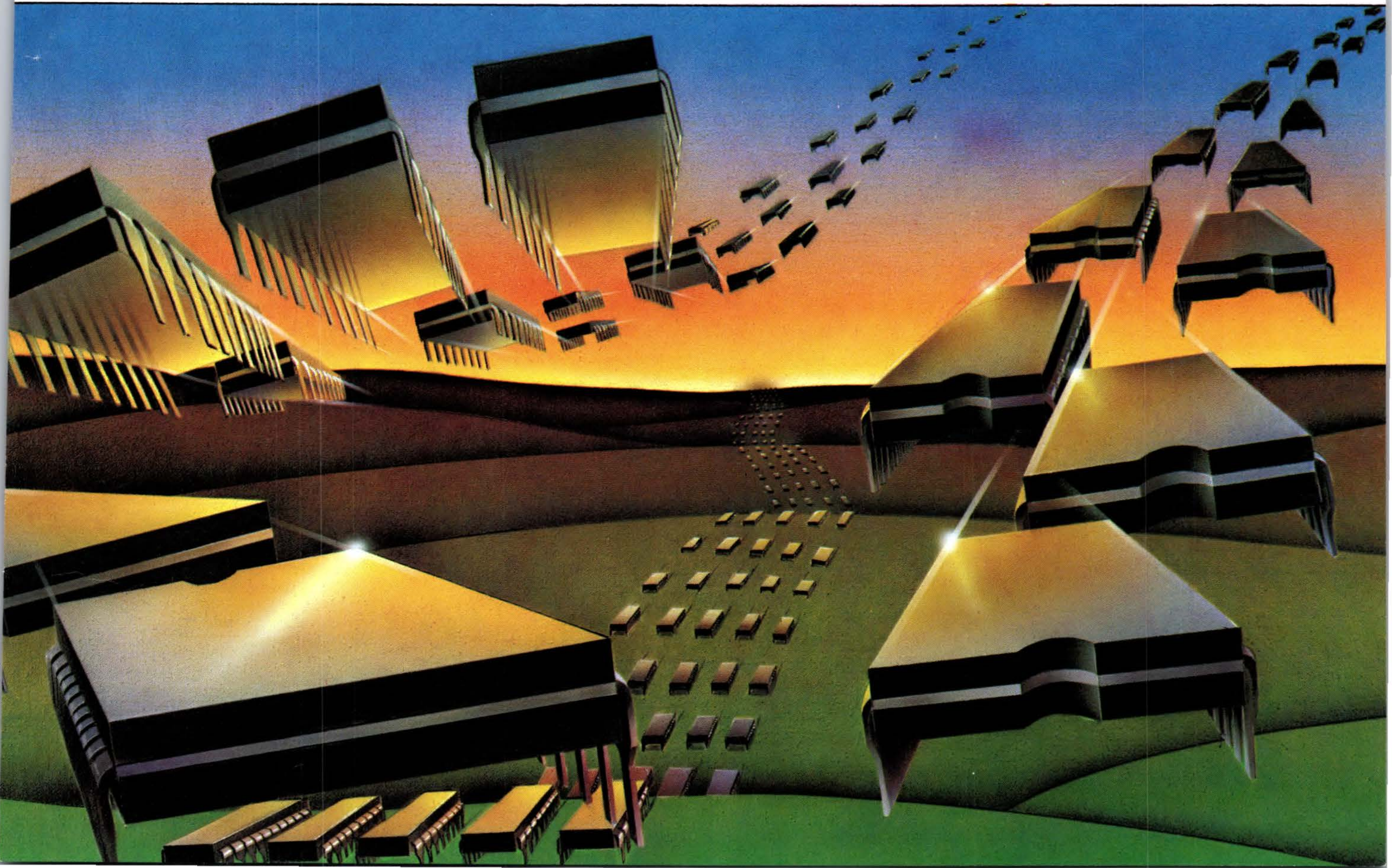
STARPLEX,™ the fully developed development system, includes an optional Universal PROM Programmer and all the required PROM personality modules. So beginning to end, you can't go wrong with National's Mil/Aero bipolar PROMs.

The product table in this article gives the part number, organization and T_{AA}. But for more information on these and other long-lasting memories, check boxes 096 and 062 on the National Anthem coupon.

TRI-SAFE, TRI-STATE and STARPLEX are trademarks of National Semiconductor Corporation.

PROM SUMMARY TABLE

PART NUMBER	T_{AA} (MAX COMM)	ORGANIZATION
DM54S188-288J/883B	35	32 x 8
DM54S287-387J/883B	50	256 x 4
DM54S570-571J/883B	55	512 x 4
DM54S472-473J/883B	60	512 x 8
DM54S474-475J/883B	65	512 x 8
DM74S573J/883B	60	1024 x 4
DM77S184-185J/883B	55	2048 x 4
DM77S190-191J/883B	65	2048 x 8



NATIONAL ANTHEM

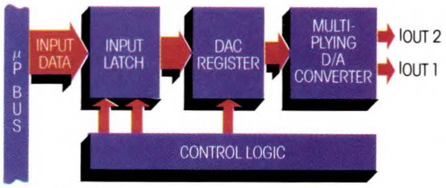
New μP-compatible converters bridge the gap from D to A.

National's line of low-cost 8-, 10- and 12-bit CMOS MICRO-DAC™ converters are double-buffered for maximum versatility.

The number of microprocessor-based designs requiring digital-to-analog conversion is increasing at an incredible rate.

In response to this demand, the linear wizards are now offering a full line of low-power CMOS D/As that interface very easily to any 8- or 16-bit μP bus. These double-buffered converters contain both an input latch and DAC register plus all the μP logic necessary for simplified design and reduced board space.

DOUBLE BUFFERED MICRO-DAC CONVERTERS



And since they're all monotonic with differential non-linearity specified over temperature, they fit particularly well in either fixed or multiplying reference applications such as servo control or synchro-to-digital converters. Thanks to their low cost, these new 8-, 10- and 12-bit D/As can also be used as programmable gain amps, digital attenuators, band-pass filters and more.

All digital inputs are TTL-compatible for more extensive interface flexibility. Their 20-pin (.3" wide) packaging keeps board space usage down while their 20mW power consumption—a factor of 10 lower than bipolar—extends battery life in portable equipment.

The high accuracies obtained by using these devices are largely due to their "end point" linearity: just set zero and full scale and linearity is met.

And to make them even more versatile, National's 8-bit DAC0830/31/32, and 12-bit DAC1230/31/32 D/As have identical pin-outs for easy interchangeability.

For complete details on the entire line of low-power MICRO-DAC converters, check boxes 051, 057 and 073 on this issue's National Archives coupon.

At National, the practicality keeps on coming through.

MICRO-DAC is a trademark of National Semiconductor Corporation.

PRODUCT SUMMARY TABLE

PART NUMBER	DIP SIZE	RESOLUTION (BITS)	ACCURACY (% OF FSR)
DAC0830	20	8	0.05
DAC0831	20	8	0.10
DAC0832	20	8	0.20
DAC1000	24	10	0.05
DAC1001	24	10	0.10
DAC1002	24	10	0.20
DAC1006	20	10	0.05
DAC1007	20	10	0.10
DAC1008	20	10	0.20
DAC1208	24	12	0.01
DAC1209	24	12	0.02
DAC1210	24	12	0.05
DAC1230	20	12	0.01
DAC1231	20	12	0.02
DAC1232	20	12	0.05

Worlds ahead in data acquisition technology.

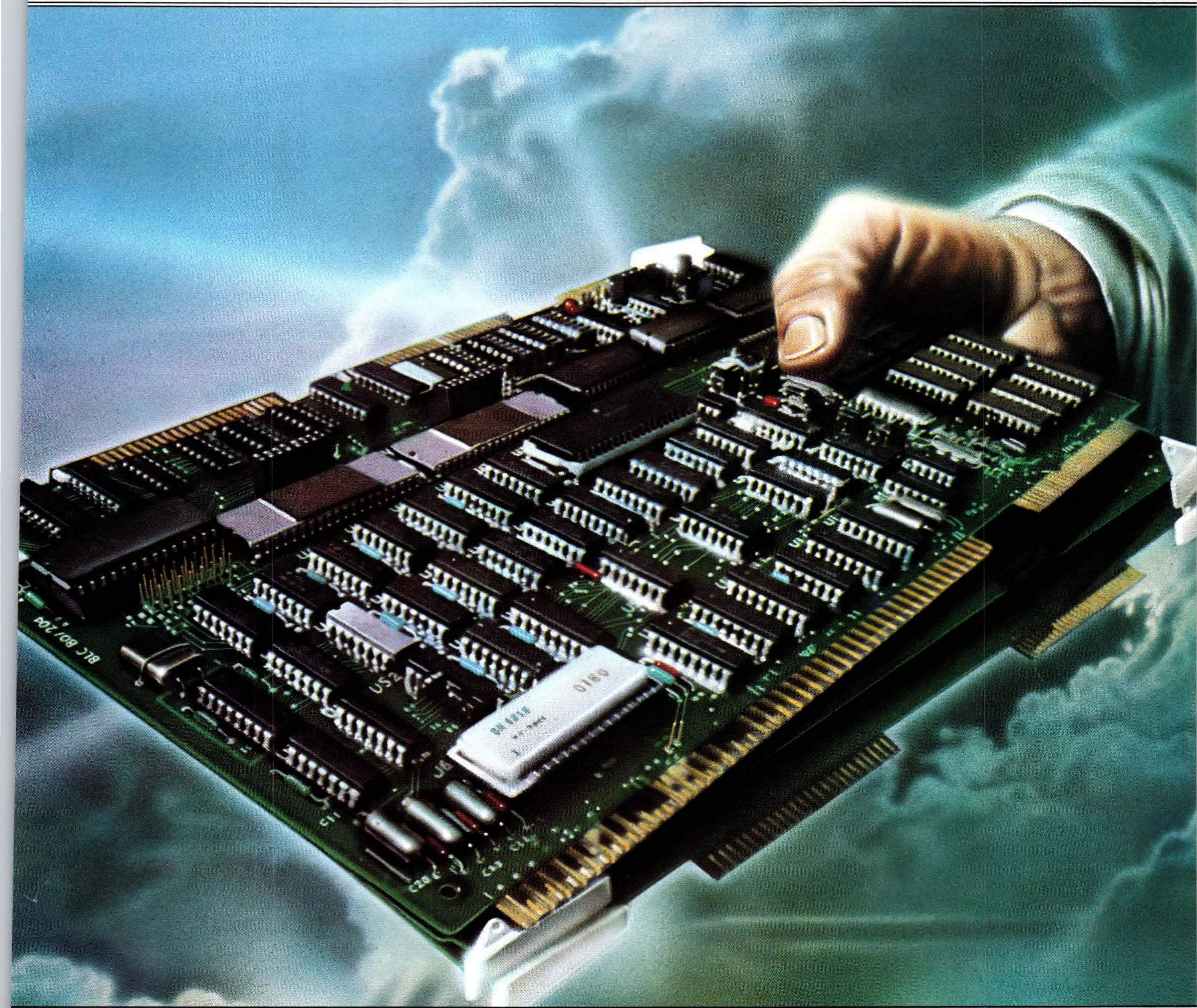
National Semiconductor, the Practical Wizards of Silicon Valley, is the world's largest supplier of data acquisition components. Over the last year, for example, they shipped over 5 million A/Ds—more than anyone else in the industry.

The key to their lead over the rest of the pack is their high volume production capabilities and extensively broad line, and their commitment to high performance at a low cost. With all of their transducers, amplifiers, filters, MUXs, sample and hold circuits, references, A/Ds and D/As, there's a National part for every application.

In addition, they're the only supplier utilizing technologies of bipolar, CMOS, NMOS and hybrid along with thin-film resistors and laser trim.

This is just a glimpse into what they're up to—designing high technologies into practical high performance data acquisition components.

National, the dedicated leader in data acquisition technology and components.



National creates the boards no one else could. SuperChips.™

SuperChips are the Multibus™ board-level solutions to your total system needs. Only National's broadline approach and technical expertise could make SuperChips a reality.

As an industry leader in state-of-the-art components, it's only natural that National should produce the industry's most powerful line of board-level system solutions. Their strong technical expertise and manufacturing muscle assure both the capabilities of their products and confidence of their customers.

The broadest family of problem-solving boards. With over 100 SuperChip products available, the Practical Wizards have more board-level solutions for more system configurations than anyone else.

For example, everyone has boards that compute and remember. There's no trick to that. But only National has boards that translate (the BLC-8488 intelligent GPIB controller board), talk (the BLX-281 speech synthesis module) and measure (the BLC-8737 and BLC-8715 analog I/O boards). The fact is, no one else in the industry can touch National when it comes to board-level technology.

12-Month Warranty. National also stands alone in the warranty business. Their entire SuperChip line carries a full 12-month warranty, the longest in the industry. Because anything less than that is less than the best.

SuperChips give you innovative system solutions based on superior design capability and leading edge technology.

Nobody knows more about building chips than National does, so they're a natural for building practical and reliable board-level products made from those chips.

For complete details on the entire line of SuperChips be sure to check box 083 on this issue's National Archives coupon.

SuperChips. Because man cannot live by chips alone.

NATIONAL ANTHEM

J-FETs–the time-proven solution to increased signal sensitivity demands.

The reliable back-to-basics solution to design overcomplexity.

National is known throughout the industry for their high performance line of J-FETs. They make over 500 standard products using 18 processes. And they're all available in quantity now.

The result is a J-FET for virtually any application problem.

The economics of plastic. No one offers plastic J-FETs with leakages as low as National's. Their PN4117A—normally used in smoke detector applications—has a leakage current of 1.0 pA max, 0.3 pA typical. Copper lead frames offer low thermal EMF voltages in ultra-low leakage switching applications such as digital volt meter range switches.

But the best news is National's plastic J-FETs offer leakages comparable to the metal can versions, with plastic devices costing 50% less. So now versatile plastic packages can be designed into applications requiring extremely tight specs.

J-FET practicality is basic reliability. The J-FETs' versatility allows them to rescue designs wrought with overcomplexity. And National's broad line of both single and dual J-FETs offers a flexibility of design along with competitive pricing and solid reliability. Together they give engineers considerable freedom of choice.

Check box number 074 on this issue's National Archives coupon or contact your local distributor or NSC sales rep for additional information. For application assistance, call one of National's FET Wizards at (408) 737-5554.

And start getting back to basics with high performance J-FETs.

Bubble memory bursts price barrier.

¼Mbit bubble memory boards for under $1800* available now from National.

National introduces the lowest priced ¼Mbit bubble memory board available—the BLC-9250. It's a non-volatile MULTIBUS™ and Series/80 compatible bubble memory board. And it's easily expandable to 1056K bytes with the BLC-9101 expansion board.

Suddenly, bubble memory becomes a cost-efficient choice for system design and life cycle enhancements. What's more, both the BLC-9250 ¼Mbit board and the BLC-9101 1Mbit expansion board are available in volume right now.

Smaller, faster and more reliable memories. National's bubble memory sub-systems use dense 16-pin memory modules designed to save board space. They have the smallest package and least number of pins for their density in bubble memory today.

In addition, they offer an average access time of 7ms and an average data rate of 75K bits per second. And they out perform others by a factor of 10 in reliability tests.

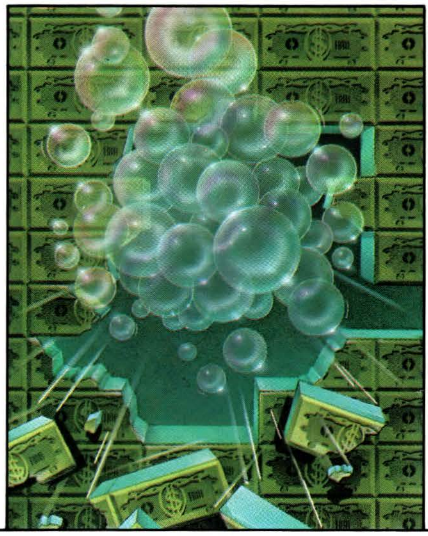
National's family support. Since both the BLC-9250 and BLC-9101 (and all Series/80 boards) are MULTIBUS-compatible, they interface with a wide variety of development systems. Including National's advanced STARPLEX™ development system with ISE™ and CP/M operating system.

For more information check box 065 on the National Archives coupon.

STARPLEX and ISE are trademarks of National Semiconductor Corporation.

MULTIBUS is a trademark of Intel Corporation.

*Single-piece U.S. price only.



Titanium-tungsten fuses improve the reliability of 16K PROMs.

National's bipolar PROMs guarantee an extra measure of reliability, thanks to titanium-tungsten fuses and today's high volume Schottky production processes.

National's 87S190 and 87S191 state-of-the-art 16K bipolar PROMs are an example of their bipolar wizardry. They're as fast and as large as any PROMs in the industry. And yet their titanium-tungsten fuses and high volume Schottky production process gives them rock-solid reliability.

These high-speed PROMs are Schottky-clamped for a typical address access of 40 ns and a typical enable access of 20 ns.

They use the same basic production flow as for other standard Schottky bipolar PROMs (from 256 to 8K bits) plus PALs and the 2900 bit slice family. It's a proven process that works time-after-time.

SCANNING ELECTRON MICROPHOTOGRAPH OF NATIONAL'S TITANIUM-TUNGSTEN FUSES IN THE OPEN STATE.

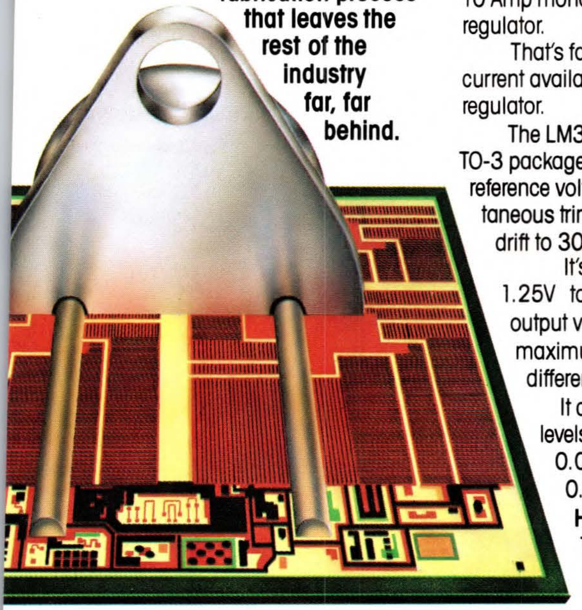
For more information check box 096 on the National Anthem coupon.

PROM SUMMARY TABLE

PART NUMBER	t_{AA} (MAX COMM)	ORGANIZATION
DM74S188/288	35	32 x 8
DM72S287/387	50	256 x 4
DM74S570/571	55	512 x 4
DM74S472/473	60	512 x 8
DM74S474/475	65	512 x 8
DM74S572/573	60	1024 x 4
DM87S180/181	60	1024 x 8
DM87S184/185	55	2048 x 4
DM87S190/191	65	2048 x 8

National's 10 Amp MOOSE™ is five years ahead of the pack.

The linear leaders are the first to introduce a 10 Amp monolithic adjustable voltage regulator. It uses National's revolutionary new MOOSE fabrication process that leaves the rest of the industry far, far behind.



MOOSE combines discrete power transistor and modern monolithic linear technologies. By combining both processes, the linear leaders have developed the world's first 10 Amp monolithic adjustable voltage regulator.

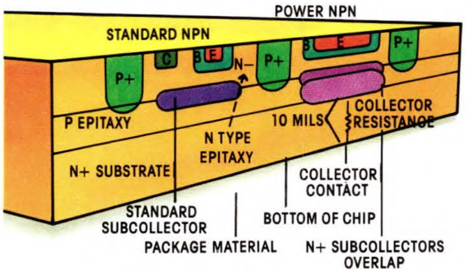
That's far and away the highest output current available in any adjustable IC voltage regulator.

The LM396—available in the standard TO-3 package—features on-chip trimming of reference voltages to ±0.5%, with simultaneous trimming of reference temperature drift to 30ppm/°C.

It's continuously adjustable from 1.25V to 15V and can satisfy higher output voltages as long as the maximum input/output voltage differential (20V) is not exceeded.

It can also handle 10A with power levels up to 70W. It also features 0.005%/V line regulation and 0.07%/A load regulation.

High performance, low price. The advanced MOOSE process results in a 2:1 reduction in die size and significant leaps in operating efficiency. These advances, backed by National's manufacturing expertise, strict quality control procedures and large volume production, result in a low $12.35* unit price for the LM396 in 100 piece quantities.



MOOSE PROCESS

You can expect to see a complete array of MOOSE-based devices from National in the future. But then, who would expect less from the linear leaders?

To get the full picture on MOOSE, check box number 069 on the National Anthem coupon in this issue.

*U.S. price only.

MOOSE is a trademark of National Semiconductor Corporation.

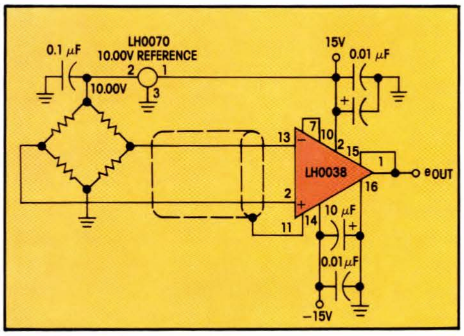
The totally self-contained low noise instrumentation amp with 12-bit accuracy.

With 0.2 µV peak-to-peak input noise voltage and 1 ppm gain non-linearity, the LH0038 allows precise gains ranging from 100 to 2000.

National, the recognized leader in linear circuitry, is offering their LH0038 precision instrumentation amplifier to design engineers working on data acquisition and related systems.

The LH0038 is the most complete single package instrumentation amp available because it requires no external resistors. In fact, the LH0038 contains four amplifiers, an extremely low-noise input stage and a precision thin-film resistor network—all in a single 16-pin metal DIP.

The pin-strap gain options on the LH0038 range from 100 to 2000, which makes it ideal for amplifying very low-level signals (such as thermocouples, low impedance strain gauges, etc).



X1000 BRIDGE AMPLIFIER

High-performance specifications. A large part of the LH0038's success in the industry is reflected in some of its key specs.

The LH0038 exhibits an excellent common-mode rejection ratio (114dB at a gain of 1000) and a closed loop gain error of only 0.5% (also at a gain of 1000).

In addition, the LH0038's input offset voltage is an ultralow 0.25µV/°C. The settling time to 0.01% is typically between 60 and 120µsec.

Also available in mil-spec version. In addition to National's own stringent REL and QA standards and procedures, a version of the LH0038 amp is also available that meets military standard 883 level B specifications.

For more information on the LH0038 precision instrumentation amp, check box 084 on the National Archives coupon.

The LH0038 single package instrumentation amp—another minor miracle from the Practical Wizards of Silicon Valley.

National creates the controller board no one else could. The BLC-8488 SuperChip.™

The BLC-8488 forms a new high-speed intelligent interface between Multibus™ and IEEE 488-1978 (GPIB) systems.

National's new BLC-8488 SuperChip makes the interface between GPIB-compatible devices and Multibus systems faster and easier to use than ever before. So easy, in fact, that all the designer needs to know about GPIB is how to configure the necessary I/O Control Blocks (IOCBs).

And the BLC-8488's 125 KB/sec throughput rate makes it over 20 times faster than the competition. So it makes the most of the GPIB's 1 MB/sec maximum data transfer rate.

Master/Slave versatility. On the GPIB side, the BLC-8488 conforms to all IEEE 488-1978 interface specifications—with a cable included for connection to male and/or female GPIB connectors.

But on the Multibus side, the micro-processor-based controller board serves equally well in either a master or slave configuration.

And in addition to 1 KB of private RAM it can address up to 1MB of system memory. The BLC-8488 also contains 2 KB of public dual-port RAM that's mappable anywhere in the 1 MB memory area.

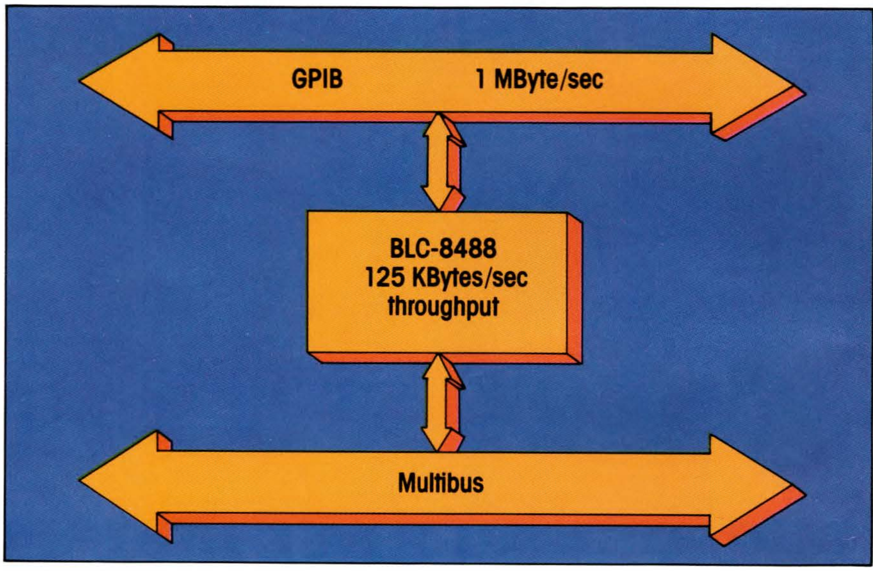
The SuperChip solution. This SuperChip versatility is even further extended to allow flexible interrupt handling/generation arrangements.

It's no surprise that the Practical Wizards are making some of the industry's hottest boards. It's just a practical extension of their technical expertise as a leading manufacturer of state-of-the-art semiconductor components.

For complete information on the new BLC-8488 intelligent GPIB controller board, simply check box number 081 on the National Archives coupon below.

SuperChips. Because man cannot live by chips alone.

SuperChip is a trademark of National Semiconductor Corporation.
Multibus is a trademark of Intel Corporation.



What's new from the National Archives?

- 051 ☐ Data Conversion/Acquisition Data Book ($7.00)
- 052 ☐ Free Subscription to the Data Update
- 057 ☐ MICRO-DAC Converter Data Sheets
- 062 ☐ Reliability Handbook ($12.50)
- 065 ☐ BLC-9250 and BLC-9101 Bubble Memory Data Sheets
- 069 ☐ LM396 "MOOSE" Data Sheet and Adjustable Voltage Regulator Brochure
- 073 ☐ Data Conversion/Acquisition Brochure
- 074 ☐ Additional J-FET Information
- 080 ☐ LH0101 Op Amp Data Sheet
- 081 ☐ BLC-8488 Data Sheet
- 082 ☐ DS3662 Data Sheet
- 083 ☐ SuperChip Family Information
- 084 ☐ LH0038 Data Sheet
- 096 ☐ Bipolar PROM Update

Enclose check or money order based upon appropriate currency. Make checks payable to National Semiconductor. All prices shown are U.S. prices only. Add applicable state and local sales tax to your order. Allow 4-6 weeks for delivery. This coupon expires on August 31, 1981.

EDN

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National Semiconductor
The Practical Wizards of Silicon Valley

NA 28

Signals & Noise

Exchange rate

Dear Editor:

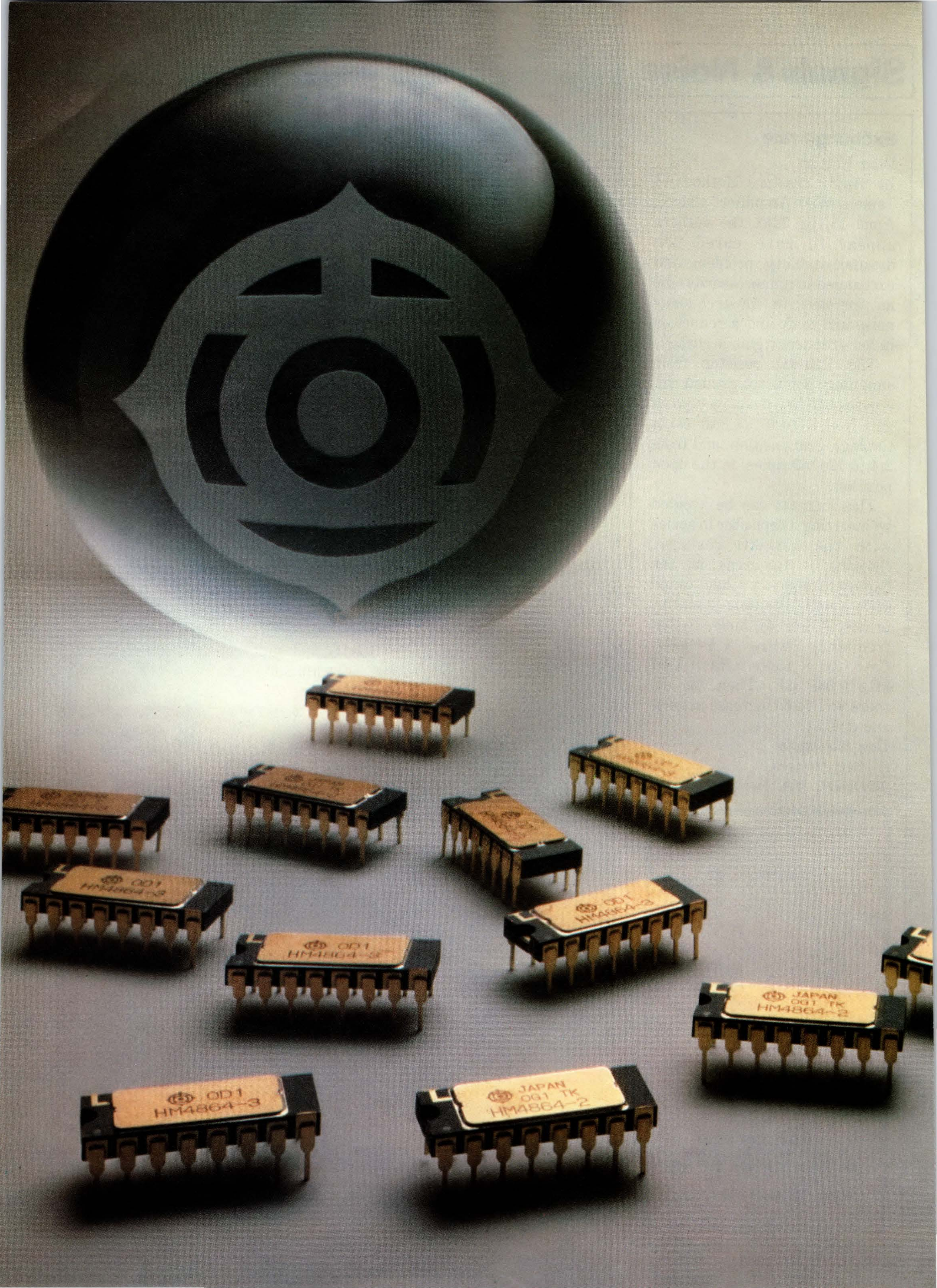
In "Apply Practical Methods to Tame a Wild Amplifier" (EDN, April 15, pg 125), the authors appear to have cured the dynamic-stability problem and exchanged it (unnecessarily) for an increase in low-frequency noise and drift and a reduction in low-frequency gain accuracy.

The 1.21-kΩ resistor from summing point to ground increases the low-frequency noise gain from 33 to 157 (4.8 times) in the high-gain position, and from 2.4 to 126 (52 times) in the open position.

This increase can be avoided by inserting a capacitor in series with the 1.21-kΩ resistor, choosing it to break at the highest frequency that would still avoid dynamic-stability problems. For example, if that frequency were 1.5 kHz, $C=1/(2\pi \times 1500 \text{ kHz} \times 1.21 \text{ k}\Omega)=0.088\ \mu F$. Then, at dc, there will be no increase in noise and drift.

Dan Sheingold
Analog Devices
Norwood, MA

"I WOULDN'T MIND IF HE'D RANT AND RAVE, OR EVEN SCREAM. BUT NO, HE JUST SITS THERE..... WITH TEARS IN HIS EYES."


OD1
HM4864-3
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NEW!

A High Speed, Low Power, Industry Standard 64K x 1 NMOS Dynamic RAM...

The HM4864 From HITACHI!!!

The New Hitachi HM4864 64K x I Dynamic NMOS RAM — In Stock, Ready For Immediate Delivery. The new Hitachi HM4864 uses the JEDEC standard 16-pin configuration, yet it provides high system bit densities and is compatible with widely available automatic testing and insertion equipment. The HM4864 features 150ns access time, a single 5V power supply, built-in VBB generator, TTL interface compatibility, on-chip address and data registers, and two chip select methods for determining appropriate speed and power characteristics of a memory system. Operation modes include read-modify-write, RAS-only refresh, and page-mode capability. The HM4864 consumes 330mW when active, and only 20mW in standby.

For more information about the new Hitachi HM4864 64K x 1 NMOS Dynamic RAM, call your local Hitachi Representative or distributor sales office.

HITACHI

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EDN 61081-180

Yes, I want to know more about the Hitachi HM4864 64K x 1 NMOS Dynamic RAM.

☐ Send detailed product literature.
☐ Have my Hitachi Representative call.

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Company ____________________
Address ____________________
City ____________________
State ____________________ Zip ________
Phone ( ) ____________________

Send to: Hitachi America, Ltd.
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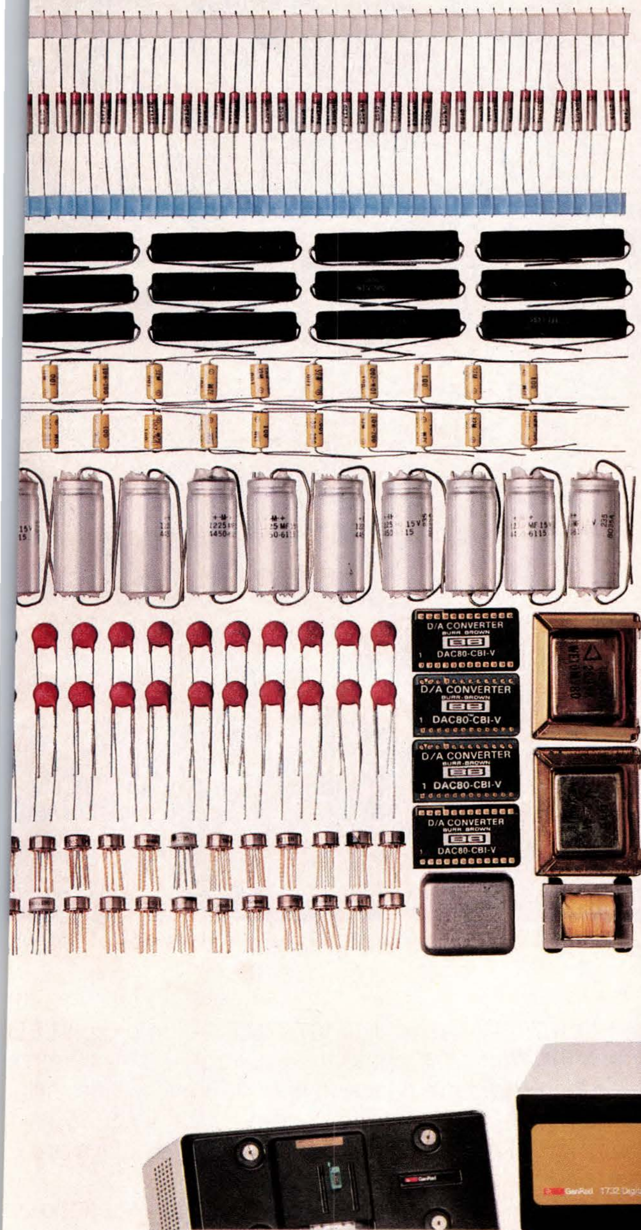
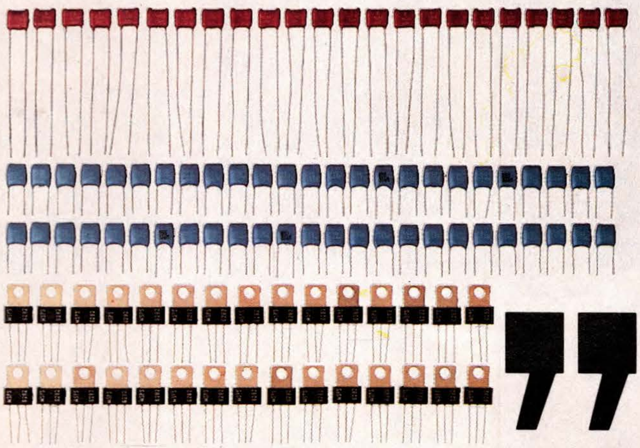
LE STATEMENT.





”

If GenRad can test more components for less money than anyone else, then we ought to be able to test your components for less. Right? Call Frank Kelliher, Component Test Division, for details. 1-617-779-2811 Ext. 303.

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I want to know more about reducing my component testing costs.
Send details on: ____ Digibridge® Testers ____ 1731 Linear IC Test System ____ 1732 Digital IC Test System ____ 2230 Passive Network Test System

EDN-6

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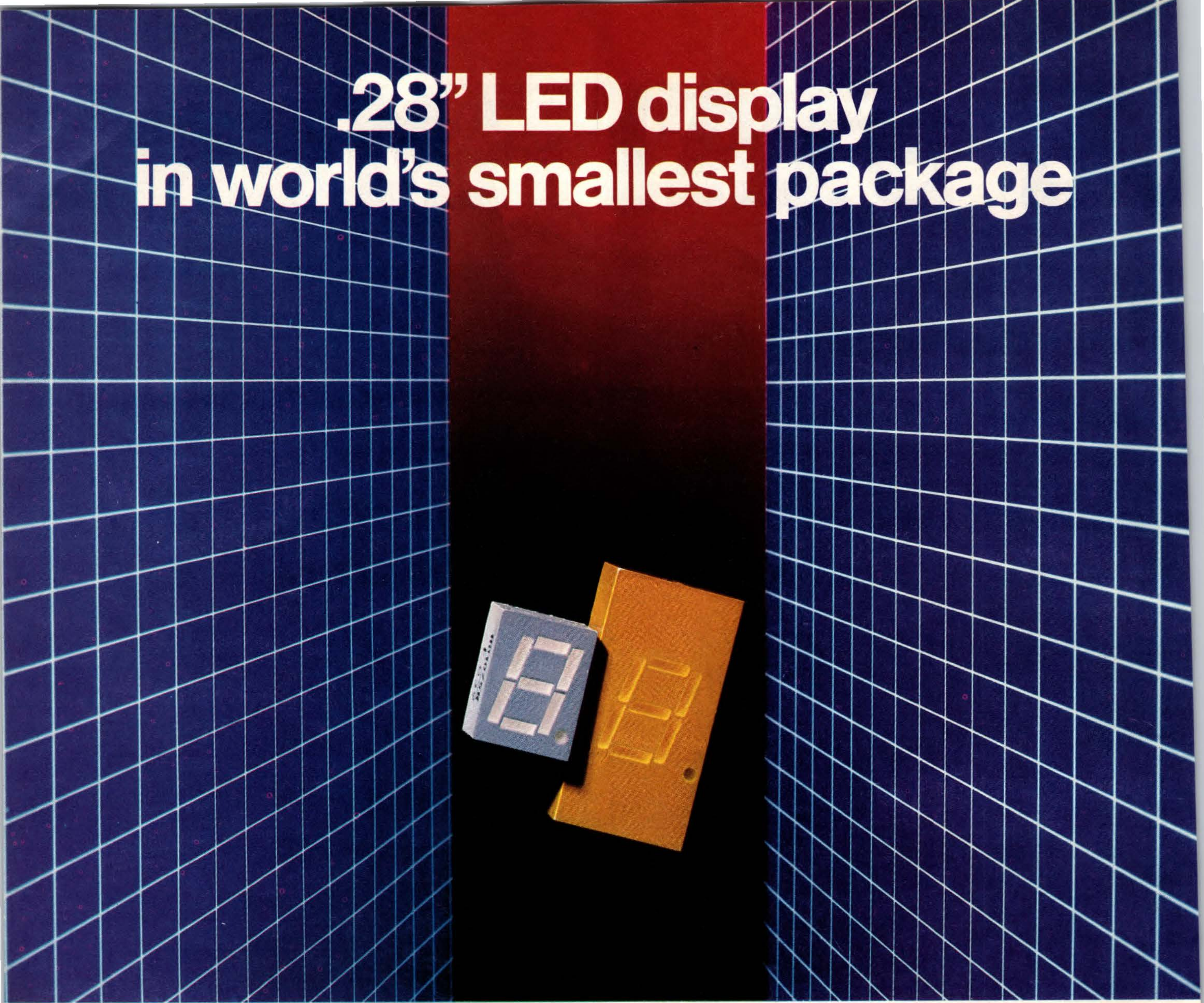
GenRad
THE BEST IN TEST.

CIRCLE NO 13

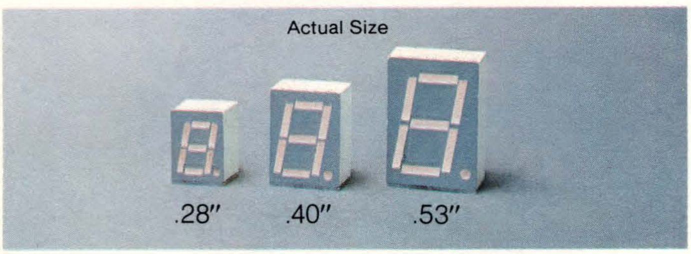


Shown above is the new .28" LED display VS the standard .3" display.

It's one of three compact Siemens digits available from Litronix.

When we became affiliated with Siemens, we joined forces to form the world's broadest and most innovative line of opto-electronic devices.

For example, we can now offer this family of extremely compact single digit displays which are less than one half the size of standard .3" displays on the market.



The HD 1075 (C.A.) and HD 1077 (C.C.) single digit LED display is a full 7mm (.28"), and the package is only 10mm x 7.6mm. On boards where space is tight and every little millimeter counts, our .28" digit will brighten a designer's eyes.

Other rugged encapsulated space saving displays are our 10mm (.40") and 13.5mm (.53") series.

The light gray face of Siemens displays enhances the on/off contrast ratio. And they are available in red, orange, yellow and green.

Next time you're caught in that Chinese puzzle of fitting too much in too little space, Litronix has the solution.

It's one instance where we'll be happy to offer you less for your money.

Litronix, 19000 Homestead Road, Cupertino, CA 95014. (408) 257-7910.

U.S. Distributors: Advent, Almac-Stroum, Arrow, Component Specialties, Gerber, Hamilton Avnet, Harvey, Kirkman, Lionex, Marshall, Moltronics, Pioneer-Standard, Summit and Zeus.

Litronix A Siemens Company

CIRCLE NO 14

Editorial

Accurate technology reporting needs your expertise

Few people in the US missed the dramatic countdown, launch and landing of the US Space Shuttle *Columbia* in April. To have seen history made was truly exciting.

But one nagging problem kept surfacing, especially during the first aborted countdown. The constant assurances by network reporters that "the scientists are examining this problem" and "the scientists will fix that fault shortly," etc, ad nauseum, bugged me considerably. And they should have annoyed you, too, if you believe, as I do, that the term "engineer" does not enjoy the stature it deserves among the general public.

Today, the term is abused to the point where it's applied to those who drive railroad trains and collect garbage (sanitary engineers). Additionally, engineers don't even get credit for true engineering accomplishments. As in the Space Shuttle coverage, many uninformed media representatives fail to distinguish between the achievements of engineers and those of scientists. Few among the general public understand that, basically, scientists study and prove theory while engineers reduce theory to practice—applications that are useful to all. Scientists don't design Space Shuttles, automobiles, computers, calculators and ICs; engineers do.

You might think that this argument has been made before and wonder what you can do about it. Simple: An organization now exists through which you can volunteer your knowledge and expertise. It's meant to help media people and public officials not trained in technology to understand that technology and discuss and report on it intelligently.

The organization, Media Resource Service, is a project of the Scientists' Institute for Public Information (SIPI). It's funded by the Ford Foundation, the Rockefeller Family Fund, the Mott Foundation and the MacArthur Foundation, consists of about 5000 engineer and scientist volunteers and is working to provide 24-hour-a-day service, even to every rural newsweekly.

Thanks to MRS, you have an opportunity to contribute to the public's growing interest in technology. If you would like to volunteer your expertise to ensure that technology is reported on and interpreted correctly by the mass media, write to MRS, Scientists' Institute for Public Information, 355 Lexington Ave, 16th Floor, New York, NY 10017, or call (212) 661-9110. (Be sure to describe your qualifications.) MRS will send information on the service and a questionnaire for you to complete.

Roy W. Forsberg

Roy Forsberg
Editorial Director

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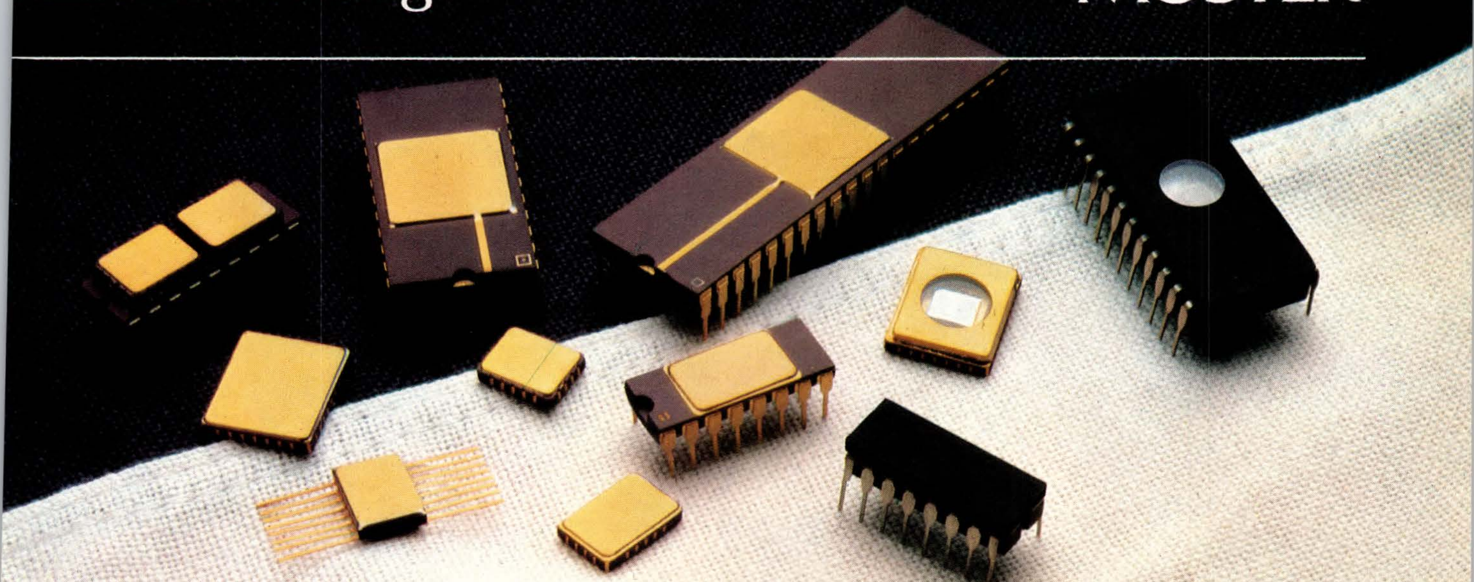
What makes America strong?

MOSTEK



A lot of little things.

And we make a lot of the little things.

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CIRCLE NO. 16

THE DIP.

The new contact is designed so it won't pull out on you. We've offset the contacts in the connector body for improved support.

The tail's right on spec, too: MIL-C-83503/6. The result: assured quality and reliability.

Choose your contacts: selectively plated with 30u" of gold. Or tin-plated, for lower costs on the right applications.

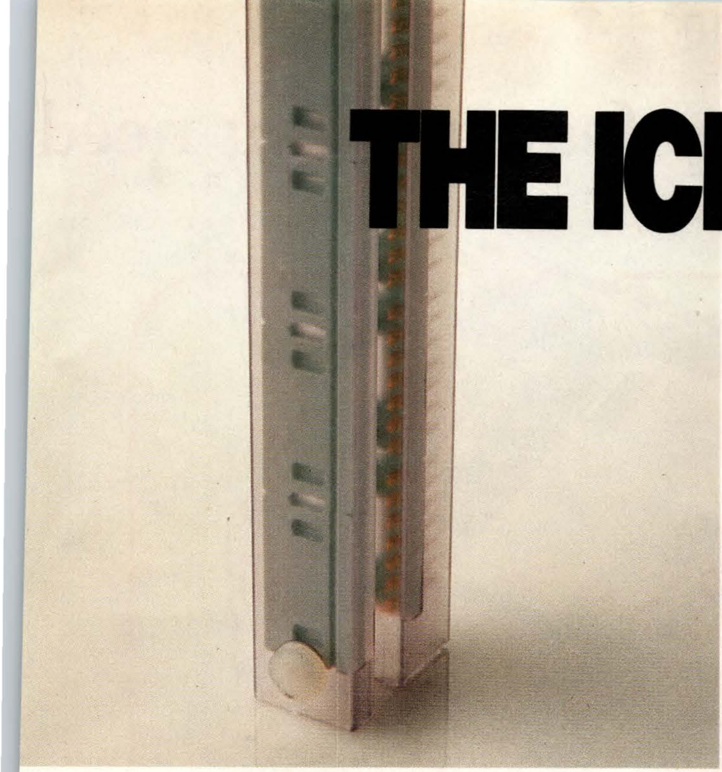
Either way, you get outstanding electrical and mechanical performance. (And Scotchflex products have successfully passed 40-year life-cycling testing)

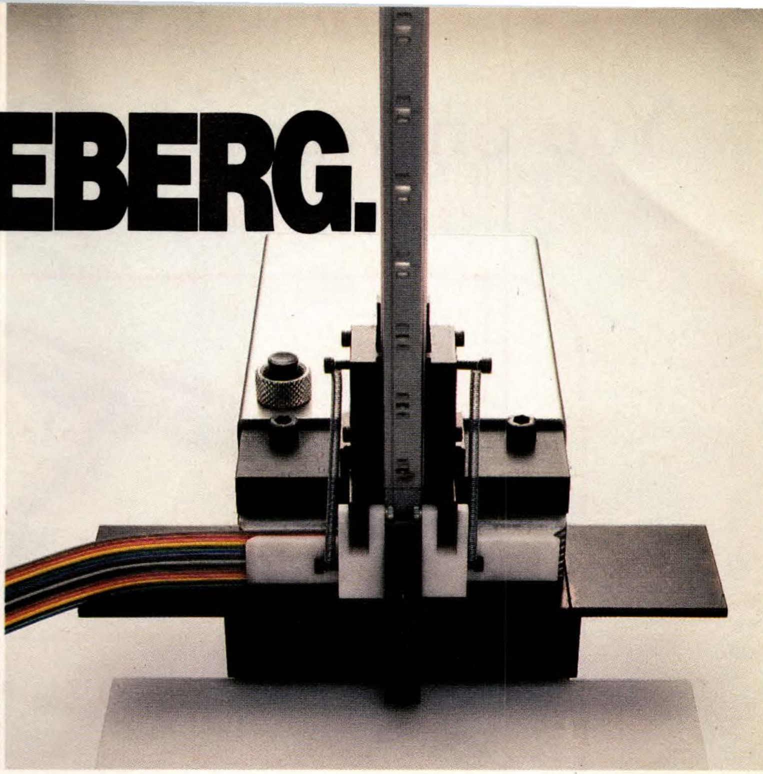
The secret behind the new Scotchflex® brand connector is riveting: the cover is locked onto the connector body so it won't come loose.

So we call it "Rivet Top." When assembled, the plastic posts are forced down and locked in place.

THIS NEW 3M CONNECTOR IS ONLY THE DIP OF THE ICEBERG.

THE ICEBERG.



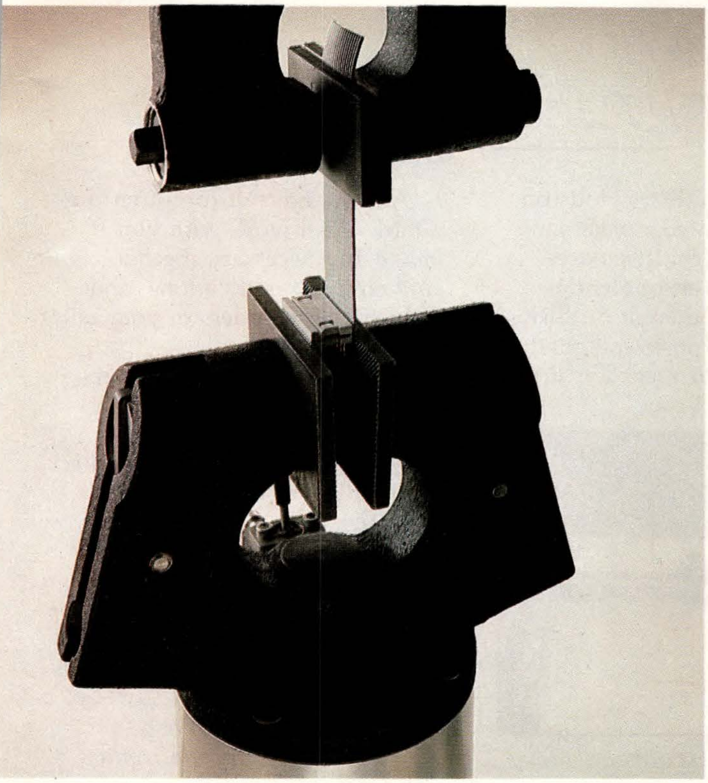


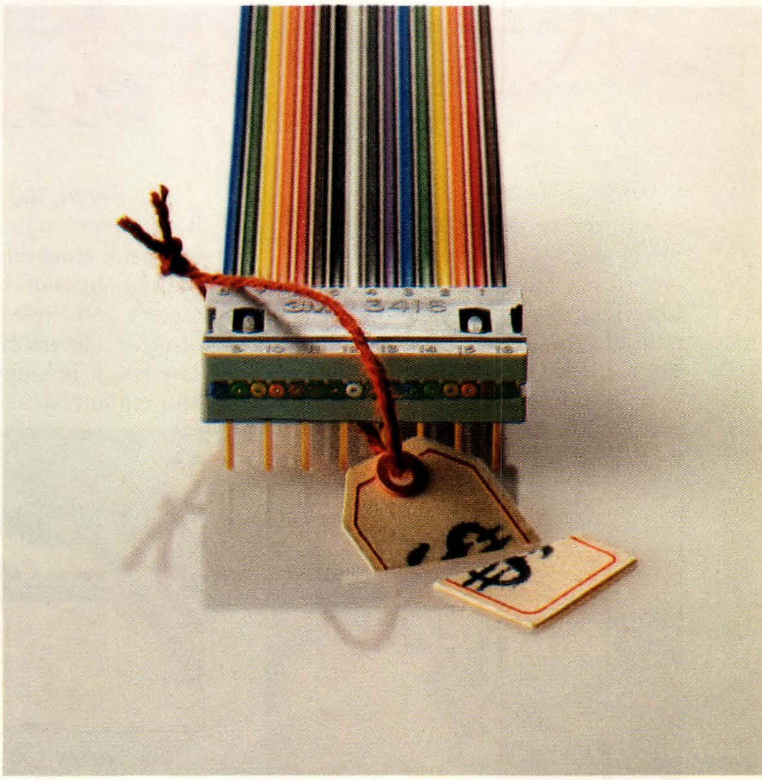
Now 3M takes you a step beyond pre-assembly, for what we think is the fastest jumper assembly system on record.

It all starts with the special magazine for 14-pin and 16-pin connectors. It comes pre-loaded. Just position the magazine in the new automatic DIP terminator.

Next, cut your cable to length. Insert it into the terminator. Activate the switch. In less time than it takes to tell, your jumper assembly is ready to go.

The system slashes production time by up to 66%; cuts reject rates; delivers every ounce of reliability you demand.





The bottom line: a connector-cable assembly with 18 pounds of retention strength—the industry's highest for 14-pin and 16-pin connectors.

Add the reliability of 3M's proven U-contacts; the high performance of Scotchflex cable: you get a system that's a lot more than the sum of its parts.

And for a change, more *costs* less, two ways. The DIP has a new, lower price—you get economy from the very first order. And the new terminator lets you boost productivity and cut assembly costs.

So call your 3M distributor for the details, or write Electronic Products Division/3M, 225-4S, 3M Center, St. Paul, MN 55144. You'll see why it pays to Specify the Source.

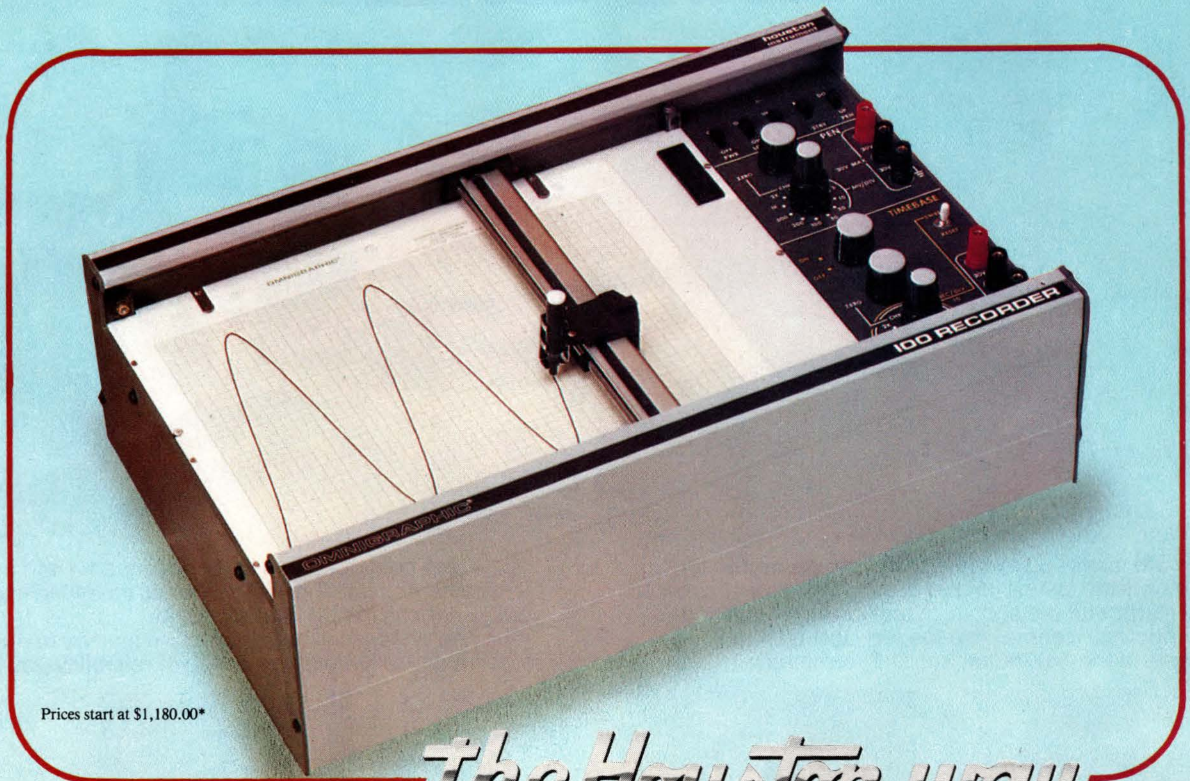
3M Hears You...

3M

CIRCLE NO 17

With the Series 100 X-Y recorders

You only pay for the features you need



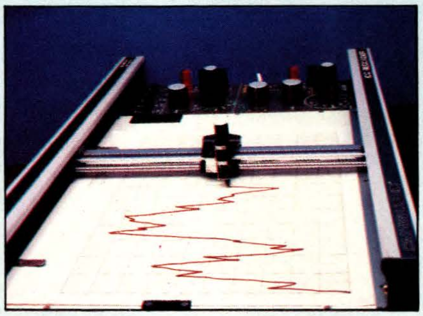
Prices start at $1,180.00*

the Houston way

With some X-Y recorders you wind up paying for features you'll never need. Not when you record the Houston Way. The Omnigraphic® Series 100's user configurable design lets you tailor the recorder to specifically meet your requirements — lab or field, production or process, OEM or dedicated.

The self-contained mainframe can serve as a stand alone recorder or act as the basic building block for your particular recorder configuration. Add your choice of options and the recorder is tailored to your application.

The Series 100 utilizes Houston Instrument's patented capacitance feedback transducer. It replaces the old slidewires and potentiometers and their inherent problems of wear, electrical noise and glitches. The result is longer recorder life and enhanced accuracy.



The Series 100 records on 8½″ x 11″ (DIN A4) paper and displays Y=f(X) or Y=f(T). The linear bearing supported pen bar assures alignment for the lifetime of the recorder. All electrical and mechanical components are easily accessible by simply removing four screws on the bottom panel.

And we haven't forgotten the OEM. We'll work with you to make any necessary mechanical and circuit modifications, and deliver the recorders in your color and with your logo.

Get in touch with Houston Instrument today. We'll show you the way to configure an X-Y recorder that's exactly suited to your application . . . the Houston Way.

Contact Houston Instrument, One Houston Square, Austin, Texas 78753. (512) 837-2820. For rush literature requests and sales office information, outside Texas call toll free 1-800-531-5205. For technical information ask for operator #2. In Europe contact Houston Instrument, Rochesterlaan 6, 8240 Gistel, Belgium. Phone 059/27-74-45.

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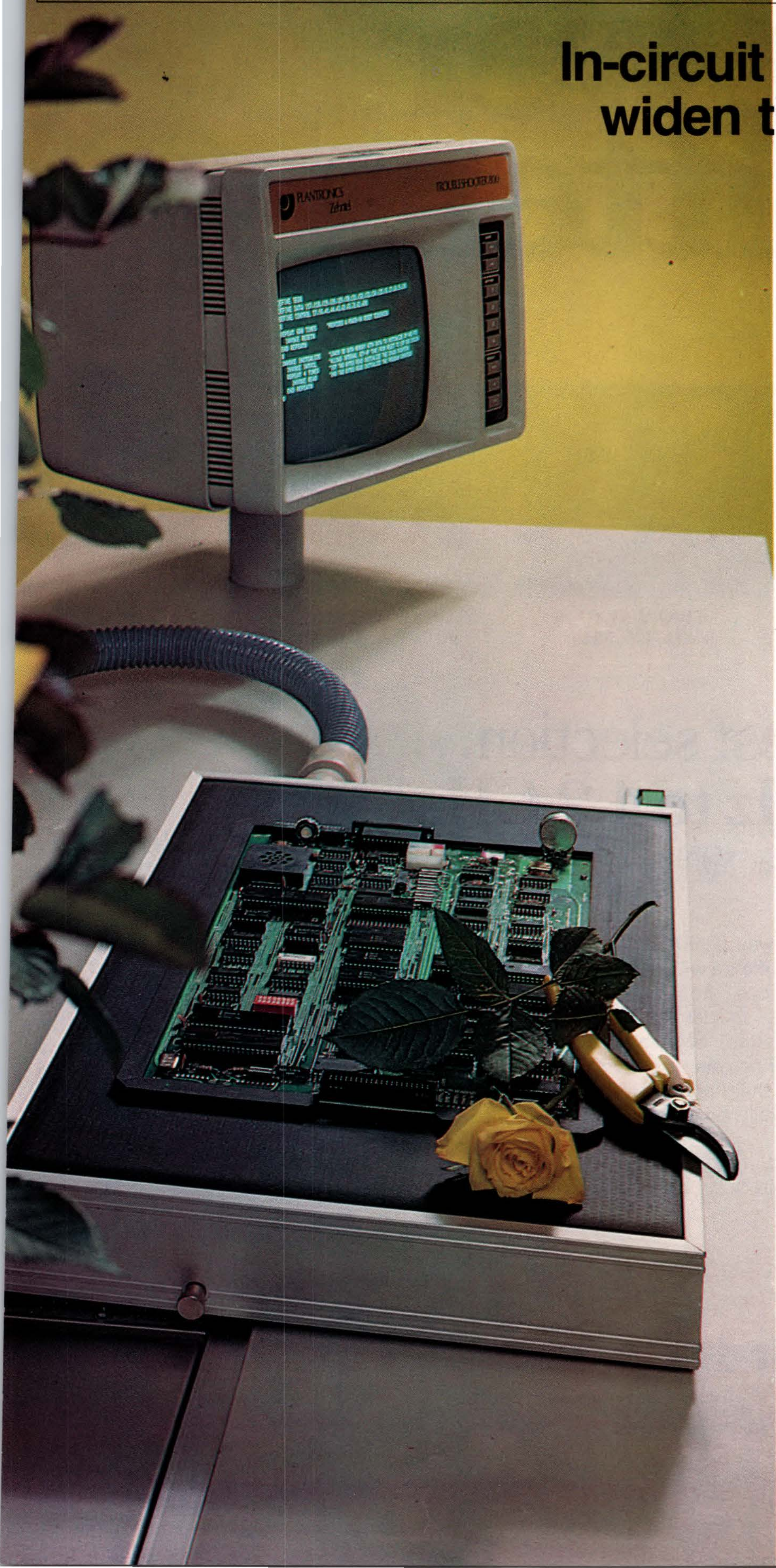
Circle no. 19 for literature

In-circuit testers widen their capabilities



Andy Santoni, Western Editor

The newest bed-of-nails automatic test systems can handle a wider variety of pc boards and test them more thoroughly than their predecessors. Along with the bare boards and mixed analog/digital boards that traditionally have been such testers' forte, the newer systems can tackle μP-based boards as well as high-speed units incorporating ECL devices. Yet these new bed-of-nails testers are also easier to program and less expensive to use than the older configurations.

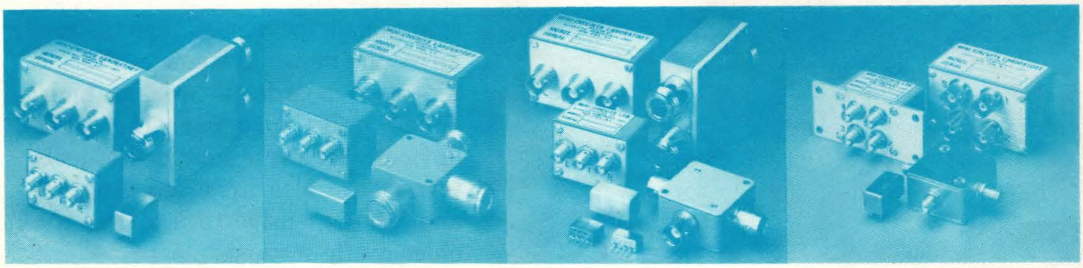
Four units in this generation of testers will make their debut this week at the ATE Seminar/Exhibit in Boston, joining several other capable instruments (from Hewlett-Packard, Teradyne and GenRad) already on the market:

- Zehntel will introduce its Troubleshooter 900, with enhancements that aim at testing boards containing μPs or high-speed ECL circuitry.
- Fluke will demonstrate its Model 3200A, which can handle basic in-circuit testing simultaneously at as many as four test stations.
- Fairchild will display its Series 30/303S, with software including automatic test-program generation and PINCHECK, which verifies connections between the test fixture and a board under test.
- Elecon will show its Model 8100, available for several

Continued on pg 42

Testing pc boards might never be a bed of roses, *but the newest systems make the job a little easier. This in-circuit Troubleshooter 800 from Zehntel handles a wide variety of pc boards; the firm's new and similar-looking Troubleshooter 900 aims more specifically at μP- and ECL-based units.*

power splitters



TWO WAY 90° (1.4-4200 MHz) | **TWO WAY 180°** (10 KHz-500 MHz) | **TWO WAY 0°** (2 KHz-4200 MHz) | **THREE WAY 0°** (0.01-750 MHz)

the world's largest selection... covering 2 KHz to 4.2 GHz

from Mini-Circuits, from $9^{95}

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For complete specifications and performance curves refer to the Microwaves Product Data Directory, EEM, or the Gold Book.

Model	Freq. range (MHz)	Min. isol-dB (Mid-band)	Max. insert. loss-dB (Mid-band)	See notes below	Price (Qty.)
		2-WAY 90°			
PSCQ2-1.5	1.4-1.7	25	0.7†	2	$12.95 (5-49)
PSCQ2-3.4	3.0-3.8	25	0.7†	2	$16.95 (5-49)
PSCQ2-6.4	5.8-7.0	25	0.7†	2	$12.95 (5-49)
PSCQ2-7.5	7.0-8.0	25	0.7†	2	$12.95 (5-49)
PSCQ2-10.5	9.0-11.0	20	0.7†	2	$12.95 (5-49)
PSCQ2-13	12-14	25	0.7†	2	$12.95 (5-49)
PSCQ2-14	12-16	25	0.7†	2	$16.95 (5-49)
PSCQ2-21.4	20-23	25	0.7†	2	$12.95 (5-49)
PSCQ2-50	25-50	20	0.7†	2	$19.95 (5-49)
PSCQ-2-70	40-70	20	0.7†	2	$19.95 (5-49)
PSCQ-2-90	55-90	20	0.7†	2	$19.95 (5-49)
PSCQ-2-120	80-120	18	0.7†	2	$19.95 (5-49)
PSCQ-2-180	120-180	15	0.7†	2	$19.95 (5-49)
PSCQ-2-250	150-250	18	0.8†	2	$19.95 (5-49)
PSCQ-2-400	250-400	16	0.9†	2	$19.95 (5-49)
PSCQ-2-450	350-450	16	0.9†	2	$19.95 (5-49)
ZSCQ-2-50	25-50	20	0.7†	2,3	$39.95 (4-24)
ZSCQ-2-90	55-90	20	0.7†	2,3	$39.95 (4-24)
ZSCQ-2-180	120-180	15	0.7†	2,3	$39.95 (4-24)
ZMSCQ-2-50	25-50	20	0.7†	2,4	$49.95 (4-24)
ZMSCQ-2-90	55-90	20	0.7†	2,4	$49.95 (4-24)
ZMSCQ-2-180	120-180	15	0.7†	2,4	$49.95 (4-24)
ZAPDQ-1	500-1000	20	0.9	2,13	$59.95 (1-9)
ZAPDQ-2	1000-2000	18	0.9	2,13	$59.95 (1-9)
ZAPDQ-4	2000-4200	20	0.9	2,13	$59.95 (1-9)
		2-WAY 180°			
PSCJ-2-1	1-200	25	0.8		$19.95 (5-49)
PSCJ-2-2	0.01-20	25	0.5		$29.95 (5-49)
ZSCJ-2-1	1-200	25	0.8	3	$37.95 (4-24)
ZSCJ-2-2	0.01-20	25	0.5	3	$47.95 (4-24)
ZMSCJ-2-1	1-200	25	0.8	4	$47.95 (4-24)
ZMSCJ-2-2	0.01-20	25	0.5	4	$57.95 (4-24)
ZFSCJ-2-1	1-500	25	1.5	5	$49.95 (4-24)
ZFSCJ-2-3	5-300	25	1.5	5	$39.95 (4-24)

1. 75 ohms impedance
†2. Average of coupled outputs less 3 dB
3. BNC connectors standard. TNC available
4. SMA connectors only
5. BNC connectors standard. TNC available. SMA & Type N available at $5 additional cost
6. BNC and TNC connectors. (SMA and Type "N" at $5 additional cost.) (BNC not available on ZAPD-4)

Please specify connectors.

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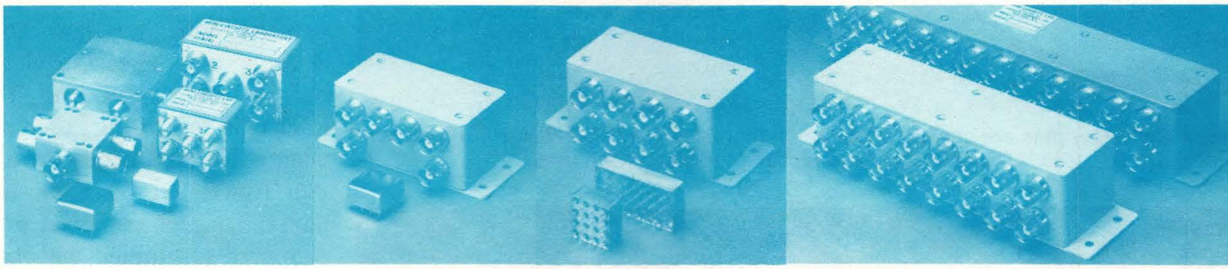
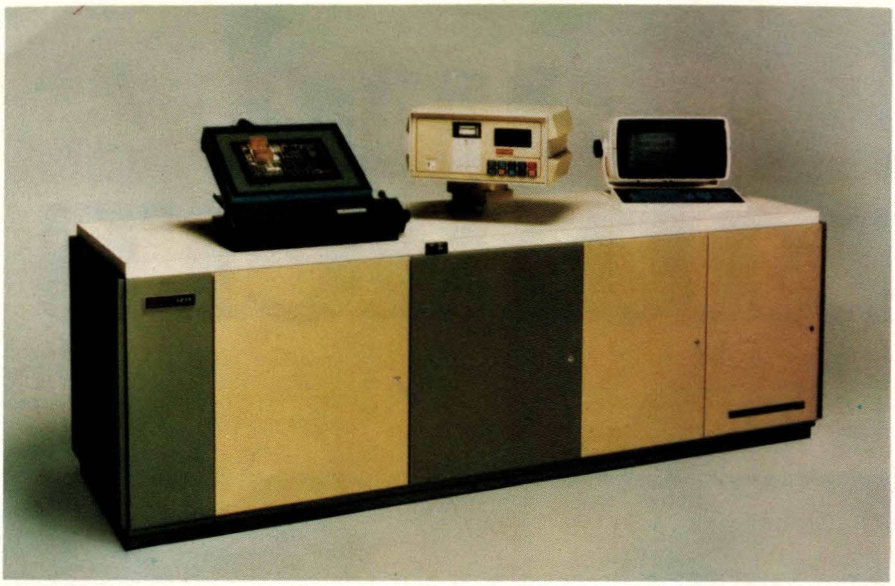


FOUR WAY 0° (2 KHz-4200 MHz) | SIX WAY 0° (1-175 MHz) | EIGHT WAY 0° (0.01-750 MHz) | SIXTEEN WAY 0° (0.5-125 MHz) | TWENTY FOUR WAY 0° (0.2-100 MHz)

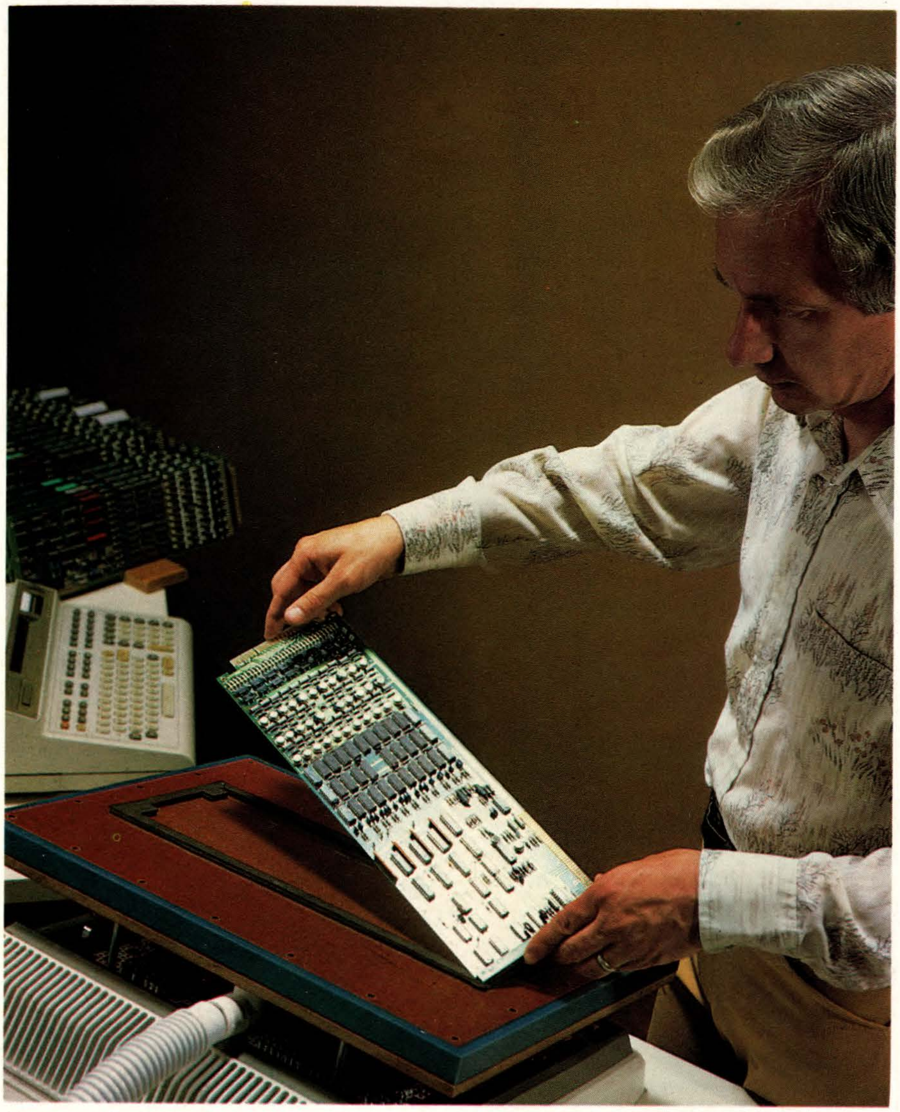
Model	Freq. range (MHz)	Min. isol-dB (Mid-band)	Max. insert. loss-dB (Mid-band)	See notes below	Price (Qty.)
2-WAY 0°					
PSC-2-1	0.1-400	20	0.75		$9.95 (6-49)
PSC-2-1W	1-650	20	0.9		$14.95 (6-49)
PSC-2-2	0.002-60	20	0.6		$19.95 (6-49)
PSC-2-1-75	0.25-300	20	0.75	1	$11.95 (6-49)
PSC-2375	55-85	25	0.5	1	$19.95 (6-24)
PSC-2-4	10-1000	20	1.2		$19.95 (6-49)
MSC-2-1	0.1-450	20	0.75		$16.95 (5-24)
MSC-2-1W	2-650	25	0.8		$17.95 (5-24)
ZSC-2-1	0.1-400	20	0.75	3	$27.95 (4-24)
ZSC-2-1-75	0.25-300	20	0.75	1,3	$29.95 (4-24)
ZSC-2-1W	1-650	20	0.8	3	$32.95 (4-24)
ZSC-2-2	0.002-60	20	0.6	3	$37.95 (4-24)
ZSC-2375	55-85	25	0.5	1,3	$37.95 (4-24)
ZMSC-2-1	0.1-400	20	0.75	4	$37.95 (4-24)
ZMSC-2-1W	1-650	20	0.8	4	$42.95 (4-24)
ZMSC-2-2	0.002-60	20	0.6	4	$47.95 (4-24)
ZFSC-2-1	5-500	20	0.6	5	$31.95 (4-24)
ZFSC-2-1-75	0.25-300	20	0.75	5	$32.95 (4-24)
ZFSC-2-1W	1-750	20	0.8	5	$35.95 (4-24)
ZFSC-2-2	10-1000	20	1.0	5	$39.95 (4-24)
ZFSC-2-4	0.2-1000	20	1.0	5	$44.95 (4-24)
ZFSC-2-5	10-1500	20	1.0	5	$49.95 (4-24)
ZFSC-2-6	0.002-60	20	0.6	5	$36.95 (4-24)
ZFSC-2-6-75	0.004-60	20	0.8	1,5	$38.95 (4-24)
ZAPD-1	500-1000	19	0.6	6	$39.95 (1-9)
ZAPD-2	1000-2000	19	0.6	6	$39.95 (1-9)
ZAPD-21	500-2000	18	0.7	6	$49.95 (1-9)
ZAPD-4	2000-4200	19	0.8	6	$39.95 (1-9)
3-WAY 0°					
PSC-3-1	1-200	25	0.7		$19.95 (5-49)
PSC-3-1W	5-500	15	1.4		$29.95 (5-49)
PSC-3-1-75	1-200	25	0.7	1	$20.95 (5-49)
PSC-3-2	0.01-30	25	0.45		$29.95 (5-49)
PSC-3-13	1-200	35	0.6		$24.95 (5-49)
ZSC-3-1	1-200	25	0.7	3	$37.95 (4-24)
ZSC-3-1-75	1-200	25	0.7	1,3	$38.95 (4-24)
ZSC-3-2	0.01-30	25	0.45	3	$47.95 (4-24)
ZSC-3-2-75	0.02-20	25	0.6	1,3	$48.95 (4-24)
ZMSC-3-1	1-200	25	0.7	4	$47.95 (4-24)
ZMSC-3-2	0.01-30	25	0.45	4	$57.95 (4-24)
ZFSC-3-1	1-500	20	0.9	5	$39.95 (4-24)
ZFSC-3-1W	2-750	20	1.0	5	$41.95 (4-24)
ZFSC-3-13	1-200	35	0.6	5	$39.95 (4-24)

Model	Freq. range (MHz)	Min. isol-dB (Mid-band)	Max. insert. loss-dB (Mid-band)	See notes below	Price (Qty.)
4-WAY 0°					
PSC-4-1	0.1-200	20	0.75		$28.95 (6-49)
PSC-4-1-75	1-200	20	0.9	1	$24.95 (6-49)
PSC-4-3	0.25-250	20	0.75		$23.95 (6-49)
PSC-4A-4	10-1000	15	1.1		$49.95 (6-49)
PSC-4-6	0.01-40	25	0.5		$29.95 (6-49)
ZSC-4-1	0.1-200	20	0.75	3	$46.95 (4-24)
ZSC-4-1-75	1-200	20	0.8	1,3	$46.95 (4-24)
ZSC-4-2	0.002-20	25	0.5	3	$69.95 (4-24)
ZSC-4-3	0.25-250	20	0.75	3	$43.95 (4-24)
ZMSC-4-1	0.1-200	20	0.75	4	$56.95 (4-24)
ZMSC-4-2	0.002-20	25	0.5	4	$79.95 (4-24)
ZMSC-4-3	0.25-250	20	0.75	4	$53.95 (4-24)
ZFSC-4-1	1-1000	18	1.5	8	$89.95 (1-4)
ZFSC-4-1W	10-500	20	1.5	8	$74.95 (1-4)
ZFSC-4375	50-90	30	1.2	1,8	$89.95 (1-4)
ZA4PD-2	1000-2000	18	1.0	14	$79.95 (1-9)
ZA4PD-4	2000-4200	18	1.0	14	$79.95 (1-9)
6-WAY 0°					
PSC-6-1	1-175	18	1.0		$68.95 (1-5)
ZFSC-6-1	1-175	20	1.2	9	$89.95 (1-4)
8-WAY 0°					
PSC-8-1	0.5-175	20	1.1		$68.95 (1-5)
PSC-8-1-75	0.5-175	20	0.8	1	$69.95 (1-5)
PSC-8A-4	5-500	18	1.8		$89.95 (1-5)
PSC-8-6	0.01-10	23	1.1		$79.95 (1-5)
ZFSC-8-1	0.5-175	20	1.1	10	$89.95 (1-4)
ZFSC-8-1-75	0.5-175	20	1.0	1,10	$90.95 (1-4)
ZFSC-8375	50-90	25	1.3	1,10	$119.95 (1-4)
ZFSC-8-4	0.5-700	20	1.5	10	$129.95 (1-4)
ZFSC-8-6	0.01-10	23	1.1	10	$109.95 (1-4)
16-WAY 0°					
ZFSC-16-1	0.5-125	18	1.6	11	$174.95 (1-4)
24-WAY 0°					
ZFSC-24-1	0.2-100	20	2.0	12	$264.95 (1-4)

7. TNC, SMA & Type N at $5 additional cost. Please specify connectors.
8. SMA connectors standard, BNC on request.
9. BNC connectors standard, TNC available, SMA available at $15 additional cost
10. BNC connectors standard, TNC available at $10 additional cost, SMA at $25 additional cost.
11. BNC connectors standard, TNC available at $20 additional cost, SMA available at $45 additional cost.
12. BNC connectors standard, TNC available at $35 additional cost, SMA available at $65 additional cost.
13. BNC connectors (not available for ZAPDQ-4), TNC available. (SMA [3MM] and Type "N" on request. Add $5 per unit.) Please specify connectors.
14. TNC, SMA, Type N please specify connectors



Verify that tester pins are making good contact *by using Fairchild's PINCHECK program. The result? Less costly failure analysis and reduced troubleshooting time.*



Bed-of-nails fixtures *aren't limited only to in-circuit board testers. The Hewlett-Packard Model 3060A can also perform functional board tests.*

months but now housed in a new package that makes it easier to operate.

Finding real-world faults

Illustrating a continuing trend, many of these and other newer bed-of-nails testers are using more functional test techniques—rather than relying on in-circuit methods—to improve fault coverage. By contrast, some older systems—from Fairchild, GenRad and Zehntel, for example—employ in-circuit testing to check for open and shorted printed wiring, then to isolate devices and check each one for proper insertion. And they use in-circuit guarding techniques to isolate ICs and other devices, then run functional tests on individual parts. In such cases, if a board is properly assembled and its devices work, the board should also work.

But reality doesn't always verify theory. A board's design might operate some of the devices to the edges of their specified limits, and the resulting compounded inaccuracies could keep the board from working. Alternatively, the board's design might not be correct at all. To deal with these problems, Teradyne's $400,000 L200 test system, for one, allows you to run functional tests on a board as a whole, as well as in-circuit tests on any part of it, to check whether the board really works as it should.

The L200's architecture allows for either separate in-circuit and functional board testing or a combination of both test techniques in the same machine, with common programming, fixturing and hardware.

Similarly, Series 70/Model 60 from Fairchild's Test Systems Group (Billerica, MA) can perform in-circuit tests to screen pc boards for assembly defects or functional tests for final board checkout. The basic Series 70/Model 60, which costs less than $150,000, comes with 512 in-circuit test points and is wired for 896 points; you can expand it to 1920. Functional test rates range as high as 5 MHz.

Combining full in-circuit and functional testing capabilities in one machine, *Teradyne's $400,000 Model L200 is the most powerful system yet available.*

A large 14-in. CRT screen displays prompts *to users of Fluke's Model 3200A, simplifying the in-circuit tester's operation. The ability to handle as many as four stations per controller holds down costs.*

Some of the newer systems, such as Hewlett-Packard's Model 3060A and Elecon's Model 8100, use bed-of-nails fixtures to perform functional tests on parts of a pc board (or on the whole board) to determine whether the board works. The HP system employs in-circuit tests to isolate individual devices and test their functionality, but like the Elecon tester, it goes beyond in-circuit techniques to operate the board under more-or-less normal conditions and check for correct responses.

Definitions become cloudy

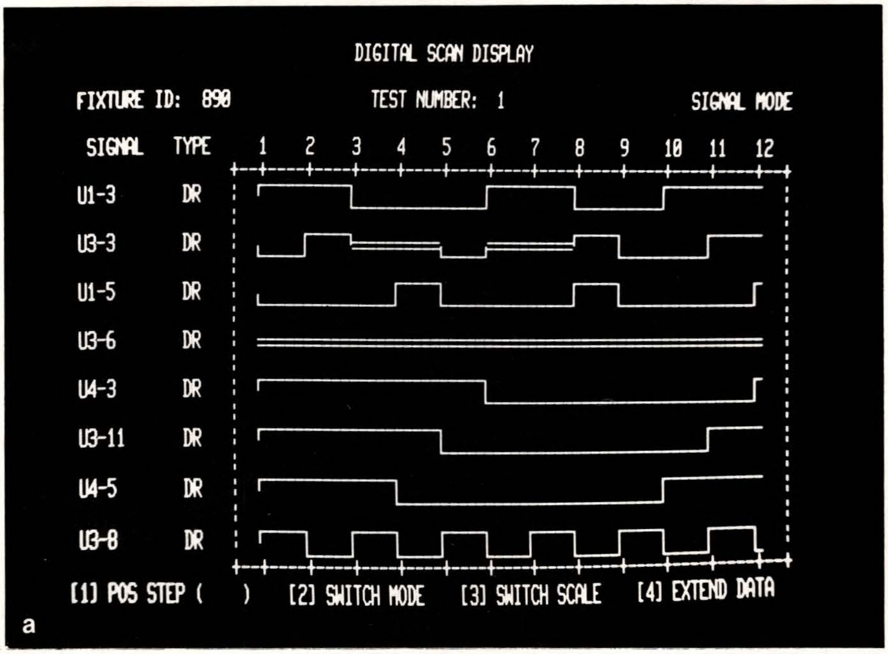
These combinations of in-circuit and functional testing techniques have made defining the terms more difficult, says John Rider, product manager at Hewlett-Packard's Loveland, CO operation. At one time, all in-circuit testers used bed-of-nails fixtures, and all functional board testers used card-edge connectors to interface with a board under test: The fixturing determined the tester type.

Today, on the other hand, testers comparable with some older functional units use bed-of-nails fixtures to gain access to a board. To make the distinctions among such testers clearer, Rider prefers to distinguish between card-edge and bed-of-nails testers as well as between in-circuit and functional test techniques.

Bed-of-nails fixturing isn't limited to in-circuit testers, agrees Elecon president Bob Axtell. In fact, he says that edge connectors are becoming obsolete for pc-board interfacing.

There are many reasons for this trend. For one, gold plating card-edge contacts is expensive. And cards often interface with one another directly, not through a mother board, so ribbon-cable interfaces are becoming common.

Additionally, μP-based boards require fewer external control lines. So although Elecon's Model 8100 can test via card-edge connections, it normally gains access via a bed-of-nails fixture. Yet it tests a



A logic-analyzer-like display (a) *helps the operator of Elecon's Model 8100 track faults to the bad part. A new package for the tester* **(b)** *brings controls readily to hand, simplifying operation.*

board's function, not just workmanship and parts functionality. Therefore, it can handle boards that are beyond the capabilities of traditional in-circuit testers.

μP testing gets attention

In the face of these developments, manufacturers of the more traditional in-circuit testers have improved their products to handle a wider variety of pc boards.

They have faced several problems. For example, although the repetition rate of signals at a test pin has been limited to less than 1 MHz by the high capacitance of bed-of-nails fixtures, μPs and ECL circuits demand higher rates to operate. So the older testers can't effectively handle these devices, says Michael Carroll, product marketing manager at Zehntel.

The newest testers overcome these problems in a variety of ways. Zehntel's Troubleshooter 900, for example, uses coaxial lines to its test fixture and other techniques to simplify testing boards containing μPs or ECL circuits. This $120,000 to $200,000 system can synchronize to an on-board clock (sometimes required for μP board testing) at up to 4 MHz and can deliver pulses with transitions as short as 5 nsec—a must for effectively testing ECL devices.

Improvements in power distribution help in testing large boards, too, says Carroll. The tester's coaxial lines carry dc power in their shields, eliminating the need for additional power leads between the interface connector and the board under test. Additionally, each pin-driver board has its own power-supply regulation, and the voltage to each pin is variable under program control. As a result, you don't have to switch power supplies as often, saving programming time. The return path from the board to power-supply ground is shorter, too, cutting ground currents.

The pin-driver cards themselves use dual-in-line-packaged transistors, CMOS logic and hybrid circuits

to pack 48 node driver/receivers on each card, compared with 16 on similar cards in the Troubleshooter 800 ($100,000 to $200,000). That's one reason the 900 can handle as many as 3024 points—nearly three times the capacity of the older machines.

According to Carroll, the tradeoff is less extensive analog testing capability—the Troubleshooter 900 can't test SCRs, FETs or op amps as effectively as the older machine can. But such devices are rarely found on the μP and ECL boards that are Troubleshooter 900's forte, he says.

Improved tester software helps in testing μP boards, too. Zehntel's Data Director, for one, allows you to write tests in a μP's own language, cutting programming time from weeks to a few days.

Hewlett-Packard uses a different approach to testing μP-based boards. According to product man-

Parallel stimulus/response facilities *help test digital boards in GenRad's Model 2270 in-circuit test system.*

ager Rider, the $91,000-and-up Model 3060A exercises a board as fully as possible, the way the board is designed to be used, taking signatures at appropriate nodes to see whether the board is operating properly. Careful design of signal paths, using such techniques as installing ferrite beads in appropriate places, increases repetition rates to 2 MHz.

Enhancements add accuracy

Another feature of the 3060A is high accuracy. Extended guarding uses three sensing buses to remotely sense guard- or input-bus potentials, either automatically in the scanner or directly at the device under test, removing from the measurement the contributions of fixture lead resistance. The scanner's thermal design minimizes EMF caused by temperature differences, and an accuracy-enhancement mode corrects for offsets, improving the accuracy and repeatability of in-circuit component measurements.

Additionally, phase-synchronous detection measures components having significantly high real and reactive characteristics, separating parallel resistors and capacitors to extend the system's measurement capabilities and increase measurement speed. As a result, accuracy in component measurements remains within 5% or better (depending on the component and board layout), compared with errors of more than 70% that can easily occur with simpler in-circuit test techniques.

In Elecon's Model 8100, the tester gains access to a board via a bed-of-nails fixture with as many as 768 pins, runs the board in a close-to-normal environment and stores the states at each node in RAM. Test patterns are transferred from the system controller to high-speed RAM before they go to the unit under test, so the controller's relatively slow speed doesn't affect test rates. Terminated bus lines, short test-signal paths, twisted-pair signal lines and test-fixture ground planes limit ringing and crosstalk.

The tester, which costs approximately $60,000 to $95,000, displays the results of a test on a CRT screen in a logic-analyzer-like format. The ONEs and ZEROs stored in RAM, which can represent logic levels from −15 to +15V, are displayed as waveforms, and differences between the tested results and known-good results are highlighted in reverse video. Software directs an operator to a board's most likely failure point by considering which nodes failed first and which could be sources for other failed nodes.

Model 8100 also incorporates features in its power supply to simplify board testing. For example, it brings the voltage at a given pin to zero between tests, assuring control when a board must be initialized. The technique also reduces voltage-settling time to less than 25 msec typ for a 10V step change. And each of the system's four supplies, which can deliver as much as 2A, is programmable from −30 to +30V.

Lower tester cost

Fluke's approach to testing μP boards takes advantage of the firm's Model 9010A microprocessor analyzer. This $4000 troubleshooter uses stored programs to test μP boards through processor simulation and signature analysis. The new Model 3200 bed-of-nails board tester can then concentrate on basic problems, such as shorts and opens, diode and transistor orientation and resistance values—the types of errors that account for 65% of board failures, says Jack Frye, marketing manager at Fluke Automated Systems. As a result, the 3200A is relatively inexpensive: Base price is $40,000, and an average system costs approximately $65,000.

The system is expandable to 65,536 test points in increments of 64, 96 or 128 pins. With testing speeds near 10,000 points/sec, it can test a typical board in less than 1 sec.

Similarly specialized for fairly simple board testing, Teradyne's

For more information...

For more information on the products described in this article, contact the following manufacturers directly.

Elecon Inc
2106 Ringwood Ave
San Jose, CA 95131
(408) 946-6000

Fairchild Test Systems Group
Fairchild Technical Center
3 Suburban Park Dr
Billerica, MA 01821
(617) 663-6562

Fairchild Test Systems Group
Subassembly Test Systems Div
299 Old Niskayuna Rd
Latham, NY 12110
(518) 783-3600

Fluke Automated Systems Inc
630 Clyde Ave
Mt View, CA 94043
(408) 965-0350

John Fluke Mfg Co Inc
Box C9090
Everett, WA 98206
(206) 342-6300

GenRad Inc
300 Baker Ave
Concord, MA 01742
(617) 369-4400

Hewlett-Packard Co
1507 Page Mill Rd
Palo Alto, CA 94304
Phone local office

Teradyne Inc
183 Essex St
Boston, MA 02111
(617) 482-2700

Zehntel Inc
Box 8016
Walnut Creek, CA 94596
(415) 932-6900

Models L427A/L429A shorts-detection system and L527A/L529A assembly-inspection system are designed to weed out boards before they reach a more sophisticated functional test system. These prescreening machines test for workmanship and component faults, so they can reduce the cost and improve the throughput of more complex and costly fault diagnosis later in the manufacturing process.

Similarly, GenRad's Model 2245 in-circuit/continuity tester aims to improve the productivity of more expensive systems by screening out boards having common, easily detectable errors. The $35,000 system uncovers errors such as over or underetched copper, poor wash and uneven cladding, and it detects resistor faults.

For more extensive testing, GenRad offers Model 2230I, priced at approximately $40,000. This instrument tests for path-to-path shorts and opens, then checks resistors, capacitors, inductors and semiconductor junctions to see whether values lie between limits.

A complementary test system, GenRad's Model 2270 offers such advanced features as memory-based parallel stimulus/response testing to handle complex digital boards. The system, which carries an average price tag of $175,000, can drive address, data and control lines in a dynamic sequence.

Local memory is behind every system-interface pin to provide complete pattern bursts for known-state device initialization, mode-setup words for interface controllers and instruction sequences for intelligent devices. As an added benefit, the system can use the same fixtures as Model 2245, reducing the high cost of fixtures. (Fixture costs for different board types are often higher than the cost of the tester itself.)

Another innovation is evident in the latest test system from Fairchild's Test Systems Group (Latham, NY). Series 30/303S incorporates the PINCHECK program to make sure the fixture is making contact with the board under test.

PINCHECK executes before each board test begins. If a connection is faulty, the pins not making contact with the board are reported, and the test sequence halts to permit correction of the program. Average selling price for the system itself is $180,000. EDN

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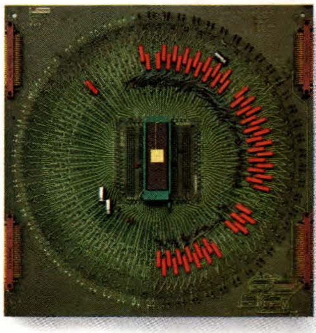

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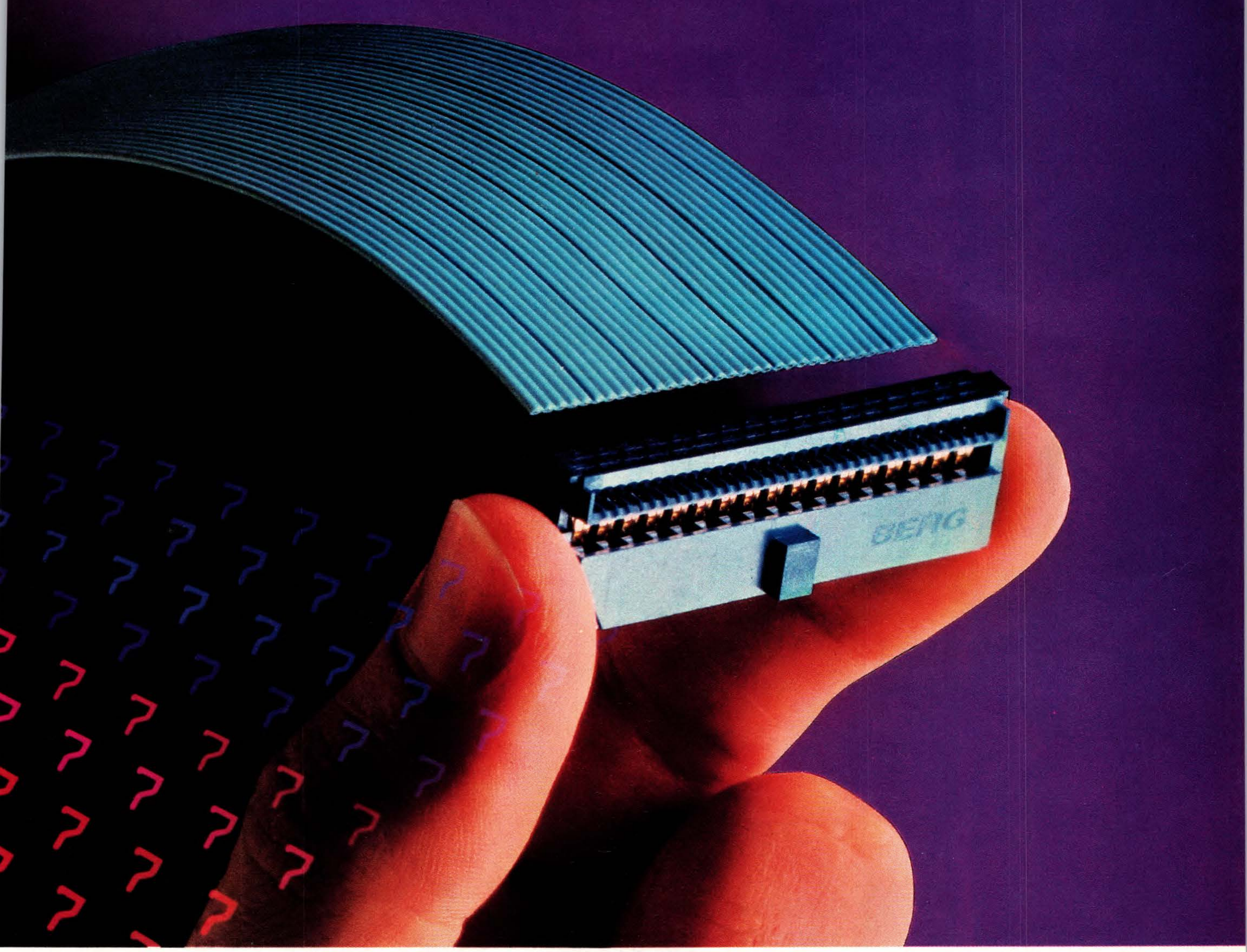

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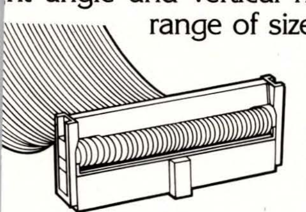

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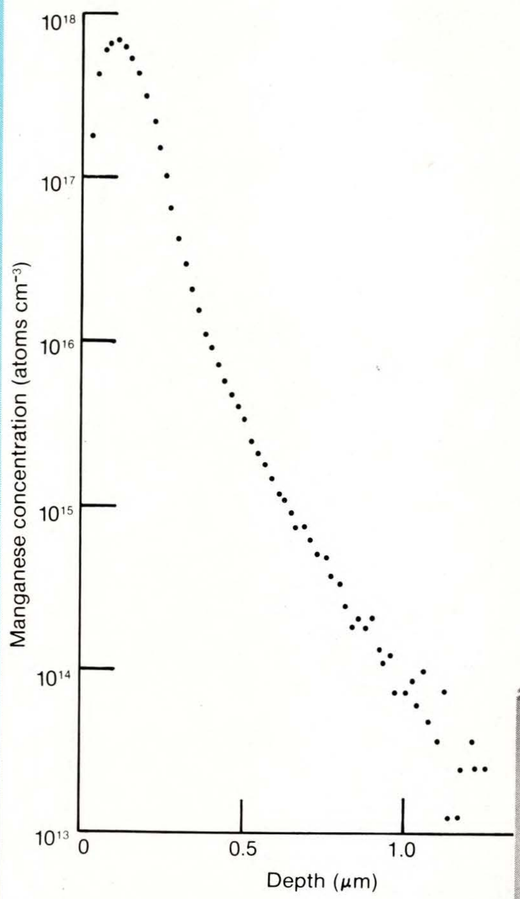

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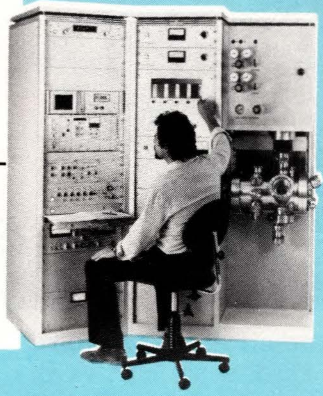

The curve above shows the concentration of manganese atoms implanted in a gallium arsenide matrix as a function of depth from the sample surface. It is drawn from data taken with ATOMIKA'S IONPROBE A-DIDA SIMS system. Manganese was detected down to a concentration of 2 x 10^{13} atoms/cm^3 — i.e., one manganese atom in 5 billion matrix atoms!

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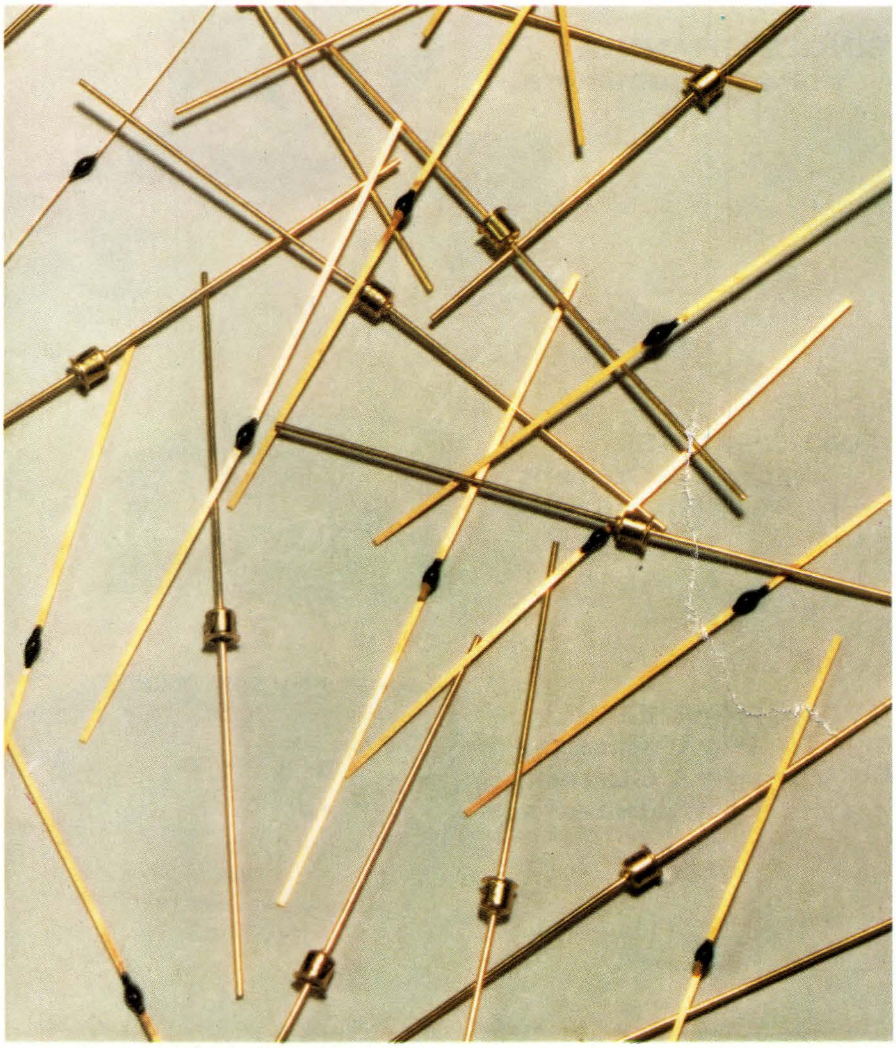
Venerable, capable tunnel diodes experience an application renaissance

Jim McDermott,
Special Features Editor



Compare the relatively large package *of General Electric's standard 3700 Series tunnel diodes with the tiny Series TD-260 packages. The ultralow capacitance of the latter devices contributes to their very-high-speed switching characteristics.*

Reports of the tunnel diode's demise are greatly exaggerated. The device is alive and well in a variety of applications, thanks to substantial improvements in fabrication and packaging in the past 20 yrs.

If you're not familiar with tunnel diodes, you've got plenty of company. Introduced with great fanfare by General Electric in 1959, these versatile 2-terminal, negative-resistance components have received minimum coverage in the trade press in recent years, leaving the impression with many older engineers that they merely faded away, and with younger EEs that they never existed at all. Yet these 2-terminal devices can function extremely effectively as kilohertz-to-gigahertz amplifiers, mixers, detectors, oscillators, subnanosecond switches and picosecond pulse generators.

Indeed, a survey of tunnel diodes (TDs) reveals significant improvements in both performance and reliability. It also reveals an expanding variety of microwave applications, such as low-level limiting amplifiers in communications satellites (Intelsat V, NATO III, DSCS II and DSCS III, now under development at GE Space Systems), microwave-relay links, radar receivers and phased-array antennas, and—most recently—cable-TV repeater amplifiers.

In the digital world, high-performance TDs now serve as very fast pulse generators in instrumentation such as Tektronix's high-speed sampling scopes and time-domain-reflectometry measuring equipment.

Giving signals a boost

Tunnel-diode-based amplifiers offer important design advantages. They're low-power devices, dissipating only milliwatts per stage. They produce bandwidths that easily span octaves (2:1) or more. Additionally, they exhibit moderately low noise figures (5 to 8 dB) from the low C Band through the Ku Band. They are also small; thus, they can be integrated into circulator structures.

TD-based amplifiers also feature excellent gain and phase stability because gain is a function of impedances, which vary little with temperature. And finally, they are simple and highly reliable when carefully selected. (In satellite communications, for example, amplifiers using tunnel diodes achieve MTBFs exceeding 100,000 hrs.)

Are there drawbacks to tunnel-diode-based amplifiers? Very few. First, because TDs are fundamentally small-signal devices, the amplifiers generally have low dynamic ranges; their 1-dB compression point is typically −40 dBm.

	MODEL	PEAK-POINT CURRENT (I_P, mA)	VALLEY-POINT CURRENT (I_V, mA) MAX	CAPACITANCE (C, pF) MAX	PEAK-POINT VOLTAGE (V_P, mV)	VALLEY VOLTAGE (V_V, mV)	FORWARD PEAK VOLTAGE (V_{FP}, mV)	SERIES RESISTANCE (R_S, Ω) MAX	NEGATIVE CONDUCTANCE ($-g_J$, MHOS × 10^{-3})	NEGATIVE RESISTANCE ($-R_J$, Ω)	RESISTIVE CUTOFF FREQUENCY (f_{RO}, GHz)	RISE TIME (t_r, pSEC)
GENERAL-PURPOSE TYPES	1N3712	1.0 ± 10%	0.18	10	65	350	500	4.0	8	125	2.3	
	1N3714	2.2 ± 10%	0.48	25	65	350	500	3.0	18	55.5	2.2	
	1N3716	4.7 ± 10%	1.04	50	65	350	500	2.0	40	25	1.8	
	1N3718	10.0 ± 10%	2.20	90	65	350	500	1.5	80	12.5	1.6	
SWITCHING TYPES	TD-263	10.0 ± 10%	1.40	9.0	75	400	500-700	1.7				350
	TD-263A	10.0 ± 10%	1.40	5.0	80	410	520-700	2.0				190
	TD-263B	10.0 ± 10%	1.40	2.0	90	420	550-700	2.5				68

Germanium general-purpose and switching-type tunnel diodes *exhibit impressive performance characteristics. (Data courtesy General Electric Semiconductor Dept)*

Additionally, they have a low burnout rating—a problem that solid-state limiters minimize with only a nominal increase in noise figure, size, cost and weight.

TD-based amplifiers exhibit "soft" limiting characteristics; therefore they can compress a large input range into a smaller output. This feature can serve to advantage with many types of displays, particularly in systems that directly display RF signals. In such equipment, the tunnel diodes provide both low-level amplification and high-level signal compression, while also preserving amplitude and phase information.

Tunnel diodes serve as detectors

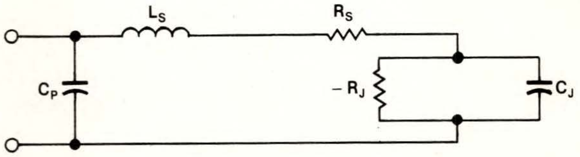
When operated in its reverse or back-voltage mode, a tunnel diode becomes a low-loss, low-noise, high-sensitivity detector. TDs aimed at such applications are designated "back diodes," are specially fabricated to optimize critical performance characteristics

Carriers tunnel under barrier

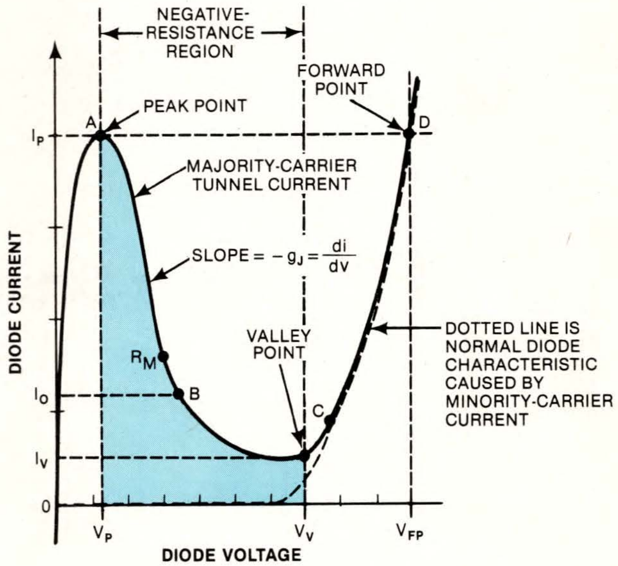
The tunnel diode derives its name from the tunneling effect. According to quantum theory, a particle can disappear from one side of a potential barrier, then appear instantly on the other side, even though it doesn't have enough energy to surmount the barrier. In effect, the particle tunnels under the barrier.

In TDs, this barrier is the space-charge depletion region of a pn junction—the same barrier that prevents reverse current from flowing in a standard rectifier diode. To make penetration possible, TDs are manufactured with extremely thin barriers (typically less than 1 μin.). In turn, the tunneling effect gives a TD a very unusual V-I curve: An initial current is produced at a very small forward bias; this current rises to a peak, then falls back to a substantially lower level as bias increases. This negative-resistance characteristic gives the device its versatility. Eventually, the curve resumes its positive slope.

Conventional amplifying devices, such as transistors, emit charge carriers into regions where their motions are influenced by signal-control (base) electrodes; these carriers eventually migrate to output (collector) electrodes. The time it takes the charge carriers to traverse the control region determines the device's maximum frequency response. By contrast, the tunnel diode's basic conduction mechanism is several orders of magnitude faster; hence it can amplify and detect signals at very high frequencies—up to 40 or 50 GHz.



The equivalent circuit *of a tunnel diode consists of five basic elements: R_J is dynamic junction resistance; C_J, junction capacitance; R_S, dc resistance; C_P, total package capacitance; L_S, package inductance.*



The reverse slope on a tunnel diode's static V-I curve *defines its negative-resistance region. Note the normal operating point (R_N) in the region of minimum noise and the point of minimum negative resistance (R_M).*

and spec superior temperature stabilities.

The back diode is a low-loss detector because it conducts as soon as the voltage across it goes through zero. Consequently, it requires no external bias. (By contrast, because the V-I curves of Schottky and point-contact diodes exhibit essentially no curvature through the origin, they do require bias voltages to operate in the region of curvature in detector applications.)

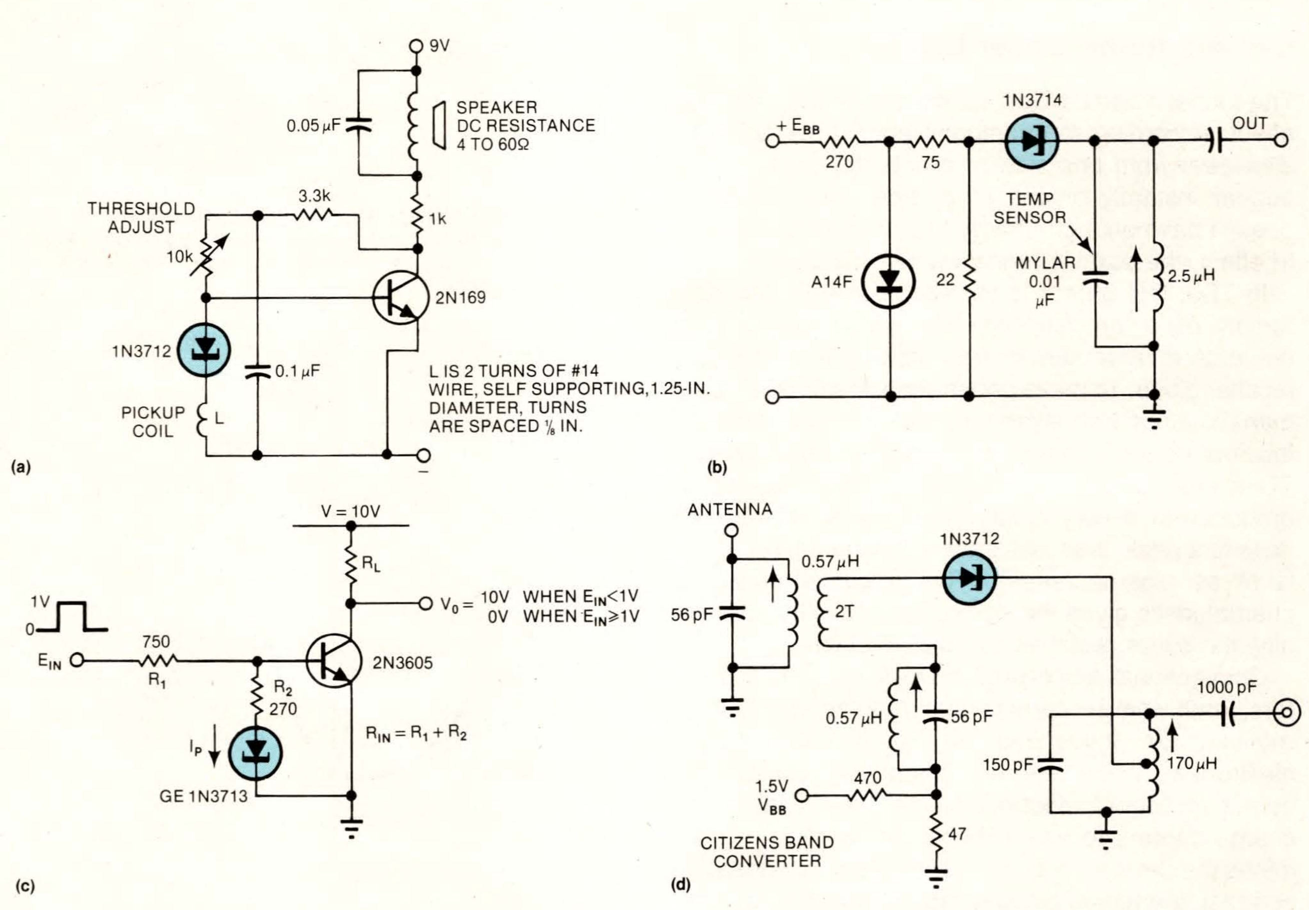
Back diodes perform extremely well in such traditional low-level, low-noise equipment as radar-astronomy receivers, broad-band video detectors and Doppler mixers. But they are also expanding into newer applications, including the cable-TV-system trunk-repeater amplifiers manufactured by Scientific Atlanta (Atlanta, GA) and Century III (Vancouver, British Columbia). In both of these systems, the TDs peak-detect pilot carrier signals, generating control voltages that compensate for variations in cable attenuation due to temperature changes.

MODEL	TEST FREQUENCY (GHz)	TANGENTIAL SIGNAL SENSITIVITY (P_{TSS}, −dBm)	SENSITIVITY (γ, mV/mW)	VIDEO RESISTANCE (R_V, Ω)	FIGURE OF MERIT ($\gamma/\sqrt{R_V}$)	SATURATION VOLTAGE OUT (mV)
MA-4C401	2	56	6000	500	250	180
	4	53	3000	500	130	180
	8	50	1500	500	65	180
MA-4C402	2	57	2600	200	180	190
	4	54	2200	200	150	190
	8	52	1000	200	70	190
MA-4C403	2	52	925	80	100	250
	4	52	850	80	95	250
	8	52	850	80	95	250

Video back-diode detector applications *using three popular Ge tunnel diodes produced the typical measured performance data shown here. (Courtesy Microwave Associates)*

Progress in materials

The first production generations of tunnel diodes were germanium (Ge) devices. And today these are the least expensive units, supplying the great majority of applications. But TDs are now also made from



Four circuits illustrate some tunnel-diode applications. *A 200-MHz RF radiation detector* **(a)** *produces an 1800-Hz audible alarm. A 1.1-MHz oscillator* **(b)** *varies its frequency as its ambient temperature changes (500 Hz/°C); the Mylar capacitor serves as the temperature sensor. In a simple level detector* **(c)**, *the output transistor turns on when E_{IN} exceeds I_PR_{IN}. And in a battery-operated citizens-band radio converter* **(d)**, *the tunnel diode provides an output for an AM radio.*

Fluke 1720A Instrument Controller

IEEE-488

Smart enough to automate testing without the keyboard. Think what else it can do.

You buy an instrument controller to solve problems, not create them. So we developed the 1720A with a unique touch-sensitive display specifically designed to put ATE system control at your operator's fingertips. With the removable keyboard protecting the program's security. Plug in the keyboard and the minicomputer intelligence makes the 1720A easy to program. Helping your programmer feel secure about easy software development and total program security.

Extensive minicomputer capabilities make programming a snap.

Don't let the simplicity of the 1720A fool you. At its core lies a powerful CPU, the brains behind its software sophistication and programming ease.

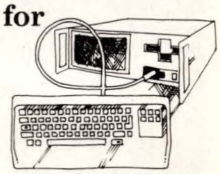
Even the language is simple. The 1720A was designed to run BASIC, familiar to programmers for high-level commands. Our BASIC is adapted specifically to enhance IEEE-488 operations, so you have the advantage of speedy programming and operation with all the usual BASIC commands—plus a few of our own.

Dynamic string functions are also built into the language.

Sophisticated memory structure.

Direct memory storage is maximized with our Virtual Arrays features extending the working memory beyond the 24 k-byte main memory. Program chaining is also standard.

More good news for programmers.



For added flexibility, we offer a new Assembly Language option, callable from our BASIC.

Concerned about the future? The 1720A is a soft-loaded system. As our software engineers develop other languages, you'll be able to easily transfer your software applications programs.

Smart programming makes for smart operation, too.

The unique touch-sensitive display prompts your operators through a test procedure without touching a keyboard. And since inexperienced operators aren't fumbling over a keyboard, there's no worry over program security.

Solve automated system problems the smart way.

Write or call toll free **1-800-426-0361** for our competitive comparison guide. Or for a demonstration.

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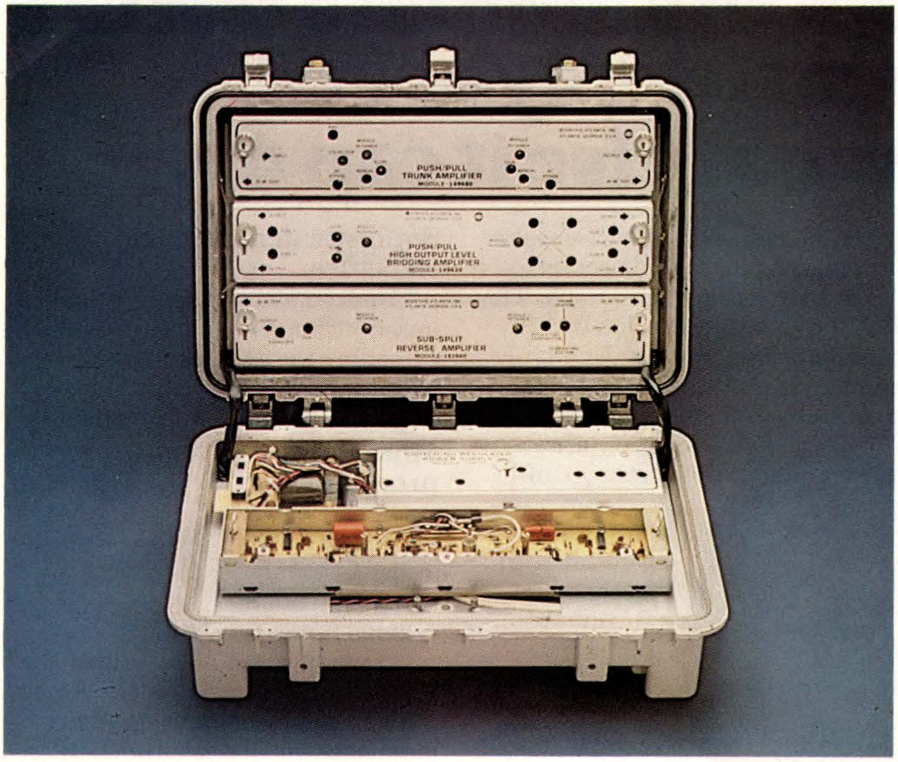
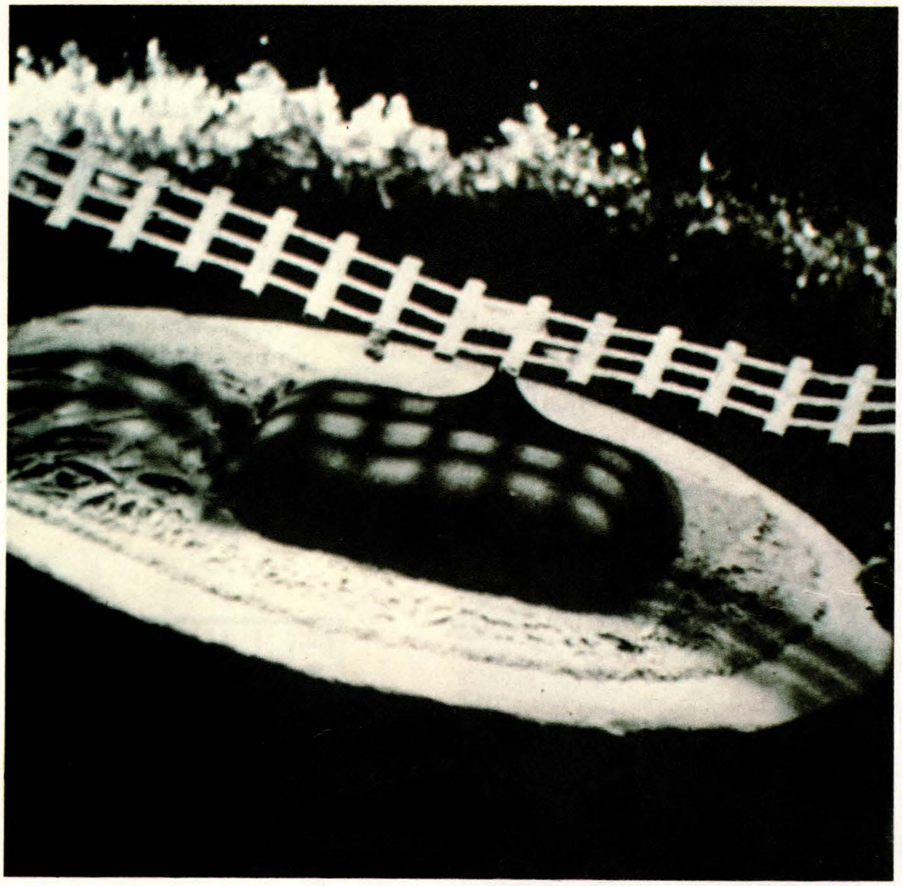
John Fluke Mfg. Co., Inc.
P.O. Box C9090, M/S 250C
Everett, WA 98206
(206) 356-5400, Tlx: 152662

For technical data circle no. 32



Tunnel diodes detect pilot-signal levels *to compensate for changes in cable attenuation with temperature in this Model 6540 ABR cable-TV trunk repeater/amplifier from Scientific Atlanta. Control signals generated by the back diodes correct for attenuation as a function of both cable length and frequency.*



Basic construction of a mesa-type tunnel diode *consists of a junction alloyed to a mesh contact that minimizes device capacitance. (Courtesy Aertech Industries)*

gallium arsenide (GaAs) and gallium antimonide (GaSb).

GaSb TDs spec the lowest noise figures and are consequently best for weak-signal, low-noise operation. Ge TDs are slightly noisier, while GaAs devices are the worst offenders.

Dynamic range also depends on device chemistry. Despite the fact that TDs made from different materials have the same value of negative resistance at minimum levels (R_M), peak currents vary: GaAs devices exhibit the highest currents; GaSb units, the lowest. Therefore, although it might sound contradictory, relatively noisy GaAs tunnel diodes offer the widest dynamic ranges, while those made from GaSb provide the narrowest.

Clearly, for optimum circuit performance, you must select the TD material with the combination of characteristics that most closely matches the requirements of your application. In microwave amplifi-

For more information...

For more information on the tunnel diodes discussed in this article, contact the following manufacturers directly.

Aertech Industries
825 Stewart Dr
Sunnyvale, CA 94086
(408) 732-0880

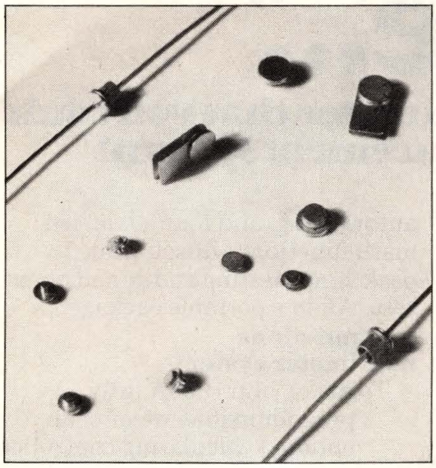
Custom Components Inc
Box 334
Lebanon, NJ 08833
(201) 236-2128

General Electric Co
Semiconductor Dept
West Genesee St
Auburn, NY 13021
(315) 253-7321

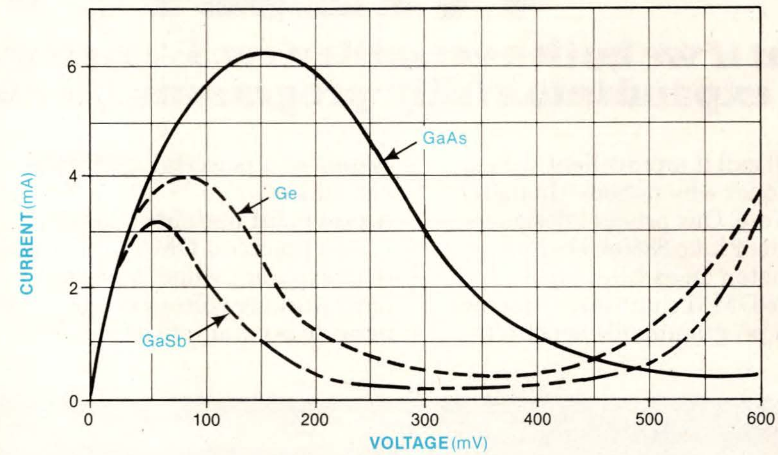
Microwave Associates
South Ave
Burlington, MA
(617) 272-3000

Microphase Corp
35 River Rd
Cos Cob, CT 06807
(203) 661-6200

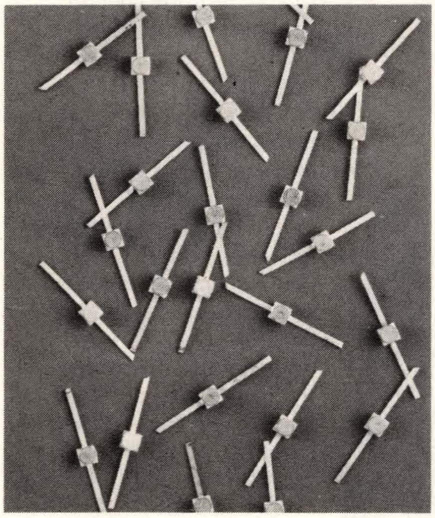
Raytheon Corp
Special Microwave
Devices Operation
5 Bearfoot Rd
Northboro, MA 01532
(617) 393-7300



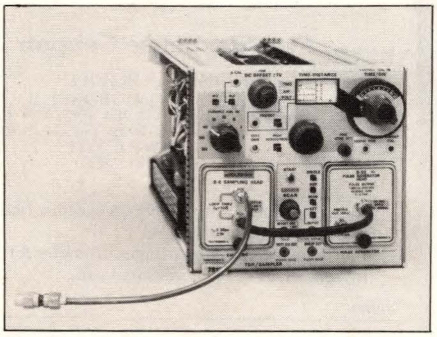
Ge and GaAs back diodes, *such as these from Microwave Associates, suit mixers and detectors through the Ku Band. Packages are available for waveguide, coaxial, stripline and microstrip applications.*



V-I curves *of Ge, GaAs and GaSb tunnel diodes differ significantly.*



Developed to integrate tunnel diodes *directly onto microstrip and microline circuit boards, these microwave packages from Custom Components provide good continuity of the transmission-line impedance into the semiconductor chip.*



Pulses with 25-psec rise times *are generated by high-speed tunnel switching diodes in the Type S-6 sampling head of this Tektronix Model 7S12 time-domain-reflectometry plug-in. Sampling scopes use similar front ends.*

ers, for example, GaAs tunnel diodes generally serve in the second or third stages to provide adequate dynamic ranges, but either GaSb or Ge devices serve as front-end preamps to maximize signal-to-noise ratios.

Aiming at computers

Research-and-development activities in tunnel-diode technology promise to extend the devices' viability. A powerful justification for this view lies in one very-high-volume potential application: the coming generations of super-high-speed computers. Using low-loss switching TDs in these advanced mainframes would significantly reduce power consumption and thus decrease cooling requirements.

Before such a market can develop, however, TD prices must sharply decline. This is a classic chicken-and-egg situation: Prices now are relatively high because current production volumes are quite low. Microwave Associates, for one, believes that the solution to this dilemma lies in an eventual device-processing breakthrough that will significantly cut manufacturing costs.

In TD packaging, by contrast, perhaps the future is already here. A clear trend is emerging: Manufacturers are reducing user-interface problems by introducing products combining TDs with related components. Two recent developments illustrate this trend.

First, Custom Components Inc has just introduced a new package that allows tunnel diodes to mate with microstrip and stripline elements. Second, Microphase recently applied for a patent on a new hybrid integrated component that it says offers improved performance and reproducibility; the new package incorporates a Ge tunnel diode in a glass/Kovar-sealed microwave module. **EDN**

NEXT TIME

EDN's June 24 issue will feature a Special Report on CMOS—envisioned by many industry experts as the premier processing technology of the 1980s and now exploding into a variety of new product areas. Other highlights include articles on

- Implementing a color-graphics processor
- Understanding the recently amended patent law

. . . and much more. Also look for Technology Update stories on CAD/CAM developments and laser technology, plus our regular Design Ideas, A Question of Law and μC Design Techniques departments. You can't afford to miss this issue!

EDN: Everything Designers Need

Leadtime Index

PASSIVE COMPONENTS

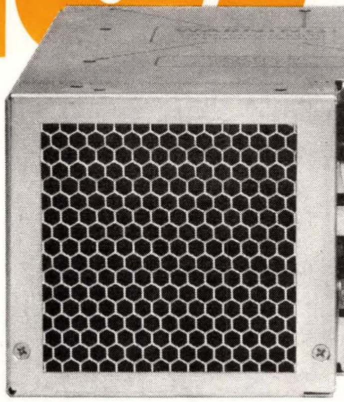
PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
CAPACITORS			
Ceramic, disc	3	12	↓
Ceramic, monolithic	3	12	↓
Electrolytic, aluminum	4	12	↓
Electrolytic, tantalum	8	16	↓
Film	2	11	=
Mica	8	15	=
Paper	4	14	=
Trimming	8	14	=
CRYSTALS, FILTERS AND NETWORKS			
Filter, active	12	16	=
Filter, EMI	8	20	=
Filter, lumped-constant	6	13	=
Filter, quartz (monolithic)	6	8	=
Freq. determining crystal	8	13	up
ENCLOSURES			
Custom	12	16	up
Modified standard	10	12	up
Standard	6	7	=
FANS AND BLOWERS	2	10	=
FRACTIONAL HP MOTORS	16	19	=
INDUCTIVE COMPONENTS			
Coil	6	12	=
Solenoid	8	10	=
Transformer, power	6	8	up
Transformer, other	6	8	up
INTERCONNECTION COMPONENTS			
Back panel	6	8	=
Flat cable	5	10	up
Multipin circular high-density	8	20	=
Multipin circular standard	8	22	=
Packaging panel	8	10	=
PC, one-piece	3	12	up
PC, two-piece	4	12	=
Rack and panel	4	14	=
RF coaxial	8	22	=
Socket	2	16	=
PRINTED CIRCUITS			
Double-sided	6	8	=
Flexible	4	16	=
Laminates	2	5	=
Multilayer	8	12	↓

PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
PRINTED CIRCUITS			
Single-sided	6	10	=
RELAYS AND TIMERS			
Crystal can	6	20	=
General purpose	6	10	=
Miniature (TO-5, square)	10	20	=
Reed, dry	8	20	=
Reed, mercury-wetted	8	18	up
Solid state	1	3	=
Telephone	6	14	=
Time delay and timer	2	10	=
RESISTORS, FIXED			
Carbon film	4	10	=
Composition	6	10	=
Metal film	8	12	=
Network	6	12	=
Wirewound	8	12	=
RESISTORS, VARIABLE			
Pot, nonprecision WW	8	12	=
Pot, precision WW	4	12	=
Pot, nonprecision comp.	7	14	=
Pot, precision comp.	10	12	=
Trimmer, WW	3	10	=
Trimmer, comp.	12	14	=
SWITCHES AND KEYBOARDS			
Circuit breaker	10	14	=
Dual in-line	7	14	=
Keyboard and keyswitch	8	11	=
Lighted pushbutton	6	12	=
Pushbutton	2	10	=
Rotary	6	8	=
Snap action	3	4	=
Thumbwheel	2	8	=
Toggle	4	10	=
TRANSDUCERS			
Pressure	7	12	=
Temperature	6	12	=
WIRE AND CABLE			
Coaxial cable	4	9	=
Flat and ribbon cable	5	8	up
Hookup wire	6	10	=
Multiconductor cable	6	13	=

Leadtimes are based on recent figures supplied to *Electronic Business* magazine by a composite group of major manufacturers and OEMs. They represent the typical times necessary to allocate manufacturing capacity to build and ship a medium-sized order for a moderately popular item. Trends represent changes expected for next month.

Dependable Switchers...

1973 1981



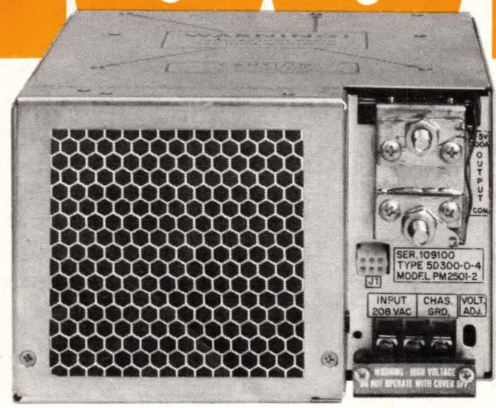
The PM2497
5V@100A/5"x8"x11"

In 1973 Pioneer Magnetics started building a 5VDC @ 100A switching power supply for applications requiring compact and efficient DC power. At the time, commercial switchers were considered state-of-the-art. We solved reliability and delivery problems for our customers that our contemporaries couldn't. As a result, our customers referred to the power supplies as the DEPENDABLES. In fact we're still delivering that same power supply to those same valued customers. We're proud to say that they've depended on us and we've responded by shipping over 100,000 high power switchers. After 8 years our supplies are still out there and running. A continuation of a tradition started in 1958.

STANDARD DC OUTPUT RATINGS.

MODEL	2V	3V	5V	12V	15V	18V	24V	28V	48V	60V	CASE SIZE
PM2496A	100A	60A	50A	30A	25A	22A	16A	13A	8A	6A	5"X8"X11"
PM2497A	200A	100A	100A 120A 150A	60A	50A	45A	33A	27A	16A	12A	5"X8"X11"
PM2500A		200A	200A	85A	70A	60A	45A	40A	24A	19A	5"X8"X11"
PM2498B	400A	300A	200A 300A	120A	100A	90A	66A	54A	32A	25A	5"X16"X11"
PM2501	400A	300A	300A	120A	100A	90A	66A	54A	32A	25A	5"X8"X11"
PM2502	500A	450A	450A	180A	150A	125A	90A	80A	47A	35A	5"X16"X11"

NOTES: 92-138VAC or 184-250VAC single phase, 47 to 63Hz.
DC input available.



The New PM2501
5V@300A/5"x8"x11"

Since 1973, we've been accepting new challenges. Within the same outline as the PM2497, we've developed output ratings of 5V @ 120A, 150A, 200A and now a new 5V @ 300, with full delivered power at 50°C.

The new PM2501 exhibits excellent dynamic response. Proven design concepts enable close control over those parameters that insure reliability. For instance, our unique heat transfer technology results in low component thermal stress, even lower than the PM2497. At three times the power level the PM2501 features an exceptionally high power density package.

Our product line includes switchers that deliver up to 2250 watts in single output and from 375 to 1500 watts in dual through quad output channels. AC or DC input.

Over 100,000 PMI switchers are in the field providing dependable, service free operation. After all, that's why customers have continuously come back to us since 1958.

Pioneer Magnetics

THE SWITCHING POWER SUPPLY PEOPLE SINCE 1958

1745 Berkeley Avenue, Santa Monica, CA 90404 (213) 829-6751

CIRCLE NO 35

Editor's Choice: New Products

Surge suppressor, filter and fuse combine to optimize line conditioning

Triple protection *(against excessive voltage, current and EMI/RFI) is a key feature of Pico-family line conditioners. Accommodating sources ranging from logic levels to 3-phase y- and delta-connected systems, they also provide bilateral protection, restricting transients into and out of the protected equipment.*

Depending on how you apply them, Pico-family line conditioners can provide three types of circuit protection—overvoltage and overcurrent safeguards and EMI/RFI filtering. The family includes three basic circuit classes: unipolar ac (TSS), zero-time ac (ZTA) and zero-time dc (ZTD). All provide bilateral performance, restricting transients into and out of the protected equipment.

Connected in shunt configuration across the power line, TSS devices absorb 95 to 98% of any transient energy that exceeds their specified clamping level. They accommodate y- and delta-type connections and are designed to serve the 10 most popular ac line voltages used in the US, Europe and Asia.

The TSS units exhibit a 20-kA pk pulse-current rating, 0.1-μsec clamping speed and 480 to 1920J power dissipation. They provide no EMI/RFI filtering and permit 1- to 2-μsec overshoot, but if you connect a TSS device to the branch panel that serves a group of terminals or a computer room, it reduces the transient energy to a level that's easier to control using a ZTA or ZTD device (these units can, of course, provide full protection by themselves).

In one package, ZTA units incorporate a line filter that eliminates differential and common-mode EMI/RFI and a special TSS circuit to delay electric transient wavefront and eliminate overshoot.

Three ZTA packages are available for North American (120V ac) and European (220V ac) voltages. ZTAP and ZTAPE models plug directly into a typical duplex receptacle. ZTAC and ZTACE are designed to be built into the protected equipment; a molded cord set then connects the unit to the line. Finally, ZTAS and ZTASE models are also built into equipment, but they employ a terminal strip for input/output connections.

The rest of the products in the ZTA line (ZTA3 through ZTA10) accommodate 3-wire single-phase and y- or delta-connected 3-phase systems.

All ZTA units are selectively fusable from 20 mA to 20A. Clamp symmetry equals ±5% max, shunt capacitance is 0.01 μF, minimum EMI/RFI attenuation (from 0.15 to 200 MHz) specs at 60 dB and response time is 0.1 μsec.

The ZTD line consists of 14 products designed for pc-board mounting.

The ZTD devices furnish bidirectional protection from EMI/RFI and transient glitches that can occur on a board. Operationally, their TSS system—rather than the devices connected to the board's power bus—dissipates surge energy.

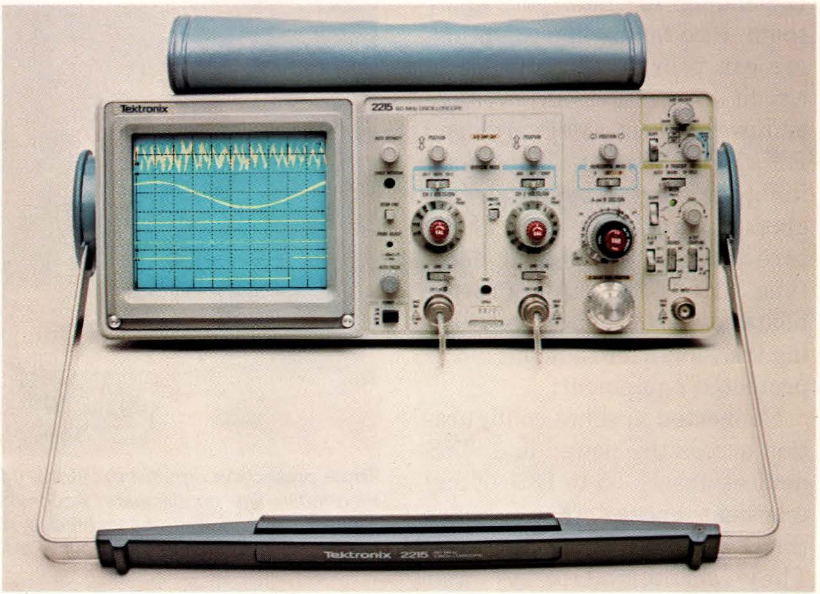
ZTD units also eliminate overshoot and provide 60-dB min EMI/RFI attenuation. They are available in seven voltage ratings to protect TTL and CMOS circuitry (5 and 12V dc), automobile batteries (14.2V dc), op-amp circuits (15V dc), industrial-control circuits (24V dc), aviation batteries (28.2V dc) and telephone systems (48V dc).

TSS and ZTA (production qty): $500 to $1000 for multiphased y and delta configurations, $100 to $200 for single-phase 3-wire, $50 to $100 for single-phase 2-wire. ZTD: $10.

***Power Integrity Corp, 300 E Wendover Ave, Suite 102, Greensboro, NC 27401. Phone (919) 379-9773.* Circle No 450**

Editor's Choice: New Products

Lightweight, low-cost scopes feature 60-MHz bandwidths



Delayed-sweep facilities and 60-MHz bandwidth *characterize the Tektronix 2200 Series scopes, which are priced at less than $1200 and weigh less than 15 lbs.*

Priced at less than $1200, Models 2213 and 2215 nevertheless feature 60-MHz bandwidths and delayed-sweep modes. The $1100 Model 2213 has a single timebase and uncalibrated delay, and the $1400 Model 2215 features dual-delay sweep facilities. Each scope weighs less than 15 lbs including probes and optional pouch and front cover, 13½ lbs without pouch and front cover.

The low prices arise in part from a simplified design in which almost all circuitry within the instruments resides on one board. As a result, cabling and interconnects are reduced, increasing reliability as well as reducing manufacturing cost. An additional contribution to low cost comes from the chassis, formed from two simple L-shaped aluminum parts rather than a handful of expensive extruded panels.

The instruments have 5-in. CRTs and typically are down 3 dB at 70 MHz or more. Fastest calibrated sweep speed is 5 nsec/div, and sensitivity spans 2 mV/div to 10V/div.

Delay modes available

Model 2213 has a single timebase and Delay mode calibrated to the screen markings for 3% accuracy. The mode makes it easier for you to position the sweep and acts as a selective magnifier.

Model 2215 has a dual timebase with 1.5% calibrated accuracy. Alternate/intensified sweep-mode switching lets you simultaneously view the A channel with its intensified segment and the intensified segment with its own B sweep.

A sweep-separation control makes it easier to set the vertical positions of B sweeps with respect to A sweeps. And a B trigger after delay helps reduce jitter in delay-time measurements.

In both instruments, true Vertical-mode alternate triggering provides asynchronous-signal triggering. Enhanced autotrigger minimizes trigger-control adjustment, and variable hold-off offers stable triggering on complex analog or digital signals.

The instruments feature automatic intensity and focus adjustments so that both sweeps are the same intensity, regardless of sweep speed.

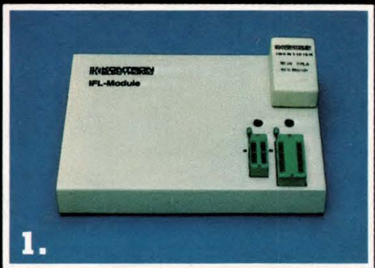
You can use both channels at their full sensitivity ranges for accurate X-Y phase measurements. And a Z-axis input lets you use the instruments with logic analyzers and other devices. Other features include a beam finder to simplify setup and a front-panel trace-rotation control for correct displays regardless of scope position.

A high-efficiency power supply operates from 90 to 250V, 50 or 60 Hz, while reducing weight and power consumption and increasing reliability by minimizing parts. New ×10 probes supplied with the instruments are lightweight and feature flexible cables. No bandwidth loss occurs at the probe tip, and an IC grabber simplifies connection to devices on boards.

An optional pouch and cord wrap enhances portability by carrying all probes, manuals and other accessories. A protective front cover is also optional.

Tektronix Inc, Box 4828, Beaverton, OR 97208. Phone (800) 547-6711. **Circle No 451**

KONTRON'S MPP 80...The total programming instrument



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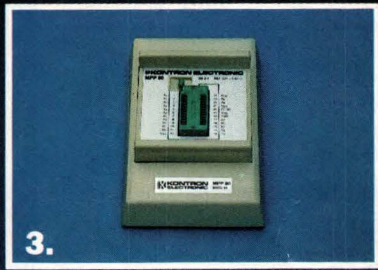

3.

Whether down-loading from a development system, servicing field equipment, or programming through a handler on the production floor... Kontron's MPP 80 can do it! **1.** Programmable logic modules to support Signetics IFL both the 28 and 20 pin (FPLA, FPGA, FPRP, FPLS), MMI PAL™, etc., with full CRT editing. **2.** Gang programming to support all popular EPROMS using interchangeable identifiers, including the new 64K EPROMS. **3.** Inexpensive personality modules for programming single devices and whole PROM families uses interchangeable socket adapters.

Features ■ All Kontron modules are submitted for device manufacturers approvals ■ Over 400 devices programmed ■ Computer development system, or terminal remote control ■ Standard UV lamp ■ These and many more features are explained in our comprehensive brochure.

Kontron's MPP 80 SAM provides data transfer capabilities over telephone lines via an approved modem and acoustic coupler. Just think! No more PROMS lost in the mail and updates are as quick as a phone call!

MPP 80SAM

PROM PROGRAMMERS:

For data on Kontron® Computer/Controllers, Digital Multimeters, Counters, PROM Programmers, Logic Analyzer and Printers, call (800) 227-8834. In California call (415) 361-1012.

KONTRON ELECTRONICS, INC.
Advanced Electronic Instrumentation

630 Price Avenue, Redwood City, CA 94063 (415) 361-1012

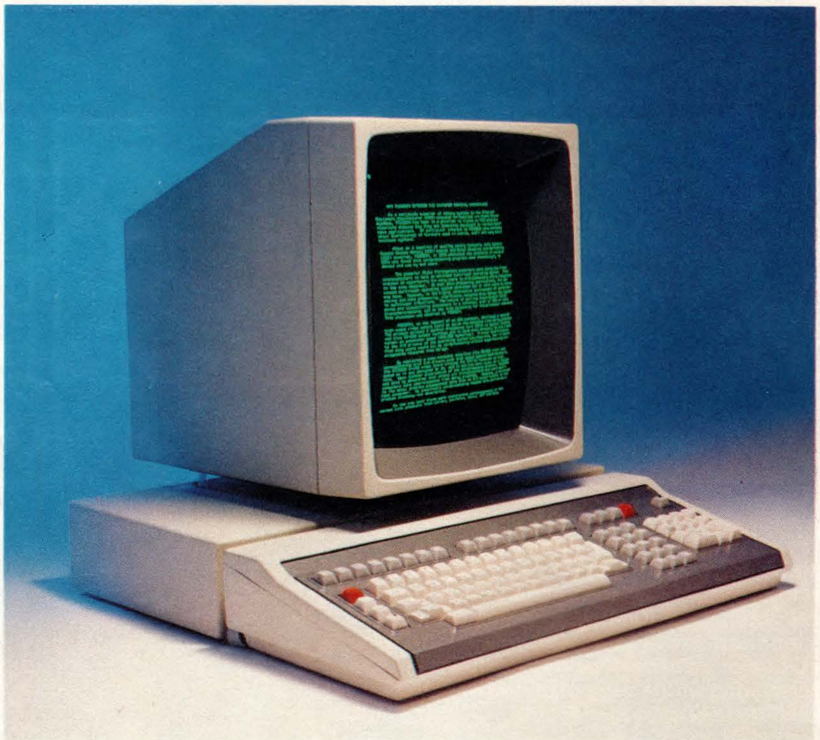
Circle no. 38 for literature

Circle no. 37 for demonstration

Editor's Choice: New Products

Remote-job-entry terminal uses 16-bit μP

If you need an extremely intelligent terminal for your time-sharing or networking system, Model 2010 could fill the bill. Built around the Intel 8086 μP and incorporating 32k bytes of RAM on one pc board, it features a full-screen (66 lines×80 characters) display configuration, a complete set of ANSI control functions, a 107-key keyboard, two RS-232C serial ports, and a rotating (±30°) detachable 15-in. screen.



Displaying 66 80-character lines *in a full-page format, Model 2010 intelligent terminal employs an Intel 8086 μP and provides two RS-232C serial ports and a detachable 107-key sculptured keyboard.*

Easy on the eyes

The terminal's modular design provides placement versatility. Screen attributes include two intensity levels, blinking, underlining, reverse video and variable character size. (The latter function is user selectable and depends on the number of lines per screen selected: 66 max, 33 min.)

The terminal employs the 128-character ASCII set. Characters are generated as a 7×9 matrix in a 9×15 cell on the vertically mounted green-phosphor CRT, which can display 5280 characters max in the full-screen mode.

The ANSI-standard control functions include area qualifiers, block-mode transmission, pagination, download and go, cursor controls with associated numeric parameters, form filling and transfer and support of downloaded software.

System communication

Because Model 2010 is designed for use primarily with a host system, its two RS-232C serial ports provide user-selectable baud rates ranging from 75 to 19.2k, either switched via hardware or under software control. The terminal transmits data in either conversational mode (byte protocol) or block mode with a variety of communication protocols.

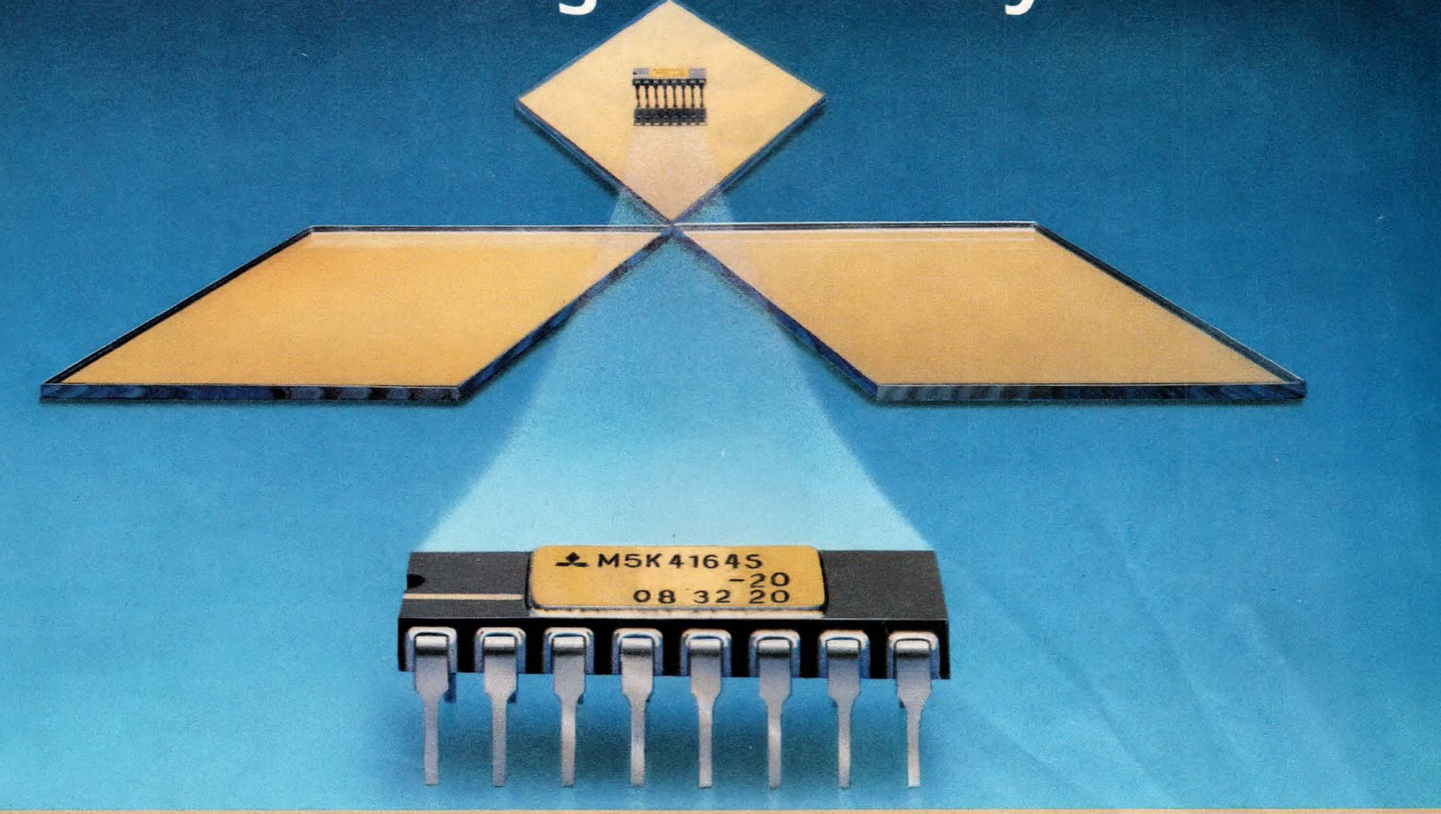
You can expand RAM to 256k and add 8k of ROM. The terminal requires a 95 to 130 or 190 to 260V ac power input at 47 to 450 Hz.

The 65-lb, 19×21×21-in. unit is available now. $2495 (50).

Piiceon Inc, Intelligent Systems Div, 2350 Bering Dr, San Jose, CA 95131. Phone (408) 946-8030. **Circle No 452**

THE MITSUBISHI 64K RAM:

The memories of tomorrow are being made today.



Today not tomorrow.

Already qualified on more state-of-the-art, high speed, primary memory specs than one might imagine, the MITSUBISHI M5K4164 carries with it the reliability and technological leadership of one of the world's most respected names in electronics. No blue sky promises, but reality.

Compatibly packaged in an industry-standard 16-pin DIP for interchangeability with any other 64K unit available, MITSUBISHI'S 65,536 word X 1-bit Dynamic RAM is now being produced in initial volumes and can be obtained from stock.

Featuring high-density, high capacitance memory cells, and low soft-error rate, the M5K4164 is manufactured via N-channel silicon gate MOS process, using VLSI techniques for reliability and production availability.

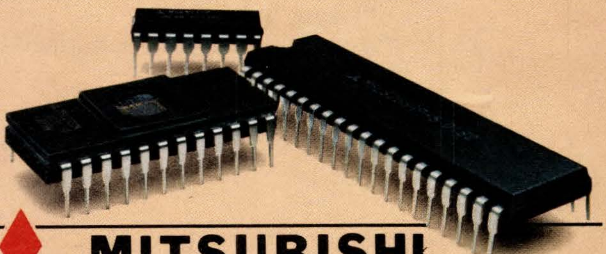
Think about it. The MITSUBISHI M5K4164 offers 150-200 ns access time, low-power dissipation, TTL compatibility, 128 refresh cycles every 2 ms, 5V single power supply operation, and a high-density polysilicon structure for superior performance characteristics. Pin 1 open or functional, your choice.

The M5K4164 is available today. And, the production quantities you'll require will be ready to ship when you want them. The credentials of our memories are recorded in the thousands of applications where MITSUBISHI 4K, 8K and 16K RAMS, EPROMS, microprocessors, LSTTL and other devices are now in use.

TEST SAMPLES AND DATA

To evaluate the M5K4164 for your system applications, simply call us. Or, write for complete data, MITSUBISHI ELECTRONICS AMERICA, INC. Factory offices located in Sunnyvale, CA (408) 730-5900; Compton, CA (213) 979-6055; Bloomington, IN (812) 339-2463; and So. Plainfield, NJ (201) 753-1600.

The reliability is MITSUBISHI. Where memories are made for you. Today.



Semiconductor Division

MITSUBISHI ELECTRONICS AMERICA, INC.
1230 Oakmead Parkway
Sunnyvale, California 94086
(408) 730-5900 TWX 910-339-9549

MITSUBISHI ELECTRONICS

CIRCLE NO 39

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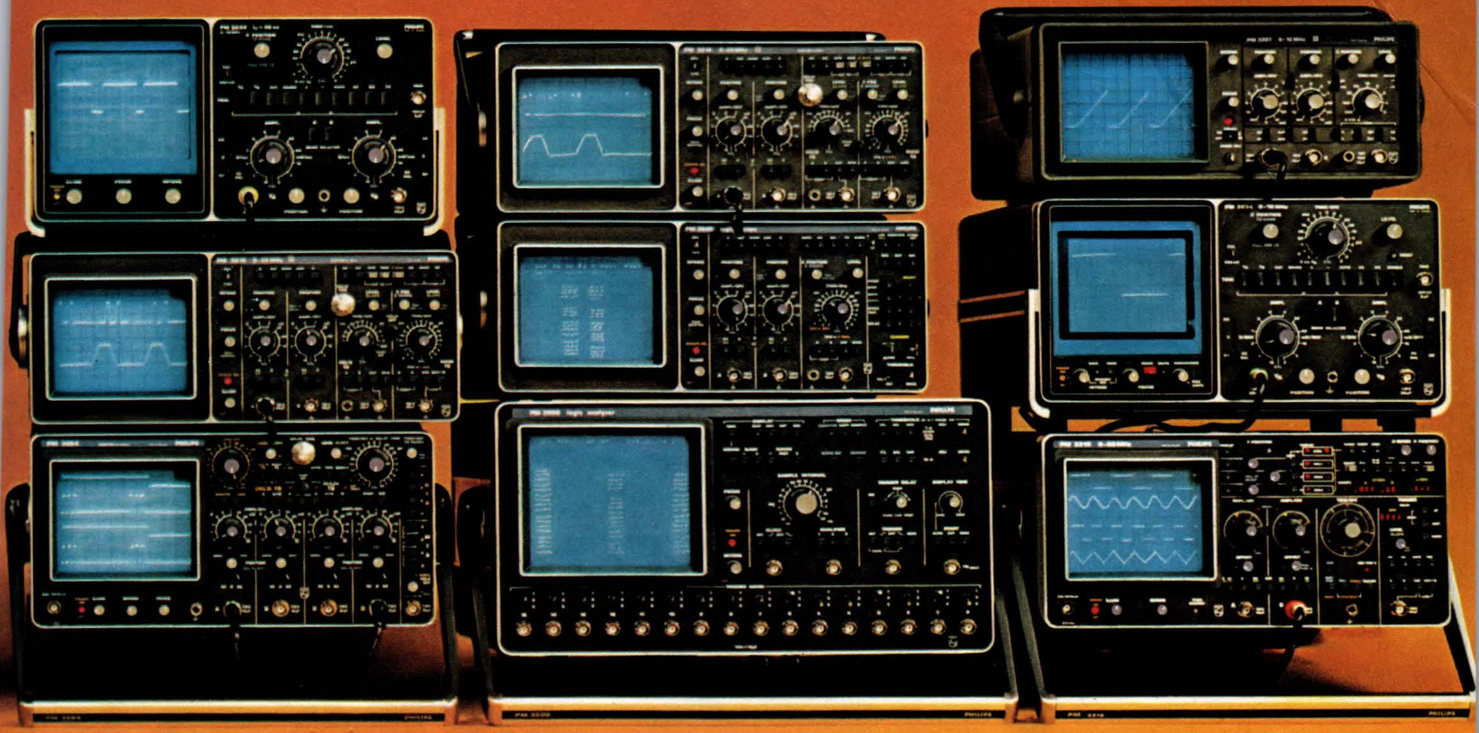

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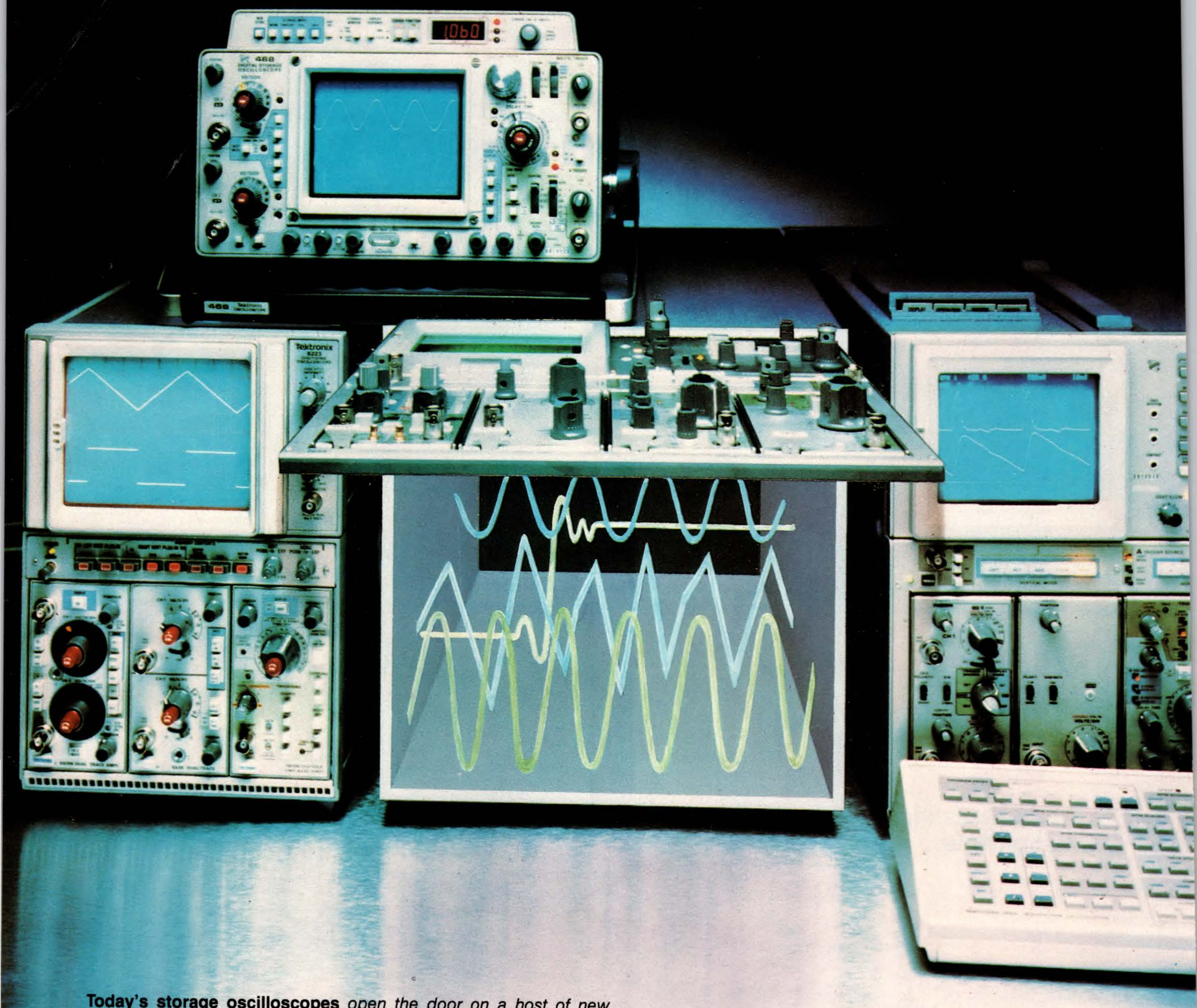
Storage oscilloscopes



Today's storage oscilloscopes *open the door on a host of new measurement capabilities. (Photo courtesy Tektronix Inc)*

Analog-storage scopes cover a broad price/performance range; digital models provide more signal-analysis flexibility. Both types furnish operating conveniences that let you concentrate on measurements rather than instrument adjustment and protection.

Rick Nelson, Associate Editor

Storage oscilloscopes now offer capabilities that allow them to serve diverse applications ranging from research and development to production testing. Features common to such instruments include "user-friendly" front panels that help provide bright, clear displays without extensive adjustment and protective functions that guard against CRT burning.

In addition to these common human-engineering and protective features, however, storage-scope manufacturers furnish a wide range of storage techniques and price/performance tradeoffs that you must consider when selecting such an instrument. Indeed, even the data sheets of these devices can confuse the selection process: They contain such esoteric terms as useful storage bandwidth (USB)—a digital-scope spec analogous to analog-scope bandwidth—that seldom confront the purchasers of general-purpose nonstorage oscilloscopes. Moreover, even such seemingly straightforward specs as a digital scope's sampling rate can have radically different interpretations: A specified sampling rate can translate to one USB in a Tektronix scope and to quite another in a Philips instrument.

To help cut through some of the confusion, this report discusses several storage techniques, features and terminologies applying to the two primary storage-scope categories:

- **Analog-storage scopes.** These instruments span the wider price/performance range of the two categories. For example, Tektronix's 10-MHz Model T912 provides a stored writing speed—the maximum spot velocity that results in the visible storage of a single-shot waveform on the CRT screen **(Fig 1)**—of only 0.25 cm/μsec and costs only $1800. The firm's 400-MHz Model 7834, on the other hand, furnishes a 2500-cm/μsec stored writing speed and costs $10,395. Another analog-storage-scope tradeoff is between stored writing speed and storage-time: For example, Hameg's $4035 Model HM 812 achieves a 48-hr storage time but only 2.5-cm/μsec stored writing speed, while Hewlett-Packard's $7200 Model 1727A offers 2000-cm/μsec stored writing speed with a 30-sec storage time.
- **Digital-storage scopes.** These devices provide the greater flexibility in waveform analysis—they feature pre- and post-trigger capabilities

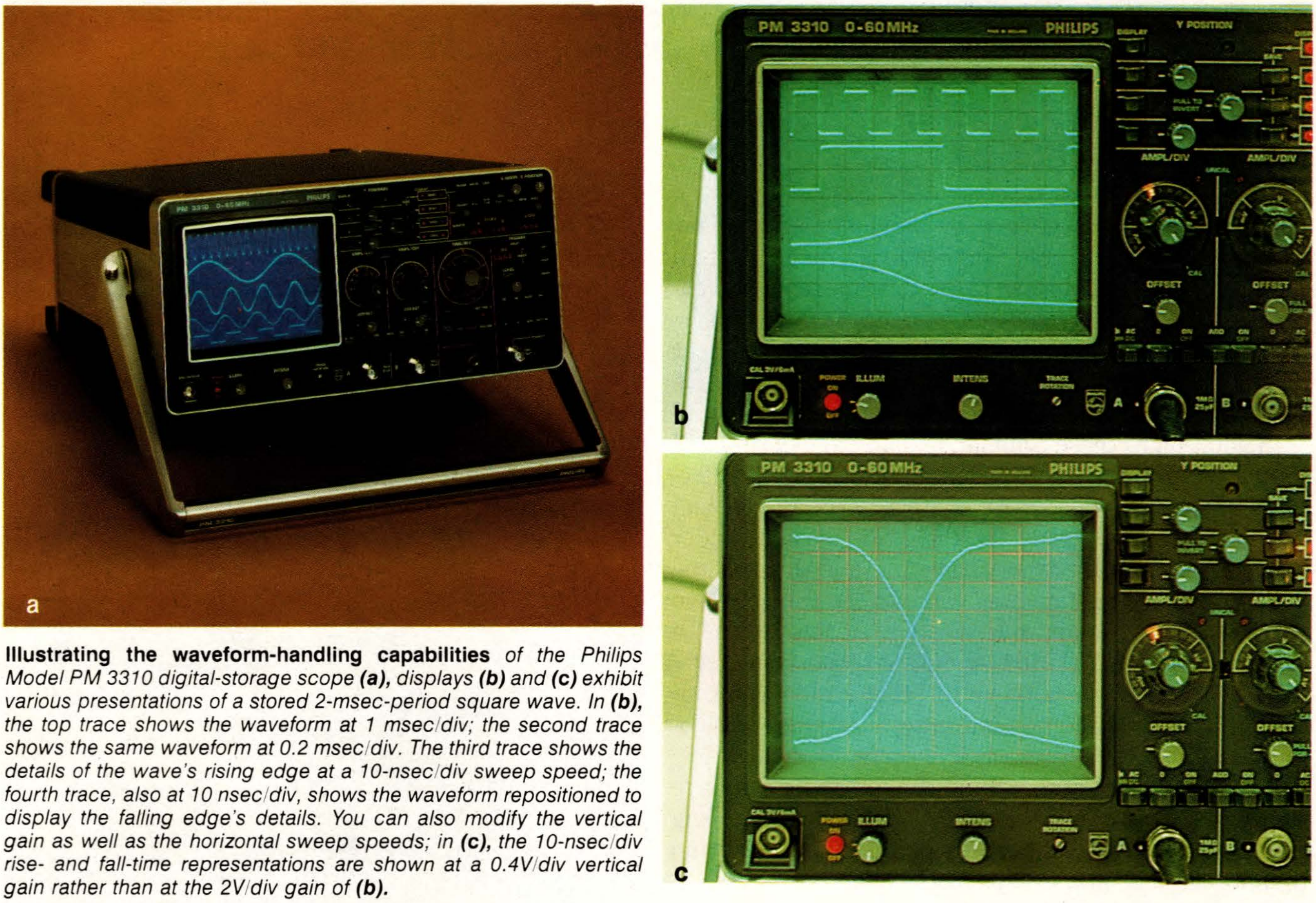
Suited to portable operation, *Tektronix's Model 468 digital-storage scope furnishes 100-MHz nonstorage capability and achieves a 25-MHz sampling rate. Combined with the unit's sinusoidal-interpolation function, this rate yields a 10-MHz useful storage bandwidth.*

Useful storage bandwidth depends on your viewpoint

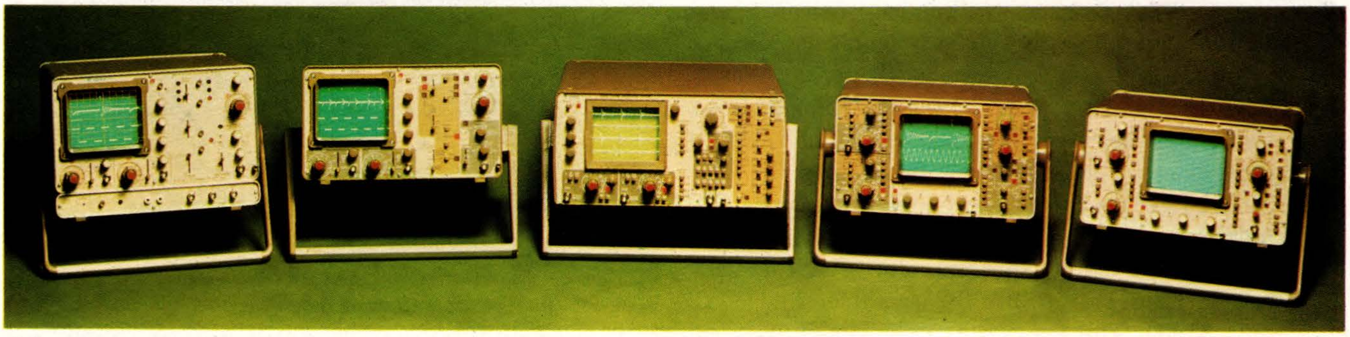
that allow you to record events occurring before as well as after a trigger condition, and they let you zoom in on any portion of a stored waveform for closer inspection. And most incorporate extremely slow-sweep-speed roll modes that let them double as solid-state chart recorders. For example, Philips's $6395 Model PM 3310 features a 1-hr/div sweep speed, which, when used with the instrument's four 256-byte memories, permits storage of 40 hrs of data. Digital scopes can also transmit digitized waveform information to a computer for further analysis; scopes such as Tektronix's $10,500 Model 7854 even permit on-board digital signal processing. Furthermore, the instruments' waveform storage times are limited only by the life of the storage medium.

Analog-storage scopes offer variety

Your choice of an analog- or digital-storage scope depends primarily in where your requirements lie in the price/performance spectrum. At the low end, you won't find any digital scopes that compete in price with Tektronix's $1800 analog Model T912, for example. (This situation might soon change, however. Although details aren't available, Hameg's US operations manager Joseph LaFiandra reports that his firm is planning to introduce a digital-storage scope this summer, priced at less than $1500.) And at the high end, you won't even find off-the-shelf digital-storage scopes that rival the



Illustrating the waveform-handling capabilities *of the Philips Model PM 3310 digital-storage scope* ***(a)****, displays* ***(b)*** *and* ***(c)*** *exhibit various presentations of a stored 2-msec-period square wave. In* ***(b)****, the top trace shows the waveform at 1 msec/div; the second trace shows the same waveform at 0.2 msec/div. The third trace shows the details of the wave's rising edge at a 10-nsec/div sweep speed; the fourth trace, also at 10 nsec/div, shows the waveform repositioned to display the falling edge's details. You can also modify the vertical gain as well as the horizontal sweep speeds; in* ***(c)****, the 10-nsec/div rise- and fall-time representations are shown at a 0.4V/div vertical gain rather than at the 2V/div gain of* ***(b)****.*



A line of five digital-storage scopes *from Gould includes models that provide sampling rates to 10 MHz, vertical resolutions to 10 bits and real-time bandwidths to 25 MHz. For example, Model DSO4020 features a 2-MHz sampling rate, 8-bit vertical resolution, 4k bytes of RAM and an IEEE-488 interface, and Model DSO440 offers 4-trace capability.*

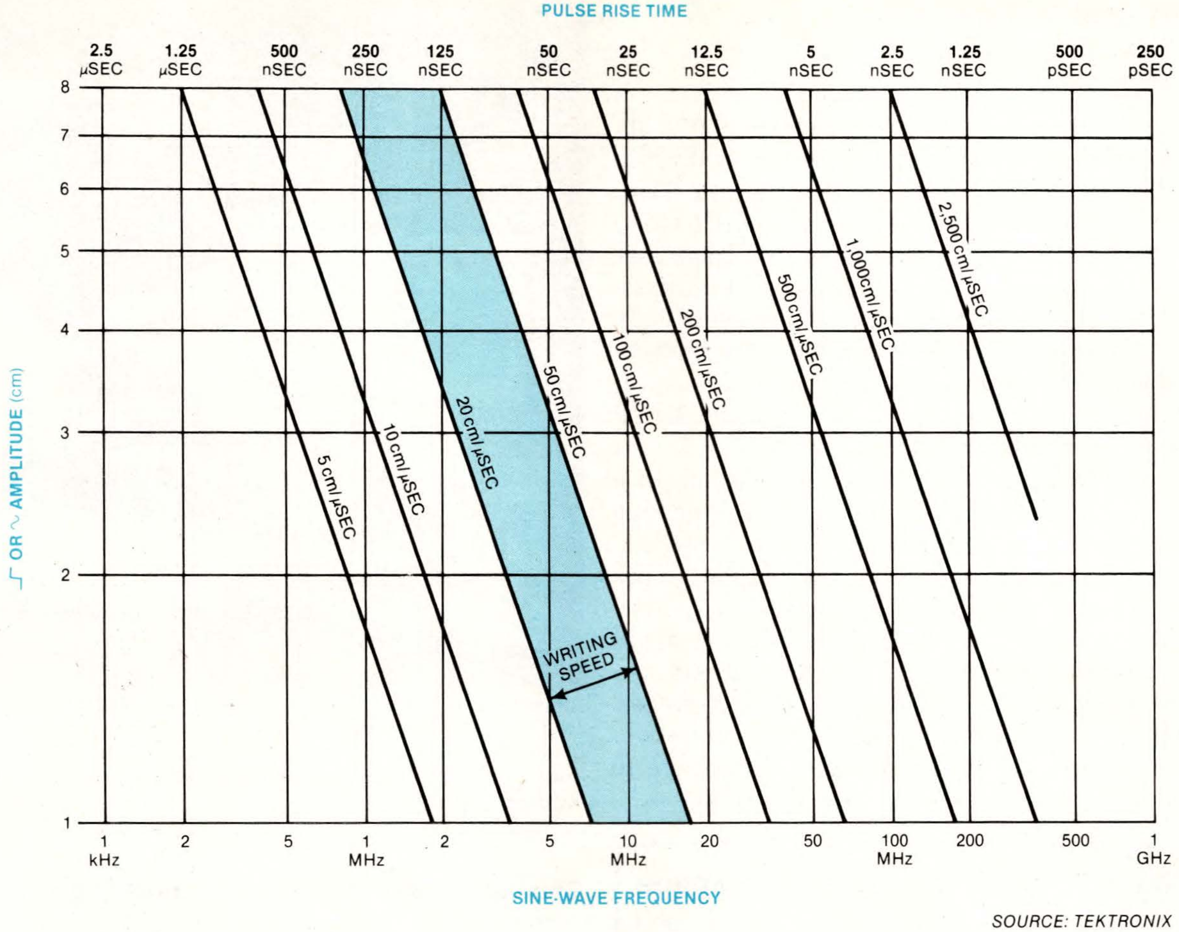


Fig 1—Required writing speed *depends on sine-wave frequency or pulse rise time as well as the peak-to-peak amplitude of the signal to be stored. Note that you would need a 2500-cm/µsec writing speed to store an 8-cm p-p 100-MHz sine wave, but only a 1000-cm/µsec writing speed to store a 3-cm p-p sine wave of the same frequency.*

waveform-capturing performance of such analog instruments as HP's Model 1727A.

(You *can* buy components that allow you to put together your own high-speed digital scope, however. For example, you can combine Tektronix's Model 7912AD waveform digitizer with a raster display to digitally record an 8-div p-p 500-MHz sine wave. The instrument costs $23,800 plus the input vertical amplifier and display, making such a system considerably more expensive than high-end general-purpose analog-storage scopes. Indeed, the instrument utilizes an analog-storage technique to furnish its high-speed performance: A scan-conversion technique writes the analog waveform under investigation onto a silicon-diode target array; subsequent scanning of this array digitizes the waveform into 512 horizontal points, each at 9-bit vertical resolution. The instrument's maximum sweep speed of 500 psec/div allows the target array to store a 5-nsec time window; thus, the 512-point digitizing yields a 100-GHz equivalent sampling rate.)

Digital scopes are price competitive

If your requirements fall in the middle of the price/performance spectrum, though, you have a choice of technologies: Analog- and digital-storage scopes with equivalent performance cost roughly the same. Why? The expensive storage CRTs that analog-storage scopes require are balanced by digital scopes' costly high-speed A/D converters and memory ICs.

Direct price comparisons between the two storage technologies are difficult to make, but consider Tektronix's analog Model 464DM44 and digital Model 468: Both cost approximately $5600, come in packages with similar form factors and furnish 100-MHz nonstorage capability. Model 468 offers a USB of 10 MHz; Model 464DM44 can write a 10-MHz sine wave with 3-cm p-p amplitude. Model 468 incorporates a calibrated cursor readout; Model 464DM44 includes a DMM.

Similar performance comparisons among other analog- and digital-storage scopes with capabilities like those of Models 464DM44 and 468 are more difficult to make. But making them reveals the price similarities in this performance range.

For example, Philips's digital Model PM 3310 and analog Model PM 3266 each cost $6395. The digital scope has a USB of at least 5 MHz; it has no analog capability but can digitize and display repetitive waveforms to 60 MHz. The analog scope provides

Variable-persistence scopes furnish fast writing rates

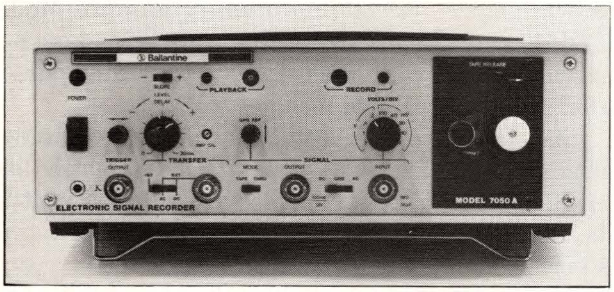
100-MHz nonstorage capability. Its Fast mode permits waveform storage to this full nonstorage-bandwidth rating, although only for 3 to 8 sec, and its Max Write mode permits longer storage times but limits writing rate to 2.5 div/μsec, which translates to a somewhat lower storage performance level than the digital scope's 5-MHz USB. Thus, if your storage requirements lie in the 5- to 10-MHz range, these examples' price similarities, coupled with digital scopes' flexibility and convenience, will probably prompt you to select the digital instruments over their analog counterparts.

And in addition to performance and initial-price considerations, factors such as total cost of ownership might also sway your choice toward the digital models. For example, the standard CRTs that digital scopes employ don't have the limited life expectancies of some analog-storage CRTs. Moreover, in field-service applications—where chances of CRT damage are greatest—the lower replacement costs of digital-storage scopes' CRTs make the digital technology more attractive. Indeed, replacement costs for storage CRTs can be 10 times the replacement costs for standard CRTs.

Aimed at both production and laboratory applications, *Tektronix's Model 7854 can capture waveforms and then determine such parameters as rise time and rms levels. The programmable instrument's calculator-type keyboard lets you tailor it to your measurement applications.*

Adding pretriggering to an analog scope

One product allows you to add storage and pre-trigger capabilities to a nonstorage analog scope. Ballantine Labs' (Boonton, NJ) $995 Model 7050 A electronic signal recorder incorporates a 2-in.-diameter×¼-in.-wide continuous computer-grade magnetic-tape loop that can store a transient signal 20 msec or less in duration. You can then play this signal back for display on any real-time scope. Using the 7050 A's output-trigger delay in conjunction with your scope's sweep-speed adjustment lets you see the entire 20-msec transient or zero in on any portion of the stored signal. The 7050 A has a 100-kHz bandwidth and pre-trigger capability adjustable from 0 to 16 msec. It provides analog-storage times limited only by the magnetic tape's life.



Add pre-trigger and storage capabilities *to a nonstorage scope with Ballantine's Model 7050 A electronic signal recorder. This 100-kHz instrument can store a transient signal lasting 20 msec or less on a continuous magnetic-tape loop for subsequent display on a standard real-time scope's CRT.*

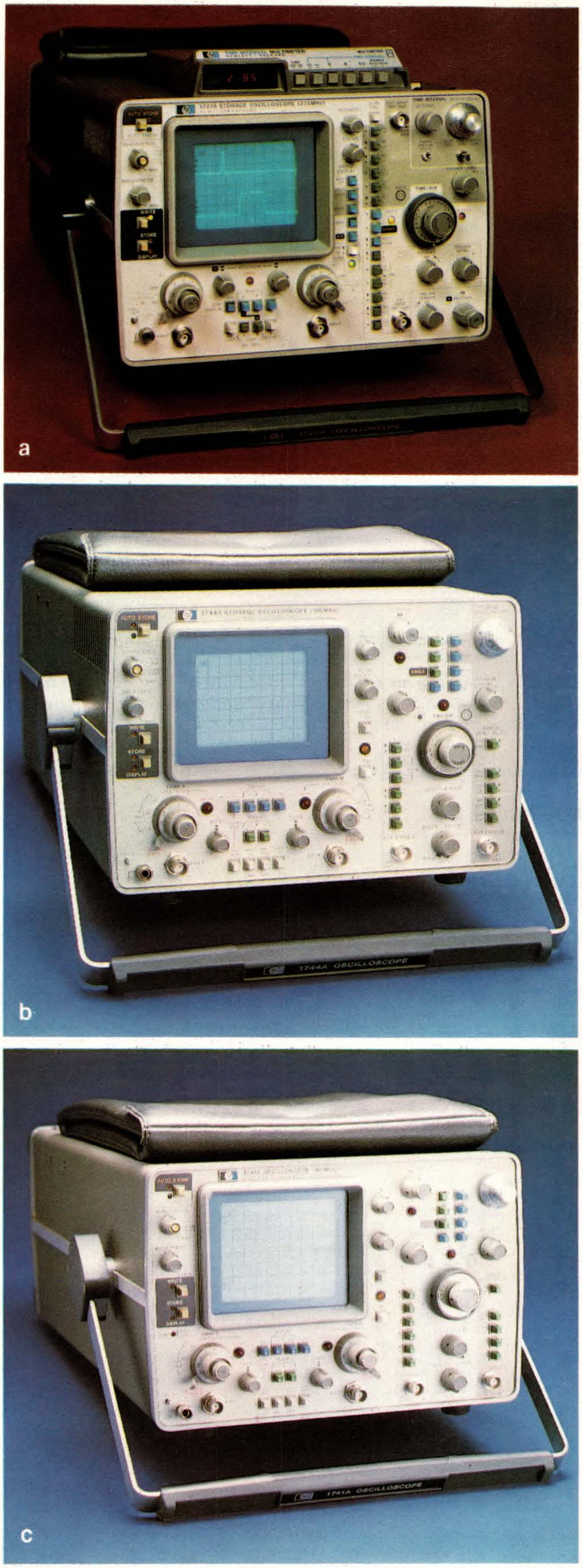
Choices are straightforward with analog scopes

Even after you choose between the two storage technologies, however, the selection process is far from over. If you've selected the analog technology, though, your further choices are relatively straightforward: Higher writing rates result in higher costs and shorter storage times. Moreover, you don't have to choose among the various pre-trigger capabilities common on digital-storage scopes; such functions are almost never available on analog-storage units (see **box,** "Adding pretriggering to an analog scope").

Other analog-storage-scope specification considerations include storage-CRT type. Bistable CRTs use their phosphor as the storage medium; each phosphor particle has two stable states: written (energized) and unwritten (de-energized). Scopes employing this storage technique usually furnish slow writing speeds but also provide low price and storage times measured in hours. Some models also provide split-screen capability, a feature that allows you to store a reference waveform on the top half of the CRT screen and then display a comparison waveform, in either a storage or nonstorage mode, on the bottom half.

Drawbacks to bistable storage include the limited lives of bistable CRTs. You can expect some of these devices to furnish only 50% of their initial brightness after 1000 hrs of operation.

A second analog-storage CRT type, variable-persistence (of halftone) CRTs (see pg 93), uses a standard phosphor and incorporates one or more storage meshes for waveform memory. These CRTs



Three variable-persistence scopes *from Hewlett-Packard provide a range of key-spec values. The $7200 Model 1727A* ***(a)*** *features a 275-MHz bandwidth and 2000-cm/µsec stored writing speed. The $5500 Model 1744A* ***(b)*** *and $4750 Model 1741A* ***(c)*** *each furnish 100-MHz bandwidths; their stored writing speeds equal 1800 and 200 cm/µsec, respectively.*

have life expectancies comparable to those of nonstorage CRTs, furnish higher writing rates than the bistable models and permit Z-axis (intensity) modulation. But they cost more and have storage times specified in minutes.

To help overcome this storage-time limitation, some scopes implement multimode storage: You can select bistable or variable-persistence operation in one instrument. For example, Tektronix's Model 7834 achieves a 30-sec storage time in its full-scan variable-persistence mode (which makes use of the CRT's full 6×8-div, 0.9-cm/div screen), furnishing a 270-cm/µsec writing rate. It also achieves this 30-sec storage time in its reduced-scan variable-persistence mode (which uses only a centered 8×10-div, 0.45-cm/div portion of the screen), providing a 2500-cm/µsec writing rate. The scope's fast bistable mode, however, achieves storage times as great as 30 min at a 45-cm/µsec full-scan writing rate or a 350-cm/µsec reduced-scan writing rate.

Among other analog-storage scopes, Hewlett-Packard's 275-MHz Model 1727A (introduced late last year) is the newest. This $7200 variable-persistence instrument furnishes its 2000-cm/µsec stored writing rate over the full CRT screen, as well as a 2000-cm/µsec variable-persistence writing speed—a spec that indicates how a scope performs in general-purpose (rather than single-shot) signal-capturing applications.

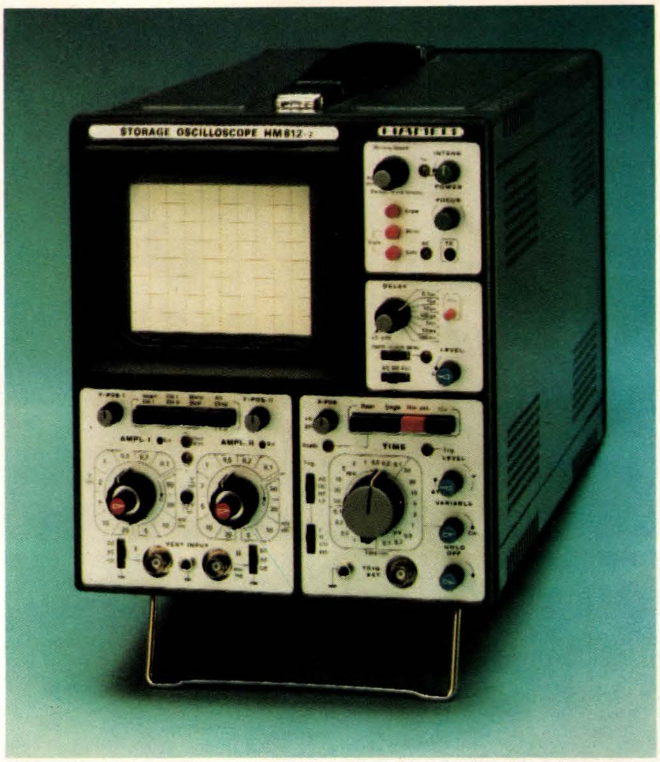
HP also offers two 100-MHz variable-persistence scopes: Model 1744A furnishes 1800-cm/µsec writing speed and costs $5500; Model 1741A achieves 200 cm/µsec and costs $4750.

Other analog-storage-scope choices include Hameg's Model HM 812. In addition to its 48-hr storage-time rating, this $4035 instrument provides 50-MHz nonstorage performance; Hameg plans to upgrade this rating to 70 MHz. Other features include an Automatic Storage mode that lets the scope capture a single-shot waveform occurring after several days of unattended operation.

If you don't need 50-MHz or better performance, consider Kikusui's 10-MHz Model 5516ST. This $1795 bistable-CRT scope provides a 0.025-div/µsec writing rate (at 0.95 cm/div) in its Normal mode and a 0.2-div/µsec writing rate in Enhanced mode. A 100-kHz chopper provides dual-trace operation.

Such chopper circuits economically provide dual-trace capability, but if you must record two high-speed single-shot signals simultaneously, the chopping frequency might interfere with the signal's display. To avoid this problem, Philips incorporates dual-beam operation in its 10-MHz variable-persistence Model PM 3234. This $3395 instrument furnishes writing speeds to 0.9 cm/µsec and storage times as great as 15 min. And Tektronix's $2640 Model 5113 also offers dual-beam performance but in a bistable, split-screen configuration, furnishing writing speeds to 0.25 cm/µsec with an optional fast-writing-speed CRT. Both the Philips and Tektronix scopes provide independent vertical beam deflection but common horizontal deflection—both

Pre-triggering capability highlights digital scopes



Capable of storing an analog waveform for 48 hrs, *Hameg's Model HM 812 features 2.5-cm/μsec writing speed and 50-MHz bandwidth, which the firm plans to upgrade to 70 MHz.*

beams in each scope must operate at the same sweep speed.

Digital-scope selection yields tough decisions

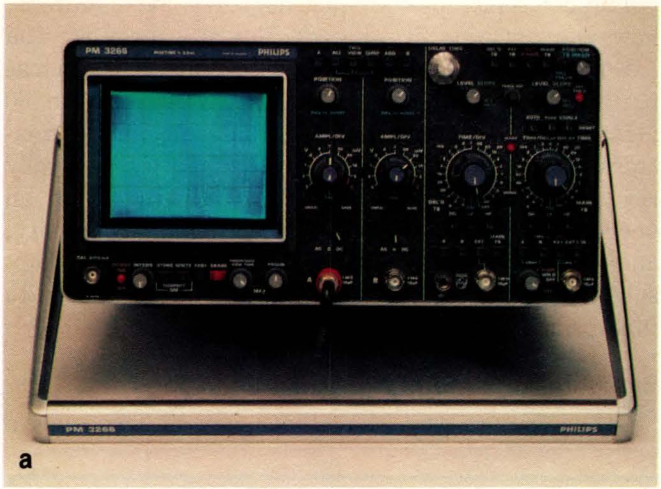
If these analog-storage scopes don't provide the signal-analysis flexibility you're looking for and you've decided on digital-storage technology, the selection process has only begun for you. The recent flurry of digital-scope introductions reflects a variety of design philosophies, and you'll have to consider such factors as front-panel design, added nonstorage operation, sampling and digitizing rates, information presentation, resolution and data-handling capability before making a choice.

Digital-scope design has occupied the recent product-development efforts of most major scope manufacturers; even Hewlett-Packard, which has yet to offer a digital-storage scope, is now working on a digitizing option for its Model 1980A (EDN, October 5, 1980, pg 172). Although the firm has not released details on this feature, one Hewlett-Packard customer told EDN in

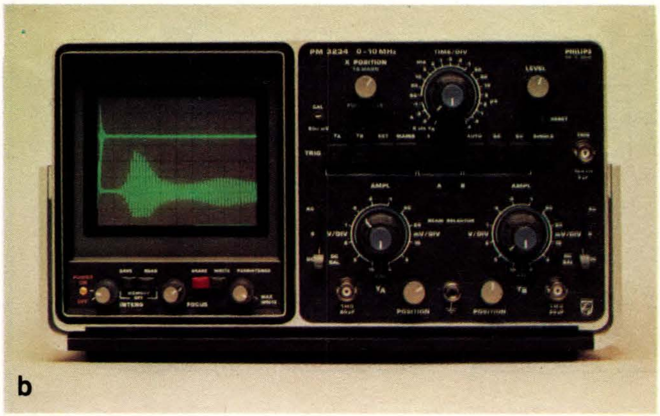
ANALOG-STORAGE SCOPES

MANUFACTURER	MODEL	STORED WRITING SPEED[1] (cm/μSEC)	VIEW TIME[1]	REAL-TIME BANDWIDTH (MHz)	PRICE	COMMENTS
HAMEG	HM 812	2.5	30 SEC	50	$4035	SAVE MODE PERMITS 48-HR STORAGE TIME
HEWLETT-PACKARD	1727A	2000[2]	10 SEC	275	$7200	STORE MODE PERMITS 30-SEC STORAGE TIMES
	1744A	1800[2]	10 SEC	100	$5500	
	1741A	200[3]	10 SEC	100	$4750	
KIKUSUI	5516ST	0.02375	DNA	10	$1795	ENHANCE MODE PERMITS 0.19-cm/μSEC WRITING SPEED
PHILIPS	PM 3266	900	15 SEC	100	$6395	STORE MODE PERMITS 1-HR STORAGE TIME
	PM 3234	0.9	1.5 MIN	10	$3395	DUAL-BEAM OPERATION; SAVE MODE
TEKTRONIX	7834	2500[4]	30 SEC	400	$10,395[5]	MULTIMODE (BISTABLE OR VARIABLE PERSISTANCE)
	466	1350[4]	15 SEC	100	$6275	135-cm/μSEC FULL-SCREEN STORED WRITING RATE
	7633	1000[4]	30 SEC	100	$6860[5]	135-cm/μSEC FULL-SCREEN STORED WRITING RATE
	7623A	135	30 SEC	100	$5250[5]	
	464	99	15 SEC	100	$5115	
	7613	4.5	15 SEC	100	$4395[5]	SAVE MODE PERMITS VIEW TIMES TO 1 HR
	5441	4.5	15 SEC	50	$3605[5]	SAVE MODE PERMITS VIEW TIMES TO 1 HR
	434	0.0975	DNA	25	$4310	SPLIT-SCREEN BISTABLE; OPTION EXTENDS WRITING RATE TO 4.875 cm/μSEC
	5115	0.254	1 HR	2	$1980[5]	10-HR VIEWING TIME AT REDUCED INTENSITY
	5113	0.0254	1 HR	2	$2640[5]	10-HR REDUCED-INTENSITY VIEW TIME; DUAL-BEAM OPERATION
	5111	0.0254	1 HR	2	$1850[5]	10-HR REDUCED-INTENSITY VIEW TIME
	214	0.0416	1 HR	0.5	$1925	3.5 LB, 3×5.25×9.5 IN., 0.26-cm/μSEC ENHANCE MODE WRITING RATE
	314	0.048	DNA	10	$3170	0.25-cm/μSEC ENHANCE MODE WRITING RATE; VIEW TIME TO 4 HR
	SC 503	0.05	4 HR	10	$2850	TM 500 PLUG-IN; ENHANCE MODE WRITING RATE TO 0.25 cm/μSEC

NOTES:
1 INDICATED VIEW TIMES CORRESPOND TO INDICATED STORED WRITING SPEEDS. SOME SCOPES FEATURE MODES THAT PERMIT LONGER FULL-INTENSITY VIEW TIMES AT SLOWER STORED WRITING RATES. "SAVE" AND "STORE" MODES PERMIT LONGER STORAGE TIMES AT REDUCED- OR ZERO-INTENSITY DISPLAYS. "ENHANCE" MODES INCREASE BISTABLE-SCOPE WRITING RATE BUT TEND TO MAKE THE DISPLAY FADE "POSITIVE" OR "ON". CONSULT THE MANUFACTURERS.
2 OVER CENTER 6×8 DIV (0.72 cm/DIV) OF CRT AND WITH VIEWING HOOD
3 OVER CENTER 7×9 DIV (0.85 cm/DIV) OF CRT AND WITH VIEWING HOOD
4 REDUCED SCAN: CENTER 8×10 DIV AT 0.45 cm/DIV
5 5000 OR 7000 SERIES MAINFRAME PRICE; VERTICAL- AND HORIZONTAL-AMPLIFIER PLUG-INS EXTRA

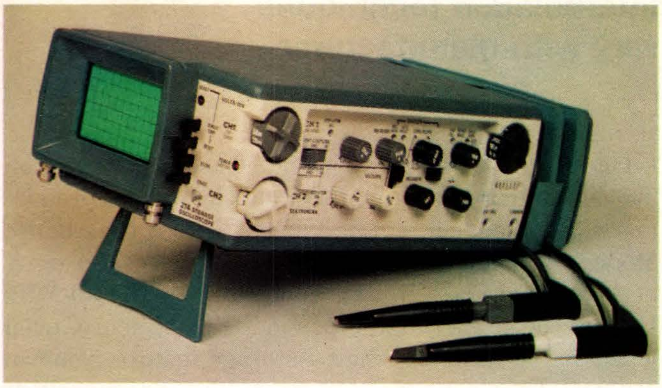


a

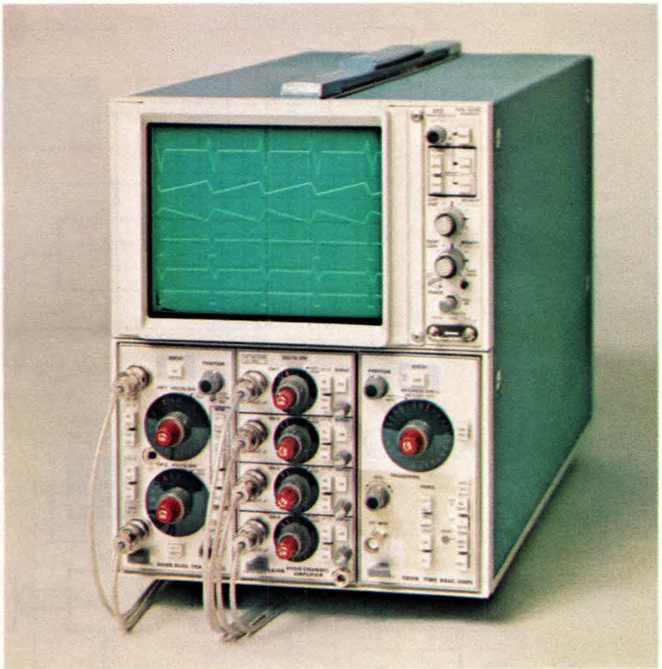


b

Furnishing 100-MHz dual-trace transfer-storage performance, *Philips's $6395 Model PM 3266* ***(a)*** *can store signals for 3 to 8 sec in its fast mode and for 1 hr in Max Write mode. The $3395 Model PM 3234* ***(b)*** *provides 10-MHz bandwidth and incorporates a dual-beam design that eliminates waveform distortion caused by chopper circuitry.*



Weighing 3.5 lbs and measuring 3×25×29.5 in., *the 500-kHz dual-trace Model 214 from Tektronix is the smallest available storage scope. Its bistable CRT achieves a 0.5-div/μsec (0.52 cm/div) stored writing speed and storage times to 1 hr.*



Dual-beam performance *highlights Tektronix's Model 5113, which features split-screen bistable operation and writing speeds to 0.25 cm/μsec with an optional fast-writing-speed CRT. Standard writing speed equals 25 cm/msec.*

April that an HP salesman had offered him the digitizing package—Option 860—for less than $3500, with delivery in 8 to 10 wks. Option 860 reportedly consists of two pc boards that plug into a basic 1980A.

Among other manufacturers, Gould, Philips and Tektronix have all introduced digital-storage scopes since last spring, and with this plethora of new products, as well as the variety of more mature instruments, come some tough choices.

Front panels show different design approaches

Differences among the offerings begin right at the instruments' front panels. One look at the Time Per Point knob on Explorer Series instruments from digital-scope pioneer Nicolet, for example, leaves no doubt in your mind that you're dealing with a digital instrument. Knowledge that a scope's horizontal axis is made up of 512, 1024 or 2048 points (depending on the model) allows you to determine the total sweep time.

Gould, Philips and Tektronix, on the other hand, have chosen the traditional front-panel labeling used on analog scopes for their digital instruments; you'll find the familiar Time/Div knob on these manufacturers' digital scopes.

You might consider such differences in labeling conventions relatively minor. (Scope manufacturers, however, consider them anything but.) The Nicolet controls might take some getting used to, but they do prompt you to keep in mind such digital-scope-related problems as aliasing (EDN, March 18, pg 134) when using the instrument. The major differences among digital-storage scopes, though, lie behind the front panel.

Some digital scopes include analog capability

Your first behind-the-panel choice in selecting a digital-storage scope is whether or not you want nonstorage analog operation along with the instrument's digital capability **(Fig 2).** Gould and Tektronix offer such analog performance on some digital-scope models—indeed, Tektronix's Model 468 is basically the firm's 100-MHz nonstorage Model 465 with 25M-sample/sec digitizing and memory capability added. Digital scopes from Nicolet and Philips, however, let you monitor only digitally processed information.

Interpolation techniques vary with manufacturer

One advantage of incorporating nonstorage operation in a digital scope, explains Tektronix lab-scopes product marketing manager Jim Geissinger, is that you can use Model 468's full 100-MHz capability when you don't need storage, rather than be limited to the 10-MHz USB of the scope's digital portion. Furthermore, even when you're using the digital-storage feature, you can switch to the analog mode to ensure aliasing isn't taking place.

Philips oscilloscope product manager Hans Toorens, however, says his firm has decided to concentrate on extending Model PM 3310's digital capabilities—such as permitting digitizing of repetitive waveforms to 60 MHz (**Fig 3**)—rather than incorporating analog nonstorage operation. He points out that aliasing generally results in an unstable waveform display that an operator can identify without using analog capability, and he recommends approaching the desired sweep-speed setting from a scope's maximum sweep speed to further aid recognition of aliasing.

Sampling rate might not equal digitizing rate

Other factors you should consider in choosing a

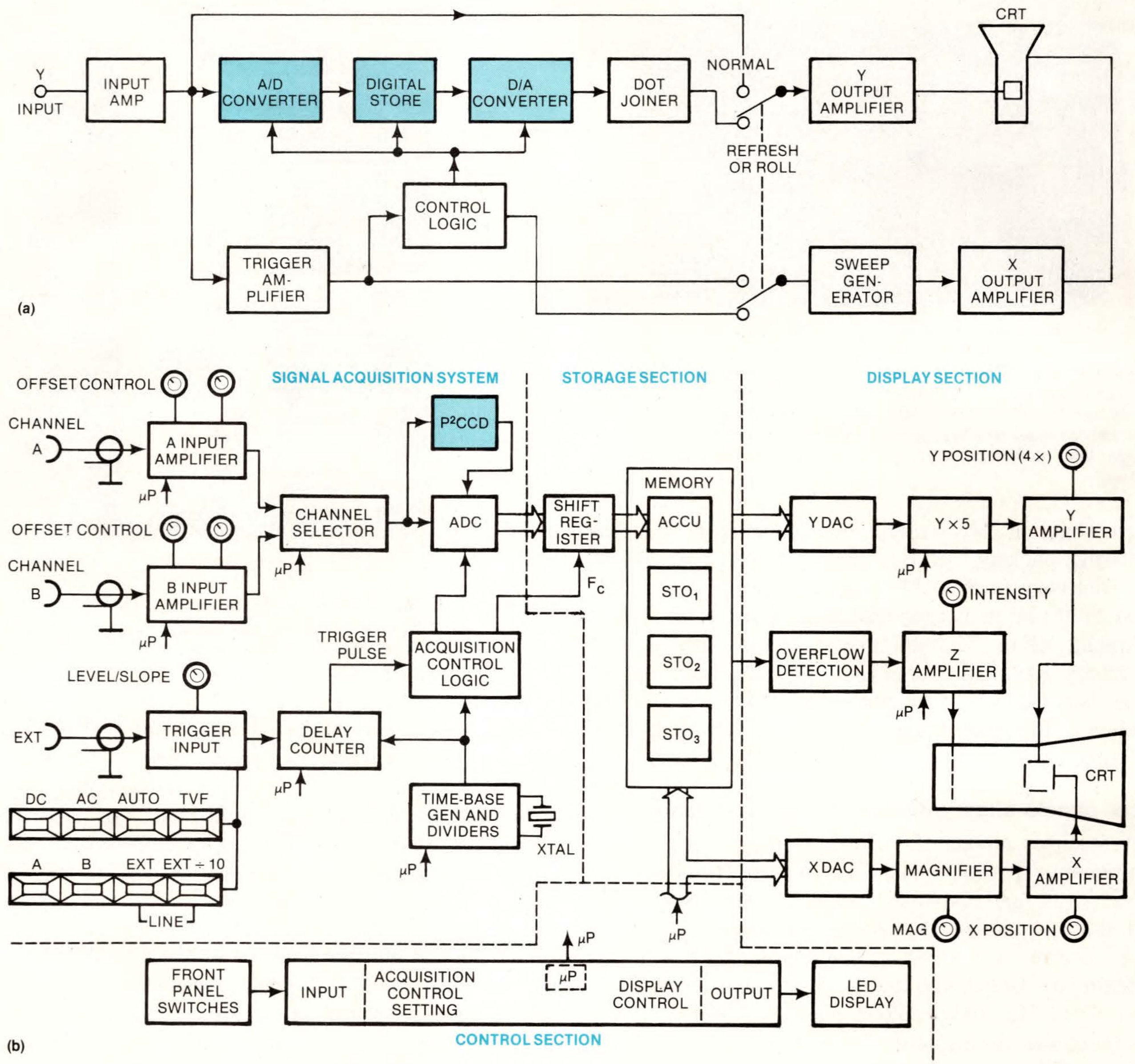


Fig 2—The simplified block diagram *of one channel of Gould's Model DSO4000* ***(a)*** *illustrates that the scope provides a choice of analog nonstorage operation or digital-storage capability. The diagram of Philips's Model PM 3310* ***(b),*** *however, illustrates that this scope furnishes only digital-storage operation. Note that the P²CCD (profiled peristaltic charge-coupled device) can sample the incoming analog waveform at 50 MHz and store these samples for subsequent digitizing by the 78-kHz A/D converter on receipt of a trigger pulse. The ADC can directly digitize the incoming signal with sweep time set at 5 msec/div or less. An 8085 μP supervises the scope's internal operation.*

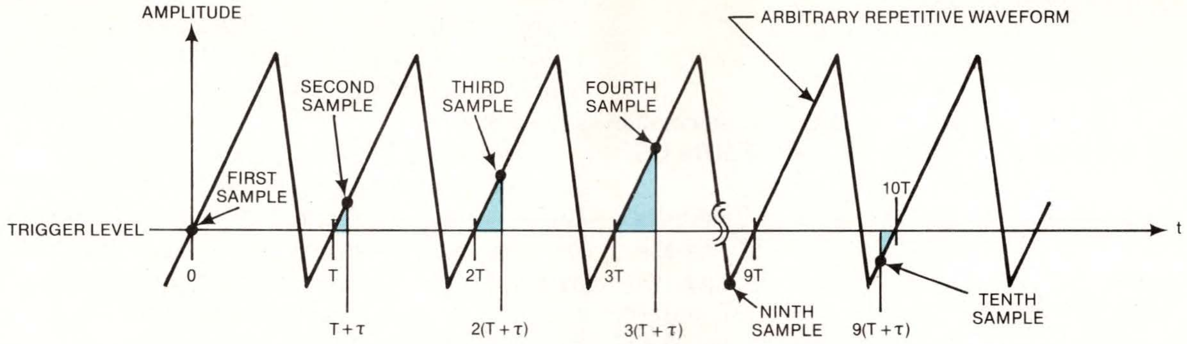


Fig 3—This sampling technique *can digitize repetitive waveforms with frequencies higher than the sampling rate. In this example, the first sample of a waveform of period T is taken at the initial trigger point at t=0. The second trigger point occurs one period later at t=T, but the second sampling is delayed until a time τ after this trigger point; thus, the second sampling occurs at t=T+τ. The sampling time is then delayed 2τ after the third trigger point so that the third sampling occurs at t=2(T+τ), and so on. If τ=T/10, at least 10 repetitions of the initial waveform are required to digitize one cycle. The trigger time and the accuracy of the τ delay are critical, but the sampling rate can be less than 1 sample per cycle. This technique allows Philips's Model PM 3310 to store repetitive waveforms with frequencies as high as 60 MHz with its 50-MHz sampling capability.*

digital-storage scope include the instrument's sampling rate, digitizing rate and method of presentation of the digitized information.

The first two parameters might appear the same, but they actually connote considerably different performance features. In some cases, they indeed have the same value. For example, Tektronix's Model 468 can sample and digitize at 25 MHz; thus, the scope can display the continuously digitized input signal in real time.

Philips's Model PM 3310, however, digitizes at only 78 kHz but can sample at 50 MHz. In this scope, a profiled peristaltic charge-coupled device (P^2CCD) can sample the input waveform at the 50-MHz sampling rate. It acts as a sort of "analog shift register" or "bucket-brigade" device that stores 256 analog levels, clocked into it at the sampling rate. If no trigger condition is present, a new analog value clocks into the P^2CCD each sample time, and the oldest sample stored in the device becomes lost. However, when a trigger condition occurs (the scope has a digital-delay function that permits positioning of a stored waveform relative to the trigger), the P^2CCD stops receiving new analog data, and the 78-kHz A/D converter can then take its own sweet time—12.82 μsec/sample—in digitizing the analog information stored in the P^2CCD.

One drawback to this approach is that at high sweep speeds, the P^2CCD can't accept new analog data during the 3.3-msec digitizing period; thus, the instrument has a blind spot between allowable triggers. The scope's display always represents the P^2CCD contents at the last trigger point, rather than the current waveform condition, except for sweep speeds of 5 msec/div and less. At these speeds the P^2CCD is not used; the ADC digitizes the input in real time.

Note that despite a scope's maximum sampling-rate capability, the actual sampling rate used during operation depends on the sweep-speed setting. For example, Philips's Model PM 3310 must fill one of its 256-byte memories each sweep. Thus, at a 5-msec/div sweep speed (corresponding to a 50-msec total sweep time), it must obtain a sample every 0.2 msec, corresponding to a 5.12-kHz sampling rate.

With an alternative approach, Tektronix's Model 468 includes an Envelope mode (EDN, February 18, pg 115) that initiates sampling at a much faster rate than called for by the sweep-speed setting. The scope then displays and stores both the maximum and minimum waveform values it detects for each horizontal point required by the sweep-speed setting—a capability that lets you display a large time chunk of a waveform and still detect glitches that might otherwise have occurred between sample points.

Interpolation techniques affect display

In addition to considering sampling techniques and rates, you should also consider the way a digital scope uses the sampled and digitized information. Although the Nyquist criterion allows you to accurately reconstruct any waveform with frequency components as high as half the sampling frequency, your eye can't readily reconstruct a sine-wave cycle from only two or three samples. This shortcoming stems from perceptual aliasing—the visual tendency to connect displayed dots based on their relative distances from one another, rather than to fit a sinusoidal curve to them.

In order to obtain a suitable visual presentation of a sampled waveform, then, you need at least ten samples per cycle, according to most scope manufacturers. Thus, a digital-storage scope's useful storage bandwidth is one-tenth the sampling frequency.

More specifically, Tektronix defines USB this way:

USB=(maximum digitizing rate)/K

where K is 25 for a dot display, 10 for a vector (connect-the-dots-with-straight-lines) display and 2.5 for a sinusoidal-interpolation display—one that fits a sinusoidal curve to the waveform's sampled points. Thus, the Tektronix Model 468's 25-MHz sampling rate

On-board processing can aid in data analysis

gives it a 10-MHz USB with the user-selectable sinusoidal-interpolation function and the 2.5-MHz USB with the vector function.

Philips's Toorens, though, disagrees with Tektronix's sinusoidal-interpolation philosophy. After all, he asks, if you know you're looking at a 10-MHz sine wave, why bother looking at it? His firm specifies USB only in terms of one-tenth the sampling frequency; thus, Model PM 3310's 50-MHz sampling rate yields a USB, with vector interpolation, of 5 MHz.

When attempting to choose a digital-storage scope, then, you won't find definite yes or no answers to questions regarding the validity of such functions as sinusoidal interpolation. For example, Tektronix's Model 468 does present a more pleasing picture of a 10-MHz sine wave than Philips's Model PM 3310. On the other hand, the Tektronix scope also presents the problem of deciding when to select the sinusoidal or vector interpolation—when monitoring an arbitrary waveform, you might have trouble telling which interpolation algorithm is providing the most accurate waveform picture. Moreover, if you're transmitting digitized waveform information to a computer for processing according to your own algorithms, the Philips scope delivers twice as much information.

Resolution needs depend on application

Other factors to consider when selecting a digital-storage scope include resolution and data-handling capabilities.

If you're choosing a digital scope primarily to replace an analog-storage unit, your resolution requirements will be relatively modest. Most analog-scope users can resolve only about 1 mm on a CRT screen—approximately 1 to 2% of full scale, roughly equivalent to 6-bit resolution. Thus, the 8-bit resolution found on many digital-storage scopes should prove more than adequate.

Keep in mind, though, that digital scopes let you zoom in on (magnify) portions of a stored waveform. Under such magnification, additional bits of resolution can prove advantageous, even if your signal analysis is purely visual. If you are transmitting waveform data to a calculator for external processing, for example, your requirements might well dictate a need for more than eight bits of resolution. Nicolet's Explorer Series now offers the highest resolution—to 12 bits vertical and to 2048 points horizontal—and Gould's Model DSO4200 offers 10 - bit vertical and 4096 - point horizontal resolution.

If your requirements call for external signal processing, consider the digital interfaces provided with various scopes. For example, Gould's Model DSO4020 supports an optional GPIB interface, and Nicolet's Explorer Series instruments feature GPIB, RS-232 and 12-bit parallel binary interfaces. One Nicolet model even includes a built-in disk drive that can store 32 waveforms per disk.

On-board processing aids data analysis

If you don't have a computer available for waveform processing but need to determine such parameters as rise time, rms values or averages, scopes such as Tektronix's Model 7854 might suit your needs. Keystroke programming via a calculator-style keyboard lets you tailor the 400-MHz instrument to your measurement tasks. And even if you do have access to a central computer for waveform analysis, Model 7854 can perform distributed processing tasks; it can calcu-

DIGITAL-STORAGE SCOPES

MANUFACTURER	MODEL	SAMPLING RATE (MHz)	MEMORY SIZE (BITS)	NONSTORAGE BANDWIDTH (MHz)	PRICE	COMMENTS
GOULD	DS04000	1.8	8 × 1024	10	$4100	
	DS04020	2	8 × 4096	10	$4700	
	DS04040	10	8 × 5120	25	$5700	4-TRACE CAPABILITY AT 1280 POINTS PER TRACE
	DS04100	1	8 × 1024	—	$3100	
	DS04200	0.8	10 × 4096	—	$3700	
NICOLET	EXPLORER I	1	12 × 4096	—	$3990	
	EXPLORER II	(1)	12 × 4096	—	$3200	
	EXPLORER III	(1)	12 × 4096	—	$5200	INCLUDES DISK DRIVE
PHILIPS	PM3310	50	8 × 1024	—	$6395	SAMPLING TO 60 MHz
TEKTRONIX	468	25	8 × 1024	100	$5600	CHOICE OF VECTOR OR SINE-WAVE INTERPOLATION
	5223	1[2]	10 × 1024[3]	10	$4995	USES 7000 SERIES PLUG-INS; ON-BOARD
	7854	0.5[4]	10 × 1024	400[5]	$10,500	DIGITAL PROCESSING

NOTES:
[1]$1700 MODEL 201-2 PLUG-IN PROVIDES 0.2-MHz DIGITIZING AT 12-BIT RESOLUTION (2-CHANNEL)
$3900 MODEL 204-A PLUG-IN PROVIDES 20-MHz DIGITIZING AT 8-BIT RESOLUTION (2-CHANNEL)
$1750 MODEL 206-1 PLUG-IN PROVIDES 2-MHz DIGITIZING AT 12-BIT RESOLUTION (1-CHANNEL)
$2600 MODEL 206-2 PLUG-IN PROVIDES 2-MHz DIGITIZING AT 12-BIT RESOLUTION (2-CHANNEL)
[2]REQUIRES $775 MODEL 5B25N TIME-BASE PLUG-IN
[3]1024 WORDS PER VERTICAL COMPARTMENT, REQUIRES 5000 SERIES PLUG-INS
[4]WITH EXTERNAL CLOCK
[5]SCOPE CAN DIGITIZE REPETITIVE WAVEFORMS TO FULL NONSTORAGE BANDWIDTH

late the waveform parameters needed by the mainframe and then transmit each parameter as a 1-number answer—rather than, for example, as a 256×8-bit description of the entire stored waveform. The instrument transfers data via the IEEE-488 bus; you can also perform all keyboard-programming functions via the bus. You can't, however, control front-panel settings via the bus, although a GPIB controller can monitor these settings and instruct a user to manually make the correct ones.

Philips's Model PM 3310 carries GPIB capability one step further. It can transmit data over the bus, and it also permits complete front-panel control via the bus (with the exception of trigger selection). It can't, however, calculate and send waveform parameters such as rise time, as can Model 7854; rather, it transmits only raw waveform data.

(Some GPIB-programmable scopes can't transmit any measurement data at all over the bus. HP's nonstorage Model 1980A, for example, features complete front-panel GPIB programmability but no bus-related data-output capability. It relies on an operator to visually interpret the CRT display and reflects the premise that in some cases, such visual waveform interpretations can yield results more rapidly than computer analysis.)

The options widen

In the future, you can expect to see digital-storage scopes that will further broaden your selection options. An example of this trend is Gould's recent introduction of three digital-storage scopes in its DSO line. Before this introduction, the line consisted of the $4100 Model DSO4000 (providing 1.8-MHz sampling, 10-MHz real-time operation and a 1024×8-bit memory) and the $3100 Model DSO4100 (featuring 1-MHz digitizing and a 1024×8-bit memory).

The new scopes include the $4700 Model DSO4020, which furnishes 10-MHz real-time operation, a 2-MHz digitizing rate and a 4096×8-bit memory. A second instrument is the $5700 Model DSO4040, which offers 10-MHz digitizing, 25-MHz real-time operation and a 5120×8-bit memory. And you can also choose the $3700 Model DSO4200, which provides 0.8-MHz digitizing and a 4096×10-bit memory.

All of these instruments use straight-line dot joining and permit dual-channel display; Model DSO4040 exhibits 4-trace capability at 1280 horizontal points per trace. All versions except Models DSO4100 and DSO4200 include a Roll mode, and all offer at least 25% pre-trigger capability and ×10 vertical expansion. Some allow pre-triggering to 100% and ×40 or ×50 vertical expansion; Model DSO4200 permits ×10 horizontal expansion.

Expect other manufacturers to follow suit in expanding the range of digital-storage scopes. In addition to Hameg's low-cost instrument and Hewlett-Packard's digitizing option, look for at least one other major digital-storage-scope introduction by year's end.

Other trends include the incorporation of digital-scope functions into other instruments. The most recent reflection of this trend is Biomation's (Santa Clara, CA) incorporation of 4-bit digitizing capability on the analog-input channel of its K500-D logic analyzer (EDN, March 18, pg 101).

Ira Spector, president of San Jose, CA-based Paratronics (the first firm to incorporate waveform digitizing in a logic analyzer), sees the combination of such functions as a trend toward total measurement systems—multifunction, monolithic configurations that can each replace several benchtop instruments and eliminate interfacing problems. He points out that such multifunction instruments are more convenient to use and cheaper than individual instruments providing equivalent performance (EDN, June 5, 1980, pg 128).

Spector adds, though, that merely packaging logic-analyzer and digital-scope functions in the same box isn't an optimum approach; he says the functions should work together to make measurements that are difficult to perform with individual single-function units. As an example, he cites measurement of the effect of a transmission line on a digital pulse; the logic-analyzer portion of Paratronics' Model 540 can monitor and trigger on the digital-pulse generation, then the 6-bit 50-MHz waveform-digitizer channel can display the attenuated pulse appearing at the transmission line's other end.

Indeed, you can consider digital-storage scopes themselves to be multifunction instruments—they

NEXT TIME

EDN's June 24 issue will feature a Special Report on CMOS—envisioned by many industry experts as the premier processing technology of the 1980s and now exploding into a variety of new product areas. Other highlights include articles on

- Designing with current-mirror ICs
- Implementing a color-graphics processor
- Understanding the recently amended patent law
- Using digital techniques in signal-processing applications

. . . and much more. Also look for Technology Update stories on CAD/CAM developments and laser technology, plus our regular Design Ideas, A Question of Law and μC Design Techniques departments. You can't afford to miss this issue!

EDN: Everything Designers Need

Digital-scope technology aids logic-analysis tasks

combine waveform digitizers or transient recorders (EDN, December 15, 1980, pg 182) with displays and controls that make them more "friendly" than systems-oriented waveform digitizers. Biomation marketing manager Ed Jacklitch points out that a major emphasis of digital-storage-scope manufacturers has been to package digitizers in a user-convenient format—to make them look and work like standard oscilloscopes. Waveform digitizers, on the other hand, tend to be more difficult to use in benchtop situations, says Jacklitch; today the majority of these devices interface to computers rather than humans.

Although Biomation is not involved in digital-scope manufacturing per se (except through parent Gould), it did pioneer the waveform digitizer with a 6-bit 10-MHz model, and it incorporates the technology in Model K500-D. Regarding multifunction instruments, Jacklitch agrees with Spector, noting "there is a growing perception that having a digitizer in a logic analyzer is the way to go."

Beyond cost reductions, also look for manufacturers to add more convenience features to their digital-storage-scope offerings. For example, one industry expert suggests that incorporation of raster displays in the instruments would not only reduce package sizes, but might also open the door to such display enhancements as color. But he adds that for the short term, cost reduction should be the major thrust as digital-storage-scope manufacturers design instruments that are increasingly competitive with their analog-storage counterparts. Indeed, he points out that a price/performance breakthrough in A/D conversion would be devastating to analog-storage scopes. **EDN**

Manufacturers of storage oscilloscopes

For more information on analog- or digital-storage scopes, contact the following manufacturers directly.

Gould Instrument Div
(Digital-storage scopes)
3631 Perkins Ave
Cleveland, OH 44114
(216) 361-3315

Hameg Inc
88-90 Harbor Rd
Port Washington, NY 11050
(516) 883-3837

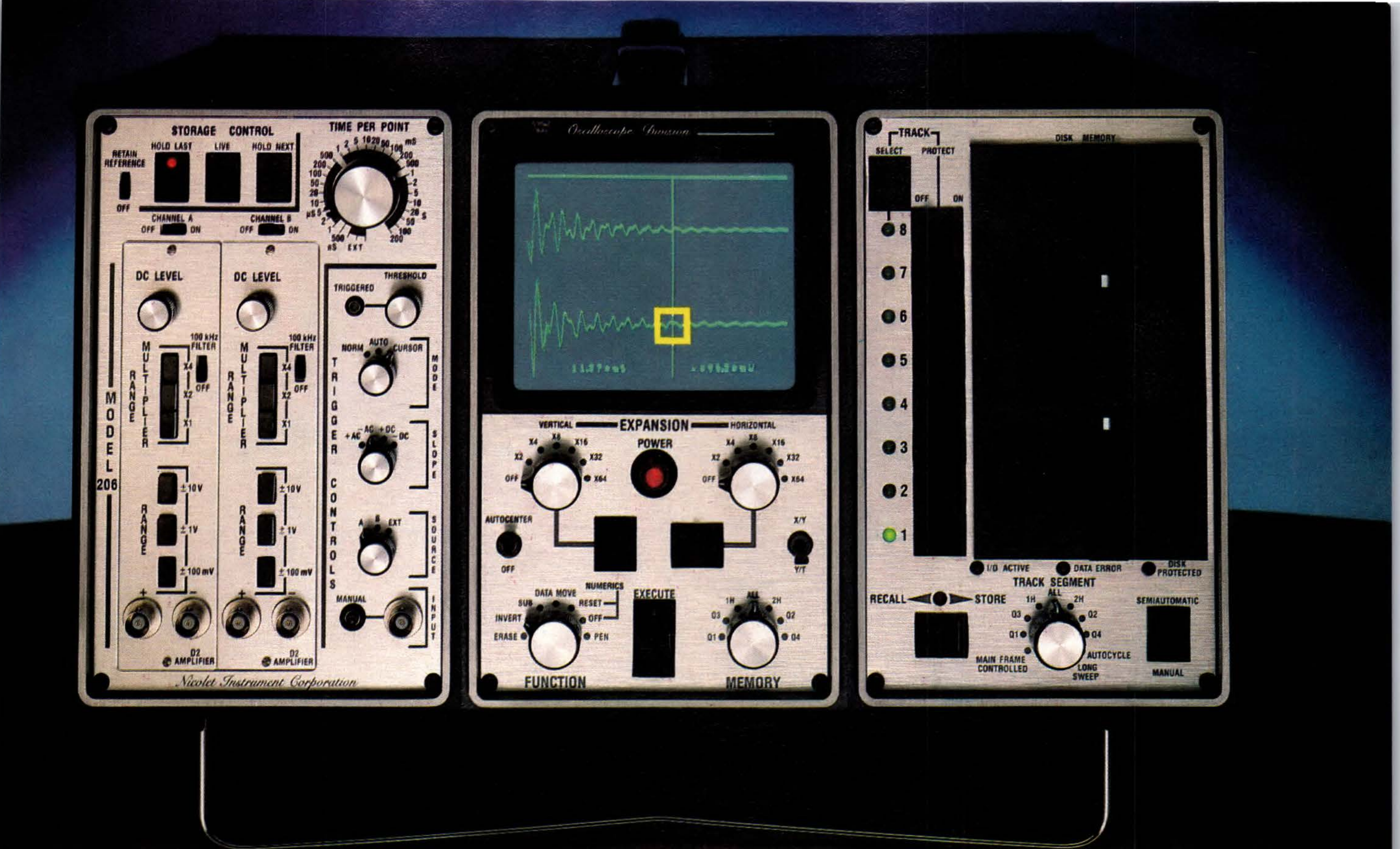
Hewlett-Packard Co
1507 Page Mill Road
Palo Alto, CA 94304
Phone local office

Kikusui International Corp
17121 S Central Ave
Suite 2M
Carson, CA 90746
(213) 638-6107

Nicolet Instrument Corp
Oscilloscope Div
5225 Verona Rd
Madison, WI 53711
(608) 271-3333

Philips Test and Measuring Instruments Inc
85 McKee Dr
Mahwah, NJ 07430
(201) 529-3800

Tektronix Inc
Box 1700
Beaverton, OR 97075
(800) 547-6711;
in OR, (800) 542-6773



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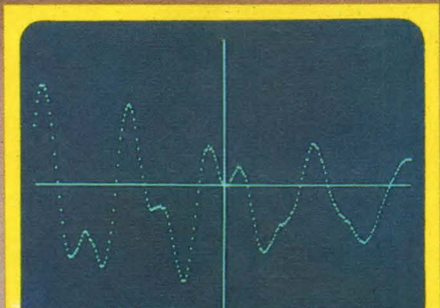

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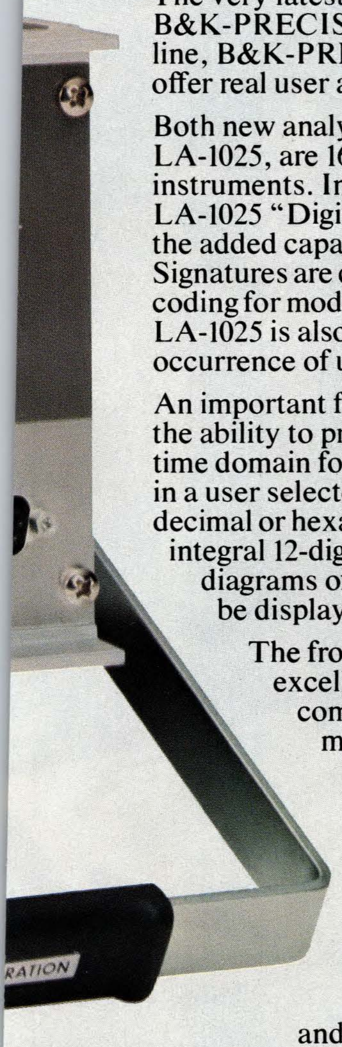

The very latest word in logic analysis is B&K-PRECISION. Not just another "L-A" line, B&K-PRECISION's new instruments offer real user advantages.

Both new analyzers, the LA-1020 and LA-1025, are 16 channel, 20MHz instruments. In addition to logic analysis, the LA-1025 "Digital Systems Analyzer" offers the added capability of signature analysis. Signatures are displayed in industry-accepted coding for modified hexadecimal format. The LA-1025 is also capable of recording the occurrence of unstable signatures.

An important feature of both instruments is the ability to present data in both state and time domain formats. State data is formatted in a user selected code... binary, octal, decimal or hexadecimal and displayed via the integral 12-digit LED display. Timing diagrams of 16 channels by 16 words can be displayed on most oscilloscopes.

The front panel controls provide excellent interactive capability, and complete control over a powerful measurement system. After hearing industry complaints of unnecessarily complex logic analyzer operation, B&K-PRECISION engineers devoted a considerable amount of design time to maximizing the instruments' ease-of-use and efficiency. The results are impressive. Not only is set-up time faster than on competitive instruments, but the new B&K-PRECISION instruments reduce the chance of user set-up errors.

Model LA-1020 $2075 Model LA-1025 $2475

Circle no. 43 for additional information
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A new trigger system was developed for these instruments. An 18-bit pattern recognition trigger is used to initiate storage into the 16-bit x 250 word system memory. Sixteen qualifiable channels are featured, plus two additional qualifiers to aid in meeting unique trigger requirements. Convenient front panel switches select a logic 1, 0 or "DON'T CARE" for all 18 inputs.

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The LA-1020 and LA-1025 interface to the circuit under test through two Model LP-1, TTL compatible, probes or LP-2 CMOS probes. Trigger capability can be increased to 34 qualifiers by adding the optional LP-3 qualifier expander probe.

An event pulse-output is provided on both analyzers, allowing interconnection of two units to expand system versatility to 32 channels, 67 qualifiers, at speeds to 10MHz.

B&K-PRECISION's LA-1020 and LA-1025 are available now for delivery or demonstration. If you're currently using logic analysis or considering a system, call B&K-PRECISION toll-free at **800/621-4627** for a no-obligation demonstration. It's the only way to see the clear choice.

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Variable persistence aids signal display

Variable-persistence oscilloscopes offer measurement advantages despite recent advances in their digital-storage counterparts. A look at variable-persistence theory and measurement applications helps put the technique in perspective with other storage methods.

Michael Gasparian, Hewlett-Packard Co

Variable-persistence oscilloscopes afford control over the perceived persistence of a CRT phosphor—you can thus tailor them to the characteristics of the signals you're measuring. Minimum settings allow you to simulate conventional-oscilloscope operation, while increased settings allow you to view bright, clear displays over a wide range of input-signal conditions.

Many of these benefits result directly from the "light-integrating" effect of long-persistence settings—long persistence permits multiple sweeps to repeatedly stimulate the phosphor, generating brighter traces than possible with conventional oscilloscopes in many repetitive-signal applications. As a result, low-repetition-rate signals and slowly changing physical phenomena, which with traditional scopes are annoying to view and even more difficult to measure, quickly integrate with variable-persistence capability from a flickering waveform or a trace too dim to see to a bright display.

Examples show the technique's advantages

One common application that illustrates the variable-persistence technique's advantages is the examination of flip flops for setup and hold violations. In such cases, the output transition is of primary concern; you must be able to capture the full spectrum of valid and invalid transitions. As one approach, you might consider making single-shot measurements, using either an analog- or digital-storage oscilloscope. But although such procedures are useful in looking at individual events, if an invalid transition only occurs once in 5000 sweeps, their chances of capturing the signal are rather low—indeed, the invalid state might not occur at all.

Thus, with a conventional oscilloscope, you would have a difficult time displaying such problem transitions, because random events mixed with repetitive signals are difficult to observe with the short-persistence phosphor commonly used in those scopes. On the other hand, a variable-persistence oscilloscope's continuously variable settings allow multiple-sweep presentations to display events that might only occur once or twice in several thousand sweeps. This multiple-trace retention provides an account of the full spectrum of transitions that take place.

Another application that illustrates variable-persistence scopes' capabilities involves monitoring a µP data bus during a read cycle. During such a cycle, a faulty component might occasionally attempt to compete with a good one in an effort to drive the bus,

Variable-persistence oscilloscopes *such as Hewlett-Packard's Model 1741A perform the electronic equivalent of finding a needle in a haystack—they can sort out one wayward signal from several thousand sweeps.*

resulting in a bus conflict. This conflict in turn results in neither a HIGH nor a LOW, but rather an indeterminate state (**Fig 1**).

Note that during the bus-read cycle, the logic levels present on the data bus (lower trace) are mostly valid HIGH or valid LOW during the read strobe (upper trace). However, when two devices incorrectly respond to the same read strobe, one attempts to drive the data-bus signal HIGH while the other simultaneously attempts to drive it LOW. Because this condition occurs rarely, the information would be difficult to extract with a standard or digital-storage oscilloscope. A variable-persistence instrument, though, readily uncovers it.

Another bus problem that a high-persistence setting can detect is the failure of a device to respond to a CPU-invoked read cycle. Such phenomena can be captured only at a very high persistence setting because of their extremely low repetition rate. This problem is frequently termed a "floating"-bus condition and occurs during the read strobe, as indicated by a faint RC-time-constant trace (**Fig 2**).

Variable persistence suits random-event capture

To see how variable-persistence scopes stack up against their digital-storage counterparts, consider how the latter instruments would handle the examples just cited. Some of the techniques available with digital oscilloscopes can be useful, but in attempting to capture random events, such as floating-bus conditions or invalid logic states, these instruments' averaging and envelope modes are of little use. Averaging techniques merely average a random event out as if it were noise. And although envelope modes (EDN, February 18, pg 115) are useful in capturing maximum excursions riding on a waveform, this technique is not effective in attempting to view transitions occurring between logic levels; the envelope masks any information between valid logic levels.

The value of variable persistence is also illustrated by certain timing measurements—even those with jitter. The amount of jitter associated with a signal is often the key to a timing relationship. And you can measure jitter—often a process more like a guess than a measurement—with a high-persistence multiple-sweep display (**Fig 3**) that clearly defines the area of jitter.

Variable persistence—its origin and operation

Some basic physics explains the technique that permits measurements such as these. Phosphors generate photon energy by means of electron excitation. This photon energy consists of a primary emission, which occurs at the time of the excitation, and a secondary emission of photon energy that continues after the stimulus is removed. The duration (persistence) of the secondary emission frequently characterizes phosphors. Standard oscilloscope phosphor (P31) decays to a 10% light-output level in about 38 μsec and a 1% level in 250 μsec.

Ideally, you would obtain the best trace display by interchanging phosphors to compensate for sweep speeds, repetition rates and other signal characteristics. Obviously, this is not a practical solution; therefore, scope manufacturers have developed an artificial method of changing persistence. Superficially, using this variable-persistence capability involves combining the Persistence, Intensity and Brightness controls to dictate a phosphor's perceived persistence.

The technique appears easy to implement, but variable-persistence storage oscilloscopes have always been surrounded by an atmosphere of mystery. Trace blooming, the most apparent problem, has complicated

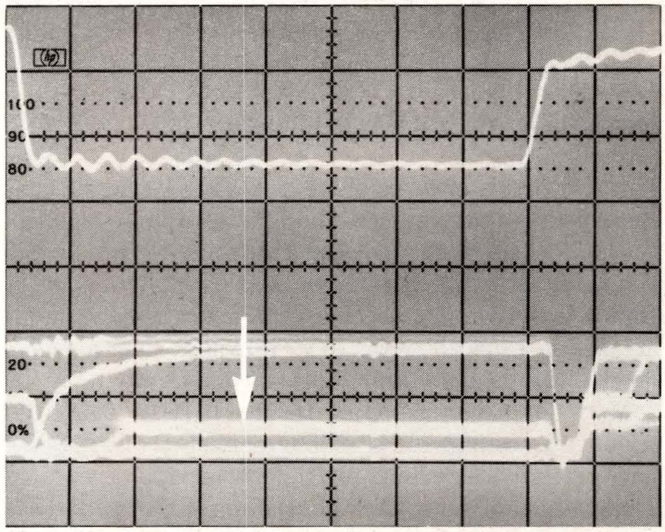


Fig 1—Monitoring a μP data bus *(lower trace) during a read strobe (upper trace) shows that a high-persistence setting easily captures the data-bus-conflict condition between the logic levels (arrow).*

the display of a sharp, well-focused trace, and potential CRT damage has always lingered in the background as a worrisome possibility.

Enhancements developed to deal with these problems include Hewlett-Packard's autointensity circuit, introduced in 1979. This circuit permits a variable-persistence fast-writing-speed storage oscilloscope to act like a general-purpose instrument. It uses the CRT's beam-current value in a feedback loop to clamp the gate voltage at high-intensity settings. The circuit satisfies two goals: The gate voltage is clamped to minimize blooming, and you need be less concerned about burning the storage mesh. These contributions make variable-persistence storage oscilloscopes with fast writing speed and high light-integrating capability much easier to operate.

The operation of the autointensity circuit is a function of the CRT beam current, the mode selected and the sweep-speed setting. In Single Shot mode, the high-intensity settings are preserved for fast stored writing speeds and easy viewing. However, in repetitive Variable Persistence mode, intensity is limited as a function of the sweep speed and CRT beam current. In summary, the circuit provides maximum intensity when needed and automatically limits intensity in repetitive modes to prevent blooming and burning.

Storing an image

Three steps combine to form the storage process: storage, projection and image erasure. Understanding the general concepts involved in these steps helps in understanding the concept of variable persistence.

A stored image results when the electron write beam interacts with the storage surface. The beam's vertical position and intensity contain all the input-signal information at a particular time. This information gets transferred to the storage surface, which consists of a fine wire mesh covered with dielectric material and in turn serves as the actual medium where the information transfer occurs.

The ability to differentiate between the areas that are hit by write-beam electrons and those that are not is the key to the storage process. Imagine three primary electrons hitting the storage surface with enough energy to dislodge three other electrons. The net effect of the interaction is zero; the charge has remained constant. However, if the same three electrons hit the storage surface with a great deal more energy, six electrons might be dislodged, creating a highly localized net positive charge. This phenomenon, termed the secondary-emission principle **(Fig 4),** provides a means of image differentiation through potential differences on the storage mesh. The secondary-emission ratio quantifies the process; it's defined as the average number of secondary electrons emitted from a bombarded material as a function of primary electron energy. In a storage CRT, the primary

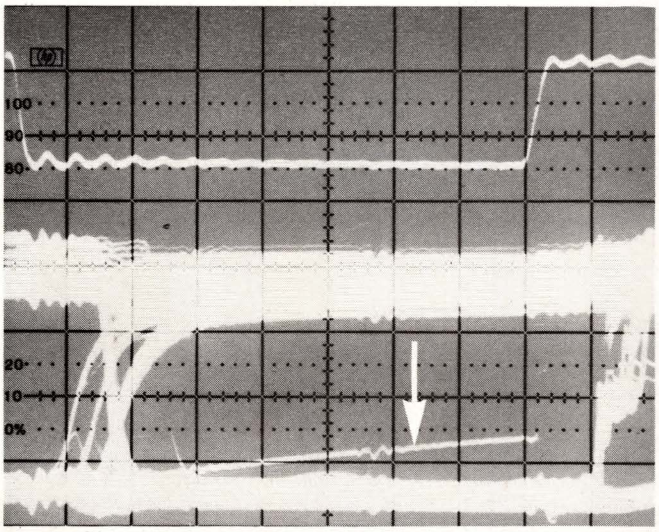


Fig 2—Very high persistence settings *extract a floating-bus condition (arrow) that could go unnoticed with conventional oscilloscopes.*

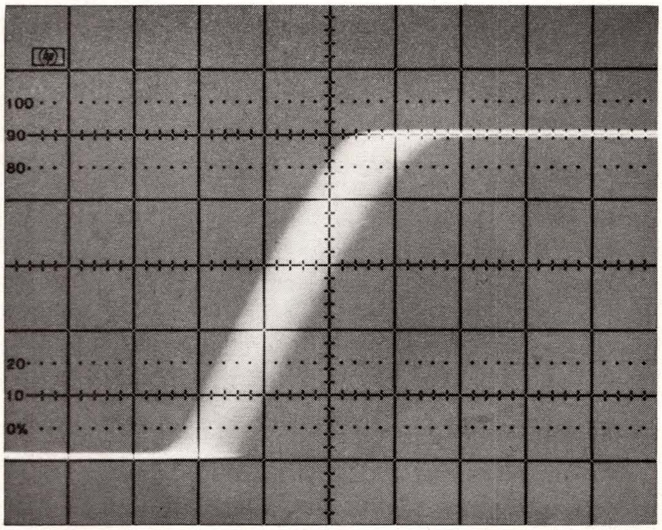


Fig 3—Jitter is clearly defined *and easily measured using variable-persistence measurement techniques.*

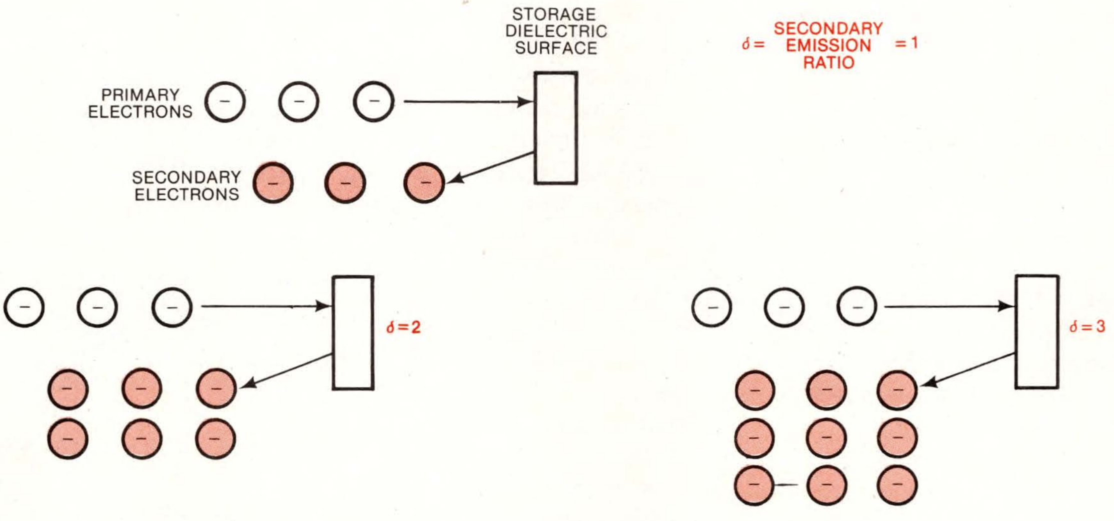


Fig 4—The secondary-emission ratio (δ) *is defined as the average number of secondary electrons emitted from a bombarded material as a function of primary-electron energy.*

Image-storing process consists of three steps

electrons accelerated from the write gun possess a great deal of energy, resulting in a secondary-emission ratio of approximately 10.

Thus, a storage CRT's high-energy write-gun electrons create a highly localized net positive charge wherever the beam strikes the storage surface. Written and unwritten areas can then be easily differentiated through the potential differences on the storage surface.

Projecting the stored image

In this process, low-velocity flood-gun electrons reacting differently to written and unwritten areas on the storage surface project the stored image to the phosphor. The CRT's collimator forms these electrons into a uniform cloud; they are then accelerated toward the storage surface. The electric fields of the written areas permit electrons to penetrate the storage mesh, while electric fields associated with unwritten areas repel electrons, resulting in a "flashlight effect" (**Fig 5**).

Once through the storage mesh, the flood-gun electrons see the high voltage of a post accelerator and accelerate to the phosphor screen. They strike the phosphor with enough energy to excite the phosphor, produce photon emission and display the stored trace.

Erasing the image

The erase cycle is both the initial and final phase of the storage process. Initially, this cycle erases any stored image, and finally, it sets the sensitivity of the storage surface to accept new information from the write beam.

The erase process starts with application of a high voltage on the entire storage mesh. This voltage accelerates the flood-gun electrons with enough energy to create a secondary-emission ratio greater than one, producing a net positive charge on the entire storage surface and forcing both written and unwritten areas to

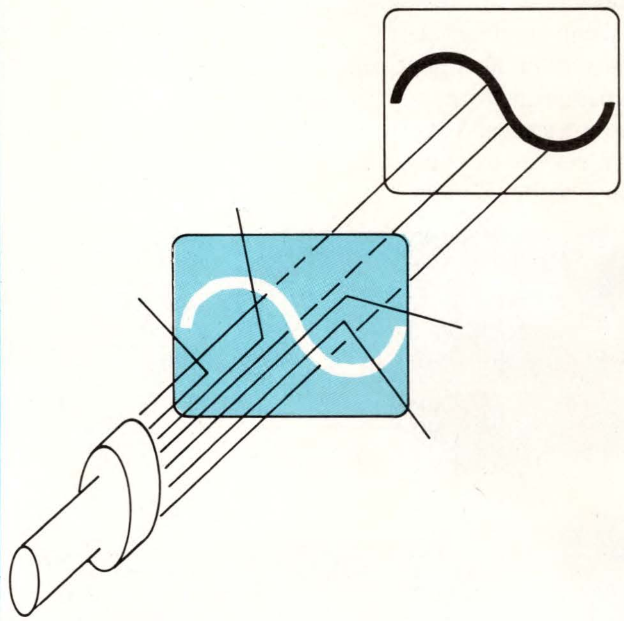


Fig 5—Electric fields *of a scope's written areas permit flood-gun electrons to penetrate the storage mesh and continue to the phosphor, while electric fields associated with unwritten areas repel these electrons.*

Using stored writing speed successfully

A stored-writing-speed specification defines the maximum beam velocity that a scope can capture and display on a single-shot basis. To simplify comparisons among oscilloscopes, it's convenient to express writing speed in centimetres per microsecond, eliminating any ambiguity regarding division size. Determining whether a particular storage oscilloscope can capture a specific single-shot signal is relatively easy: Calculate the maximum signal-spot velocity and compare it with the specified writing speed.

Here's how to calculate the maximum spot velocity of a single-shot sine wave and the transition time of a pulse. Make all writing-speed measurements using a viewing hood to avoid variations in perceived writing speeds arising from different ambient-light conditions.

You can convert writing speed in centimetres per microsecond to divisions per microsecond by dividing the first figure by the graticule division size in centimetres. For example, the HP Model 1727A has 0.72-cm/div graticule markings with a 2000-cm/μsec stored writing speed; therefore, its stored writing speed equals 2778 div/μsec.

When a beam writes a sine wave, the vector spot velocity (V) is composed of a vertical (V_y) and a horizontal (V_x) component, related through

$$V = \sqrt{V_y^2 + V_x^2}.$$

Vertical displacement (y) is defined as

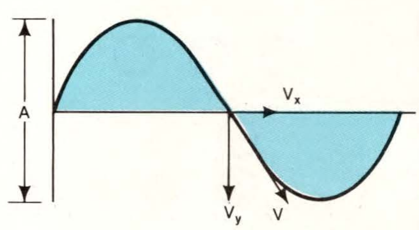
$$y = A\sin(2\pi ft)/2;$$

therefore,

$$dy/dt = V_y = A\pi f\cos(2\pi ft).$$

Maximum spot velocity occurs at the point (B) where $\cos(2\pi ft) = 1$. Therefore,

$$V_y(max) = A\pi f.$$



When a CRT beam writes a sine wave, *the vector spot velocity (V) is composed of a vertical (V_y) and horizontal (V_x) component.*

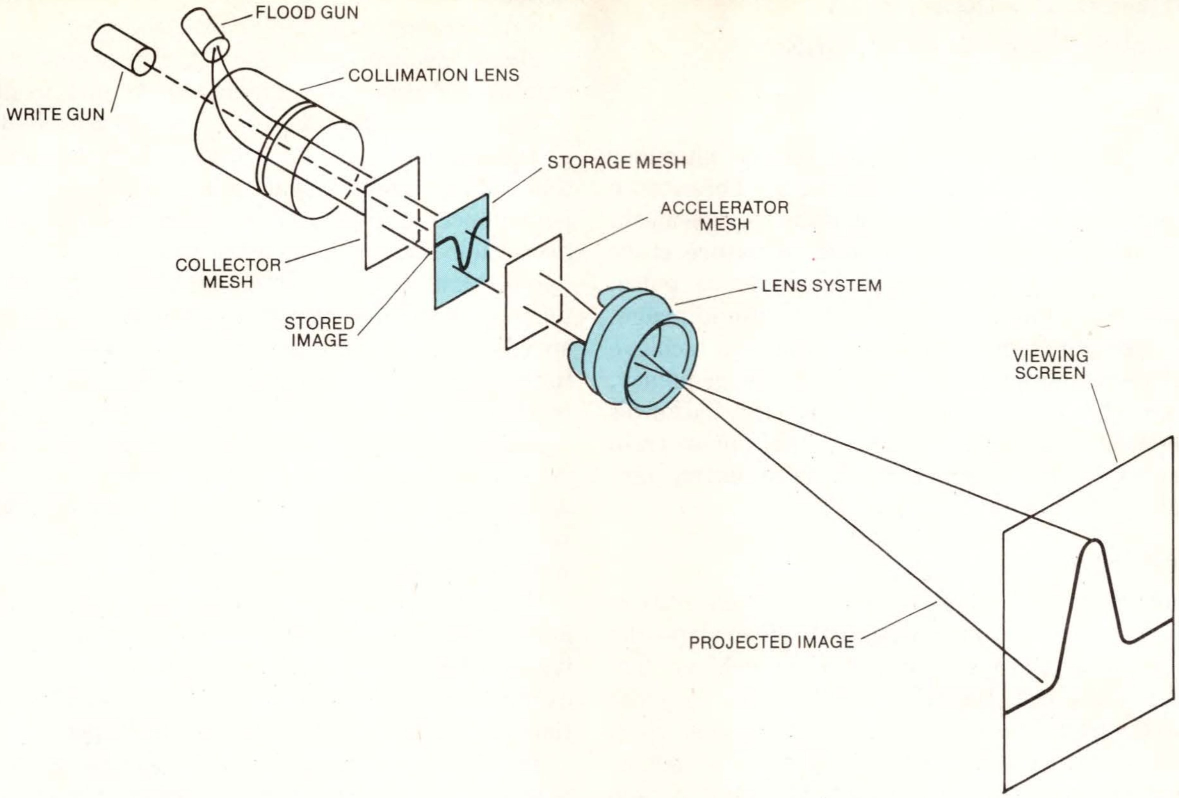


Fig 6—An expansion-type storage CRT *combines a small precision storage mesh with a static-electric-field lens system to achieve high writing speeds in both Variable Persistence and Single Shot modes.*

the same potential, eliminating any differentiation.

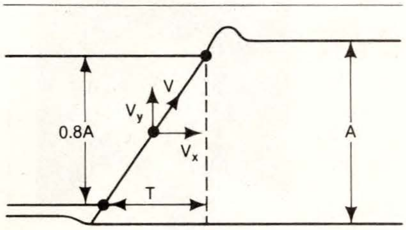
After this high-voltage step, the storage surface returns to a nominal voltage and is prepared for writing new information. The Brightness control, which regulates the voltage on the storage mesh, establishes the mesh's sensitivity.

Variable persistence involves slow erasure

The principle underlying variable-persistence operation in a storage scope is relatively simple. Imagine a stored image being projected to the phosphor. So long as that image remains stored, it continues to be displayed on the face of the CRT. But if that stored

Horizontal spot velocity is constant and equals the inverse of the time-base setting (divisions per microsecond). Therefore, when f is measured in megahertz,

$$V(max) = \sqrt{(A\pi f)^2 + (1/(\mu sec/div))^2}.$$



When calculating maximum spot velocity *for single-shot pulse measurements, assume that the quantity equals the average velocity between a waveform's 10% and 90% points.*

When several cycles (approximately 10) are displayed on screen, the horizontal-spot-velocity component is small with respect to the vertical component and can be neglected. In this example,

$$V(max) = A\pi f.$$

When a beam traces a single-shot pulse (assuming that the maximum spot velocity equals the average velocity between the 10 and 90% points),

$$V_y = 0.8A/T$$

where T is the observed rise time for most oscilloscopes:

$$T_{obs} = \sqrt{t_{pulse}^2 + t_{slope}^2}.$$

Because horizontal spot velocity is constant,

$$V(max) = \sqrt{\left(\frac{0.8A}{T_{obs}}\right)^2 + \left(\frac{1}{\mu sec/div}\right)^2}$$

$$= \frac{0.8A}{T_{obs}} \text{ for } V_y >> V_x.$$

Note the relationship between signal amplitude and stored writing speed. For example, a 275-MHz sine wave, four divisions high at a sweep speed of 1 nsec/div, generates a maximum velocity of 2590 cm/μsec, while the same signal three divisions high requires only 2000-cm/μsec writing speed. Understanding this tradeoff can result in significant savings in terms of an instrument's price and performance.

Expansion-storage CRTs use static-electric-field lens

image is erased slowly, the image on the phosphor slowly fades away. This process results in a persistence that depends on the rate of erasure of the storage mesh.

The erase process occurs through miniature erase pulses rather than one large standard erase pulse. These mini erase pulses slowly erase the stored image, and by varying their frequency, you can achieve different persistence levels. The higher the frequency, the faster the erase process. In Hewlett-Packard's variable-persistence oscilloscopes, a 1-kHz pulse train corresponds to the minimum persistence setting (approximately 100 msec).

One mesh or two?

In addition to exploring these storage and erasure techniques, consider one additional dimension—the techniques that storage scopes use to achieve fast stored writing speed. Basically, two technologies exist today—expansion storage and transfer storage. Each technique can achieve fast, single-shot writing speeds; however, the methods of capture and display in each case are radically different. Applications for each technique emphasize the merits and limitations of each approach.

Expansion storage achieves its fast writing speed by combining a miniature precision storage mesh and an electronic lens system that magnifies and projects the stored image. The storage mesh is about one-fifth the size of the viewing screen and is sandwiched between the collector and accelerator meshes, directly in front of the deflection plates **(Fig 6).** Any image written on the storage mesh gets magnified by a static electric-field crossover-lens system and projected to the viewing screen. Extremely fast writing speeds are possible with expansion storage, and these speeds occur in both the Variable Persistence and Single Shot modes.

Transfer storage, on the other hand, achieves its fast writing speed by using two meshes adjacent to the CRT phosphor. The write beam traces an image on the first mesh, an extremely sensitive one optimized for writing speed and usually called the fast mesh because it can capture fast write-beam slew rates. The high sensitivity of this mesh allows a store time no greater than a few seconds; therefore, once the image is captured, it gets transferred to a bistable mesh for long store times.

This method of storage offers very fast storage speeds and long storage times in Single Shot mode. The method of capture and display is to write (on the fast mesh), transfer (to the bistable mesh), erase (fast mesh) and reset to capture the next event.

Three items dictate your choice

Three key parameters can serve to determine which storage technique is most advantageous in your application: blind time, variable-persistence writing speed and stored writing speed. Consider them when evaluating a variable-persistence storage oscilloscope.

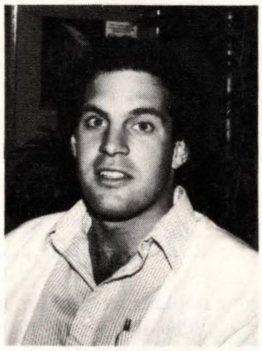
Blind time directly affects a storage scope's ability to scan data streams for random events such as glitches, noise, coupling and other spurious signals. It depends on the storage technology used and can be as short as that of a conventional oscilloscope for variable-persistence storage and as much as six orders of magnitude longer for transfer storage.

Indeed, although oscilloscopes using transfer-storage techniques achieve very fast single-shot stored writing speeds, they have blind-time limitations. This blind time arises from a combination of erase, transfer and reset times and is generally about 1 sec. Alternatively, oscilloscopes using the high-writing-speed variable-persistence storage technique achieve fast writing speeds in a variety of operating modes and have the same blind time as conventional instruments (it varies with sweep speed but is on the order of microseconds).

Variable-persistence writing speed is often overlooked as a key specification when for many applications it's the most important one. Moreover, a technique exists for viewing signals with trace velocities greater than the variable-persistence writing speed.

To illustrate this perceived increase in variable-persistence writing speed, consider the HP Model 1727A with variable-persistence writing speed of 2000 cm/μsec and display time of 10 sec. Determine the number of signal repetitions occurring within the display time and then multiply by the variable-persistence writing speed. Then compute the maximum signal-spot velocity using the formulas for stored writing speed (see **box,** "Using stored writing speed successfully"). For example, a 275-MHz sine wave with a displayed amplitude of eight divisions has a maximum spot velocity of 5028 cm/μsec. It would appear that the signal is too fast to be captured. However, a clear display of this waveform only requires three sweeps of the signal during the display time of 10 sec (3×2000 cm/μsec is greater than 5028 cm/μsec). EDN

Author's biography



Michael Gasparian, an engineer at Hewlett-Packard's Colorado Springs, CO Div, develops applications for instrumentation and explores potential uses of planned products. Before joining HP 1 yr ago, he earned a BSEE and BA in management science from Duke University, Durham, NC. In his spare time, Michael enjoys camping, fishing and playing soccer with HP's City League team.

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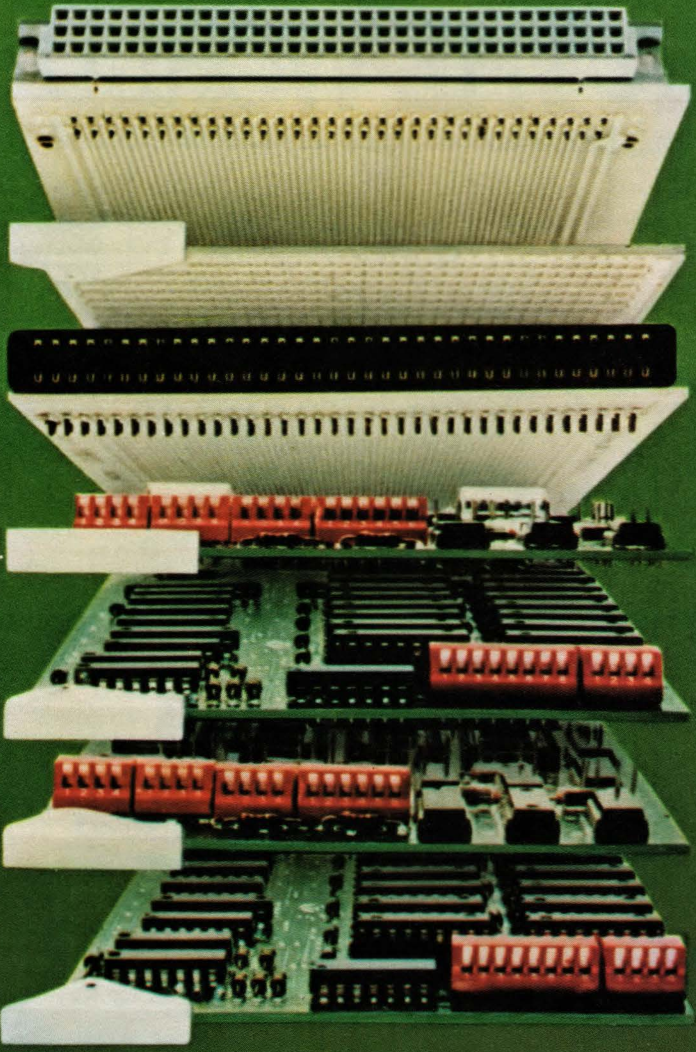

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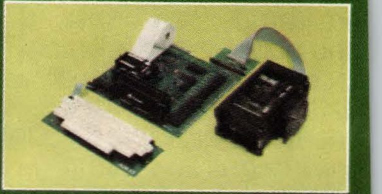

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CIRCLE NO 48

Understand the tradeoffs in development-system selection

Define your hardware needs and consider programming languages, emulation support, and initial and ongoing costs. Then project the savings in your production and marketing efforts.

Fred E Warren, Plantronics/Zehntel

You can use the information presented in this article to help choose a software-development system from the sometimes bewildering array of products now available (EDN, September 5, 1980, pg 140). And chances are good that as a manager, you will be required to make such a choice, because software-development systems have assumed increasing importance as the software content of μC-based OEM products rises—thanks in turn to rapidly evolving computer technology and its use in new and more complex applications.

The choice of a software-development system begins with a knowledge of available equipment, then calls for understanding the major considerations underlying the selection process. With regard to the first point, five basic types of software-development systems are available. In order of increasing sophistication, they are

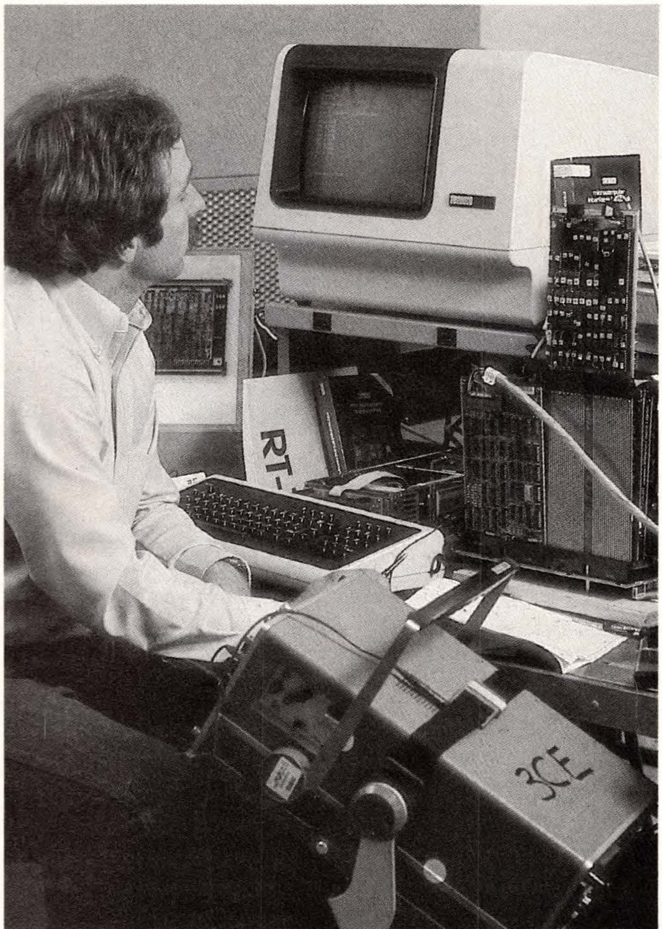
- Product-based systems
- Single-user development systems
- Multiuser development systems
- Central development systems
- Network systems

Examine each type in turn to start the selection process.

Product based: simplest, but can incur problems

When you only have a limited amount of software to develop, a product-based system might suffice. Rather than purchase additional computer hardware to use exclusively for software development, you can adapt the μC-based product itself—perhaps by adding a terminal and floppy-disk drive—to serve as a dedicated development system. Not only does this choice save capital outlay, it also guarantees that the software, once debugged, will work in its application environment. This system type requires no product simulation or cross compilation; software, as it's developed, runs on the product itself—a feature that can prove a great advantage when the product is a real-time device with a complex hardware/software interface.

A major drawback of product-based systems is their primitive nature: They have few if any built-in development tools. Additionally, because only one engineer can use such a system at a time, production efficiency suffers, particularly if the hardware product is still under development while the software is being created.



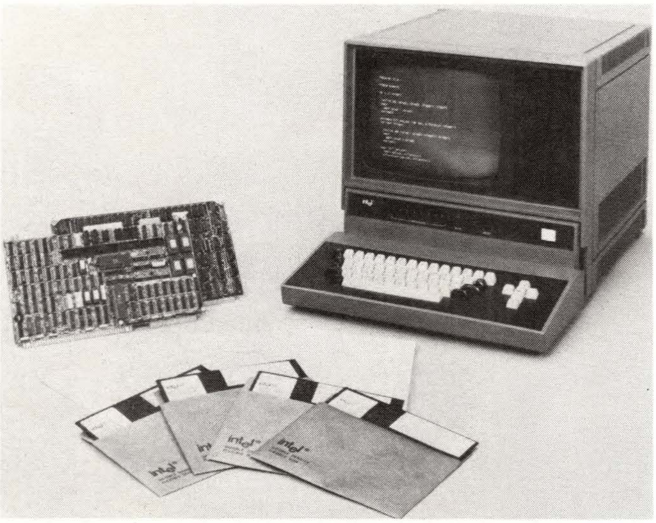
Writing software on a target product *often proves difficult. Most lack the built-in development tools found in this system from Digital Equipment Corp.*

If you find that you must produce more software than you anticipated, these limitations become even more severe. Thus, if you want to dynamically respond to changing market pressures, you need a more sophisticated approach to software development.

Store-bought systems provide power, efficiency

If your software-development effort is sufficiently large to warrant purchase of a system designed specifically for the task, your first option is a single-user development system supplied by the vendor of the µP used in your product. Unlike a typical product-based system, a commercial single-user development system contains its own complete computer. This computer utilizes assemblers and compilers, which produce programs that run in your microcomputer-based environment.

Additional utility programs move your application programs to and from the main computer. Not needing



A single-user development system, *such as this Intel Intellec unit, has its own computer and is optimized for a particular processor or processor family.*

to rely for software execution on the microcomputer contained in the product, your software-engineering staff can develop software without having to share the system with hardware designers—at least for the 80% of software development that typically doesn't require interaction with hardware at all. (A language recognizer, for example, is quite independent of the hardware on which it executes.)

A single-user software-development system is ideal for OEMs developing a modest amount of software for products that all utilize the same processor or processor family. Because the µP vendor sells the development system, these small systems are usually optimized for developing software for the specific processors supported. In addition to helping you write better software than you could with your own product-based system, development systems built by µP vendors allow you to take better advantage of the processors' capabilities.

One example of a single-user system is Intel's Intellec, which can be configured to support software development for products based on the 8080, 8086 and other Intel processors.

Depending on the nature of the work, a single-user development system can usually support as many as three software engineers. Typical cost of such a system—including CRT terminal, processor module with memory and peripheral interfaces, floppy-disk drives and printer—runs from $10,000 to $30,000.

The traditional single-vendor dedicated system has in recent years encountered much competition from multivendor systems manufactured by instrument companies. Rather than support a single processor family, these universal systems handle a wide variety of processors. And although no system on the market is truly universal, several, such as AMI's Phoenix I, accommodate more than a dozen popular µPs and µCs.

Although the software-development system that supports only one µP or µC might be well tailored to that device, the development tools and capabilities of such a system can lack sophistication. And you might require more powerful development tools for efficient software production because systems that support one µP are generally produced by vendors whose main business is something other than producing software-development systems—only a limited amount of such a vendor's resources are devoted to development-system production. Most systems that support one processor also execute slowly compared with those that support a variety. For these reasons, you might want to consider the latter type of system.

But regardless of the number of processors supported, you also face the problem of deciding how many *users* your system will have to support. Larger workloads require several single-user systems or one or more multiuser systems; the choice—as with many other system-selection factors—doesn't depend on one but a variety of considerations related to your current and anticipated software-development requirements.

Multiuser system proves more complex

A multiuser development system typically supports three to 10 concurrent users and costs $30,000 to $100,000. Although some microprocessor vendors provide such systems, the more widely known systems come from companies specializing in systems built for software development. Multiuser systems usually support more than one processor vendor's products, allow simultaneous software development for a variety of microcomputers and permit several engineers to interact during a team's development effort.

One typical multiuser system is Texas Instruments' AMPL DS990/10, which consists of a processor unit, hard-disk drive and as many as eight terminals. It supports software development and in-circuit emulation (see pg 121 in this issue) for six different TI µPs.

With another example, Boston Systems Office offers an unusual approach to multiuser development systems. It supplies a variety of software-development tools, including cross assemblers, cross loaders, simulators and a PASCAL cross compiler, that execute on standard scientific or business computer systems. If you're using or need a computer for other purposes, this approach eliminates the need for purchasing hardware solely for software-development use.

The clear advantage of a multiuser development system over a single-user configuration is more efficient use of expensive hardware. Even though these systems are more expensive than single-user systems, their cost per user is usually lower. Additionally, the hard-disk storage and greater computer power characteristic of most multiuser systems allow them to perform more efficiently and more rapidly than their smaller, floppy-based cousins.

Unlike those of single-user systems, vendors of multiuser systems that support a variety of processors usually make a major marketing commitment to their software-development products and tend to support new processors and development tools more thoroughly than vendors who supply development systems only as support aids for chip production. But the same tradeoff also exists: It isn't economically feasible for vendors of general-purpose development systems to spend a lot of time and development dollars optimizing their software for the particular processors an OEM uses. You'll notice some inefficiency, therefore, when you compare these systems with those from the processor manufacturers.

For OEMs with a large development effort, even a multiuser system can prove inadequate. As more users are supported by such a system, response time becomes longer. (In many cases, if the system operates at more than 90% of capacity—ie, handles more than 90% of the number of programs it can run simultaneously—any increase in utilization actually *cuts* productivity.) You can avoid this problem by always using the system at less than full capacity, realizing that such a reduction will prove difficult to justify to upper management. Additionally, if the system is based on a general-purpose computer, conflicts can arise between software engineers and personnel from other departments when the latter need to retrieve and print data. In many cases, then, the only solution is to buy an even larger development system.

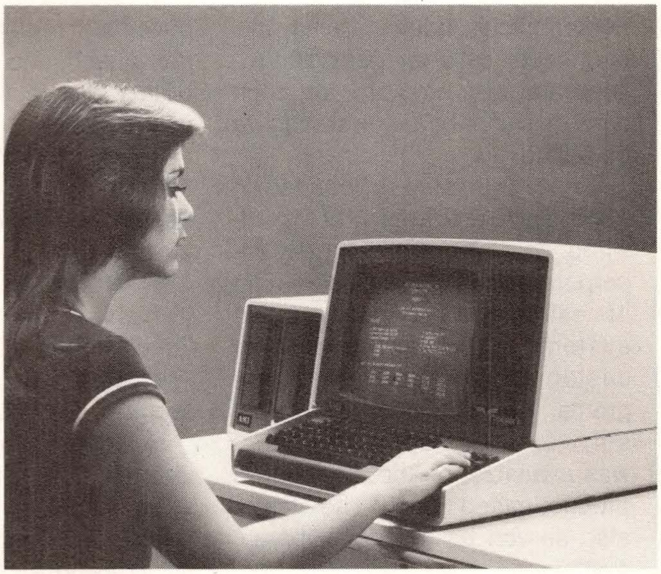
Central development facility: another step up

A central software-development facility is such a system; it's an extension and elaboration of the basic multiuser-development-system concept whose distinction is mainly one of scale.

You can consider time-sharing systems supporting more than 10 simultaneous users to be central development facilities. Although this definition might seem somewhat arbitrary, it's based on the actual situation in today's marketplace: Some vendors sell systems that support a maximum of 10 concurrent users, while others sell configurations supporting 10 users or more. (Actually, relatively few vendors fit into this latter category. A handful sell prepackaged turnkey systems, but most configure custom systems to meet individual OEMs' needs.) The cost of a central development system ranges from $100,000 to several times this figure—a price less than that of several multiuser systems with the same total capacity.

A major advantage of a central development facility is the large computer it usually includes—one that can run many powerful existing development-software packages. One example is the text-editor software used in Plantronics/Zehntel's central development facility (see **box,** "One OEM's solution"). This text editor won't run on a multiuser system; utilizing its advantages calls for the computing power of a central development facility.

Software packages such as this and dozens of others represent thousands of man-hours of programming and debugging. For the OEM who needs the capacity of a central development facility, the ability to use these pre-existing software packages eliminates the huge programming task of trying to create equivalent software-development tools in house.



This universal development system *from American Microsystems Inc supports a variety of μCs and μPs.*

Although the size of your development effort can dictate the use of a central development facility instead of a multiuser system, note that selection of a large system demands that you show more sophistication—not only to accurately determine your development needs, but also to understand the technical methods available for meeting them. If you find that none of the turnkey systems available are quite right for your needs, you must design your own software-development system, which necessitates selecting an operating system and computer, then researching the availability of cross assemblers, cross compilers and other utility programs that can support software development for the microcomputers in your products. This latter step can be time consuming and might not even succeed.

Furthermore, not all microprocessors are supported on every central development system. And in those cases where support is available, unpredictable difficulties can arise.

Multiuser systems use hardware efficiently

The complexity of configuring a central development system points up another tradeoff: You might avoid it by instead purchasing several multiuser systems, despite the higher overall cost. This approach might be an ideal solution if you have several independent, medium-sized software-development projects underway. For other situations, though, where control and communication are necessary between large groups of engineers working on one project or several related ones, a central facility is usually preferable.

In addition to complexity, a central development facility has other drawbacks. One relates to its high initial cost: Central facilities are usually sufficiently expensive to require purchase approval at the highest management level. Thus, because approval procedures can be time consuming, you might wish to avoid them; one way to do so is to purchase several multiuser systems, one at a time.

Another central-system drawback concerns mainte-

One OEM's solution

Plantronics/Zehntel (Walnut Creek, CA) manufactures equipment that automatically performs component-by-component in-circuit testing of every device on a printed-circuit board. Using this equipment calls for generating a separate test program for each type of circuit-board assembly to be tested.

When Zehntel was founded in 1966, such programs were hardwired. In 1973, the company incorporated microprocessors into its testers and began developing system software to support customer-generated test programs. At that time, no suitable software-development system was available, so the firm used a product-based one: The tester also served as the development system.

Eventually, users demanded greater programming capabilities, necessitating developing more system software and thus requiring a more powerful development system. The system had to support at least 20 to 25 programmers and utilize a well-known high-level language for software implementation.

This latter requirement was based on two considerations. First, the company needed a significant amount of software developed quickly—a factor that superseded any requirement for minimizing memory utilization. Second, the new programmers weren't experienced in working with the language used on the test system, but they had been writing software for large computers.

Having outgrown its product-based system, Zehntel examined the alternatives.

- **Single-user system**—Rejected because 15 to 20 would have been required. At $10,000 or more each, and with limited capabilities at that, this choice wasn't cost effective.
- **Multiuser system**—While addressing the firm's immediate needs, this approach left no room for growth.
- **Network system**—No available system of this type was large enough.
- **Central development facility**—Proved the best choice.

However, after much research, Zehntel couldn't find a turnkey system of this type to meet its needs. So it decided to configure its own—only after locating a company (Tymshare Computer Maintenance) that would maintain a multivendor system. After conducting further research, Zehntel chose to configure the entire project around the UNIX/PWB operating system, the Whitesmiths Ltd C-language compiler and a DEC PDP/11-70 computer.

UNIX proved the best choice as the operating system because:

- It's a well-known operating system written entirely in a high-level language. Zehntel programmers could use it to do their own software maintenance.
- It's easy to use for software development, because that's what it was designed for.
- It incorporates several powerful and well-tested software tools, including compiler-generator utilities, well-written text-processing routines, (invaluable in program documentation) and an electronic-mail feature that boosts efficiency by allowing a project team to communicate effectively.
- It has excellent configuration-management tools for tracking and combining pieces of software such as those that make up the firm's automatic test-program generator.
- It's widely used in a variety of applications. Moreover, the user community is a source of free or virtually free software.

By configuring the system itself, Zehntel saved a significant percentage of what the nearest equivalent single-vendor system would have cost.

After a month of fine tuning, the system ran smoothly. Its cross compiler has been used extensively; one application—developing a new automatic test-program generator—involved thousands of lines of C code executing on a microcomputer. Such an extensive programming effort would have proved extremely difficult without the power of both a high-level language and the development tools of the UNIX-based central-development-facility system.

Each organization must evaluate its own needs and projected applications. Zehntel's experience, however, serves to illustrate that a manufacturing company can successfully configure and implement a large software-development system.

nance and support. A large system requires frequent file-system backup, regular hardware maintenance and occasional total-system regenerations for software or hardware updates. It can be susceptible to power failures and overheating and usually requires at least one staff expert to train users and help them perform their jobs. Training can continue well beyond an instruction period, and ongoing training sessions inevitably throw off development schedules.

Despite all of these drawbacks, though, OEMs requiring the power and size afforded by a central development system generally find that this alterna-

In the future, *more development stations will be tied into networks, like this Hewlett-Packard system is, to maximize power yet maintain flexibility.*

tive's advantages—especially the ability to use a large base of existing software, the ease of control and communication between engineers and the potentially lower cost compared with that of several multiuser systems—far outweigh its disadvantages.

Network systems: wave of the future

A new concept in software-development systems—and a fifth alternative—has emerged in the last 2 yrs: the distributed network. In these systems, each workstation (or group of two or three workstations) has its own computer to develop software. The stations interconnect so that each can interact with any other or with any printer, disk storage device or other peripheral in the system.

Because no industry standard for local-network protocol exists, the only network systems available are those supporting a single vendor's equipment. Examples of this system type are Hewlett-Packard's HP 64000S, which serves as many as six users and costs $18,000 to $150,000, GenRad/Futuredata's 2300 (eight users, $8000 to $20,000) and Zilog's Z-Lab 80 (as many as 255 intelligent stations and shared disk units, $8550 per station).

Over the next 2 to 5 yrs, though, as local-network protocols such as Ethernet become standardized, the single-vendor limitation will disappear. Then networks—especially those supporting many users—will undoubtedly replace multiuser systems and even central development facilities. They will do so because they provide an ease of expansion not available with any other configuration. With a network system, an incremental addition in capacity requires only an incremental addition of intelligent hardware—inexpensive hardware at that, because of today's computers' low cost. By contrast, once a multiuser system is working at capacity, you can add a workstation only by purchasing an additional complete multiuser system.

Thus, if you expect your needs to grow, a network system could be the ideal choice. But keep two factors in mind. First, network capabilities are expensive. If a network must only support, say, six to 10 users at first, a multiuser system probably represents significantly lower initial capital outlay. Second, network technology remains new. With no standard protocols as yet, networks currently serve only OEMs willing to accept one source for all their development-system components. Newness also means that you might need a strong technical staff to iron out possible bugs and reliability problems.

Select a system with care

Having gained an understanding of the five types of development system, you're now ready to examine the main system-selection considerations:

- Target-hardware environment and programming language to be used
- Software-development-staff size
- Emulation support
- Speed
- Expected benefits
- Initial and ongoing costs
- Political factors.

An OEM planning to manufacture a low-cost intelligent terminal based on, say, an 8080 μP has a hardware environment where memory space is at a premium; the cost of even 1k more of memory for system software could produce a competitive disadvantage. On the other hand, an OEM developing a $150,000 process-control system based on the same 8080 has an entirely different type of hardware environment. Here, ease of operation by the end user—not memory space—could be the key consideration.

The nature of the hardware environment relates directly to the choice of programming language to be used for software development. The OEM building an intelligent terminal will probably need a development system that supports an assembler for the 8080, unless he produces custom terminals in dozens of special versions. Then the choice could be a large development system and high-level language to quickly meet low-volume special applications. The OEM building the process-control system will also want to support a high-level language and provide efficient software-modification/maintenance capabilities for developing

Include necessary software tools and utility programs

the large volume of software the product requires. The cost of the additional memory space required will be insignificant compared with overall product cost.

Another consideration in choosing a language is the range of microcomputers for which you're developing a particular piece of software. If the software must run on more than one μC, its transportability becomes important, especially if it will later be upgraded in sophistication for execution on a more powerful microcomputer. In most cases where software transportability is a factor, implementation must proceed via a high-level language.

In addition to specifying what implementation languages will be supported, be sure that your development system includes appropriate software tools and utility programs. Sorting, text editing, disk maintenance and backup are some of the routines you might require. For large systems, you'll also need sophisticated file and version controls.

The number of software engineers who will simultaneously use the system is another crucial factor. Thus, plan staff size as early as possible. A multiuser system might be adequate today, but perhaps you'll need a network system or central development facility within 2 yrs. Purchasing a large, expandable system now might prevent paying more in the long run for accumulating several multiuser systems that can't be linked together. The choice is yours.

The software-production cycle

The process of developing software is a repetitive series of operations, each of which can benefit from one or more features of a software-development system. It starts with writing or modifying a program—a step usually accomplished with the aid of a text editor.

The next step is to translate the program into a form executable by a computer. The programs that accomplish this step are language compilers, assemblers and loaders.

Finally, the program must execute on the computer and produce results. Utility programs termed debuggers can be used to aid in this process step.

Once you've inspected a program's results, you're quite likely to find a problem. If so, you return to the initial step and begin the process again. This activity continues until the program performs as desired and expected. (At this point, another major activity begins: documenting the software, which involves writing detailed instructions on how to use it. Here, too, text-editor routines can greatly help.)

Because the three steps in the software-production cycle depend upon relatively few support programs, these critical program capabilities form the mainspring of any development system. Improvements in any of them improve productivity.

Consider support and speed

Debugging by means of in-circuit emulation usually requires only a small portion of the overall development time for a software item—typically 2 wks out of a 6-month project. But during this period the emulation capability is critical, whether it's used for the integrated debugging of the hardware/software interface in a new product or for modifying a program that works on the development system but won't run on the existing product after cross compilation. Look carefully into the emulation capabilities of systems you're considering (EDN, March 20, 1980, pg 190). Emulation systems are available either in "unbundled" (stand-alone) configurations such as the Tektronix 8100, or as an integral part of a development system, such as the Intel Intellec Series II.

A major reason for purchasing a software-development system is increased programmer productivity. Therefore, an important part of system selection is determining which system most quickly carries out the software-production cycle's three phases: editing, translation and execution (see **box**, "The software-production cycle").

Having ascertained the speed with which a proposed system can help engineers with each software-production-cycle phase, calculate the number of man-hours the system will save. Then weigh this figure, converted to dollars, against system costs to determine the system's overall cost effectiveness.

Man-hours saved can also mean other opportunities gained. The first OEM to get a product on the market can usually count on a significantly greater market share than the second or third to arrive with a similar item. Although harder to quantify than simple man-hours saved, this factor alone could justify the purchase of a very expensive software-development system. Ask the marketing department to predict how many additional units will be sold if the product is ready 2 months earlier than planned to gain some idea of the financial benefits of getting to market sooner.

Consider the costs

Also consider hardware, software, installation and maintenance costs in pricing a system. Hardware costs include not only the cost of the development system's computer, but also that of the peripherals and supplies. Indeed, peripherals can be a major cost factor in certain systems. Single-user configurations, for example, typically have no built-in provision for sharing line printers. Thus, if you purchase several single-user systems, you'll need a separate printer for each. (The alternative is to locate, purchase and install a series of switches to allow all the development systems to share one printer—a bother, to say the least. And in the case of some peripherals, such as magnetic-tape drives, such switches might not even be available.)

You can save money when you assemble a system from hardware components made by a variety of vendors rather than purchase one ready made. Professional help in configuring and maintaining such a multivendor system, however, might be difficult to obtain.

Leasing is another cost-factor option you might explore. Although it can prove expensive in the long run, it can also be valuable as a means of learning about and trying out one or more software-development approaches before actually buying. The rapid evolution of new hardware and capabilities might even make leasing a *less* expensive alternative for the OEM who always wants the latest equipment in order to maintain the best possible development system.

Short-term leasing can be very attractive, especially for individual components. This scheme is particularly efficient for emulator use, because you generally need an emulator for only a small portion of any given project. And leasing an entire system often makes sense from a corporate viewpoint because in many cases it can provide a company with tax and cash-flow advantages.

Turnkey systems include the necessary development software. Alternatively, in systems configured from components supplied by a variety of vendors, you frequently have an initial choice of which software to include. If, for example, a simulator for a particular μP or FORTRAN capability isn't needed immediately, you can push their cost forward into another budget period. This added flexibility makes it easier to obtain the most economical, appropriate and useful system in the near term and to retain growth possibilities for meeting future needs.

Installation costs can run from near zero on small, single-user systems to several thousand dollars on a large time-sharing system. In the latter case, if site preparation—such as the creation of a climate-controlled room—is necessary, allow extra leadtime and anticipate spending additional capital for air-conditioning equipment and contract labor.

Never overlook maintenance costs, either. The success of a software-development project often hinges on the continued proper operation of the development system, which requires a strong maintenance program. A vendor usually provides a warranty of several months on a development system and makes service contracts available afterwards.

Make arrangements not only for hardware maintenance but for software maintenance as well. The latter, which requires incorporating updates of operating-system software whenever they become available, ensures that you're using the most up-to-date, error-free development tools available for your particular system.

In some localities, independent support organizations are available and can often maintain computer systems composed of a variety of different vendors' equipment, providing services on monthly terms competitive with those of computer manufacturers.

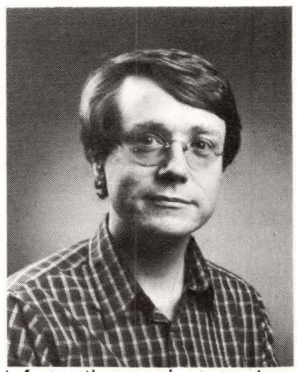
Finally, another factor sometimes overlooked in the selection of a software-development system is your company's political environment. Some upper-level managers simply won't consider anything but a turnkey system. Others buy only from a particular vendor. And others are more open minded. You must deal with the political environment at the decision-making level: It can be the deciding factor in a software-development-system purchase and can also govern what type is chosen.

You must, therefore, involve the company decision-making people as early as possible in the system-selection process. Fully explain the need and intended use of the proposed system to ease its introduction into any environment. Also educate the company employees who will be affected daily, and prepare programmers for the change. If a general-purpose computer will be used for other tasks as well as software development, consult people in the affected departments, such as accounting and manufacturing, so that you can agree on how to harmoniously share computer time. **EDN**

References

1. Mhatre, Girish, "Microprocessors: The Issues—Development Tools," *Electronic Engineering Times,* September 15, 1980, pgs 88-104.
2. Santoni, Andy, "Microcomputer Development Systems," *EDN,* September 5, 1980, pgs 141-151.
3. Stiefel, Malcolm L, "Special Report: Development Systems—A Guide to Tool Selection," *Mini-Micro Systems,* August 1980, pgs 68-76.
4. Stock, Bruce, and Ulloa, Miguel, "A Centralized Design Support Center," *Mini-Micro Systems,* August 1980, pgs 87-92.
5. Weisberg, Martin J, "Development-Phase Tools Unravel the Hard/Software Knot," *EDN,* March 20, 1980, pgs 187-193.

Author's biography



Fred E Warren is a software-project manager developing program generators and language processors for automatic test equipment at Plantronics / Zehntel (Walnut Creek, CA). Before joining that firm in 1979, he worked on mainframe IBM equipment for the Bank of America and programmed automatic-test-system software for Hewlett-Packard. Fred holds a BA in information and computer science from the University of California at Santa Cruz. His interests include metaphysics, car-stereo equipment and leather-bound books.

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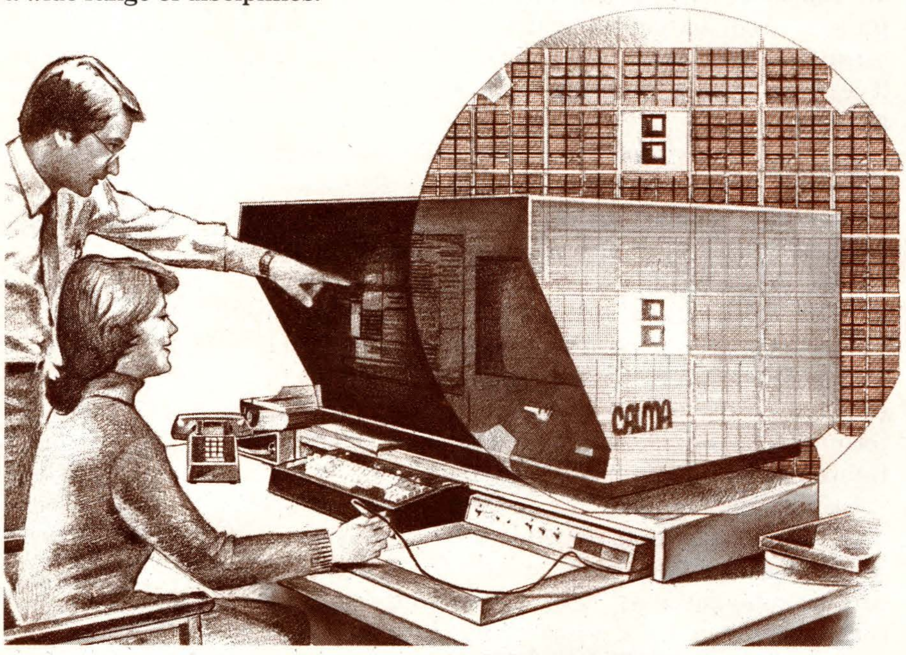

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CIRCLE NO 50

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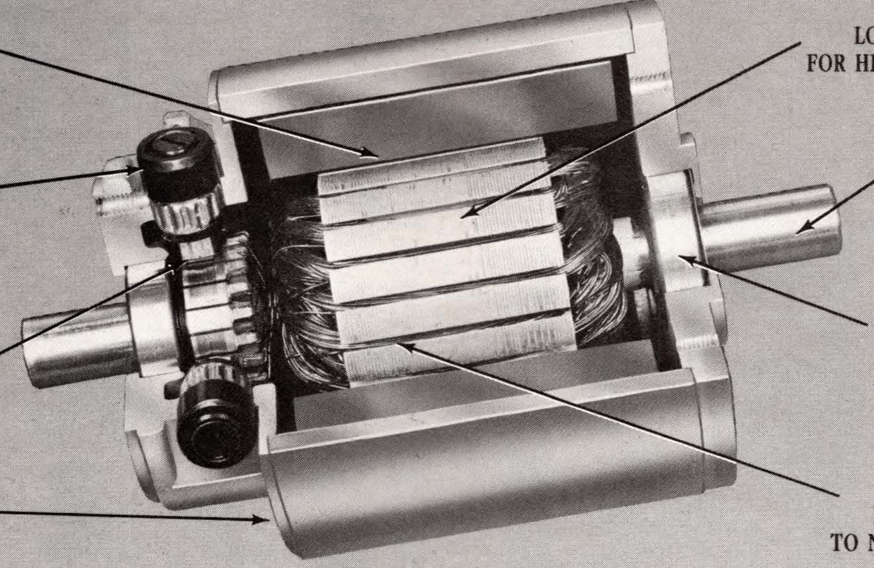

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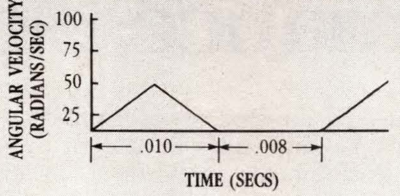
Now EG&G Torque Systems offers an inexpensive alternative with its proprietary "Focused-Flux, Ferrite-Field" servo motor design.

Using low-cost, ferrite magnets, this "SNAPPER" design exhibits motor performance equalling that usually obtained with an Alnico field. The unique configuration of the field magnets serves to concentrate, or "focus", the magnetic flux at the pole faces. As a result, continuous and peak torque (up to 170 oz-in and 1500 oz-in respectively) values are considerably higher than would normally be obtainable within the same physical size.

TYPICAL INCREMENTAL MOTION VELOCITY PROFILE



HIGH ACCELERATION

As a further benefit, the high torque of the SNAPPER motor combines with unusually low rotor inertia to produce acceleration characteristics that are generally associated with printed circuit motors (see curve). Cogging is negligible in most applications.

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CIRCLE NO 53

Phase-angle voltmeters solve noise problems

Signal impurities can hinder your efforts to measure complex ac waveforms using conventional instrumentation. But phase-angle voltmeters handle even noisy and distorted signals with no degradation in accuracy.

Kenneth Salz and **Arthur Freilich,**
North Atlantic Industries Inc

If noise and distortion in ac signals prevent you from making accurate measurements using digital voltmeters, phase meters and oscilloscopes, try a phase-angle voltmeter (PAV). Although they've been available for some time, PAVs can maintain measurement accuracy in harsh control- and servo-system environments—a capability that's sparking new interest in them.

This article describes typical noisy-signal measurement problems and discusses how the PAV design philosophy helps solve them. Also included are explanations of specific meters' performance features and some specific measurement applications. Although this discussion isn't all-inclusive, it should get you up to speed on PAVs.

Characterize the measurement problem

Accurately measuring complex ac signals has always been a tough engineering problem. Regardless of its accuracy, for example, a standard digital voltmeter can't truly represent a complex ac waveform that includes significant amounts of noise and harmonics. And DVMs aren't the only instruments with this drawback.

As an alternative, phase meters generally read only the phase difference between two signals, using zero-crossover detection. And although they provide fairly high resolution, they exhibit accuracy that's almost totally dependent on the input signal's distortion characteristics. Thus, even with minimal signal harmonics, accuracy can degrade significantly.

In fact, phase meters become virtually useless if harmonics affect the signal fundamentals' crossover points—and they usually do in ac servo systems. Noise on the signal also degrades measurement accuracy. In essence, phase meters aren't very useful in applications involving synchro/resolver servos, transformation-ratio measurements or high-accuracy ac measurements.

Within limits, you can use oscilloscopes to measure phase. Unfortunately, these instruments furnish poor resolution and accuracy; it's nearly impossible to derive useful information from signals containing even small amounts of noise and/or harmonics. Thus, because signals found in ac-servo-control systems contain varying amounts of noise and harmonics, oscilloscopes are a poor choice for these applications.

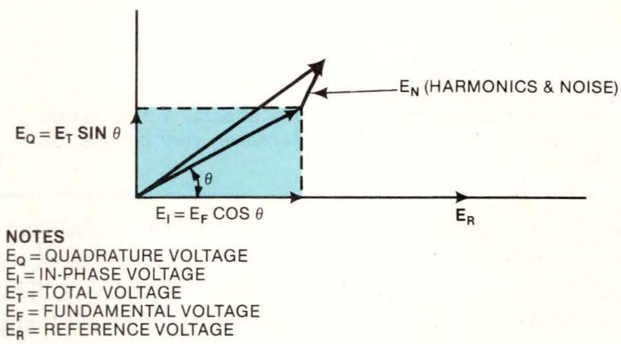

Fig 1—Using phase-sensitive demodulator techniques, *phase-angle voltmeters accurately measure an ac signal's vector components and phase angle.*

Complex ac-signal measurements thus demand an instrument capable of monitoring a signal while ignoring the noise and distortion in typical ac-control- and servo-system applications. The phase-angle voltmeter meets these requirements.

Using phase-sensitive demodulator techniques, PAVs quickly and accurately measure ac-signal vector components—quadrature, in-phase, fundamental and total voltage—and phase angle. They measure in-phase and quadrature vectors for both magnitude and direction with respect to the fundamental vector **(Fig 1).**

Unlike conventional voltmeters, PAVs provide a very sharp null reading unaffected by harmonics and noise. For this purpose, a variable phase shifter provides subtle but important advantages. As shown in **Fig 2,** for instance, a conventional voltmeter provides a very

Phase-angle voltmeters eliminate low-pass-filter needs

broad null indication. Adding some filtering improves null-point definition, but measurements still suffer from the effects of residual quadrature voltage. But by canceling quadrature-voltage effects and thereby substantially increasing sensitivity, a PAV defines the true null very precisely. In fact, you'll commonly see PAV signal-to-noise ratios of 72 dB or greater.

Take a look at PAV operation

When PAVs make measurements, a phase-sensitive demodulator converts a complex ac waveform into a dc voltage—proportional to the signal's fundamental component—whose value is multiplied by the cosine of its phase angle with respect to a reference voltage. The demodulator also eliminates harmonic effects to any desired degree.

Conventional full-wave phase-sensitive demodulators accept a reference square wave (E_R) and a signal (E_S) as inputs. The output's average value is then proportional to the cosine of the phase angle between the two inputs. Operation involves multiplying E_S by E_R, whose amplitude alternates from +1 to −1.

If each signal-frequency component is multiplied by each reference-frequency component, a dc output results only if the signal contains frequencies also present in the reference square wave that aren't in quadrature phase with the signal. In essence, the operation eliminates dc response to even harmonics (relative to the fundamental response) because they don't appear in the reference signal and reduces dc response to odd harmonics in inverse proportion to each harmonic's order. Additional low-pass filtering in both reference and signal channels can reduce odd-order harmonics by 60 dB or more; even-order harmonic rejection can typically run 80 dB.

A digital phase-sensitive demodulator eliminates the need for low-pass filtering, however. How? If the multiplying signal (E_R) were perfectly sinusoidal, the resultant multiplication would yield a dc output proportional only to the signal component that has the same frequency as the reference; the output would thus be independent of harmonics. Using digital techniques, PAVs can synthesize a multiplying reference having an infinite number of points.

A practical implementation of this concept **(Fig 3a)** utilizes a phase-locked loop (PLL) and a digital multiplier consisting of a sine-programmed ROM and a 4-quadrant multiplying DAC. The PLL locks the voltage-controlled oscillator to a multiple of the reference-signal frequency to set the sampling frequency ω_S; the binary counter's division ratio determines this frequency.

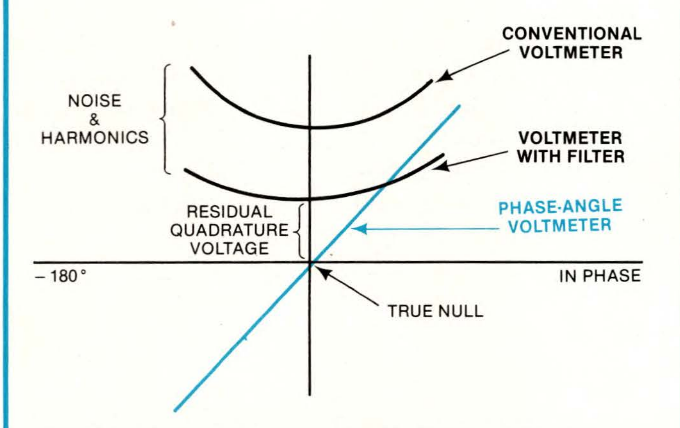

Fig 2—By canceling quadrature effects, *a PAV serves applications requiring a highly sensitive, very precise null detector.*

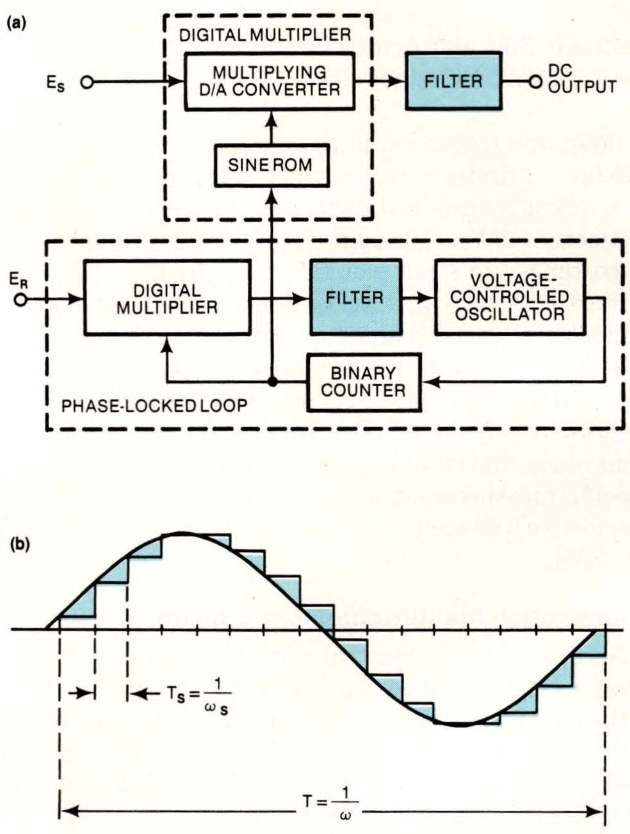

Fig 3—Improve harmonic rejection *without using low-pass filtering by employing a digital phase-sensitive demodulator **(a)**. Each angular increment (T_S) of the reference-voltage sinusoid **(b)** is defined by a digital-word output from the binary counter.*

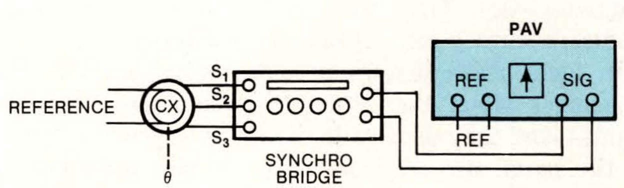

Fig 4—Recognizing true null is easy *when using a PAV and a synchro bridge—read the shaft position CX directly from the bridge.*

REPRESENTATIVE PHASE-ANGLE VOLTMETERS

MANUFACTURER	MODEL	SALIENT FEATURES	PRICE RANGE (APPROXIMATE)
AILTECH/EATON CORP 2070 FIFTH AVE RONKONKOMA, NY 11779 (516) 588-3600	PAV-4 SERIES	AVAILABLE WITH VARIOUS PLUG-INS TO ACCOMMODATE DIFFERENT REFERENCE-FREQUENCY RANGES. VOLTAGE ACCURACY EQUALS 2%. MIDBAND PHASE ACCURACY MEASURES ±1°. ANALOG DISPLAY. ISOLATION OPTIONAL.	\$2800-\$4000
DYTRONICS 4800 EVANSWOOD DR COLUMBUS, OH 43229 (614) 885-3303	244	SINGLE 400-Hz REFERENCE FREQUENCY (OTHERS AVAILABLE ON SPECIAL ORDER). TYPICAL VOLTAGE ACCURACY EQUALS 2%. PHASE ACCURACY MEASURES ±1°. ANALOG DISPLAY. ISOLATION OPTIONAL.	\$1895
	250	SIMILAR TO 244 BUT CAN ACCOMMODATE UP TO FOUR FILTERED FREQUENCIES. ANALOG DISPLAY. ISOLATION OPTIONAL.	\$3355
NORTH ATLANTIC INDUSTRIES 60 PLANT AVE HAUPPAUGE, NY 11787 (516) 582-6500	213C	SINGLE (USER SPECIFIED) REFERENCE FREQUENCY. VOLTAGE ACCURACY EQUALS 2%. PHASE ACCURACY MEASURES 1°. ANALOG DISPLAY. ISOLATION INCLUDED.	\$1840-\$2270
	321	WIDE FREQUENCY RANGE: 10 Hz TO 100 kHz. BUILT-IN REFERENCE ISOLATION. OPTIONAL SIGNAL ISOLATION. REQUIRES NO FILTERS. VOLTAGE ACCURACY EQUALS 2%. PHASE ACCURACY MEASURES 0.5°. ANALOG DISPLAY.	\$4365-\$4900
	225	DIGITAL UNIT. AUTOMATIC PHASE-ANGLE READING. 4½-DIGIT DISPLAY. INTERNAL REFERENCE AND SIGNAL ISOLATION. AUTO-RANGING. UP TO FOUR USER-SPECIFIED FREQUENCIES. REMOTE PROGRAMMING. OPTIONAL IEEE-488 GPIB. VOLTAGE ACCURACY EQUALS 0.1%. PHASE ACCURACY MEASURES 0.25°.	\$6690-\$8900
	225R	RATIOMETER VERSION OF MODEL 225. SAME FEATURES BUT ADDS RATIO CAPABILITY FOR ALL MODES.	\$7700-\$9800

The counter's output consists of digital words, each of which corresponds to an angular increment T_S of the reference sinusoid **(Fig 3b)**. The ROM converts the digital words to the sine of each angle, and the D/A converter at the ROM output performs the multiplication function on input signal E_S. This same digital multiplier serves as a phase-sensitive demodulator at the PLL input to minimize reference-harmonic effects.

Shopping for a PAV?

The nearby **table** lists a few manufacturers that currently market phase-angle voltmeters. The specs are condensed from data-sheet information and are listed only to show relative performance. (Check with the manufacturers for up-to-date specs and prices.) Every PAV listed includes a null meter and the ability to phase-shift the reference voltage by means of a calibrated dial.

With the exception of North Atlantic Industries' Model 225 (which has automatic phase reading; see **box,** "A closer look at a novel PAV"), all meters use the same phase-angle measurement technique: You first measure the input voltage's quadrature component and then observe the amount of additional phase shift required to make this quadrature voltage disappear.

To make the measurement, you switch the PAV to its quadrature-reading mode, introducing a fixed 90° phase-shift network into the reference channel, and read the quadrature voltage on a coarse scale. You then adjust the phase-shift network to reduce the quadrature voltage toward zero, progressively improving instrument sensitivity by switching to lower voltage scales until you achieve the desired accuracy. The phase-shift dial then shows the actual phase difference

A closer look at a novel PAV

A digital instrument providing a 4½-digit readout, Model 225 from North Atlantic Industries advances the measurement accuracy of phase - angle - voltmeter (PAV) technology. With a bandwidth of 30 Hz to 100 kHz (in Total mode), it features 0.25° midband-angle accuracy and 0.1% FS in-phase and quadrature voltage accuracy.

The 225 displays phase angle directly—it requires no manual adjustments. An autoranging feature speeds null measurements by circumventing the need to manually down-range for higher sensitivity. Compatible with either stand-alone bench or ATE applications, the 225 offers a choice of output options—standard parallel digital or GPIB.

Additional features include 60-dB min harmonic rejection, 6-decade (10 mV to 1000V FS) measurement range, 1-μV resolution on the 10-mV scale, 0.2 to 200V reference-voltage range and broad-band signal and reference isolation. The meter accommodates one to four discrete phase-sensitive frequencies spanning 30 Hz to 54 kHz (400 Hz is standard for the first frequency).

An alternative configuration, Model 225R, also measures signal-to-reference input levels. Additionally, it measures and displays in-phase, quadrature and total voltage ratios over a full-scale range of ±0.0002 to ±20.

Non-Linear Systems' Touch Test 20. The 2 lb. 4 oz. test lab.

The Touch Test 20 DMM weighs only 2 lbs. 4 oz. Yet it puts twenty key test functions at your fingertips. Plus exclusive light pressure touch function selection. Shown from above on leather shoulder sling (optional).

Touch Test 20 at a glance

Measurements		
	AC Voltage	10 μV to 750 VRMS, 6 ranges.
	DC Voltage	10 μV to 1000 VDC, 6 ranges.
	AC Current	10 μA to 10 A, 4 ranges.
	DC Current	0.01 μA to 10 A, 7 ranges.
	Resistance	10 milli Ω to 20 meg Ω, 7 ranges.
	Temperature	−40°C to 150°C, −40°F to 302°F; 2 ranges.
	Conductance	0.01 nS to 200 nS (equivalent to 5 megohms to 100,000 megohms) 2 ranges.
	Capacitance	1 pF to 200μF, 6 ranges.
Tests		
	Diode	Diode and transistor junctions in conducting and non-conducting directions.
	Continuity	Audible signal.
Size		2.9" H x 6.4" W x 7.5" D (74 mm x 163 mm x 191 mm)
Weight		2 lb. 4 oz. (1.02 kg)
Price		$467.00 with batteries $435.00 without batteries

Road test the remarkable Touch Test 20. Now, with its 20 key test functions at your fingertips, (plus the ability to measure 10 electrical parameters and 44 ranges) you can take one lab to the field instead of a cumbersome collection of individual testers.

Another bright idea. The Touch Test 20 is the only DMM with light pressure touch function selection. No more dials to fiddle with. Instead, an LED shows the function you choose. And when you switch, you get an audible bleep and a visual blip to let you know.

Operation's a snap. A light touch chooses the function. An LED shows it.

Functional. Not gimmicky. We believe that in DMM design, form should follow function. For example, it's rare that a DMM is used hand-held. Usually it's placed so the operator's hands are free to manipulate the test leads and the equipment being tested. That's why we developed the Touch Test 20—to fit where and how it would be used. The result is the most innovative portable/bench-type multimeter in the industry today.

Small wonder. The Touch Test 20 is designed specifically for mainline electronics measurement and testing. It checks AC and DC voltage, AC and DC current as well as resistance. Analyzes temperature in Celsius and Fahrenheit. Measures conductance and capacitance. It also performs diode/transistor and continuity tests. All with the accuracy that's synonymous with the name Non-Linear Systems.

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The Touch Test 20 comes with test leads, temperature probe and resistor/capacitor test adapter. It features automatic polarity and overload indication plus in-circuit test capabilities. The Touch Test 20 is available in two models—rechargeable battery or line operated. All parts and labor are guaranteed for a full year. And each model is available with optional accessories like a leather carrying case with shoulder strap and belt loop, to help you get the job done.

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A PAV's phase sensitivity provides highly accurate nulls

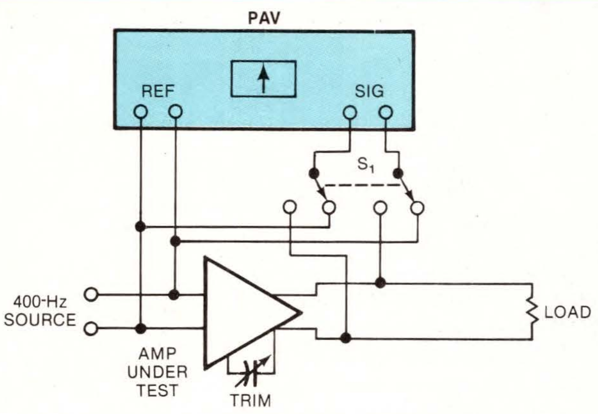


Fig 5—Aligning carrier-type servos for maximum torque *is straightforward when using a PAV. You merely employ the calibrated phase shifter in the reference channel. The test circuit shown yields trims of well under 1°.*

between input and reference.

Put the PAV to use

When you make such phase measurements, harmonics, noise and phase relationship significantly affect instrumentation sensitivity and accuracy. Because synchro/resolver bridge measurements best exemplify the problem's severity, consider the task of synchro zeroing, nulling and phase-shift testing (**Fig 4**) as an example of PAV use.

In aligning servo systems, you must physically zero each synchro when the output is zero—electrical zero is the datum for generating error curves. Because of the presence of harmonics and noise, you can't obtain an accurate null using nonphase detectors such as DVMs. And DVMs require you to align the scribe mark on the shaft to distinguish true zero from the false electrical zero that's 180° away.

If you use a PAV, though, the nulling operation presents no problems. You can instantly recognize the true zero: Just rotate the shaft counterclockwise slightly and the needle must swing to the right. You can also readily measure phase shift (the difference between the fundamental components of the primary and secondary voltages) at the first position of maximum coupling while rotating the shaft counterclockwise from electrical zero.

With a PAV, you can obtain two null-voltage measurements. Set in its Total measurement mode, the instrument measures total null voltage including harmonics and noise. In the Fund mode, internal filtering eliminates the harmonics and noise.

PAVs' phase-sensitive characteristics also let you achieve levels of synchro null accuracy unobtainable with conventional instruments. When adjusting the synchro bridge for null on the PAV, you can read the CX electrical shaft position directly on the bridge.

In most cases, you can't monitor servo-amplifier stages using conventional instruments because the chopped waveforms can lead to prohibitively large measurement errors. Obtaining maximum output torque becomes a straightforward task with a PAV, however. In fact, you can monitor the servo output directly because the meter reading equates to motor output.

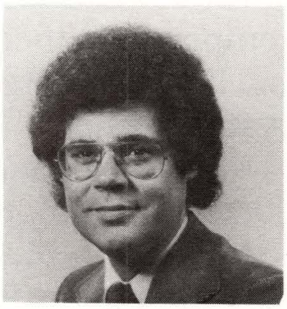
A PAV also simplifies transformation - ratio testing. For example, you can easily check the transformation ratio of RXs, CXs, CDXs, CTs, transformers, etc, directly using a ratiometer-type PAV. This technique eliminates the need to use the time-consuming ratio-box nulling technique.

Consider now the problem of gyro-drift measurements. For small drift angles, the PAV's dc recorder output is directly proportional to a pickoff sensor's deviation. In gyro-drift-rate tests, for example, you can adjust the PAV and synchro bridge for a null at the beginning of a run. With a chart recorder, you can then record gyro drift rate in degrees per hour (setting desired scaling using the recorder's gain control).

Finally, it's frequently necessary to align units such as phase-compensation circuits, summing circuits and amplifiers to reduce the quadrature effect to an acceptable minimum and establish a transfer function at precise phase-angle values. Usually, you can't conveniently monitor carrier-type servomechanism-amplifier stages using conventional instruments because the useful or torque-producing signals typically bear some phase-angle relationship to the carrier reference. But with a PAV, such measurements are straightforward: You merely use the calibrated phase shifter in the PAV's reference channel.

Fig 5 illustrates a setup used to check the phase-angle transfer characteristics of a 400-Hz-carrier amplifier. Switch S_1 exactly adjusts the 90° point. This circuit yields trims of a fraction of a degree. EDN

Authors' biographies



Kenneth Salz is director of marketing and sales at North Atlantic Industries, Hauppauge, NY. A graduate EE (from the City College of New York and Hofstra University), he's been with the company for 8 yrs. Ken's spare-time interests include photography, music and computers.

Arthur Freilich, VP for engineering, is involved with the engineering management of North Atlantic's Qantex Peripherals and Instruments Divisions. He has earned BSEE (City College of New York) and MSEE (Columbia University) degrees and is a registered PE (New York State) and an IEEE member. Arthur spends his spare time on the golf course or tennis court.

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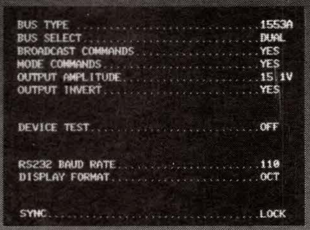

The SBA has an automatic test capability that is implemented through a soft key programming function. This provides the operator with the capability of initiating customized complex tests with a single key stroke.

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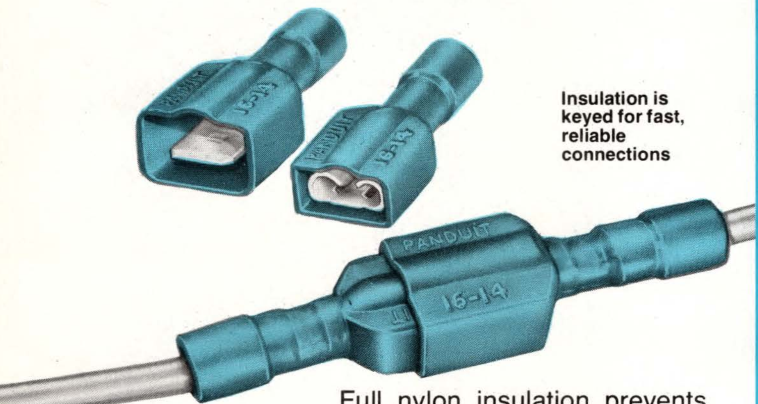

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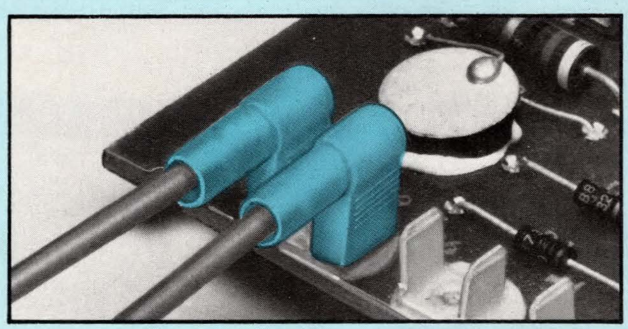

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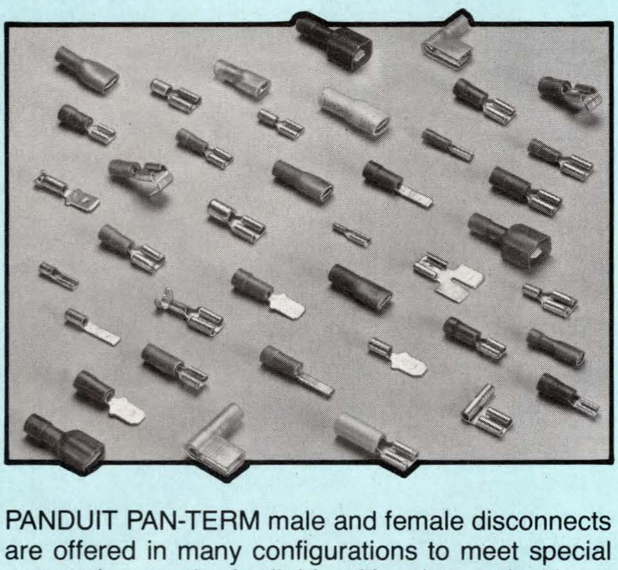

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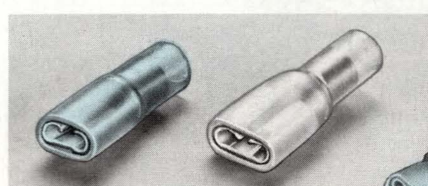

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Understand emulator use to increase prototyping skills

To take full advantage of μP emulators, you must completely master the interactive hardware/software dynamics they make possible.

Mike Mihalik and **Bob Francis,** Tektronix Inc

Although microprocessor emulators can provide powerful prototype-hardware/software analysis (with or without a development system), using them wisely calls for a detailed knowledge of their strengths and limitations. Armed with this information, you can more effectively utilize an emulator's diagnostic capabilities in your new product's integration process. The result: design-time and cost savings.

To help you achieve these goals, this article explains the emulation process, summarizes emulator types and describes basic emulator tasks. Additionally, it explores common emulator usage and specification problems, as well as potential future emulation techniques.

Start with the fundamentals

Emulators come in several versions. Some units form an integral part of a development system; others function in a stand-alone manner within the confines and support of such systems; still others function as self-contained, stand-alone instruments, independent of

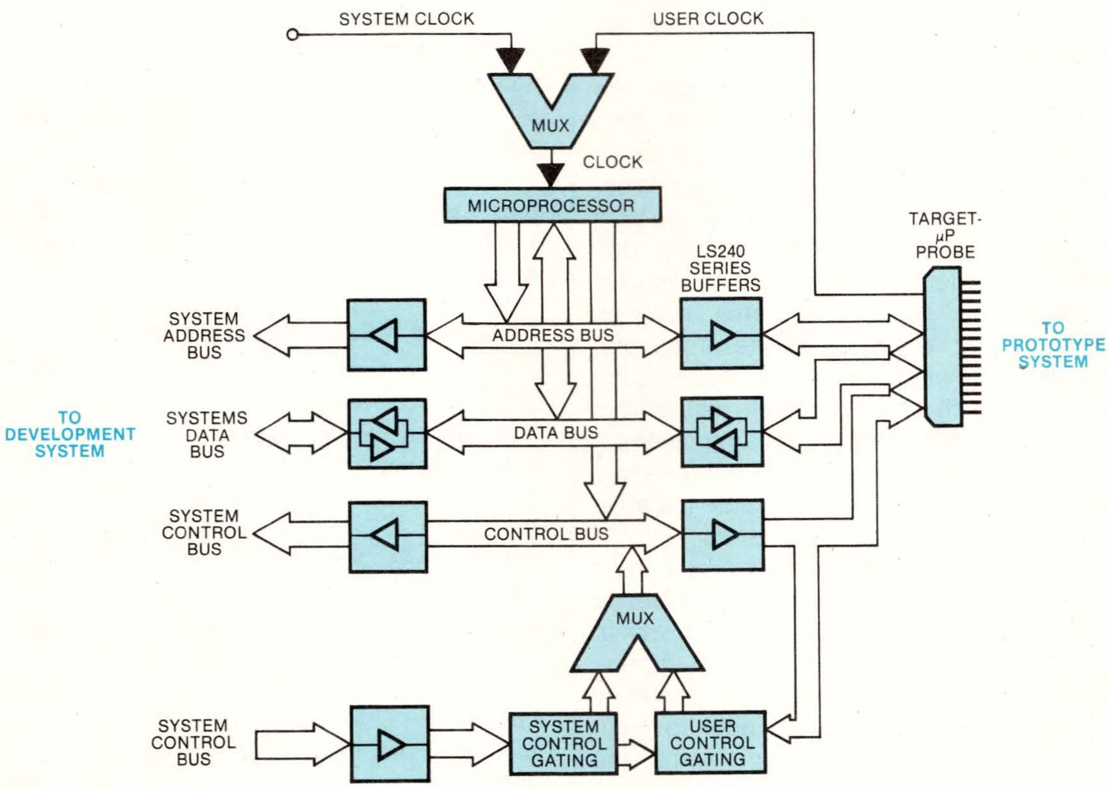


Fig 1—With help from a development system, *an emulator can monitor, control and modify the interaction between a μP-based prototype's hardware and software. To carry out these tasks, it contains interface, control and gating logic, buffers and multiplexers and a μP that closely resembles that of the prototype.*

development systems. This article concentrates on the first two types.

Before considering emulators, though, first examine their intended mission—μP emulation. Executing this task calls for replacing the target μP in a prototype circuit or system with a probe or pod connected to the development system. Such a setup combines software or firmware execution and debugging facilities with prototype hardware in an operating environment closely resembling that expected of the final product.

A basic emulator (or emulator processor) designed for such use comprises one or more logic cards that plug into a compatible development system and connect via cable to the probe. The probe itself contains a μP with electrical characteristics similar to those of the target μP. To use the emulator, you remove the prototype μP from its socket and insert the probe's cable connector in its place. The emulator's μP can thus execute the prototype's program, as well as special operating-system programs, to examine, change or modify the prototype's memory, I/O and μP registers. Additionally, the emulator's μP allows you to start, stop and monitor prototype-program execution using the development system's commands.

In most cases, the emulator uses an emulation μP of the same type as the target or emulated μP. However, single-chip μCs such as the 8048 demand special attention; they must operate in an expanded mode to allow access to their address, data and control lines, and the emulator must simulate their I/O ports with additional hardware.

How an emulator works

Functionally, an emulator contains a processor section, a prototype-control section and a target-μP probe **(Fig 1)**. The processor section interfaces the development-system bus to the μP bus. It permits emulator use of development-system resources such as memory, breakpoint circuitry and memory-mapping control.

Connected to the processor section via flat-ribbon cable, the prototype-control section contains cable drivers and receivers, the target μP and control circuits. These circuits switch μP signals between the prototype and the development system. The μP located in the prototype-control section is chosen to be as electrically close to the prototype μP as possible to minimize propagation delays of key processing signals. Minimizing such delays becomes critical when emulating fast μPs, especially in real-time operation.

The target-μP probe joins the prototype system to the prototype-control section. It usually contains circuits that buffer key clock and interrupt lines. These buffers prove necessary for crystal- or RC-type clock sources; tying a clock source directly to the μP pins with interconnecting cable adds capacitance that could prevent oscillation.

Ideally, the emulator manufacturer should physically locate the target μP at the probe socket. Electrical and mechanical limitations, however, don't allow for such proximity.

Emulation relies on breakpoints

To use a typical emulator, you initially define the prototype's environment for the development system. You then establish commands that specify the prototype's memory, the development system's memory and logical-address range, the program memory's write-protected areas and the operating system's active service calls. Whichever method you use to activate service calls, make sure it permits relocation anywhere in memory or I/O space should the predefined locations conflict with prototype addresses.

After you set up the prototype's environment and emulation mode (see **box,** "An emulator's operational modes"), you load the prototype's program into the emulator's memory. You next specify the program's starting address and begin program execution there. Inevitably, however, problems arise at this point in the emulation process (see **box,** "Some typical emulator problems").

Some typical emulator problems

Common emulator problems stem from using emulators with μP-based prototypes. Often they materialize from obvious design oversights. Here are two prevalent scenarios.

In one case, the prototype works with the emulator but not with its own μP. This situation usually results from overlooked hardware considerations during the prototype's design and development. A common difficulty, for example, arises from μP bus overloading (either capacitive or dc). Additionally, timing deficiencies, based on different initial conditions (ie, control-line states, such as Reset, when power is applied to the prototype), frequently show up when the μP functions in the prototype circuit. Such a timing problem results from an overly short or noisy Reset signal on power-up. This defect might affect the μP's internal initialization but gets ignored by the emulator because emulator execution begins after power-up.

In the second case, the prototype works with its own μP but not with the emulator. This situation arises many times because of tight bus timing, power-supply noise, development-system ground loops or the requirement of real-time operation at all times after power-up. In many cases, after development, the prototype masks these problems and therefore appears to work properly. Such problems, though, often occur intermittently and then mysteriously disappear. Even a proven design might exhibit them.

An emulator's operational modes

To execute a prototype μP's program, an emulator needs several components:

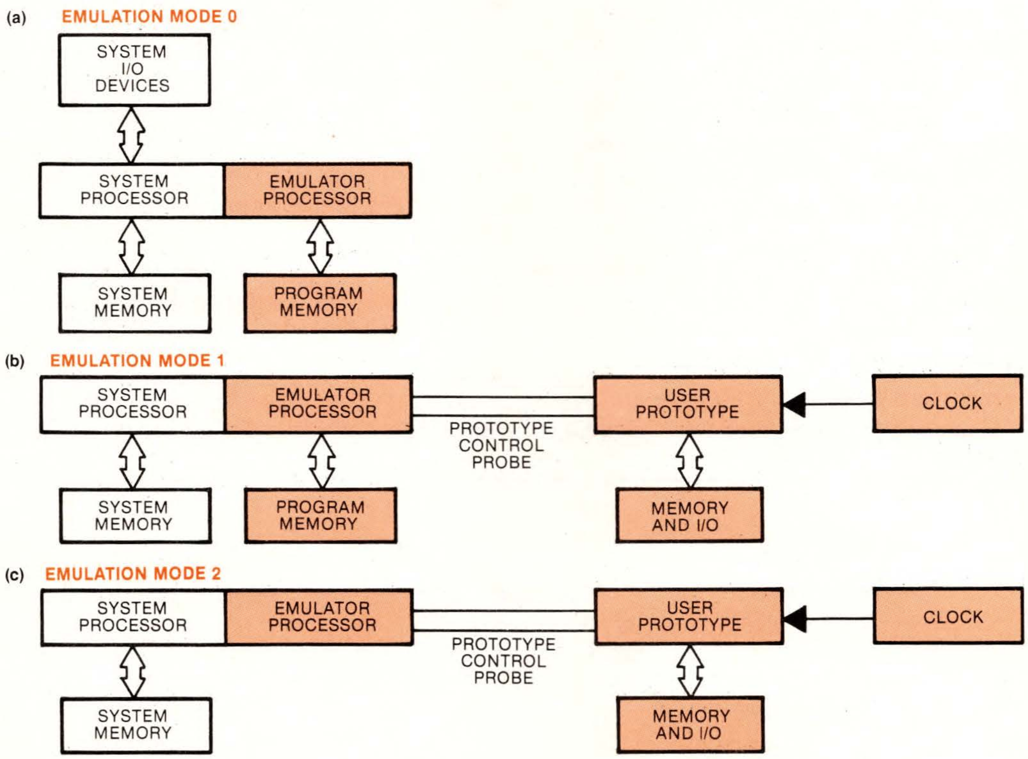
- A μP to execute the program
- A clock to drive the μP
- A memory to store the program
- I/O circuits to control or respond to program execution.

The associated development system provides or simulates the prototype's environment for executing or debugging the prototype program before prototype hardware is available. When the prototype is built, you can transfer the necessary hardware functions, such as RAM, ROM or I/O, from the development system to the prototype.

The development system and the emulator should apportion these functions between the development system and the prototype on several operational levels. By specifying one of three emulation modes **(figure),** you can indicate the functions slated for development-system handling and those for prototype handling:

- Mode 0 (System mode) uses the development system's clock as the μP's clock. The development system also provides memory space. No external interrupts are allowed, and I/O gets simulated via service calls to the development system's operating system. Until prototype hardware is available, the prototype's program can execute only in Mode 0.
- Mode 1 (Partial Emulation mode) employs the prototype's clock as the μP's clock and uses service calls for simulated I/O. It can also employ the prototype's I/O facilities. Additionally, Mode 1 allows the emulator's program to access memory in either the development system or the prototype. With memory located in the development system (for example, in the same address location as the prototype's ROMs), you can then simulate the ROM's environment without programming a PROM. The development system's memory should have program-write-protect capability in case a fault causes memory writes to the ROM-address area. A memory map in the development system determines whether a particular address refers to development-system memory or prototype memory.
- Mode 2 (Full Emulation mode) utilizes the prototype's memory, clock and I/O facilities.

In all three emulation modes, the emulator substitutes for the target μP slated for installation in the working prototype.



Emulation modes *define the functions performed by an emulator and those executed by its associated development system. In Mode 0* ***(a),*** *the development system and the emulator can simulate prototype software operation without the need for the prototype's hardware. In partial emulation, Mode 1* ***(b)*** *allows the emulator's program memory to access both the development system's and prototype's memories. Mode 2* ***(c)****—the Full Emulation mode—employs the prototype's memory, clock and I/O facilities.*

Breakpoints allow flexible control over hardware/software diagnostics

To verify proper program operation, you could single-step through the entire program, checking performance at each instruction. To save time, though, it's easier to set a breakpoint at the end of a particular operation sequence and examine the results at that point. Establishing such breakpoints can isolate a problem within a small program section. You can then concentrate debugging efforts on that section.

Breakpoints halt program execution

As a key capability, an emulator can trigger conditional breaks to stop prototype-program execution for analysis. Multiplexer-type circuits in the emulator switch the μP between the prototype and the development system whenever you want such a conditional program break. (You might need this break capability to accommodate a breakpoint, a service call to the operating system or an instruction single-step operation, or merely to cease prototype-program execution.)

To determine the μP's status—its registers' contents at the breakpoint—the emulator software directs the μP to execute a software routine that dumps register information to the development system's memory. After storage, the development system's operating system can gain access to this register information without disturbing the prototype's status information.

To locate the program-execution breakpoint, the emulator latches the address bus on the instruction fetch occurring just before the break. The location of the instruction executed just before the breakpoint is termed PCLAST. After latching it, the μP is forced to execute an instruction sequence to obtain its status information. During this forced jump, several events occur:

- The address bus latches during the current instruction fetch to obtain PCNEXT (program counter next)—the address where program execution should continue.
- The buffers switch from the prototype and allow the μP to execute special software routines. These routines could reside in the same memory area that the prototype requires, but the buffers allow complete switching transparency.
- The emulator's μP-probe pins get forced to a predefined state or sequence. The prototype's environment thus undergoes only minimal disturbances during this sequence. In particular, memory writes occurring during this status transfer should not affect the prototype.

The emulator's operating system and μP use this status information to define the prototype's current state. The information—presented as a trace line—contains the following data **(Fig 2):**

- Program-counter contents (PCLAST) when break occurred
- Disassembled opcode of instruction just executed
- μP registers' current contents
- Reason for break.

You can then alter memory contents or change register values before continuing with prototype-program execution. However, before starting the prototype program, the operating system must restore the μP's contents to their states before the break or to a new state as commanded.

At this point, the μP gets forced to execute a restore program. It then starts program execution at the memory location specified by PCNEXT. (You can continue program execution at another location by specifying a new PCNEXT with the appropriate command.)

Flexible triggers vary break conditions

For flexibility in specifying break conditions, an emulator should allow you to choose among several trigger methods. The simplest method utilizes a trigger based on an address location; you can extend this method by also specifying read or write operations.

For increased breakpoint flexibility, you can specify memory or I/O operations and define different bus-transaction types, such as interrupt-acknowledge cycles, address-space references and memory-stack operations. And for still more flexibility, you can specify a trigger based on the μP's control signals or on external hardware. The generated trigger is also available externally to activate test equipment, such as a logic

INSTRUCTION EXECUTED

μP REGISTERS' CURRENT CONTENTS

LOC	INST	MNEM	OPER	SP	F	A	B	C	D	E	H	L	IM	SOD
0106	86	ADD	M	0000	04	0F	01	00	00	00	05	04	07	0
0106	<BREAK		BKPT1>											

PCLAST

REASON FOR BREAK (BREAKPOINT 1)

Fig 2—A trace line *displays address, data and status information for the processor cycle executed just before a breakpoint. This information includes the program-execution breakpoint location, the last instruction processed and the μP's registers' current contents. For user convenience, the Trace line indicates the information in assembly-language mnemonics.*

What an emulator can and can't do

Emulators can execute prototype programs in several environments, including the prototype hardware's. Along with a development system, an emulator also provides removable prototype-debugging capabilities. You could permanently install such facilities into the prototype, but they would add significantly to the product's cost. Additionally, unskilled product users wouldn't be able to implement the debugging tools. (Obviously, however, skilled product users would profit from these capabilities.)

Most importantly, though, an effective emulator should operate completely transparently to the user until a fault arises; only then do you use the emulator's capabilities to pinpoint the problem.

Emulators do exhibit some operational restrictions. One concerns μP-status information displays; they interrupt the prototype program. Additionally, an emulator can generate extraneous signals on the μP-probe lines. And buffers inserted between the μP and the prototype, plus the connecting cable's propagation delay, produce timing skews that mandate prototype design care.

Still another restriction centers on direct-memory-access (DMA) capabilities built into the prototype. You can't expect to force DMA capability into the development system's memory. When operating in DMA mode, the μP gets bumped off the bus because DMA circuits access memory directly. Because the only path connecting the development system to the prototype goes through the emulator's μP socket, the DMA bus-arbitration circuit disconnects this path and isolates the μP socket from DMA activity.

Yet another restriction arises when you attempt to mimic the μP used on another emulator/development-system combination. Specifically, emulators can generate μP-timing variations and add propagation delays, clock skews and different drives or loads.

analyzer, for assistance in verifying prototype operation.

During that operation, random faults commonly occur, preventing trigger definition on an invalid condition. A powerful development system, however, can define triggers for a breakpoint whenever the prototype does not meet trigger definition. The prototype's program thus breaks only when the problem occurs. If available externally, the trigger can also arm a logic analyzer or oscilloscope to capture the prototype's status record at the time of the trigger.

Logic analyzers aid real-time checking

When using an emulator, recall that any time the development system displays status information or interrupts the prototype program for other reasons, the program doesn't execute in real time. It proves helpful, then, if an emulator can extract μP-status information on the fly without forcing the μP to execute a system software routine. Unfortunately, emulators for currently available μPs require such routines.

Despite claims to the contrary, all emulators pause momentarily during prototype-program execution while μP-status information passes to the operating system. Only the amount of time spent processing and displaying information varies with different emulators.

Analysis methods that execute externally to the emulator, however, can capture μP information on the fly. One such method uses a dedicated logic analyzer, which monitors the μP bus and records bus transactions as they occur or if they meet predefined trigger conditions.

Design for emulator compatibility

Keep in mind certain prototype-design considerations when planning on using an emulator for product development and debugging (see **box,** "What an emulator can and can't do"). In terms of hardware design, make sure that the emulator's specs define timing skew so that you can design adequate margins into the prototype. Additionally, check that adequate space exists around the μP socket to receive the prototype-control probe.

More importantly, carefully investigate the emulator's transparency (see **box,** "What to look for in an emulator"). The emulator must not require that you avoid certain memory areas or I/O addresses to accommodate its functions.

Inspect the emulator for proper connections to special I/O interfaces that monitor instruction execution in parallel with the μP. Monitoring becomes important when information from development-system memory—corresponding to the μP's data lines—appears on the emulator's probe pins. If the prototype's buffers get turned in the wrong direction, the emulator's buffers will probably win the bus-contention contest. Likewise, should a DMA (direct memory access) or multiprocessor environment exist in the prototype, the emulator must handle the necessary bus arbitration.

In terms of software design, remember that the emulator takes time away from the prototype whenever the development system displays the μP's status. Additionally, whenever the development system must communicate with the emulator's μP, the μP must suspend prototype-program execution for a very short time. One proposed application of a μP involves using a software-refresh program for the prototype's dynamic RAMs. But unless an emulator can assure that its μP acknowledges the interrupts asking for a refresh cycle, its memory continually loses its contents during development-system operations. Note, though, that

A Trace line displays address, data and control-signal activities

prototypes not relying on software refresh of dynamic memory should work with most available emulators.

Processor problems can thwart emulation

Switching the emulator's μP between prototype and development-system operations appears simple. In practice, though, this switching becomes complex. Not all μPs, for example, provide the same interface for their interrupt, address, data and control lines. Additionally, some μPs (such as the 6800 family) don't indicate when an instruction-fetch cycle occurs. For these μPs, the emulator must add hardware to supply this information in order to determine PCLAST and PCNEXT. With other μPs, the emulator can't employ a forced-jump sequence to execute special dump/restore routines. Instead, it must activate the μP with available interrupts.

Still other μPs, such as pipelined types, impose unusual problems. A pipelined μP commonly includes two separate processors and a queue or cache memory. The first (bus-interface) processor fetches instructions and operands from memory and places them in a queue. The second (execution) processor takes instructions from the queue, decodes them and performs the desired functions.

The advantage gained in this configuration? While the execution processor performs an internal register operation that requires no memory access—such as multiplying the contents of two registers—the bus-interface processor can fetch instructions to fill the queue. A full queue frees the memory bus for other uses in a multiprocessor application.

Consider a pipelined processor such as the 8086. With this μP, you're most likely to be interested in true execution information rather than in the activity occurring on the μP's pins. Such information proves important because it follows the program's logic. On the other hand, prefetching by the bus-interface processor accesses instructions that might never be executed (ie, a branch or jump instruction prevents the execution of instructions following it in the queue). The bus-interface processor must therefore clear and refill the queue from the new branched-to location.

Consequently, an emulator must derive current address, data and control information so that breakpoint conditions are met by executed instructions, not by those placed in the pipeline and never executed because of an interrupt or branch.

In addition to emulators, other capable product-development software-debugging and integration tools exist, such as simulators, romulators and partial emulators. However, these tools share a common deficiency—they distort the prototype's environment.

Simulators, devices in which a software program represents the target μP, can't accurately recreate interrupt or internal processor conditions present in the prototype. This drawback becomes critical if you're working on a real-time control application.

Romulators normally provide partial memory or I/O-resource substitution in the prototype by the development system. For these devices, the μP remains in the prototype. And other notable disadvantages exist:

- You must add circuits and jumpers or straps to the prototype to disable its memory and/or buffers, complicating the hardware and software interfaces.
- You can't use the romulator approach with single-chip μCs.

Partial emulators suffer from problems related to deficiencies in user transparency and special μP handling.

Unless future μPs contain debugging capabilities, future emulators will become complex and prohibitively expensive. Current 16-bit-μP families (eg, 8086/8088, Z8001/Z8002 and 68000) provide limited software-debugging capabilities by means of trace bits and software interrupts.

To provide real-time debugging, though, manufacturers might have to incorporate more of the functions that an emulator typically provides into custom emulator

What to look for in an emulator

Before you choose an emulator, carefully check its capabilities. The most significant emulator capability embodies user transparency in the intended application. Transparency in this case refers to the limitations imposed on the prototype's design by the emulator in the following areas (the more transparent the emulator, the fewer the limitations):

- Address range available and restrictions on certain locations
- System-I/O facilities available and restrictions on locations
- Interrupts
- Microprocessor control signals
- Probe timing, including the ability to run at the μP's full rated speed
- Support of the μP's special functions and operating modes, such as internal timers and multiprocessor interfaces.

Also evaluate the emulator's ease of use. Considerations for the uninitiated include design help and tutorial facilities; for the experienced, fast and simple setup and control commands.

Another important consideration encompasses the emulator's operational display. Via a Trace line, this display must indicate the μP registers' contents, disassembled instructions and the emulator's state at a breakpoint. It should also show the memory's information in disassembled mnemonics, ASCII or various number bases. Look for an ample mix of features and complete but simple displays.

Future emulators could become complex without changes in μPs

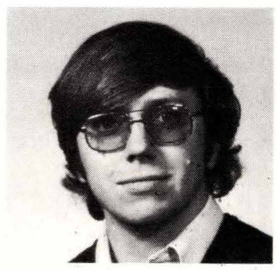
chips. The 8051, for example, requires special bondout options to bring out important status information for use in emulator designs. Moreover, the 8086 and 8088 provide queue-status information when configured for Maximum-mode operation—critical information for the emulator designer to extract.

The 68000, furthermore, calls for an emulator with instruction-fetch and true-execution-information capabilities. Instruction prefetching provides an indication of the approximate execution address when interrupted. This lack of precision stems from the absence of status information provided by the 68000. The lack of externally available internal-queue-status information in turn masks execution activity from both the user and the emulator designer. This μP might thus have to slight the interests of both of them. **EDN**

References

1. Green, E, "Debugging Microprocessors in Real Time," Session 31, 1978 Midcon Professional Program.
2. Miller, G, "Using Microprocessor Development Systems," *Digital Design,* September 1977, pgs 101-104.
3. Miller, G, "Zeroing in on a Universal MDS," *Mini-Micro Systems,* August 1977, pgs 41-47.
4. Carson, J H, "Design of Microprocessor Systems, Section 3, Tools," *IEEE Computer Society,* 1979, pgs 57-170.
5. Francis, R, and Teitzel, R, "Real-Time Analyzer Aids Hardware/Software Integration," *Computer Design,* January 1980, pgs 140-150.
6. Francis, R, "Emulation and Logic Analysis Techniques for the Development of Multiple-Microprocessor Systems," *IMMM Proceedings,* June 1979, pgs 184-190.

Authors' biographies



Mike Mihalik, manager at Tektronix Inc (Beaverton, OR), designs and develops emulators for the firm's 8550 MDL. Before joining Tektronix 6 yrs ago, he earned a BSECE from Clarkson College of Technology. Mike's leisure-time activities include skiing and flying.

Bob Francis is project manager for instrument mainframes at Tektronix. Before starting his 5-yr service with the firm, he received his BSEE and MSEE from Clarkson College of Technology. Bob enjoys photography and home computing in his spare time.

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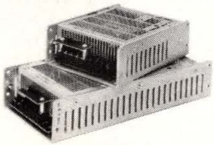

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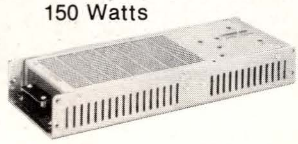

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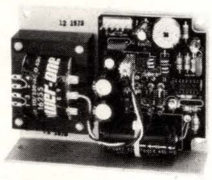

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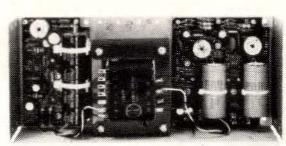

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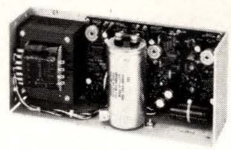

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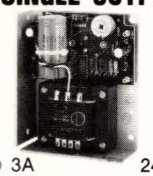

5V @ 3A
12V @ 1.7A
15V @ 1.5A
24V @ 1.2A
28V @ 1.0A
250V @ 0.1A

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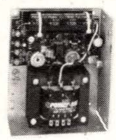

5V @ 6A
12V @ 3.4A
15V @ 3.0A
24V @ 2.4A
28V @ 2.0A
48V @ 1.0A

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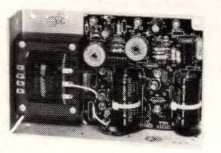

± 12V @ 1.0A or
± 15V @ 0.8A

HAA15-0.8 : $39.95

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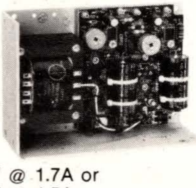

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± 15V @ 1.5A

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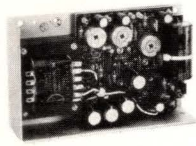

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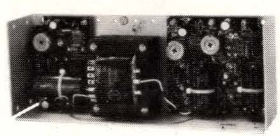

5V @ 3A
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± 15V @ 0.8A

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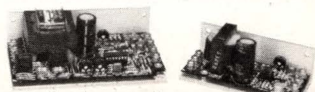

- Indicates pending system power loss.
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CIRCLE NO 64

Digital ICs switch analog phones for high performance, low cost

Advanced semiconductor devices are converting yesterday's analog-only telephone systems to today's digital methods. Your next design can benefit by incorporating these dedicated ICs.

Neil Wellenstein, Motorola Inc

By applying dedicated digital ICs to your next telephone-network design, you can enhance system performance as well as reduce initial development costs and increase overall reliability. And although a typical digital central-office system (**Fig 1**) controls and routes 10,000 phones, this same scheme applies to both larger and smaller installations, including PABX systems.

Fig 1's architecture depends on a central-μP-supervised distributed multichannel concept. The μP coordinates the activities of the channel groups, each of

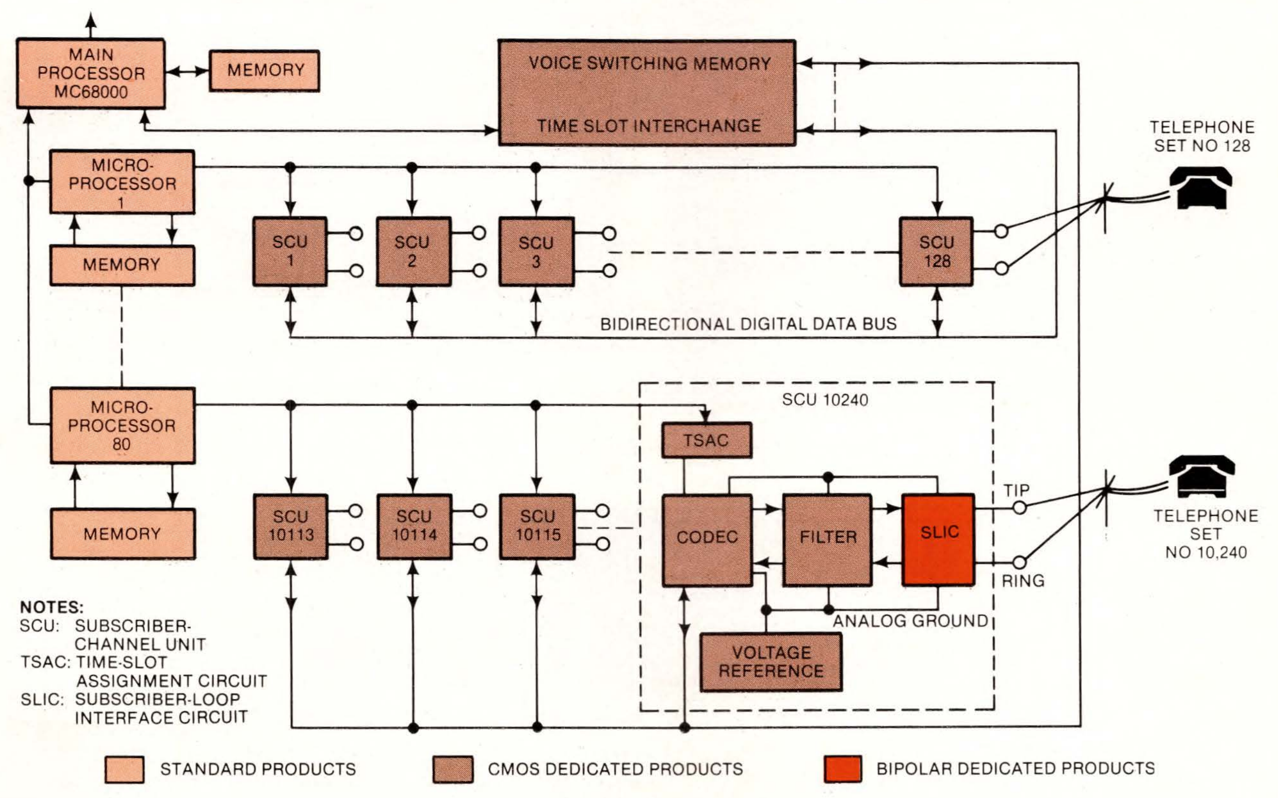


Fig 1—Modern telephone systems *employ μP-controlled digital voice- and status-information-handling techniques. One main processor can oversee the activities of as many as 10,240 subscribers by delegating traffic-handling tasks to subsidiary μPs.*

which handles 128 subscribers. Every channel group is in turn controlled by its own μP. Thus, you can incorporate as many channel groups as your current requirements demand and leave room for future expansion that won't require extensive redesign.

Simplify complex subscriber interfaces

What dedicated ICs make this approach possible and cost effective? Because of the number and functional complexity of required components, a subscriber-channel unit (SCU) contributes the lion's share of the cost of manufacturing—as opposed to developing—a digital switch. But as shown in **Fig 2,** a few dedicated ICs reduce this complex problem to a simple solution.

Four specialized building blocks form the heart of this approach. (You can find a complete description of the devices' functions in the **box,** "Modern telephones: More than a hand crank".) Briefly, **Fig 2**'s SCU performs voice-encoding functions via the MC14407 codec (note the on-chip ADC and DAC). Following this component, the MC14413 filter handles 10-, 20- and 60-Hz rejection along with transmit antialiasing and receive restoration filtering; you can use its on-chip

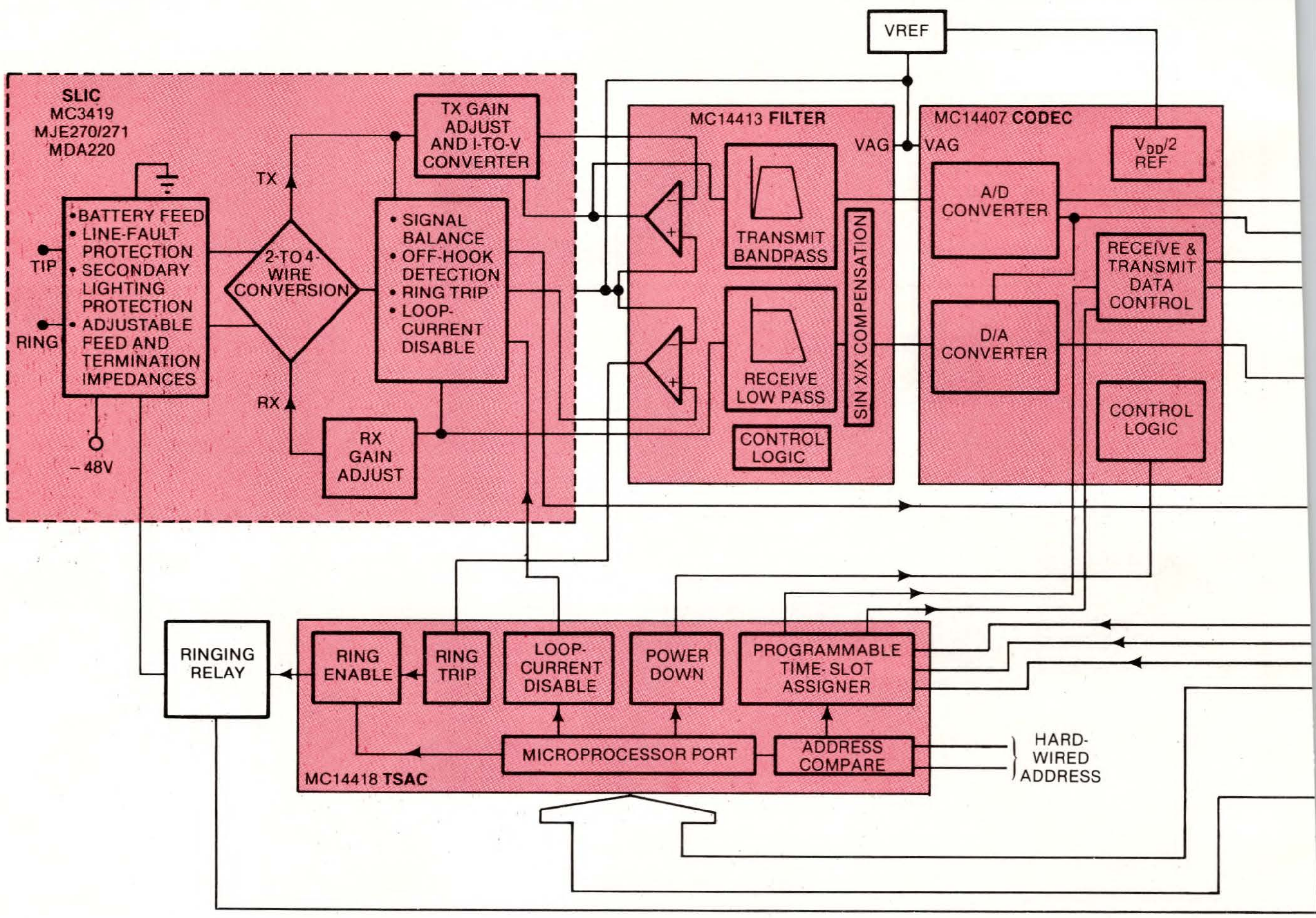
Modern telephones: More than a hand crank

The days are long gone that you can ring up the operator and ask to be plugged into your party. Integrated circuits have not only replaced yesterday's massive matrix-like switchboards, they have also improved quality and reliability of service by taking on tasks no operator could handle.

The building blocks shown in the **figure** handle these diverse tasks. (A more detailed schematic appears in the main text as **Fig 2.**)

The SLIC (subscriber-loop interface circuit) chip performs the standard BORSHT functions (battery, overvoltage, ringing, supervision, hybrid and test). In addition to this dedicated IC, the circuit employs Darlington power transistors, a diode bridge, a current regulator and several resistors and capacitors. These devices, applied in combination, provide a myriad of specialized functions. For example:

- The MC3419 and its associated networks handle the 2-wire-balanced-to-4-wire-single-ended conver-



A few dedicated ICs *perform telephonic functions that previously required many discrete devices. Shown are the operational blocks required to service each subscriber.*

uncommitted op amps for transmit-gain-adjustment and ring-trip functions.

The MC3419 SLIC (subscriber-loop interface circuit) chip meets several diverse requirements, including 2-to-4-wire conversion, battery feed, secondary-lightning and line-fault protection and signal-balancing functions. Finally, under the μP's guidance, the MC14418 TSAC (time-slot assigner circuit) chip governs line-circuit control.

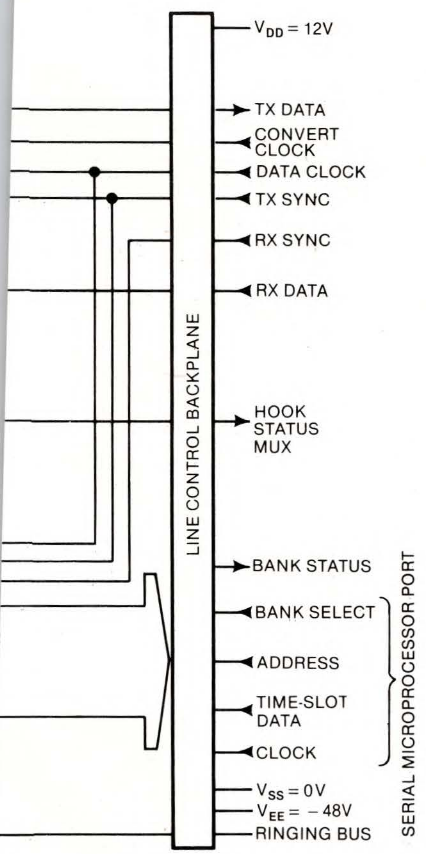
One moment please; I'll connect you

Because all the circuit signals except dc power and ground are digital, you can connect the SCU to the rest of the phone system via a backplane hookup. And because the standard telephone-line voltage is −48V dc, the SLIC, at least, must operate from this source. The codec, filter and TSAC, however, require a 10 to 15V supply. If you use the −12V supply indicated in **Fig 2,** the SCU doesn't require any additional level shifting, and you gain the advantage of CMOS's noise immunity.

Note that a system's channel-group μP might have to interface to 0 and 5V logic levels. In this case, the codec, filter and TSAC require a +12V supply with the TSAC's V_{CC} pin at 5V. Interfacing to the SLIC, however, then requires that you capacitively couple the analog ground (V_{AG}) and level-shift the power-down input (PDI), hook-status output (HSO) and tip-sense

sion that previously required a transformer.

- The diode bridge protects against temporary power-line faults and furnishes protection against 1500V secondary lightning. (And you can further enhance the capability by employing an SCR configuration in lieu of the diodes.)
- The circuit monitors various ring- and tip-current limiting and status functions.



The MC14407 codec encodes voice information. This chip converts the analog input to a digital format in Transmit mode and decodes it back to analog form in Receive mode. Encoding follows the 8-bit μ-Law format, and you can select either μ- or A-Law companding by adjusting the chip's pin 9 input connection. Additionally, this chip provides an isolated analog ground (V_{AG}) for the codec and filter and the SLIC's 4-wire side, minimizing supply-noise pickup and eliminating common-ground crosstalk between channels.

The MC14413 filter IC, a switched-capacitor device, contains two 5-pole elliptic low-pass filters and a 3-pole Chebyshev high-pass filter. Although the transmit-filter sampling rate is 128 kHz, you should band-limit it to 124 kHz to prevent aliasing into the audio band. (Connect the high-pass and one of the low-pass sections in series to achieve the transmit-bandpass function.) The receive filter incorporates a ⅛-duty-cycle, 8-kHz presampler that eliminates the codec's 8-kHz PAM-induced sinX/X distortion. You can use the two on-chip uncommitted op amps to adjust the transmit path's gain and detect off-hook during ringing.

The MC14418 TSAC (time-slot assigner circuit) chip permits the channel-group μP to address and control each of the system's 128 SCUs—four banks of 32 channels—from an 8-bit-wide backplane control bus. One of the four banks is enabled by the appropriate select line (CS_1 through CS_4), and all 32 TSACs in that bank clock in eight bits from the address line (AD) and eight from the data line (DI). One of these TSACs responds to its own address, latches in the time slot and control data, and—via the CTS line—informs the μP that the data has been accepted.

The selected TSAC then sends an enable pulse to the codec at the proper time, and the codec in turn transmits data to and receives data from the digital voice-data bus. In a 32 - channel bank, the data rate equals 2.048M bps. Thus, during each 125-μsec frame, the codec transmits and receives eight voice-data bits. (You can increase the system's capacity to 40 channels by clocking at 2.56 MHz.)

In addition to implementing time slots, the TSAC performs SCU supervisory and control functions. For example, the address's first three bits serve as control bits and determine the logic states of the control outputs, Q_0 through Q_2. You can then employ these signals to control such functions as power down, ring- and test-relay enable and data-path selection.

To receive additional information on these devices, **Circle No 499.**

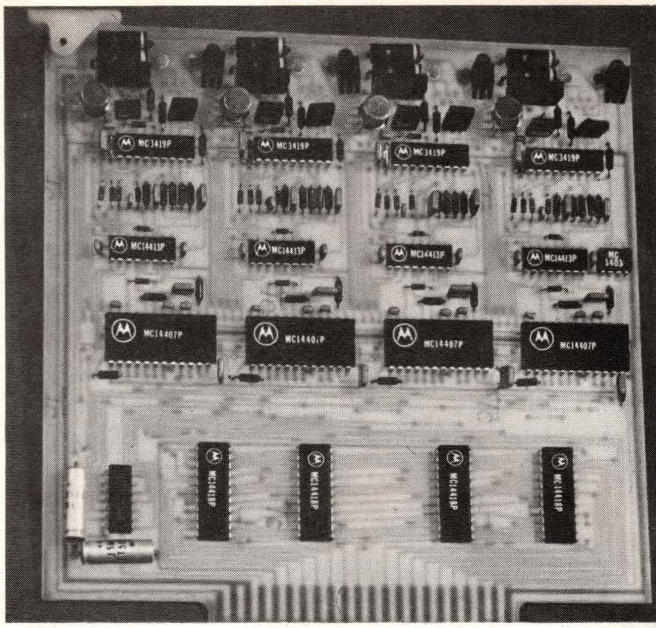


Fig 3—One μP controls four channel banks *of 32 channels each for a total of 128 subscriber lines. Because the μP/TSAC interface requires two frames (250 μsec) to transfer to each channel, the entire 128 channels can be updated every 32 msec. You can mount eight of these cards in a 343-in.[3] space to service 32 customers.*

output (TSO).

In addition to the eight μP bus lines, power and ground, nine other signal lines run on the channel-group backplane. The codec uses one of these signals, Data Clock—which operates at a 2.048-MHz rate in a 32-channel bank—to clock data on and off the lines.

Outgoing information on the backplane is termed TX Data; the incoming signal, RX Data. Tone-signaling data—busy signals, dial or ringing tones, etc—coming to the subscriber over another line is labeled RX Tone. TX Sync and RX Sync establish the beginning of the TX and RX data frames; they need not coincide, but they must be synchronous with Data Clock.

Another backplane signal, Convert Clock, controls the codec's analog-to-digital-conversion sequence; a 128k-bps input yields a 64k-bps full-duplex output. And note that you can control two voice channels (each at 64k bps) by doubling this input to 256k bps to achieve a

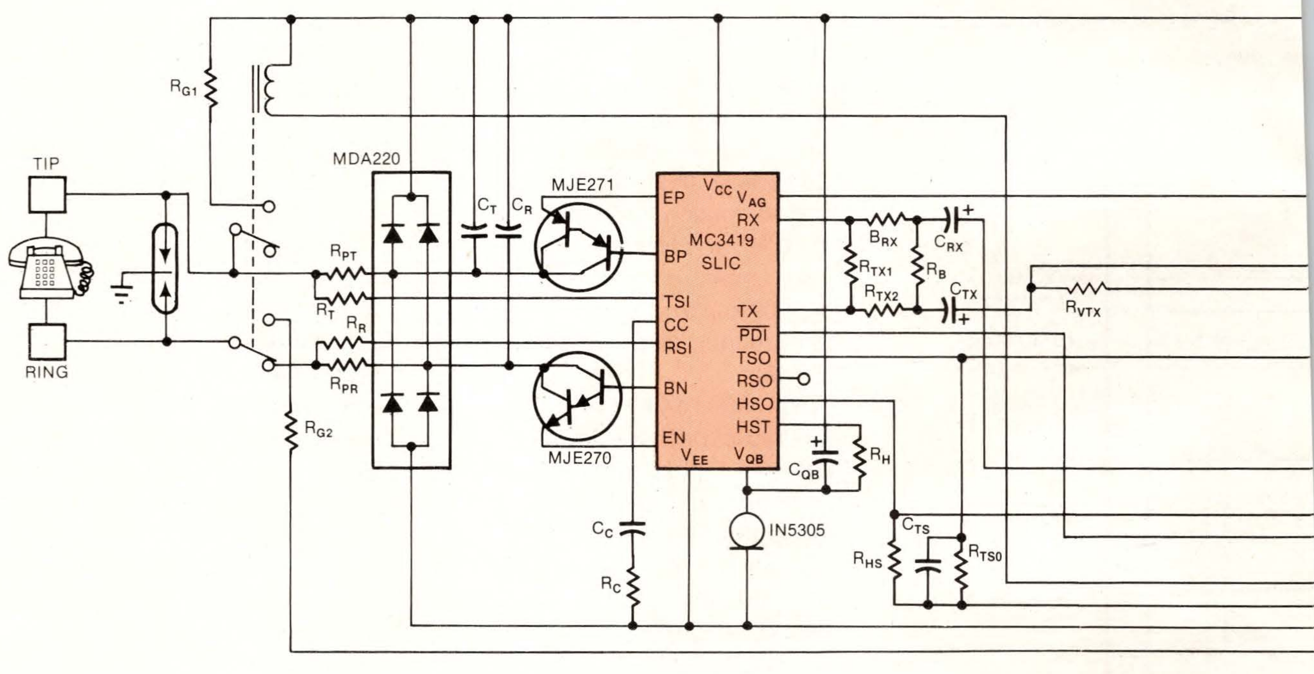
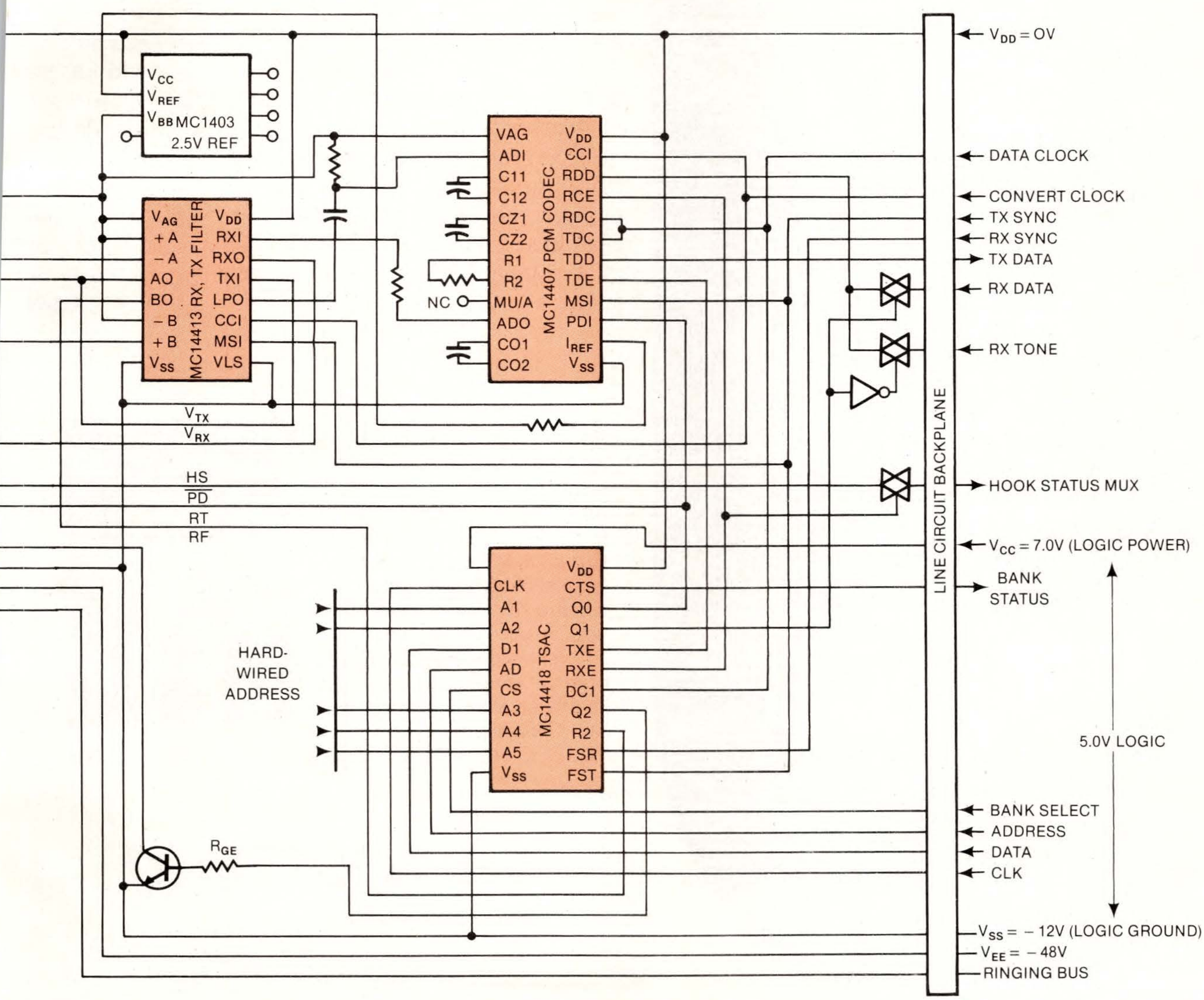


Fig 2—Each subscriber-channel unit (SCU) *employs several dedicated digital ICs to perform critical voice- and status-data handling. In addition to the codec, filter, SLIC and TSAC ICs, the circuit contains several logic-controlled transmission gates, a voltage-regulator IC and a diode-bridge transient arrester.*

TYPICAL END-TO-END PERFORMANCE OF CODEC AND FILTER

(ALL MEASUREMENTS MADE USING HP3779B PCM TEST SET)

SPECIFICATION	TYPICAL PERFORMANCE OF MC1440/4 CODEC AND MC14413 FILTER	BELL SYSTEM D4 VOICE FREQUENCY REQUIREMENTS PUB 43801
CHANNEL SATURATION	+3 dBm0	+3 dBm0
GAIN TRACKING WITH 1-kHz TONE		
+3 TO −40 dBm0	±0.2 dB	≤±0.5 dB
−40 TO −50 dBm0	±0.3 dB	≤±1.0 dB
−55 dBm0	±0 5 dB	≤±3.0 dB
QUANTIZING DISTORTION @ 1 kHz		
+3 TO −30 dBm0	37 dB	≥33 dB
−35 dBm0	34 dB	≥30 dB
−40 dBm0	31 dB	≥27 dB
−45 dBm0	25 dB	≥22 dB
IDLE-CHANNEL NOISE WITH VTX = VAG	16 dBrnc0	≤23 dBrnc0
QUIET CODE NOISE (ALL ONES AT DECODER (RDD) INPUT)	10 dBrnc0	≤15 dBrnc0
FREQUENCY RESPONSE @ 0 dBm0 INPUT		
50-Hz GAIN (RELATIVE TO 1.02 kHz OR 0.820 kHz)	−28 dB	—
60-Hz GAIN	−24 dB	≤−20 dB
200- TO 300-Hz RIPPLE	±0.20 dB	≤±0.3 dB
3400-Hz GAIN	−1.0 dB	≥−3.0 dB
4000-Hz GAIN	−32 dB	≤−28 dB
≥4600-Hz GAIN	<−62 dB	≤−60 dB
SINGLE-FREQUENCY SPURIOUS RESPONSE		
IN BAND WITH INPUT 1 kHz @ 0 dBm	≤−44 dB	≤−40 dB
OUT OF BAND WITH INPUT 0 TO 12 kHz @ 0 dBm	≤−32.5 dB	≤−28 dB
DIFFERENTIAL DELAY DISTORTION		
1150 TO 2300	58 μSEC	≤60 μSEC
1000 TO 2500	72 μSEC	≤100 μSEC
900 TO 2700	91 μSEC	≤200 μSEC



32-channel system occupies a 7-in. cube

3-party conferencing capability. Convert Clock also controls the transmit/receive-filter functions.

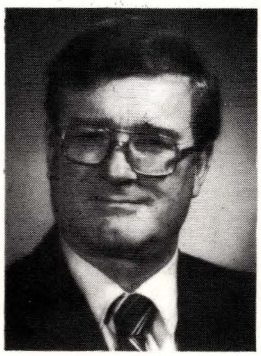
The Hook Status MUX signal indicates hook information to the channel group's μP, and a TSAC-controlled transmission gate puts the information on the bus during the TX time slot assigned to the channel.

Fewer devices yield better specs

Does integrating many highly specialized functions into a few dedicated chips improve a design's performance as well as its cost effectiveness? A look at the **table** provides the affirmative answer. An end-to-end (analog to analog, including two codecs and two filters) performance comparison of this approach's 4-wire portion appears, along with the relevant Bell System specs. As favorable as these results are, the specs that aren't shown are even better. For example, AT&T's *Technical Advisory No 64* specifies that the separation between the transmit and receive paths must equal at least 20 dB. The MC3419 SLIC achieves a minimum value of 23 dB, and if you trim the balance network, you can realize transhybrid rejections greater than 60 dB.

Designing with dedicated ICs carries with it an additional advantage: size reduction. **Fig 3** shows what a 4-channel line card might look like. This design incorporates provisions for ringing, ring trip, hook-status signaling, power-down and transient protection on each channel. Because the PCM "highway" can be clocked at 2.048 MHz, you can combine eight cards into a 32 channel bank and still occupy only 7×7×7 in. of space. **EDN**

Author's biography



Neil Wellenstein, telecommunications marketing development manager for Motorola's Phoenix, AZ Semiconductor Group, is involved with identifying and developing new telecommunications-related products. A Motorola employee for 17 yrs, he obtained his BSEE from the University of Nebraska and an MSEE from Arizona State University. A member of the IEEE, Neil enjoys flying, camping and photography.

Money Grubber

(**mŭn'ē grŭb' br** *org. ME monie: mint; OHG grubilon: to dig* 1. habitual saver of capital, hoarder of funds. 2. cautious investor. 3. budget slasher who calls Leasametric to rent quality general purpose electronic test equipment. *Motto: It's cheaper to rent than to buy.*)

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HP	5150A	Digital Printer
HP	5328A	Universal Frequency Counter
HP	3437A	System Voltmeter
HP	8620C	Sweep Generator
TEK	465B	100 MHz Portable Oscilloscope
TEK	475A	250 MHz Portable Oscilloscope
TEK	7L13	Spectrum Analyzer
Wavetek	164	Function Generator
Dranetz	616B	Power Line Analyzer
Data	I/O 950-0099	System 19 Unipak
Data	I/O 990-1903	System 19

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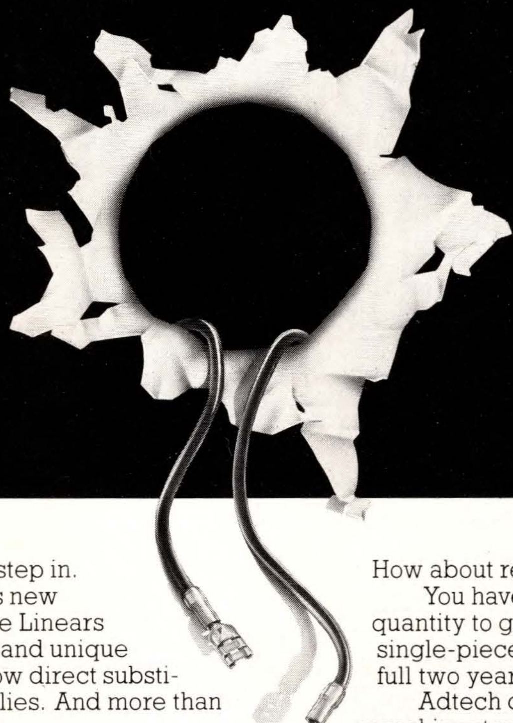

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In fact, our Universal Series gives you several good reasons to change. But judge for yourself.

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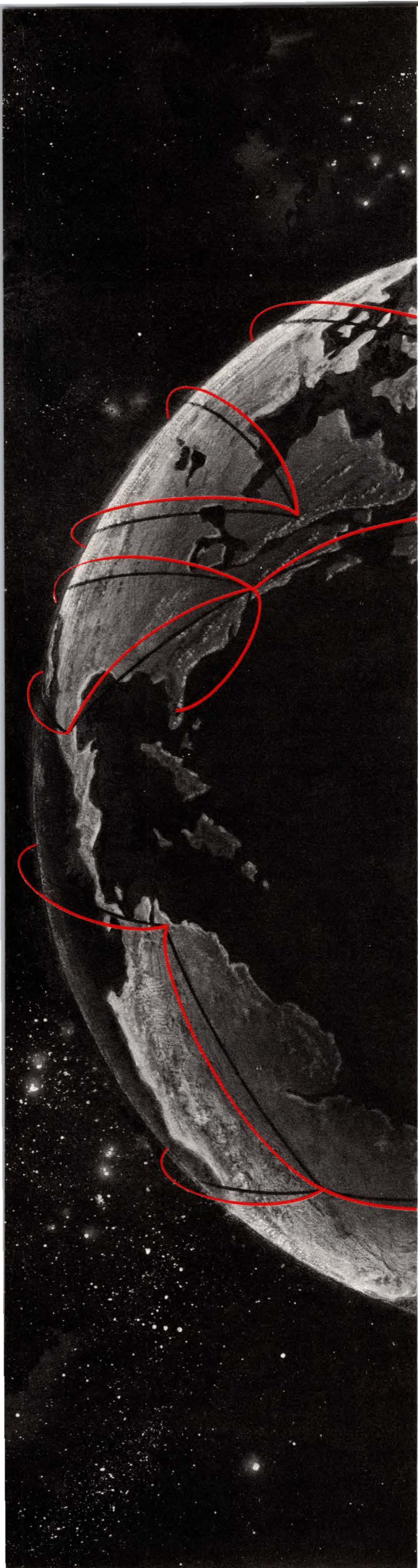
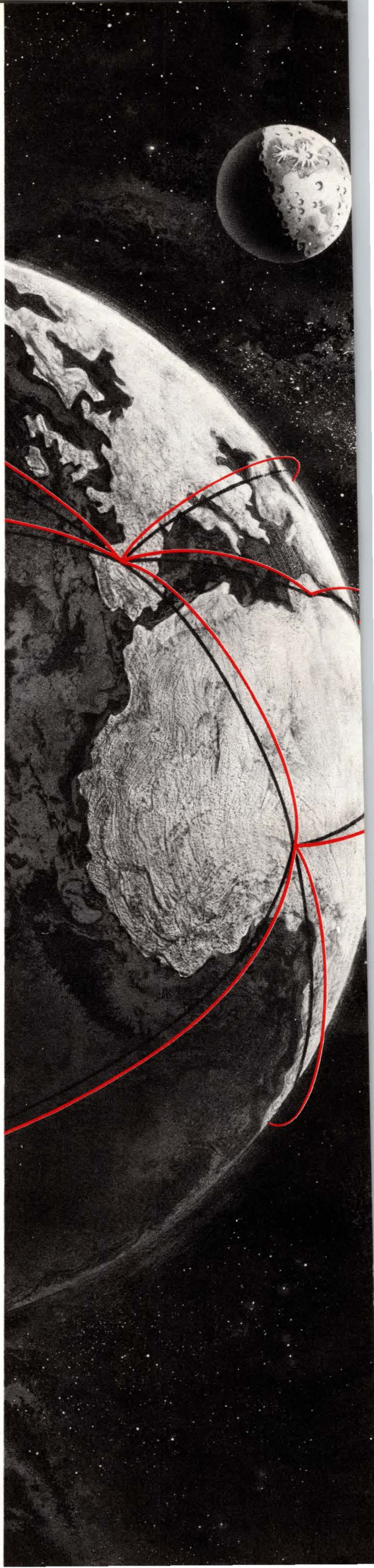
ADTECH POWER

CIRCLE NO 68





Compare μC-bus specs to find the bus you need

When you choose a μC bus, use this guide to match up the capabilities you require with the specs you can get.

Carl Warren, Western Editor

Applying the bus concepts explained in Part 1 of this Designer's Guide (EDN, May 27, pg 158) and the profiles of specific buses presented in this installment and the final one can help you turn complex system-design problems into straightforward tradeoffs.

In this part of the guide, you'll find the detailed specs—mechanical and electrical—for three 8-bit μC buses: the Exorciser bus, the S-100 and the STD Bus. Part 3, to appear in a subsequent issue of EDN, will contain information on four high-performance buses: the Multibus, P896 futurebus, Versabus and Z-Bus.

Consider four application areas

For an overview of the highly segmented market for bus-related products, consider the four application areas shown in **Fig 1.** High-end industrial applications

Text continues on pg 144

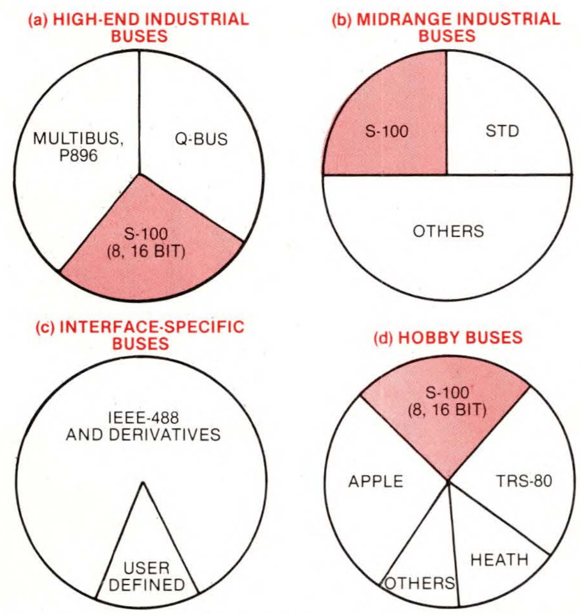


Fig 1 — Bus application areas

Fig 2 — Bus Checklist

CRITERION	DESIRED FEATURE
1. NUMBER OF PHYSICAL LINES	______
2. DATA-FIELD WIDTH	______
3. TRANMISSION MECHANISM (PARTIALLY) MULTIPLEXED, FULL PARALLEL)	______
4. SYSTEM GEOMETRY (ONE PC BOARD, ONE CRATE (HOUSING), SEVERAL CRATES)	______
5. ACCESS TO MEMORY AND I/O (METHOD)	______
6. MULTIPROCESSOR CAPABILITY	______
7. NUMBER OF REDUNDANT TRANSMISSION PATHS	______
8. ADDRESS-LINES WIDTH (WILL MULTIPLEXING BE USED?)	______
9. DATA-LINES WIDTH (WILL MULTIPLEXING BE USED?)	______
10. NUMBER OF CONTROL LINES	______
11. NUMBER OF TIMING LINES	______
12. EXTRA LINES (FOR FUTURE USE)	______
13. POWER LINES	______
14. DATA-LINE USE (UNIDIRECTIONAL, BIDIRECTIONAL)	______
15. ADDRESS EXPANSION (POSSIBLE? TO WHAT EXTENT?)	______
16. MAXIMUM NUMBER OF DEVICES THE BUS SUPPORTS ELECTRICALLY	______
17. MAXIMUM NUMBER OF DEVICES SUPPORTED BY ADDRESSING CAPABILITY	______
18. DATA TRANSFERS (ASYNCHRONOUS, SYNCHRONOUS)	______
19. MULTIPLE OPERATIONS REQUIRED	______ *
20. CARD SIZES REQUIRED	______ **

NOTES:

*SOME SYSTEM DESIGNS REQUIRE ONLY SINGLE OPERATIONS. HOWEVER, IN MULTIPROCESSOR SYSTEMS, THE BUS MUST HANDLE FUNCTIONS SUCH AS MULTIPLE UNINTERRUPTIBLE OPERATIONS, MULTIPLE INTERRUPTIBLE OPERATIONS AND MULTIPLE-SOURCE READS AND WRITES.

**THE CARD SIZE THAT FITS ON THE BACKPLANE BUS CAN BE CRITICAL. THIS CARD DETERMINES HOW MUCH REAL ESTATE A DESIGNER CAN EMPLOY TO IMPLEMENT A FUNCTION OR FUNCTIONS. IN SOME DESIGNS, SUCH AS THE STD BUS, EACH BOARD PERFORMS ONLY ONE FUNCTION, THUS PERMITTING SMALL BOARD SIZES. HOWEVER, IN SYSTEMS THAT USE HIGH-PERFORMANCE BUS ARCHITECTURES, EACH BOARD IMPLEMENTS MANY FUNCTIONS, THUS CALLING FOR MORE REAL ESTATE.

BUS FEATURES

	APPLE	CYBERBUS	EUROBUS	EXORCISER	FASTBUS	HEATH	IEEE-488
NUMBER OF LINES SPECIFIED/AVAILABLE	50/50	72/72	64/64	43/43	/86+4	50/50	48/48
DATA-FIELD WIDTH	8	16	18	8	32	8	8
TRANSMISSION MECHANISM (PM=PARTIALLY MULTIPLEXED, FP=FULLY PARALLEL)	FP	FP	PM	PM	PM	PM	FP
SYSTEM GEOMETRY (PC=ONE PCB, OC=ONE CRATE, SC=SEVERAL CRATES)	OC	OC	SC	OC	OC	OC	—
UNIFIED ACCESS TO MEMORY AND I/O?	Y	Y	Y	Y	Y	Y	—
MULTIPROCESSOR CAPABILITY?	Y	Y	Y	N	Y	N	—
REDUNDANT TRANSMISSION PATHS SPECIFIED?	N	Y	N	Y	N	N	—
ADDRESS LINES WIDTH (M=MULTIPLEXED)	16	18,M	18,M	16,M	32,M	16	8,M
DATA LINES WIDTH (M=MULTIPLEXED)	8	16,M	18,M	8	M	8,M	8,M
CONTROL LINES	3	19	7	8,M	9	11	8
TIMING LINES	3	6	5	15	7	2	1
LINES OTHERWISE SPECIFIED	2	13	9	10	25	0	—
RESERVED LINES	1	0	0	2	?	0	—
FREE-USE LINES	1	0	9+62	8	?	0	—
POWER LINES (M=MULTIPLE)	4	10,M	16,M	11,M	4	4	—
DATA-LINE USE (U=UNIDIRECTIONAL, B=BIDIRECTIONAL)	B	B	B	B	B	B	B
ADDRESS EXPANSION POSSIBLE?	N	Y	N	Y	N	N	N
MAXIMUM EXPANDED ADDRESS FIELD	—	18	—	—	—	—	—
MAXIMUM NUMBER OF DEVICES BY ELECTRICAL DRIVE CAPABILITY	8	24	20	14	20	10	—
MAXIMUM NUMBER OF DEVICES BY DEVICE ADDRESSING CAPABILITY	256	2^{16}	—	256	20	256	—
BUS-ACCESS MANAGEMENT—CENTRALIZED?	Y	Y	Y	Y	—	Y	Y
—DAISY CHAIN?	Y	Y	N	Y	—	N	N
—PARALLEL POLLING?	N	N	N	N	—	N	—
—SERIAL POLLING?	N	N	N	N	—	N	—
—DIRECT LINES?	N	Y	Y	Y	Y,CODED	Y	—
—OTHER?	N	N	N	—	—	N	—
PROGRAM-INTERRUPT MANAGEMENT—CENTRALIZED?	Y	Y	Y	Y	—	Y	—
—DAISY CHAIN?	Y	Y	N	Y	—	N	—
—PARALLEL POLLING?	N	N	N	N	—	N	—
—SERIAL POLLING?	N	N	N	N	—	N	—
—DIRECT LINES?	N	Y	N	Y	—	Y	—
—OTHER METHODS?	N	N	N	—	Y	N	—
MAXIMUM TIMES FOR A SINGLE REQUEST—BUS-ACCESS DETECTION (AS=ASYNC)	300 nSEC	AS	—	500 nSEC	?	AS	—
—PROGRAM INTERRUPT DETECTION	Y	—	—	500 nSEC	?	1INST	—
—PROGRAM INTERRUPT LATENCY	—	—	—	1INST	?	1INST	—
—PROGRAM INTERRUPT PROCESSING	—	N	—	1INST	N	2INST	—
DATA-TRANSFER TYPE—SYNCHRONOUS (FIXED TIMING)?	Y	Y	N	N	Y	Y	—
—ASYNCHRONOUS?	N	N	N	N	N	N	—
—SYNCHRONIZED (HANDSHAKE)?	Y	N	N	Y	N	N	Y
SINGLE OPERATIONS ONLY?	Y	N	N	—	N	Y	Y
MULTIPLE UNINTERRUPTIBLE OPRATIONS?	N	Y	N	N	Y	N	—
MULTIPLE INTERRUPTIBLE OPERATIONS?	N	Y	—	N	Y	N	—
MULTIPLE-SOURCE READ?	N	Y	Y	N	Y	N	—
MULTIPLE-DESTINATION WRITE?	N	N	Y	N	N	N	—
DISTINCTION BETWEEN BYTE/WORD TRANSFER?	N	Y	N	Y	N	N	—
SPECIAL LINES — HOLD?	N	Y	N	Y	Y	Y	Y
—WAIT?	Y	Y	Y	Y	N	Y	Y
—INITIALIZE-RESET?	Y	Y	Y	Y	N	Y	Y
—POWER FAIL/WARNING?	Y	Y	Y	Y	N	N	—
—INTERRUPT REQUEST?	N	Y	N	Y	N	Y	—
—INTERRUPT ACKNOWLEDGE?	Y	Y	N	Y	N	Y	—
—OTHERS?	Y	Y	N	—	N	N	—
LINES FOR HANDLING ERRORS—TRANSMISSION ERRORS?	N	N	N	Y	Y	N	—
—OPERATIONAL (USER ERRORS)?	N	Y	Y	—	N	N	—

NOTES:

SOME TABLE ENTRIES ARE BASED ON THE MICRPROCESSOR BUS EVALUATION PREPARED BY THE MULTIPROCESSOR/MULTITASK SUBGROUP OF THE EUROPEAN DISTRIBUTED INTELLIGENCE STUDY GROUP, SUPPLIED COURTESY MICROSCOPE MAGAZINE. OTHER DATA WAS GATHERED FROM MANUFACTURERS' DATA SHEETS AND BUS MANUALS.

*P896 HAS TWO LEVELS, 1 AND 2. LEVEL-1 LINES ARE 64 SPECIFIED/64 AVAILABLE AND LEVEL 96 SPECIFIED/96 AVAILABLE.

THE LEVEL-2 DESIGN IS STILL UNDER REFINEMENT, AND LEVEL 1 IS BEING REVISED TO EXACT

MODUS	MICROBUS	MUBUS	MULTIBUS	NOVA GPIB	P896	Q-BUS	STD BUS	SS50C	S-100 (8-BIT)	S-100 (16-BIT)	VERSABUS	Z BUS
18/	29/—	62/62	86/86	48/48	*	72/72	56/56	50/49	82/100	82/100	140/132	96/96
16	8	16	16/32	16	32	16	8	8	8	16	16/32	16
PM	FP	FP	FP/PM	FP	FP	PM	FP	PM	FP	PM	FP	PM
OC	OC	OC	OC	SC	OC	SC	OC	OC	OC	OC	OC/SC	?
Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N	Y	N
Y	N	Y	Y	Y	Y	Y	Y	N	—	—	Y	Y
Y	N	N	N	Y	Y	N	N	N	N	N	Y	N
16,M	16	16	16	—	32,M	16,M	16	16	16	16	16/32	32,M
16,M	8	16	16	16	32,M	16,M	8	8,M	16	16	16/32	32,M
16,M	5	20	15	16	UND	16	22	11	40	35	18	28
2	—	6	2	1	UND	1	—	2	4	2	4	3
—	—	2	8	—	UND	2	—	1	—	—	9	7**
—	—	2	7	—	UND	13	0	1	—	—	8	2
—	—	0	0	—	6	8	0	0	25	25	10	0
2	—	10,M	24,M	—	M	16,M	10,M	3	6,M	6,M	20,M	21
U/B	B	B	B	B	B	B	B	B	U	B	B	B
Y	Y	N	Y	—	Y	N	—	Y	Y	N	Y	Y
12×64	—	—	20	—	32	—	—	—	—	—	32	24
32	10	20	8	—	32	15	—	15	20	20	24	—
50	—	—	256	—	2^{32}	4096	—	256	256	256	2^{32}	—
Y	Y	N	Y	Y	—	Y	—	N	Y	Y	Y	N
—	—	Y	Y	Y	S	Y	Y	Y	N	N	Y	Y
Y	—	N	N	—	T	N	—	N	N	N	N	N
—	—	N	N	—	I	N	—	N	N	N	N	Y
—	—	N	N	—	L	N	—	Y	Y	Y	Y	N
—	—	N	N	—	L	N	—	N	N	N	N	—
μPDEP	—	—	N	Y		Y	N	Y	Y	Y	Y	N
—	—	—	N	Y	I	Y	N	N	—	—	Y	Y
Y	—	—	N	—	N	N	N	N	—	—	N	N
Y	—	—	N	—		N	N	N	—	—	N	Y
—	—	—	Y	—	P	N	N	Y	Y	Y	Y	N
—	—	—	N	—	L	N	N	N	—	—	N	Y
400 nSEC	—	—	100 nSEC	300 nSEC	A	AS	—	500 nSEC	—	—	30 nSEC	50 nSEC
800 nSEC	—	—	50 nSEC	300 nSEC	N	AS	—	1INST	—	—	1INST	50 nSEC
—	—	—	1INST	—	N	18 μSEC	—	1INST	—	—	1INST	95 nSEC
—	—	—	1INST	—	I	16 μSEC	—	VARIES	—	—	30 nSEC	25 nSEC
Y	—	N	N	Y	N	N	—	Y	—	—	Y	N
—	—	Y	N	N	G	Y	—	N	Y	Y	Y	N
—	—	N	Y	N		N	—	N	—	—	Y	Y
—	—	N	N	—	O	N	—	Y	—	—	N	N
Y	—	N	Y	Y	R	Y	—	N	—	—	Y	N
—	—	Y	N	Y		N	—	N	—	—	Y	Y
Y	—	—	N	Y	R	N	—	N	—	—	Y	N
Y	—	—	N	Y	E	N	—	N	—	—	Y	Y
Y	N	N	N	Y	V	Y	N	N	N	Y	Y	Y
N	—	Y	Y	Y	I	Y	N	N	Y	Y	Y	N
N	N	Y	Y	Y	S	Y	Y	Y	N	N	Y	Y
N	Y	Y	Y	Y	I	Y	Y	Y	Y	Y	Y	Y
N	N	N	N	Y	O	Y	N	Y	Y	Y	Y	N
N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
N	—	Y	N	Y		Y	Y	Y	Y	Y	Y	Y
N	—	N	N	Y		Y	N	N	Y	Y	Y	Y
N	N	N	N	Y		N	N	Y	N	N	Y	N
N	N	N	N	Y		N	N	N	N	N	Y	N

PIN-OUTS.

**MEMORY AND I/O SEGMENTATION (128 SEGMENTS)

? = UNRESOLVED

— = NOT APPLICABLE OR UNDEFINED

1INST = ONE INSTRUCTION

2INST = TWO INSTRUCTIONS

μPDEP = μP DEPENDENT

Check your bus needs against available specs

are dominated by the Intel Multibus; the midrange industrial segment is currently shared by the STD Bus and S-100 bus; interface-specific applications depend almost solely on the IEEE-488 bus; and the low-end hobby-bus arena is very segmented. The latter group encompasses a tremendous variety of bus architectures and offers many special design and marketing opportunities to OEM designers.

Note in **Fig 1** that the S-100 bus falls into three of the four market segments. Although disliked by some designers, this bus has enjoyed an extremely high level of popularity among industrial and hobby designers alike. And its recent standardization as IEEE-696 has boosted its acceptance as a low-cost method of implementing high-performance μC systems in a variety of applications.

Possibly even more interesting to small-systems designers is the fact that in the hobby-bus segment, the TRS-80, Apple and Heath buses share the market almost equally. This hobby segment represents well over 500,000 machines, as reported by a recent *Popular Electronics* poll (conducted by Market Probe International in January 1981), plus an untold number of cottage-industry manufacturers supporting various hobby systems.

The μC market is huge. Market projections indicate that well over a million hobby systems will be in use by late next year, for example, with Heath/Zenith selling approximately 2500 units a month and Radio Shack selling more than twice that number. Moreover, industry analysts peg the total number of μC-based systems at about two million and growing at approximately 200% per year.

Thus, you can imagine the growing market for system add-ons. By choosing your basic system design carefully, you can either tap existing markets or fill gaps that arise as the market grows.

Use a bus checklist to compare specs

To aid in such tasks, you can utilize a bus checklist (**Fig 2**) adopted from *MicroScope* magazine (Lausanne, Switzerland). To make the most of this list, compile your bus requirements and compare them with the specifications shown in the following bus guides and those in Part 3. Be aware, however, that no one bus can meet all your requirements and that you must make some tradeoffs.

To facilitate its usefulness, this part of the Designer's Guide includes an evaluation **table** covering several popular buses. Based on a table compiled by W Mahr for the Multiprocessor/Multitask Subgroup of the European Distributed Intelligence Study Group (November 29, 1978), the **table** presented here contains extensive additions. It does, however, rely on the study-group notes for both tabular and bus-guide information.

The detailed specs presented on the following pages cover three of the 8-bit buses in the **table** that suit three types of μC applications: The Exorciser bus was designed primarily for use in development systems; the S-100 bus evolved from hobby status to a prominent place among more generally applicable buses; and the STD Bus employs single-function cards that implement specific system needs. **EDN**

For more information...

For more information on the buses listed in the **table** but not covered in a detailed-spec section, contact the following sources.

Apple bus
Apple Computer Inc
10260 Bandley Dr
Cupertino, CA 95014
(408) 996-1010

Cyberbus
Cybersystems Inc
8300 Whitesburg Dr South
Huntsville, AL 35802
(205) 883-4410

Eurobus, Fastbus, Microbus, Modus, Mubus
Prof J D Nicoud
Mini and Microcomputer Lab
Swiss Federal Institute of Technology
Bellerive 16 Ch-1007
Lausanne, Switzerland
(41) (21) 472642/472686

H8
Heath Co
Benton Harbor, MI 49022
(616) 982-3200

IEEE-488
Hewlett-Packard Co
1000 NE Circle Blvd
Corvallis, OR 97330
(503) 757-2000

Nova GPIB
Data General Corp
4400 Computer Dr
Westboro, MA 01580
(617) 366-8911

Q-bus
Digital Equipment Corp
1 Iron Way
Marlboro, MA 01752
(617) 467-5780

SS50C
Southwest Technical Products
219 W Rhapsody
San Antonio, TX 78216
(512) 344-0241
or
Gimix Inc
1337 W 37th Pl
Chicago, IL 60609
(312) 927-5510

EXORCISER II

SOURCE

Motorola Microsystems
3102 N 56th St
Phoenix, AZ 85018
Phone (602) 244-5557

GENERAL INFORMATION

The Exorciser II μC bus is an 8-bit-wide bus with 16 address paths. The standard mother board as defined by Motorola supports as many as 14 separate system modules and incorporates an embedded groundplane to meet high-speed μPs' high-noise-immunity requirements. Additionally, eight lines are present for user-defined applications, thus making the bus ideal for numerous 8-bit uses.

BUS SIGNALS

PIN NUMBER	SIGNAL MNEMONICS	SIGNAL NAME AND DESCRIPTION
A, B, C	+5 VDC	+5V dc Power—Used for the system's logic circuits and available to users for prototype-module requirements (15A total max).
D	$\overline{\text{IRQ}}$	Interrupt Request—A LOW-level-sensitive input signal to the MPU II Module used to request generation of an MPU interrupt sequence. The MPU waits until it completes the instruction being executed before it recognizes the request. At that time, if the interrupt mask bit in the MPU Condition Code Register is not set, the MPU begins executing the interrupt sequence.
E	$\overline{\text{NMI}}$	Nonmaskable Interrupt—A LOW-going, edge-sensitive input signal to the MPU II Module used to request generation of MPU nonmaskable-interrupt sequence. The MPU waits until it completes the instruction being executed before it recognizes the request. At that time, regardless of the logic state of the Interrupt Mask bit in the MPU Condition Code Register, the MPU begins executing the nonmaskable interrupt.
F	VMA	Valid Memory Address—A HIGH-level, TTL-compatible signal produced by the MPU II Module and used to indicate to the Debug II Module that a valid memory address is present on the address bus.
H	—	Not used—Reserved for system expansion.
J	ϕ_2	Phase 2—One of the biphase clock signals generated by the clock circuit on the MPU II Module.
K	GND	Ground—Power ground for ±12V dc.
L	MEM CLK	Memory Clock—An ungated, TTL-level ϕ_2 clock signal used to refresh all dynamic-RAM modules within the system.
M	−12 VDC	−12V dc Power—Available to users for custom-designed prototype modules (1.5A max).
N	$\overline{\text{TSC}}$	3-State Control—This input signal to the MPU II Module, when HIGH, places all the address and data lines on the module into their OFF or high-impedance state. The VMA and BA signals go to their OFF or high-impedance state. Because the MPU is a dynamic device, it should not be held in the 3-state Control mode for more than 4.5 msec.
P	BA	Bus Available—A normally LOW-level output signal from the MPU II that, when activated, goes HIGH to indicate that the MPU has halted and the address bus is available. This condition occurs whenever the GO/HALT signal is in the HALT (LOW) state or the MPU is in the Wait state as a result of executing a Wait instruction. When this sequence occurs, all MPU 3-state output drivers go to their OFF (high-impedance) state and other outputs to their normally inactive state. A maskable or nonmaskable interrupt removes the MPU from the Wait state.
R	MEM RDY	Memory Ready—A signal generated by the user that permits the Exorciser II to work with slow memory modules. When this signal is LOW, the ϕ_1 and ϕ_2 clock signals are stretched, with the ϕ_1 signal held LOW and ϕ_2 signal held HIGH for one clock cycle. After one clock cycle has elapsed, the MEM RDY signal is made HIGH, thus enabling the clock to once again generate the ϕ_1 and ϕ_2 clock signals at the normal operating frequency.
S	—	Not used—Note: The original Exorciser 8k Dynamic-RAM Module (MEX6815-1) used this line for refresh control. However, this signal is now considered obsolete. Motorola reserves this line for system expansion.
T	+12 VDC	+12V dc Power—Available to users for custom-designed prototype modules (2.5A max).
U	STANDBY	Standby Power—This line is reserved for use with battery-backup memory modules. If battery backup is not required, the Standby line is not used.
V	$\overline{\text{PWR FAIL}}$	Power Fail—This signal line is reserved for use with memory modules requiring battery backup. When used, this LOW-level signal disables the protected memory module. (The Exorciser II does not provide this feature.)
W	$\overline{\text{PARITY-ERR}}$	Parity Error—This signal line is normally held HIGH by the Debug II Module. If a memory module that incorporates a parity-check circuit is used within the Exorciser II and a parity error is detected, this signal will be forced LOW for one clock cycle.
X, Y, Z	GND	Ground
$\overline{\text{A}}$	—	Not used—Reserved for system expansion.
$\overline{\text{B}}$	GND(REF)	Reference Ground—Available to users for prototype modules that require an isolated ground. This ground line is not connected to the normal Exorciser II ground connection.
$\overline{\text{C}}$, $\overline{\text{D}}$, $\overline{\text{E}}$, $\overline{\text{F}}$	—	User defined—These signal lines, along with their counterpart pin numbers (25, 26, 27 and

		28), are reserved by Motorola for possible expansion of the data bus to 16 bits. Because compatibility of 16-bit data-bus modules with existing modules is unlikely, these eight lines can be used for custom modules.
$\overline{H}$	$\overline{D3}$	Data bus (bit 3)—One of eight bidirectional data lines used to provide a 2-way data transfer between the MPU II Module and all other plug-in modules within the system. The data-bus drivers on the other modules are in their OFF or high-impedance state except when selected during a memory read or write operation.
$\overline{J}$	$\overline{D7}$	Data bus (bit 7)
$\overline{K}$	$\overline{D2}$	Data bus (bit 2)
$\overline{L}$	$\overline{D6}$	Data bus (bit 6)
$\overline{M}$	A14	Address bus (bit 14)—One of 16 address lines from the MPU II Module that permits the MPU to select any addressable memory location within the Exorciser II.
$\overline{N}$	A13	Address bus (bit 13)
$\overline{P}$	A10	Address bus (bit 10)
$\overline{R}$	A9	Address bus (bit 9)
$\overline{S}$	A6	Address bus (bit 6)
$\overline{T}$	A5	Address bus (bit 5)
$\overline{U}$	A2	Address bus (bit 2)
$\overline{V}$	A1	Address bus (bit 1)
$\overline{W}$, $\overline{X}$, $\overline{Y}$	GND	Ground
1, 2, 3	+5 VDC	+5V dc Power—Used for the system's logic circuits and available to users for prototype-module requirements (15A total max).
4	G/H	Go/Halt—When this input to the MPU II Module is HIGH, the MPU fetches the instruction addressed by the program counter and starts instruction execution. When LOW, all activity in the MPU halts. This input is level sensitive. In Halt mode, the MPU stops at the end of an instruction, the Bus Available signal goes HIGH, the Valid Memory Address signal and all other 3-state lines change to their OFF or high-impedance state.
5	$\overline{\text{RESET}}$	Reset—This buffered input/output signal to/from the MPU II Module is used to restart the Exorciser II when power is initially applied. Restart occurs on the LOW-to-HIGH transition of the Restart signal. If the Restart pushbutton switch, located on the front panel of the Exorciser II, is depressed while the system is operating, the LOW-to-HIGH transition of Reset signal causes the MPU II Module to execute the Exbug restart routine or the restart routine indicated by the user.
6	R/W	Read/Write—This signal is generated by the MPU II Module and indicates to the other system modules that the MPU is performing a memory-read (HIGH) or -write (LOW) operation. This signal's normal standby state is read (HIGH). Additionally, when the MPU is halted, this signal is in read state.
7	ϕ_1	Phase 1—One of the biphase clock signals generated by the clock circuit on the MPU II Module.
8, 9	GND	Ground—Power ground for ±12V dc.
10	VUA	Valid User's Address—This signal is produced by the Debug II Module. When HIGH, it indicates that the address on the address bus is valid and the MPU II Module is not addressing the Exbug program.
11	−12 VDC	−12V dc Power—Available to users for custom-designed prototype modules (1.5A max).
12	$\overline{\text{REF REQ}}$	Refresh Request—This input signal to the MPU II Module, when LOW, initiates a memory refresh cycle of the dynamic-memory modules. During refresh operation, the clock is inhibited from generating its ϕ_1 (held HIGH) and ϕ_2 (held LOW) clock signals. During a refresh operation, however, the MEM CLK signal is still generated to provide the necessary refresh clock.
13	REF GRANT	Refresh Grant—This output signal from the MPU II Module, when HIGH, instructs the dynamic-memory modules to refresh their memories.
14	$\overline{\text{DEBUG}}$	Debug—This LOW-level signal from the Debug II Module indicates to the MPU II Module that the Debug Module is installed in the Exorciser II. The signal is used to determine whether the Valid User's Address (VUA) signal is controlled by the Debug II Module or the MPU II Module. When the Debug II Module is not used, the MPU II Module forces this signal line HIGH.
15	TSG	3-state Grant—This signal is generated by the MPU II Module in response to a 3-state Control request ($\overline{\text{TSC}}$). During normal operation, the TSG signal is LOW. During a 3-state operation, it is made HIGH.
16	+12 VDC	+12V dc Power—Available to users for custom-designed prototype modules (2.5A max).
17	STANDBY	Standby Power—Same as Standby on Pin U.
18	CLOCK	Clock—A free-running, symmetrical clock signal generated on the MPU II Module and available to peripheral modules that require a clock unaffected by MPU and/or memory timings. This clock signal has the same frequency as MEM CLK, but is not stretched during slow memory operations (initiated by the MEM RDY signal on Pin R).
19	VXA	Valid Executive Address—A HIGH-level signal generated by the Debug Module in place of the VUA signal (refer to description of VUA on Pin 10) when the Exorciser II is operating in the Dual Map Mode and the Exbug Program is addressing the memory map's Executive portion. Additionally, all peripheral modules (such as memories) must be set to respond to VXA to permit operation of those modules in the Executive portion of the map.

20, 21, 22	GND	Ground
23	—	Not used—Reserved for system expansion.
24	GND(REF)	Reference Ground—Available to users for prototype modules that require an isolated ground. This ground line is not connected to the normal Exorciser II ground connection.
25, 26	—	User defined—These signal lines, along with their counterpart pin numbers ($\overline{C}$, $\overline{D}$, $\overline{E}$ and $\overline{F}$) are reserved by Motorola for possible data-bus expansion to 16 bits. Because compatibility of 16-bit data-bus modules with existing modules is unlikely, these eight lines can be used for custom modules.
29	$\overline{D1}$	Data bus (bit 1)
30	$\overline{D5}$	Data bus (bit 5)
31	$\overline{D0}$	Data bus (bit 0)
32	$\overline{D4}$	Data bus (bit 4)
33	A15	Address bus (bit 15)
34	A12	Address bus (bit 12)
35	A11	Address bus (bit 11)
36	A8	Address bus (bit 8)
37	A7	Address bus (bit 7)
38	A4	Address bus (bit 4)
39	A3	Address bus (bit 3)
40	A0	Address bus (bit 0)
41, 42, 4	GND	Ground

S-100/IEEE-696

SOURCE

Howard Fullmer, Chairman
IEEE-696 Committee
Parasitic Engineering
Box 6314
Albany, CA 94706
Phone (415) 839-2636

GENERAL INFORMATION

The S-100 so-called hobby bus is one of the older backplane μP-bus architectures. Originally designed as a quick and convenient way to interconnect the MITS Altair μC system, it found its way into numerous system designs ranging from business systems to industrial control. To overcome the many problems associated with this bus, the IEEE assigned Task Number 696.1/D2 for assigning standard definitions to pins and solving the problems associated with ringing, termination and loading.

In the process of standardizing the bus, the IEEE added additional attributes to make it workable with 16-bit μPs. In doing so, the address paths were extended to 24 bits, the data-in and -out buses ganged to form a 16-bit-wide data bus for 16-bit transactions and two additional handshaking lines added to permit intermixing 8- and 16-bit memory cards.

Furthermore, the inclusion of a binary-encoded multiple-master arbitration bus permits as many as 16 masters on the bus at a time with the necessary logic on one chip. To bring the bus to high-performance standards, additional ground lines, a power-fail line and an error line have been added. Moreover, three additional user lines meet specialized needs.

The bus now stacks up well against other 16-bit buses and can in most cases hold its own when compared with high-performance bus architectures.

BUS SIGNALS

The S-100 bus consists of a set of signal lines used to carry all information, interface messages and device-dependent messages. Its structure is organized into eight sets of signal lines, which include:

- 16 data lines
- 16 or 24 address lines
- Eight status lines
- Five output control lines
- Six input control lines
- Eight DMA control lines
- Eight vectored-interrupt lines
- 20 utility lines

PIN NO	SIGNAL & TYPE	ACTIVE LEVEL	DESCRIPTION
	+8V (B)	1	Instantaneous minimum greater than 7V, instantaneous maximum less than 25V, average maximum less than 11V.
2	+16V (B)		Instantaneous minimum greater than 14.5V, instantaneous maximum less than 35V, average maximum less than 21.5V.
3	XRDY (S)	H	One of two ready inputs to the current bus master. The bus is ready when both these ready inputs are true. See pin 72.

4	VI0*(S)	L OC	Vectored interrupt line 0.
5	VI1*(S)	L OC	Vectored interrupt line 1.
6	VI2*(S)	L OC	Vectored interrupt line 2.
7	VI3*(S)	L OC	Vectored interrupt line 3.
8	VI4*(S)	L OC	Vectored interrupt line 4.
9	VI5*(S)	L OC	Vectored interrupt line 5.
10	VI6*(S)	L OC	Vectored interrupt line 6.
11	VI7*(S)	L OC	Vectored interrupt line 7.
12	NMI*(S)	L OC	Nonmaskable interrupt..
13	PWRFAIL*(B)	L	Power-fail bus signal.
14	DMA3*(M)	L OC	Temporary-master priority bit 3.
15	A18 (M)	H	Extended address bit 18.
16	A16 (M)	H	Extended address bit 16.
17	A17 (M)	H	Extended address bit 17.
18	SDSB*(M)	L OC	The control signal to disable the eight status signals.
19	CDSB*(M)	L OC	The control signal to disable the five control output signals.
20	GND (B)		Common with pin 100.
21	NDEF		Not to be defined. Manufacturer must specify any use in detail.
22	ADSB*(M)	L OC	The control signal to disable the 16 address signals.
23	DODSB*(M)	L OC	The control signal to disable the eight data-output signals.
24	ϕ (B)	H	The master timing signal for the bus.
25	pSTVAL*(M)	L	Status-valid strobe.
26	pHLDA (M)	H	A control signal used in conjunction with HOLD* to coordinate bus-master transfer operations.
27	RFU		Reserved for future use.
28	RFU		Reserved for future use.
29	A5 (M)	H	Address bit 5.
30	A4 (M)	H	Address bit 4.
31	A3 (M)	H	Address bit 3.
32	A15 (M)	H	Address bit 15 (most significant for nonextended addressing).
33	A12 (M)	H	Address bit 12.
34	A9 (M)	H	Address bit 9.
35	DO1 (M)/DATA1 (M/S)	H	Data-out bit 1, bidirectional data bit 1.
36	DO0 (M)/DATA0 (M/S)	H	Data-out bit 0, bidirectional data bit 0.
37	A10 (M)	H	Address bit 10.
38	DO4 (M)/DATA4 (M/S)	H	Data-out bit 4, bidirectional data bit 4.
39	DO5 (M)/DATA5 (M/S)	H	Data-out bit 5, bidirectional data bit 5.
40	DO6 (M)/DATA6 (M/S)	H	Data-out bit 6, bidirectional data bit 6.
41	DI2 (S)/DATA10 (M/S)	H	Data-in bit 2, bidirectional data bit 10.
42	DI3 (S)/DATA11 (M/S)	H	Data-in bit 3, bidirectional data bit 11.
43	DI7 (S)/DATA15 (M/S)	H	Data-in bit 7, bidirectional data bit 15.
44	sM1 (M)	H	The status signal indicating that the current cycle is an opcode fetch.
45	sOUT (M)	H	The status signal identifying the data-transfer bus cycle to an output device.
46	sINP (M)	H	The status signal identifying the data-transfer bus cycle from an input device.
47	sMEMR (M)	H	The status signal identifying bus cycles that transfer data from memory to a bus master, which are not interrupt-acknowledge instruction-fetch cycles.
48	sHLTA (M)	H	The status signal that acknowledges execution of a HLT instruction.
49	CLOCK(B)		2-MHz (0.5%) 40 to 60% duty cycle. Needn't be synchronous with any other bus signal.
50	GND (B)		Common with pin 100.
51	+8V (B)		Common with pin 1.
52	−16V (B)		Instantaneous maximum less than −14.5V, instantaneous mimimum greater than −35V, average minimum greater than −21.5V.
53	GND (B)		Common with pin 100.
54	SLAVE CLR* (B)	L OC	A reset signal to reset bus slaves. Must be active with POC* and can also be generated by external means.
55	DMAO* (M)	L OC	Temporary-master priority bit 0.
56	DMA1* (M)	L OC	Temporary-master priority bit 1.
57	DMA2* (M)	L OC	Temporary-master priority bit 2.
58	sXTRO* (M)	L	The status signal that requests 16-bit slaves to assert SIXTN*.
59	A19 (M)	H	Extended-address bit 19.
60	SIXTN* (S)	L OC	The signal generated by 16-bit slaves in response to the 16-bit request signal sXTRO*.
61	A20 (M)	H	Extended-address bit 20.
62	A21 (M)	H	Extended-address bit 21.
63	A22 (M)	H	Extended-address bit 22.
64	A23 (M)	H	Extended-address bit 23.

65	NDEF		Not to be defined.
66	NDEF		Not to be defined.
67	PHANTOM* (M/S)	L OC	A bus signal that disables normal slave devices and enables phantom slaves—primarily used for bootstrapping systems without hardware front panels.
68	MWRT (B)	H	pWR*-sOUT (logic equation). This signal must follow pWR* by not more than 30 nsec.
69	RFU		Reserved for future use.
70	GND (B)		Common with pin 100.
71	RFU		Reserved for future use.
72	RDY (S)	H OC	See comments for pin 3.
73	INT* (S)	L OC	The primary interrupt-request bus signal.
74	HOLD* (M)	L OC	The control signal used in conjunction with pHLDA to coordinate bus-master transfer operations.
75	RESET* (B)	L OC	The reset signal to reset bus-master devices. It must be active with POC* and can also be generated externally.
76	pSYNC (M)	H	The control signal identifying BS_1.
77	pWR* (M)	L	The control signal signifying the presence of valid data on DO bus or data bus.
78	pDBIN (M)	H	The control signal that requests data on the DI bus or data or data bus from the currently addressed slave.
79	A0 (M)	H	Address bit 0 (least significant).
80	A1 (M)	H	Address bit 1.
81	A2 (M)	H	Address bit 2.
82	A6 (M)	H	Address bit 6.
83	A7 (M)	H	Address bit 7.
84	A8 (M)	H	Address bit 8.
85	A13 (M)	H	Address bit 13.
86	A14 (M)	H	Address bit 14.
87	A11 (M)	H	Address bit 11.
88	DO2 (M)/DATA2 (M/S)	H	Data-out bit 2, bidirectional data bit 2.
89	DO3 (M)/DATA3 (M/S)	H	Data-out bit 3, bidirectional data bit 3.
90	DO7 (M)/DATA7 (M/S)	H	Data-out bit 7, bidirectional data bit 7.
91	DI4 (S)/DATA12 (M/S)	H	Data-in bit 4 and bidirectional data bit 12.
92	DI5 (S)/DATA13 (M/S)	H	Data-in bit 5 and bidirectional data bit 13.
93	DI6 (S)/DATA14 (M/S)	H	Data-in bit 6 and bidirectional data bit 14.
94	DI1 (S)/DATA9 (M/S)	H	Data-in bit 1 and bidirectional data bit 9.
95	DI0 (S)DATA8 (M/S)	H	Data-in bit 0 (least significant for 8-bit data) and bidirectional data bit 8.
96	sINTA (M)	H	The status signal identifying the bus input cycle(s) that can follow an accepted interrupt request presented on INT*
97	sWO* (M)	L	The status signal identifying a bus cycle that transfers data from a bus master to a slave.
98	ERROR* (S)	L OC	The bus-status signal signifying an error condition during current bus cycle.
99	POC* (B)	L	The power-on clear signal for all bus devices; when it goes LOW, it must stay LOW for at least 10 msec.
100	GND (B)		System ground.

NOTE:
OC=OPEN COLLECTOR

READ/WRITE-CYCLE TIMING PARAMETERS

		MIN (nSEC)	**MAX** (nSEC)
t_{CY}	ϕ PERIOD	166	2000
t_{CYH}	ϕ PULSE WIDTH HIGH	$0.4t_{CY}$	
t_{CYL}	ϕ PULSE WIDTH LOW	$0.4\ t_{CY}$	
$t_{\phi SY}$	DELAY ϕ HIGH TO pSYNC HIGH; DELAY ϕ LOW TO pSYNC LOW	10	$0.4t_{CY} \approx 100$@4 MHz
t_{SY}	pSYNC PULSE WIDTH HIGH	$0.7t_{CY}$	
$t_{\overline{ST\phi}}$	pSTVAL* LOW PRIOR TO ϕ LOW DURING pSYNC	0	
t_{ST}	pSTVAL* PULSE WIDTH HIGH	50	
$t_{\overline{ST}}$	pSTVAL* PULSE WIDTH LOW	50	
t_{STSY}	pSTVAL* FALLING EDGE PRIOR TO pSYNC HIGH	0	
$t_{\overline{AST}}$	ADDRESSES STABLE PRIOR TO pSTVAL* LOW DURING pSYNC HIGH	70	
$t_{S\overline{ST}}$	STATUS STABLE PRIOR TO pSTVAL* LOW DURING pSYNC HIGH	40	
t_{DB}	pDBIN PULSE WIDTH HIGH	$0.9t_{CY}$	

READ/WRITE-CYCLE TIMING PARAMETERS (Cont)

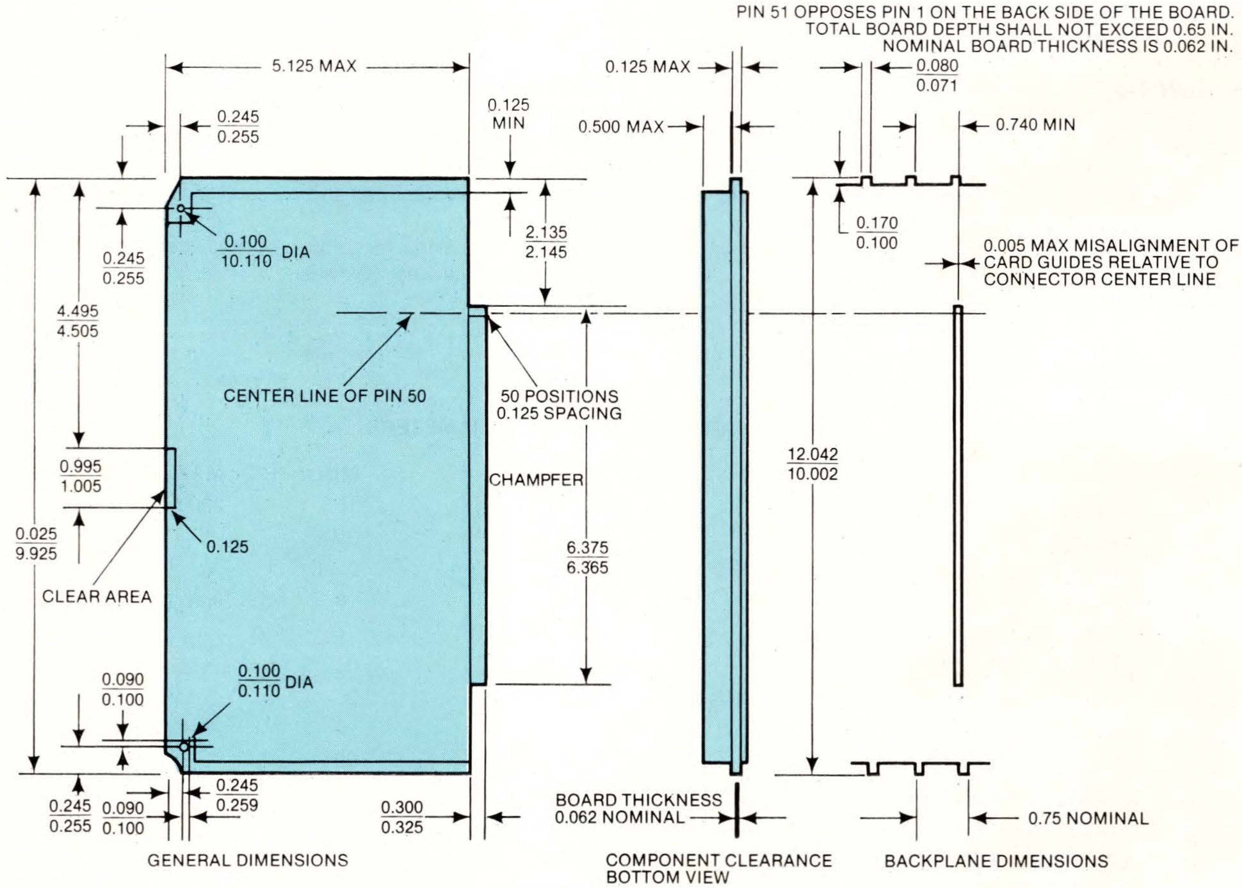
		MIN (nSEC)	MAX (nSEC)
$t_{\overline{STDB}}$	DELAY pSTVAL* LOW TO pDBIN HIGH	20	
$t_{\overline{DBSY}}$	DELAY pDBIN LOW TO pSYNC HIGH	0	
$t_{\overline{DBAS}}$	HOLD TIME FOR ADDRESSES AND STATUS AFTER pDBIN LOW	50	
$t_{\overline{DBZ}}$	DELAY pDBIN LOW TO SLAVE DI DRIVERS Hi-Z		$25 + 0.1t_{CY}$
$t_{DB\overline{Z}}$	DELAY pDBIN HIGH TO SLAVE DI DRIVERS ACTIVE	10	$25 + 0.1t_{CY}$
t_{ACC}	DELAY pSTVAL* LOW TO DATA VALID	SPECIFIED BY MANUFACTURER. WORST-CASE MAXIMUM FOR ALL SLAVES AND WORST-CASE MINIMUM FOR ALL MASTERS.	
$t_{S\overline{DB}}$	DATA VALID SETUP TIME TO pDBIN LOW		
$t_{\overline{WP}}$	pWR* PULSE WIDTH LOW	$0.9t_{CY}$	
$t_{\overline{STWP}}$	DELAY pSTVAL* LOW TO pWR* LOW	30	
t_{WRSY}	DELAY pWR* HIGH TO pSYNC HIGH	0	
$t_{D\overline{WR}}$	SETUP TIME DO VALID TO pWR* LOW	$0.1t_{CY}$	
t_{WRASD}	HOLD TIME ADDRESSES, STATUS AND DO FROM pWR* HIGH	$0.2t_{CY}$	
t_{WRMR}	DELAY pWR* LOW TO MWRT HIGH; DELAY pWR* HIGH TO MWRT LOW		30
$t_{\overline{RDY}\phi}$	SETUP TIME RDY, XRDY, SIXTN* TO ϕ RISING	80	
$t_{\phi RDY}$	HOLD TIME RDY, XRDY, SIXTN* AFTER ϕ RISING	70	

BUS-TRANSFER TIMING PARAMETERS

t_{SET}	DELAY pHLDA TO ADSB*, SDSB*, DODSB*	30	
t_{DV}	TIME BOTH TEMPORARY AND PERMANENT MASTER DRIVE THE CONTROL OUTPUT LINES	$0.5t_{CY}$	
t_{DH}	HOLD TIME ADDRESS, STATUS, AND DATA OUT DURING DMA CYCLE	$0.2t_{CY}$	
t_{REL}	SETUP TIME, END OF BUS TRANSFER TO pHLDA RISING EDGE	20	

MECHANICAL SPECIFICATIONS

BOARD SIZE



STD BUS

SOURCE

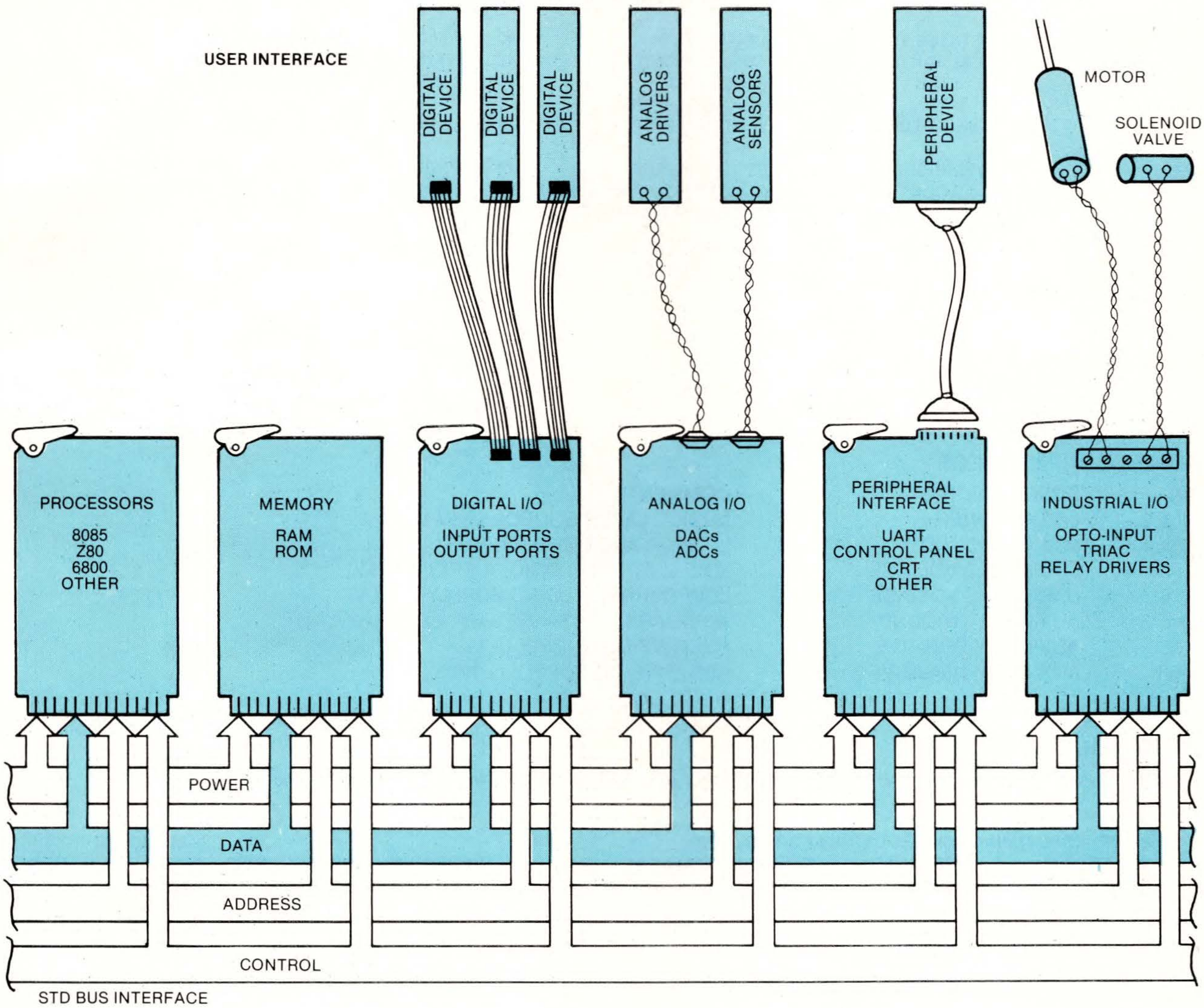
Pro-Log Corp
2411 Garden Rd
Monterey, CA 93940
Phone (408) 372-4593
and
Mostek Corp
1215 Crosby Rd
Carrollton, TX 75006
Phone (214) 323-6000

GENERAL INFORMATION

The STD Bus standardizes the physical and electrical aspects of modular 8-bit-μP card systems. The 56-pin interconnect lines permit any card to work in any slot. The bus permits a serial priority-interrupt scheme whereby each card needing priority must have logic on board.

In addition to serial priority, the bus allows a parallel scheme. This approach implies use of a parallel priority card on the bus and requires that individual requests be made from the edge of each user card.

TYPICAL STD IMPLEMENTATION



BUS SIGNALS

The 56-pin STD Bus is organized into four functional groups on dual 28-pin edge connectors:

- Dual power buses (pins 1-6 and 53-56)
- Data bus (pins 7-14)
- Address bus (pins 15-30)
- Control bus (pins 31-52)

	COMPONENT SIDE				CIRCUIT SIDE			
	PIN	MNEMONIC	SIGNAL FLOW	DESCRIPTION	PIN	MNEMONIC	SIGNAL FLOW	DESCRIPTION
LOGIC POWER BUS	1	+5VDC	IN	LOGIC POWER (BUSED)	2	+5VDC	IN	LOGIC POWER (BUSED)
	3	GND	IN	LOGIC GROUND (BUSED)	4	GND	IN	LOGIC GROUND (BUSED)
	5	VBB #1	IN	LOGIC BIAS #1 (−5V)	6	VBB#2	IN	LOGIC BIAS #2 (−5V)
DATA BUS	7	D3	IN/OUT	LOW-ORDER DATA BUS	8	D7	IN/OUT	HIGH-ORDER DATA BUS
	9	D2	IN/OUT	LOW-ORDER DATA BUS	10	D6	IN/OUT	HIGH-ORDER DATA BUS
	11	D1	IN/OUT	LOW-ORDER DATA BUS	12	D5	IN/OUT	HIGH-ORDER DATA BUS
	13	D0	IN/OUT	LOW-ORDER DATA BUS	14	D4	IN/OUT	HIGH-ORDER DATA BUS
ADDRESS BUS	15	A7	OUT	LOW-ORDER ADDRESS	16	A15	OUT	HIGH-ORDER ADDRESS
	17	A6	OUT	LOW-ORDER ADDRESS	20	A13	OUT	HIGH-ORDER ADDRESS
	19	A5	OUT	LOW-ORDER ADDRESS	22	A12	OUT	HIGH-ORDER ADDRESS
	21	A4	OUT	LOW-ORDER ADDRESS				
	23	A3	OUT	LOW-ORDER ADDRESS	24	A11	OUT	HIGH-ORDER ADDRESS
	25	A2	OUT	LOW-ORDER ADDRESS	26	A10	OUT	HIGH-ORDER ADDRESS
	27	A1	OUT	LOW-ORDER ADDRESS	28	A9	OUT	HIGH-ORDER ADDRESS
	29	A0	OUT	LOW-ORDER ADDRESS	30	A8	OUT	HIGH-ORDER ADDRESS
CONTROL BUS	31	WR*	OUT	WRITE TO MEMORY OR I/O	32	RD*	OUT	READ MEMORY OR I/O
	33	IORQ*	OUT	I/O ADDRESS SELECT	34	MEMRQ*	OUT	MEMORY ADDRESS SELECT
	35	IOEXP	IN/OUT	I/O EXPANSION	36	MEMEX	IN/OUT	MEMORY EXPANSION
	37	REFRESH*	OUT	REFRESH TIMING	38	MCSYNC*	OUT	CPU MACHINE CYCLE SYNC
	39	STATUS 1*	OUT	CPU STATUS	40	STATUS 0*	OUT	CPU STATUS
	41	BUSAK*	OUT	BUS ACKNOWLEDGE	42	BUSRQ*	IN	BUS REQUEST
	43	INTAK*	OUT	INTERRUPT ACKNOWLEDGE	44	INTRQ*	IN	INTERRUPT REQUEST
	45	WAITRQ*	IN	WAIT REQUEST	46	NMIRQ*	IN	NONMASKABLE INTERRUPT
	47	SYSRESET*	OUT	SYSTEM RESET	48	PBRESET*	IN	PUSH-BUTTON RESET
	49	CLOCK*	OUT	CLOCK FROM PROCESSOR	50	CNTRL*	IN	AUX TIMING
	51	PCO	OUT	PRIORITY CHAIN OUT	52	PCI	IN	PRIORITY CHAIN IN
AUXILIARY POWER BUS	53	AUX GND	IN	AUX GROUND (BUSED)	54	AUXGND	IN	AUX GROUND (BUSED)
	55	AUX +V	IN	AUX POSITIVE (+12V DC)	56	AUX −V	IN	AUX NEGATIVE (−12V DC)

NOTE
*LOW-LEVEL ACTIVE

ELECTRICAL SPECIFICATIONS

POWER-SUPPLY SPECS

PIN	DESCRIPTION	COMMENTS
1 & 2	LOGIC POWER	LOGIC POWER SOURCE (+5V DC)
3 & 4	LOGIC GROUND	LOGIC POWER RETURN BUS
5	LOGIC BIAS VOLTAGE	LOW-CURRENT LOGIC SUPPLY 1 (−5V)
6	LOGIC BIAS VOLTAGE	LOW-CURRENT LOGIC SUPPLY 2 (−5V)
53 & 54	AUXILIARY GROUND	AUXILIARY POWER RETURN BUS
55	AUXILIARY POSITIVE	POSITIVE DC SUPPLY (+12V)
56	AUXILIARY NEGATIVE	NEGATIVE DC SUPPLY (−12V)

PROCESSOR SUPPORT

The STD Bus is versatile enough to support a number of μPs and includes provisions for handling them:

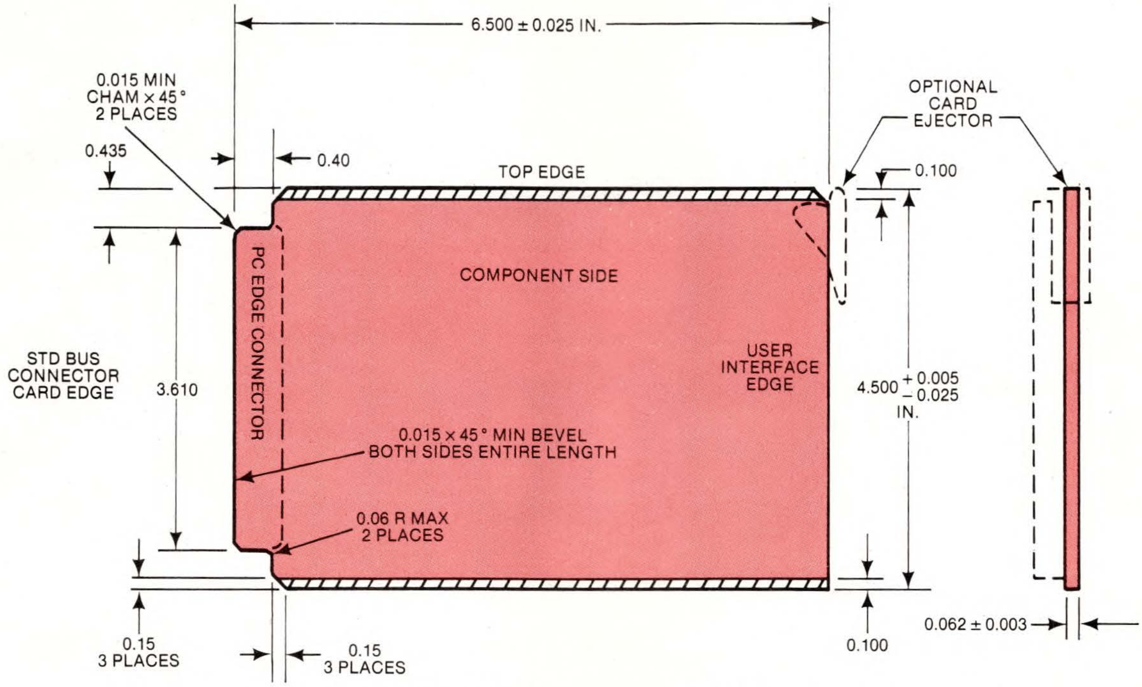
PERIPHERAL TIMING-CONTROL LINES FOR 8-BIT μ Ps

	REFRESH* (PIN 37)	MCSYNC* (PIN 38)	STATUS 1* (PIN 39)	STATUS 0* (PIN 40)
8080	—	SYNC*	M1*	—
8085	—	ALE*	S1*	SO*
NSC800	REFRESH*	ALE*	S1*	SO*
8080	—	ALE*	DT/R*	SSO*
Z80	REFRESH*	(RD* + WR* + INTAK*)	M1*	—
6800	—	ϕ2*	VMA*	R/W*
6809	—	EOUT* (ϕ2*)	—	R/W*
6809E	—	EOUT* (ϕ2*)	LIC*	R/W*
6502	—	ϕ2*	SYNC*	R/W*

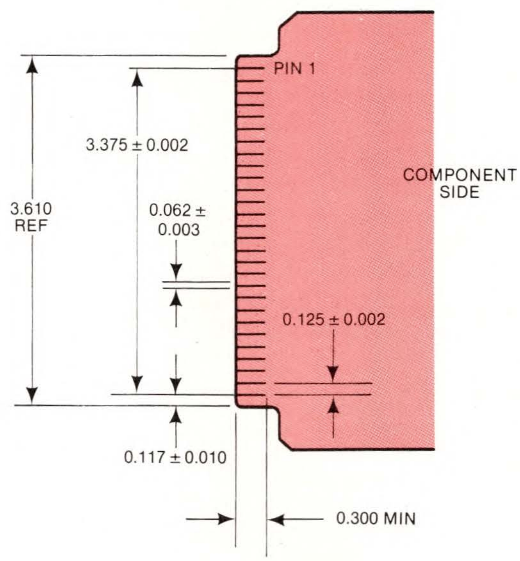
PROCESSOR	NO OF MEM ADR LINES	ADDRESS LINES DURING REFRESH	NO OF I/O ADDRESS LINES: I/O MAPPED I/O	NO OF I/O ADDRESS LINES: MEMORY MAPPED I/O
8080	16	—	LOWER 8	16
8085	16	—	LOWER 8	16
Z80	16	LOWER 7	LOWER 8	16
6800	16	—	—	16
6809	16	—	—	16
6502	16	—	—	16
NSC800	16	LOWER 7	LOWER 8	16

NOTES:
* = LOW-LEVEL ACTIVE
— = NOT USED
R/W* = READ HIGH, WRITE LOW
DT/R* = DATA TRANSMIT HIGH, RECEIVE LOW

MECHANICAL SPECIFICATIONS
CARD SIZES



TOLERANCES: 0.XX = ± 0.03,0.XXX = ± 0.010 IN.
SHADED AREA MUST BE KEPT FREE OF COMPONENTS.



NEXT TIME

EDN's June 24 issue will feature a Special Report on CMOS—envisioned by many industry experts as the premier processing technology of the 1980s and now exploding into a variety of new product areas. Other highlights include articles on

- Designing with current-mirror ICs
- Implementing a color-graphics processor
- Understanding the recently amended patent law
- Using digital techniques in signal-processing applications

. . . and much more. Also look for Technology Update stories on CAD/CAM developments and laser technology, plus our regular Design Ideas, A Question of Law and μC Design Techniques departments. You can't afford to miss this issue!

EDN: Everything Designers Need

RF trans-formers

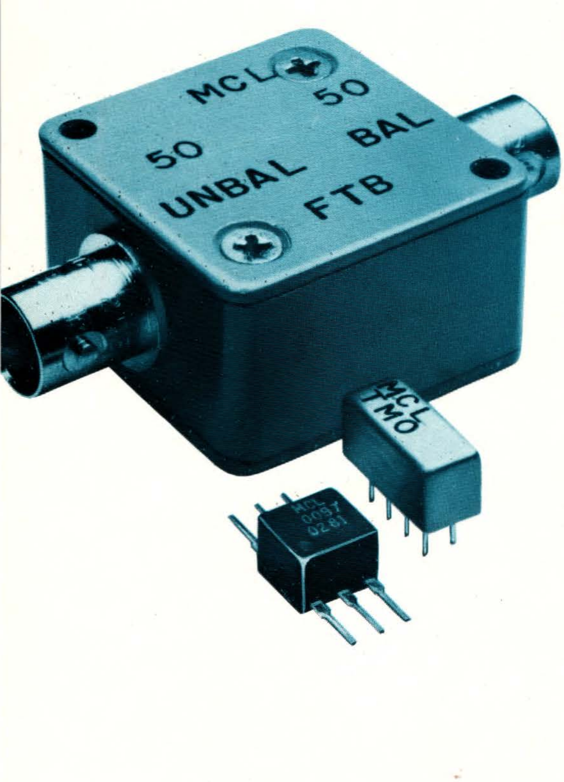
the world's widest selection of matching ratios
10KHz-800MHz...balanced, DC isolated, center-tapped
46 off-the-shelf models from Mini-Circuits from $2^{95}

Select from the economical, microminiature T-series (plastic case) or TMO series (hermetically-sealed metal case) covering 10 KHz to 800 MHz. These models operate from 12.5 to 800 ohms with insertion loss typically less than 0.5 dB.

For large dynamic range applications, specify the T-H series which can handle up to 100 mA primary current without saturation or distortion.

Need a connector version? Select from the FT or FTB series, available with unbalanced or balanced outputs. Connector choices are female (BNC, Isolated BNC, and Type N) and male (BNC and Type N). These units operate from 10 KHz to 500 MHz with impedances of 50 and 75 ohms.

Of course, Mini-Circuits' one-year guarantee is included.



DC ISOLATED PRIMARY & SECONDARY

Model No.	T1-1 TMO1-1	T1-1H	T1.5-1 TMO1.5-1	T2.5-6 TMO2.5-6	T4-6 TMO4-6	T9-1 TMO9-1	T9-1H	T16-1 TMO16-1	T16-1H
Imped. Ratio	1	1	1.5	2.5	4	9	9	16	16
Freq. (MHz)	.15-400	8-300	.1-300	.01-100	.02-200	.15-200	2-90	.3-120	7-85
T Model (10-49)	$2.95	$4.95	$3.95	$3.95	$3.95	$3.45	$5.45	$3.95	$5.95
TMO model (10-49)	$4.95		$6.75	$6.45	$6.45	$6.45		$6.45	

CENTER-TAPPED DC ISOLATED PRIMARY & SECONDARY

Model No.	T1-1T TMO1-1T	T2-1T TMO2-1T	T2.5-6T TMO2.5-6T	T3-1T TMO3-1T	T4-1 TMO4-1	T4-1H	T5-1T TMO5-1T	T13-1T TMO13-1T
Imped. Ratio	1	2	2.5	3	4	4	5	13
Freq. (MHz)	.05-200	.07-200	.01-100	.05-250	.2-350	8-350	.3-300	.3-120
T Model (10-49)	$3.95	$4.25	$4.25	$3.95	$2.95	$4.95	$4.25	$4.25
TMO model (10-49)	$6.45	$6.75	$6.75	$6.45	$4.95		$6.75	$6.75

UNBALANCED PRIMARY & SECONDARY

Model No.	T2-1 TMO2-1	T3-1 TMO3-1	T4-2 TMO4-2	T8-1 TMO8-1	T14-1 TMO14-1
Imped. Ratio	2	3	4	8	14
Freq. (MHz)	.025-600	.5-800	.2-600	.15-250	.2-150
T model (10-49)	$3.45	$4.25	$3.45	$3.45	$4.25
TMO Model (10-49)	$5.95	$6.95	$5.95	$5.95	$6.75

FT FTB

Model No.	FT1.5-1	FTB1-1	FTB1-6	FTB1-1-75
Imped. Ratio	1.5	1	1	1
Freq. (MHz)	.1-400	.2-500	.01-200	.5-500
(1-4)	$29.95	$29.95	$29.95	$29.95

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Design Ideas

Stand-alone TTL tester indicates Go/No Go

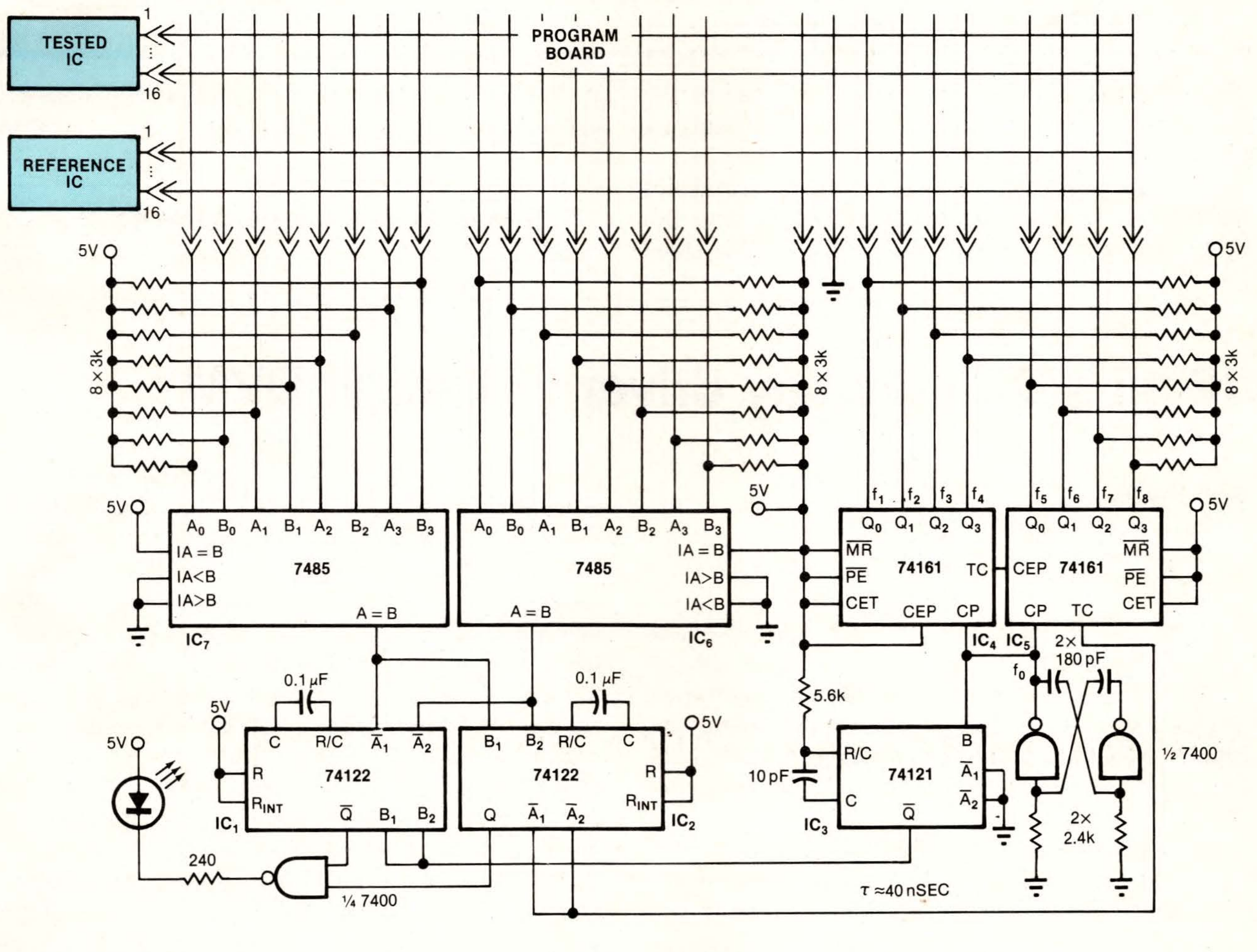
Florin Nestor Mugioiu
Institute for Electronic Research, Bucharest

Using the design shown in the **figure**, you can functionally test TTL devices without tying up any special equipment or highly trained personnel. The circuit locates performance defects—such as truth-table errors, nonfunctioning inputs or outputs and out-of-spec propagation delays—by comparing a device with a standard unit.

The synchronous counters (IC$_4$, IC$_5$) operate at approximately 1 MHz and sequence the tested chip's parallel-connected common inputs. This scheme allows you to make a differential propagation-delay measurement because the tested ICs' outputs separately feed the A/B inputs of comparators IC$_6$ and IC$_7$. Thus, when an IC tests good, the LED lights because retriggerable one-shot IC$_1$ isn't triggered although IC$_2$ is.

If any of the tested IC's inputs are grounded, counter sequencing stops. Although this action in itself doesn't generate an error signal, it does prevent LED lighting because IC$_2$ isn't triggered.

False No Go results are prevented by the remaining one-shot (IC$_3$). Its 40-nsec output inhibits IC$_1$ from falsely rejecting a tested IC just because the



Functionally test TTL ICs *by comparing their performance with that of a concurrently tested reference device of the same type. By sequentially driving the devices' like inputs in parallel and making an A=B comparison of their outputs, you can find such faults as grounded inputs, truth-table errors and excessive propagation delays.*

PIN CONNECTIONS

TESTED IC REF IC TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
7400, 7402	f_1	f_2	A_0 IC_6	f_3	f_4	A_1 IC_6	GND	A_2 IC_6	f_5	f_6	A_3 IC_6	f_7	f_8	5V		
7403, 7408	f_1	f_2	B_0 IC_6	f_3	f_4	B_1 IC_6	GND	B_2 IC_6	f_5	f_6	B_3 IC_6	f_7	f_8	5V		
7409, 7413																
7420, 7440																
7486																
7473	f_1	f_8	f_5	5V	f_2	f_7	f_6	A_0 IC_6	A_1 IC_6	f_4	GND	A_2 IC_6	A_3 IC_6	f_4		
	f_1	f_8	f_5	5V	f_2	f_7	f_6	B_0 IC_6	B_1 IC_6	f_4	GND	B_2 IC_6	B_3 IC_6	f_4		
7490, 7492	f_1	f_6	f_7	GND	5V	f_7	f_8	A_0 IC_6	A_1 IC_6	GND	A_2 IC_6	A_3 IC_6		f_2		
7493	f_1	f_6	f_7	GND	5V	f_7	f_8	B_0 IC_6	B_1 IC_6	GND	B_2 IC_6	B_3 IC_6		f_2		
74192	f_3	A_0 IC_6	A_1 IC_6	f_7	f_1	A_2 IC_6	A_3 IC_6	GND	f_4	f_4	f_6	A_0 IC_7	A_1 IC_7	f_8	f_3	5V
74193	f_3	B_0 IC_6	B_1 IC_6	f_7	f_1	B_2 IC_6	B_3 IC_6	GND	f_4	f_4	f_6	B_0 IC_7	B_1 IC_7	f_8	f_3	5V

Create individualized programming boards *for the TTL tester by making the indicated crosspoint connections. For testing sequential devices such as counters and flip flops, the indicated clock inputs (f_1 and f_2) should be HIGH long enough to catch devices with excessively long propagation delays.*

IC's propagation delay isn't within 40 nsec of the reference's. (You can adjust this window by changing the appropriate RC values.)

You can program this tester via a crosspoint matrix board of the type manufactured by Sealectro or by through-connecting a matrix-like double-sided pc board. The **table** indicates which crosspoints you connect for a variety of TTL chips. **EDN**

To Vote For This Design, Circle No 453

12-bit ADC+display driver=3¾-digit DVM

David Watson
Intersil Inc, Basingstoke, England

By combining a 12-bit ADC chip with any of several counter/display-driver ICs, you can easily construct the 3¾-digit autopolarity meter shown in the **figure.** Depending on your display-type requirement, you can drive common-anode LEDs using the ICM 7225, LCDs with the 7224 or fluorescent displays using the 7236.

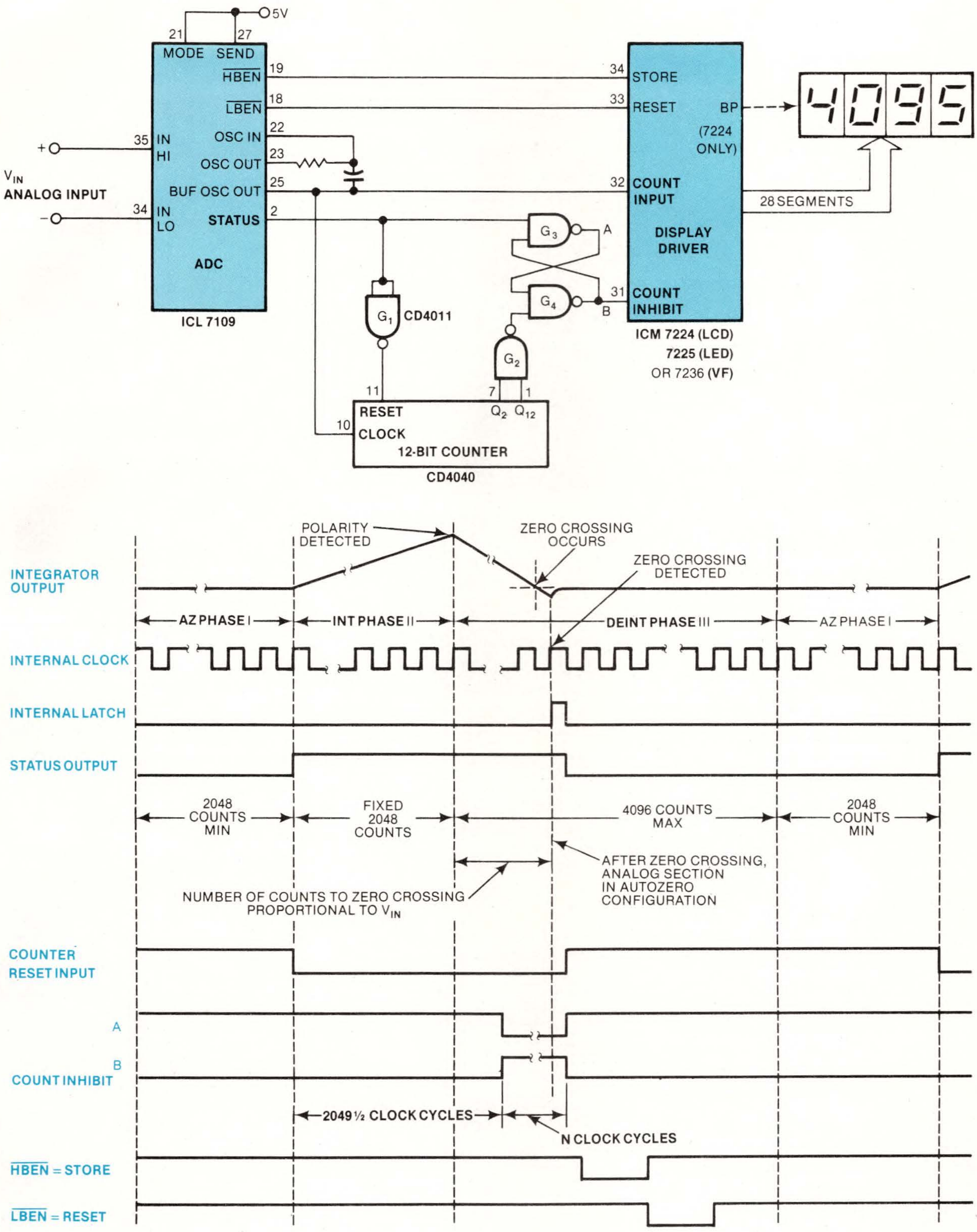
The display drivers have identical input configurations and (except for the 7224's backplane output connection) identical outputs. And because they—like the ICL 7109 ADC—require only one 5V supply, you can employ a common pc-board layout.

Intended originally for use as a 12-bit ADC for μP applications, the ICL 7109 operates somewhat differently in this design. For example, the circuit uses none of the IC's binary outputs. The **figure**'s timing diagram shows the signal-processing sequences.

The ADC requires 8192 clock cycles to complete a conversion: 2048 for the autozero (AZ) phase, another 2048 to integrate the signal (INT) and 4096 for deintegrating the reference. Thus, to obtain a 3¾-digit (4096 counts) full-scale reading, you must subtract out the nondata-related clock cycles.

During the AZ phase, Status is LOW. This condition in turn drives the counter's Reset line HIGH and, by setting the G_3/G_4 flip flop, pulls the display driver's Count Inhibit line LOW. After 2048 cycles, Status goes HIGH, signal integration begins and the counter starts counting clock cycles. After another 2048 cycles, the reference-deintegrate phase commences. One-and-a-half cycles after a zero crossing is detected, Status drops LOW again. At this time, the total count equals 2050 (2048+1½) plus a

Continued on pg 160



A 3¾-digit voltmeter *results when you combine a 12-bit ADC with a display's decoder/driver IC. You can use any standard display type; choose an ICM 7225 for LEDs, a 7224 for LCDs (note the indicated backplane connection) or the 7236 for vacuum-fluorescent units. The counter subtracts the first 2050 nondata-related clock cycles so that the remaining count, N, is directly proportional to the unknown analog input.*

Can your application use

number (N) proportional to the unknown analog input signal.

To recover N's value and thus display the correct analog equivalent count, you must subtract the surplus 2050 from the total. You perform this task by, in effect, not allowing the display driver to start counting until after the first 2050 cycles have occurred. That's the 12-bit counter's function. By NANDing its Q_2 and Q_{12} outputs via G_2, you can (at count 2050) reset the flip flop and therefore enable the display driver's counter. The resulting count and display shows the number of cycles proportional to the analog input.

You can expand this scheme to achieve higher resolution measurements. Just replace the 12-bit ADC with the ICL 8052A/7104 16- and 14-bit ADCs—their outputs interface like the 7109's. And you can directly cascade the display drivers. However, in that case you'd have to extend the counter chain to perform the count-inhibit function. Subtract 8194 counts if you use a 14-bit ADC and 32,770 for 16 bits. EDN

To Vote For This Design, Circle No 454

Locate random addresses with PROMs, DEMUXs

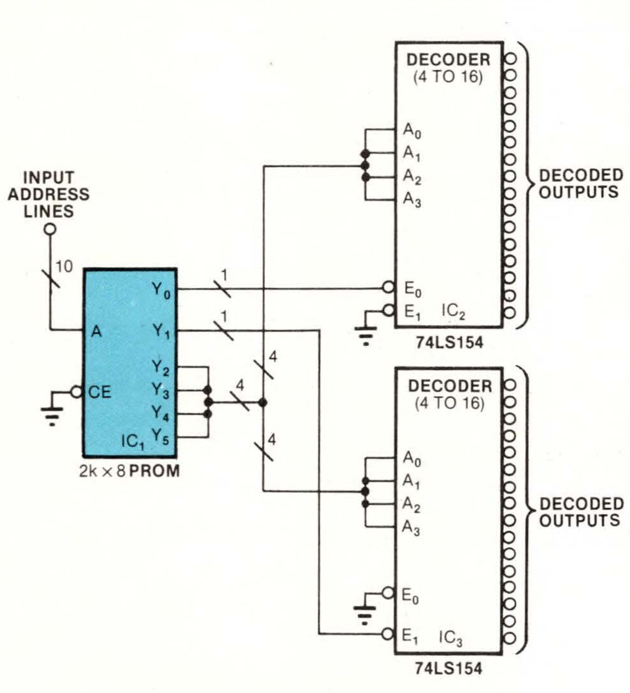
Jeff Taragin and **Don Anderson**
AAI Corp, Cockeysville, MD

The next time you must decode multiple nonconsecutive addresses, don't fall into the trap of sorting out everything only to use a few. Instead, give this idea a try; you can expand the concept to meet your needs.

The scheme depicted in the **figure** decodes 32 nonconsecutive addresses out of a possible 1024 by combining a PROM with two 16-bit decoder/demultiplexers. You drive the 2k×8 PROM (IC_1) with the 10 input address lines; it in effect functions as an address translator. At the desired addresses, you can employ the PROM's 6-bit output to access decoders IC_2 and IC_3.

Note how the PROM's most significant outputs (Y_0, Y_1) serve to enable (and therefore select) the appropriate 4-to-16 decoder chip. By incorporating this trick, you can use the PROM's four remaining outputs as parallel inputs to the decoders. The result? One and only one of the decoders' outputs responds to the desired 32 of 1024 possible inputs. Any other addresses always contain code combinations that disable the decoders.

You can easily expand this concept to decode any number of nonconsecutive addresses by using additional decoders and, if necessary, another PROM. EDN



Decode nonconsecutive addresses *by using a PROM to translate the inputs to a format that can then be sorted out by an m-in/n-out decoder. Here, the PROM's most significant output allows the decoders to yield a 32-of-1024 sort.*

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CIRCLE NO 77

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Combine USART and 8086 with care

Robert D Grappel
Hemenway Associates Inc, Boston, MA

When designing a μC system, you must often scan many pages of data sheets, looking for just the right "magic" that will make the project go. Such a problem arose in the design of an 8086 disk operating system (DOS), which combines the features of a monitor (including automatic baud-rate selection) with those of a simple disk system.

Using Intel's 8251A USART as the serial interface and an 8253 programmable timer as the serial clock source, the program times one or two "U" characters from the console and sets itself up for the incoming baud rate. During the design process, it worked quite well—most of the time. Sometimes, however, it wouldn't initialize at all. If the baud-rate-selection code worked at all, the operating system worked fine, but if it didn't work, no monitor was available for debugging.

A large amount of documentation is available on the 8251A; you can easily get source-code examples to show how to use it. Unfortunately, if you don't understand the chip well, and your application even better, you might not find the information you need.

Specifically, all of the examples indicate the need to meet special timing constraints. Yet each puts different delays in different program locations. And because the 8086 DOS had to fit into 4k bytes, it wouldn't tolerate such delays everywhere.

Because the 8251A uses both Synchronous- and Asynchronous-mode operation, it requires fairly intricate initialization sequences; its state after power-up isn't well determined. One bit of 8251A "magic," therefore, involves sending the device a null byte three times on power-up, guaranteeing that it's ready for command. Then send the chip a reset command; the mode and command byte follow to complete the initialization.

A second bit of "magic" (found in note 4 of the 8251 data-sheet section describing ac characteristics) lies in the fact that the 8251A requires six clocks between writes during initialization and a minimum of eight clocks between writes once in Asynchronous mode. (Synchronous mode requires 16 clocks.) The 8086 is fast enough to overdrive these timings. Depending on other timing factors, such as dynamic-memory refresh and timer interrupts, code might be slow enough in one case but not in another. Thus, every once in a while, if you don't insert delays, the USART goes haywire.

```
; INITIALIZE AN 8251A USART
; ASSUME POWER-ON CONDITIONS
;
        MOV DX,SIOSTA           ;POINT TO USART STATUS
        MOV AL,0
        OUT DX,AL               ;SEND A NULL
        SCAS                    ;DELAY
        OUT DX,AL               ;SEND A NULL
        SCAS                    ;DELAY
        OUT DX,AL               ;SEND A NULL
        SCAS                    ;DELAY
        MOV AL,040H             ;RESET COMMAND
        OUT DX,AL
        SCAS                    ;DELAY
        MOV AL,04EH             ;MODE SET
        OUT DX,AL
        SCAS                    ;DELAY
        MOV AL,037H             ;COMMAND SET
        OUT DX,AL
;
; ASSUME INSTRUCTIONS HERE GENERATE DELAY
; BEFORE USART IS USED NEXT
;
```

A proper 8086 initialization sequence *puts delays between writes to the USART.*

The 8086 program shown in the **figure** illustrates an 8251A initialization sequence for asynchronous operation. Note the use of the Scan String (SCAS) instruction as a time delay. Each SCAS takes 15 clocks—providing a great deal of overkill. Three NOP (no operation) instructions would take up nine clocks—a sufficient solution, but one requiring two more code bytes than an SCAS. **EDN**

EDN Software Note #70

Utility program dumps TMS9900's memory

Ralph Tenny
George Goode & Associates Inc, Dallas, TX

Texas Instruments' TM990/189 single-board μC, with its on-board line-by-line symbolic assembler, adapts easily to new tasks. The assembler leaves the application program in memory, ready to run, thereby minimizing start-up time. And after you finish a job, you can use the μC's cassette-dump facility to save the program. Software maintenance would prove much simpler, however, with some means of making hard-copy documentation.

The program shown in the **figure** deals with this need. It produces a standard memory dump in one of two formats. The form shown in the example generates the memory image as 16 columns of single bytes—a format suiting text better than program material. Comments indicate the modifications needed to produce a listing with eight columns of 2-byte words.

The TM990/189 contains a socket that accepts 1k×8 or 2k×8 EPROMs. The listing shows the program starting at the beginning address for that socket. Because the program resides in ROM,

```
0010 0000           *THIS PROGRAM DUMPS MEMORY CONTENTS FROM A TM 990/189
0020 0000           *UNIVERSITY BOARD TO ANY RS232 PRINTER, USING A SIXTEEN
0030 0000           *COLUMN FORMAT.  THE PROGRAM EXPECTS TO FIND THE
0040 0000           *STARTING ADDRESS OF THE DUMP TO BE IN R1 AND THE
0050 0000           *NUMBER OF BYTES IN R2.  SUBSTITUTE A NOP AT LINE
0060 0000           *NUMBER 370 AND >2F06 AT LINE 410 FOR EIGHT-
0070 0000           *COLUMN FORMAT. USE EVEN BYTE COUNT ONLY.
0080                      IDT  'MEMDMP'
0090 0800                 AORG >800
0100 0800                 DREG                ASSEMBLER DIRECTIVE
0110 0800 02E0 STRT LWPI >180                 INITIALIZE WORKSPACE
     0802 0180
0120 0804 04E0            CLR  @>36           SWITCH TO EXTERNAL TERMINAL
     0806 0036
0130 0808 C0C1            MOV  R1,R3          SAVE START ADDRESS
0140 080A C102            MOV  R2,R4          SAVE BYTE COUNT
0150 080C 0205            LI   R5,>0D0A       CARRIAGE RETURN AND LINE FEED
     080E 0D0A
0160 0810 0206            LI   R6,>2000       SPACE CHARACTER
     0812 2000
0170 0814 0209            LI   R9,4           SET UP SHIFT COUNT CONSTANT
     0816 0004
0180 0818 2F05            XOP  R5,12          OUTPUT CARRIAGE RETURN AND
0190 081A 06C5            SWPB R5             THEN A
0200 081C 2F05            XOP  R5,12          LINE FEED TO RESET THE
0210 081E 06C5            SWPB R5             PRINTER CARRIAGE
0220 0820 C203 OUT1 MOV  R3,R8                GET CURRENT ADDRESS, THEN
0230 0822 C289            MOV  R9,R10         INITIALIZE SHIFT COUNTER
0240 0824 0BC8 SHF1 SRC  R8,12                SHIFT EACH CHARACTER TO
0250 0826 2E08            XOP  R8,8           LOW ORDER NIBBLE TO SEND
0260 0828 060A            DEC  R10            COUNT THE SHIFT
0270 082A 16FC            JNE  SHF1           LOOP UNTIL DONE
0280 082C 2F06            XOP  R6,12          OUTPUT TWO SPACES
```

Providing hard copy *of programs developed by the TM990/189 μC's symbolic assembler, this utility program simplifies documentation. (Listing continues on next page)*

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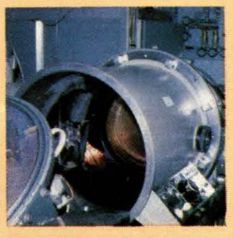

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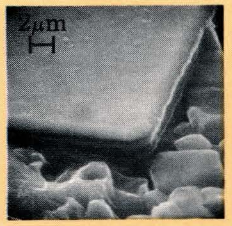
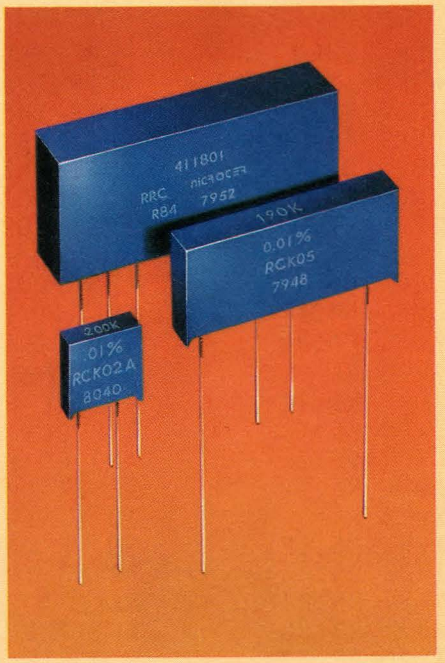


Massive SEM enlargement shows clean wall of ion beam etched conductor pattern.



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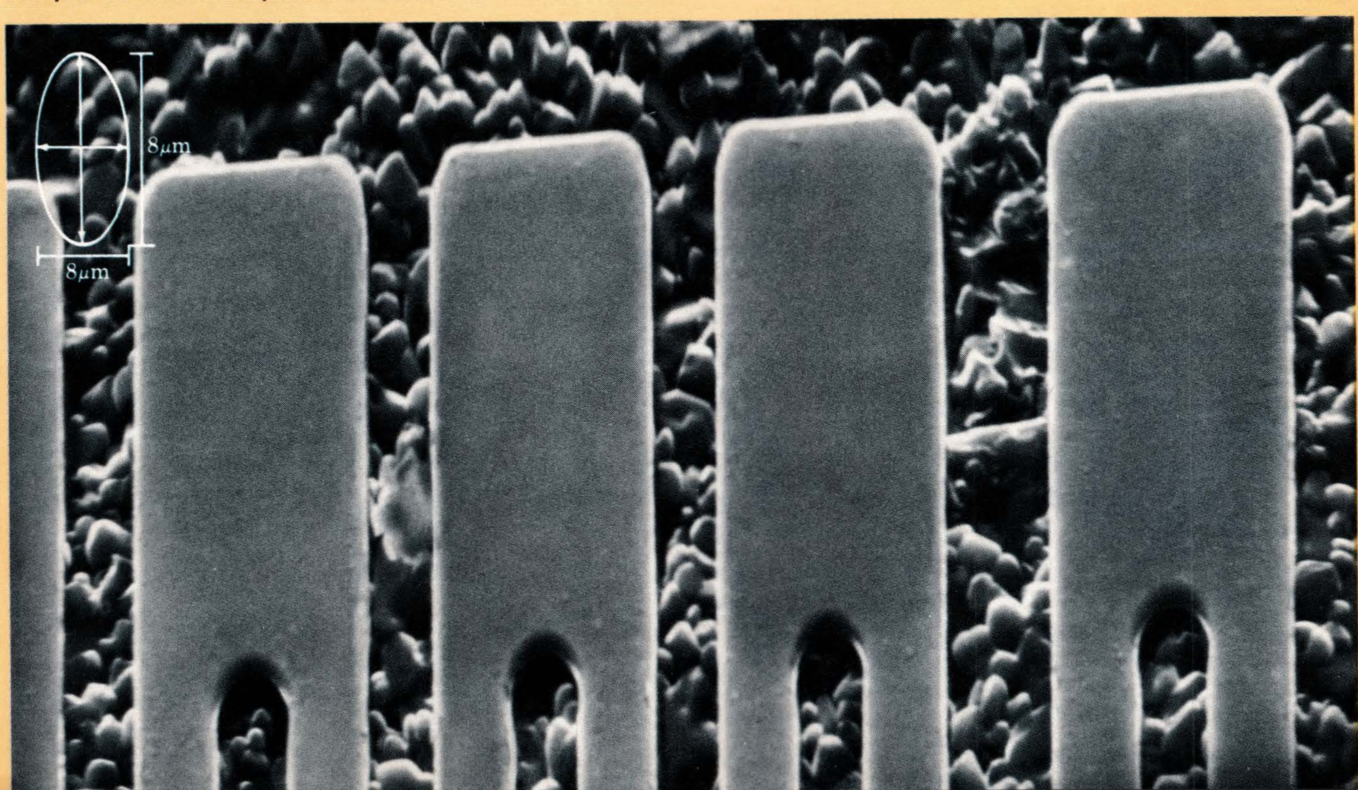
CIRCLE NO 78

SEM photo shows etched pattern of Resistor Research resistors.



```
0290 082E 2F06        XOP  R6,12       FOR PRETTY FORMAT
0300 0830 04C7 OUT2   CLR  R7          MAKE A COLUMN COUNTER
0310 0832 04CA NMBR   CLR  R10         AND A SHIFT COUNTER
0320 0834 C213 GET    MOV  *R3,R8      GET A WORD OF DATA
0330 0836 0BC8 SHF2   SRC  R8,12       AND SEND IT AS TWO BYTES
0340 0838 2E08        XOP  R8,8        SEPARATED BY
0350 083A 0BC8        SRC  R8,12       A SPACE
0360 083C 2E08        XOP  R8,8        SEND SECOND CHARACTER
0370 083E 2F06        XOP  R6,12       SUBSTITUTE NOP FOR 8 COL. MODE
0380 0840 05CA        INCT R10         COUNT THE NIBBLES SENT
0390 0842 028A        CI   R10,3       AND TEST FOR THE LAST
     0844 0003
0400 0846 12F7        JLE  SHF2        REPEAT UNTIL DONE
0410 0848 1000        NOP              OUTPUT A SPACE IN 8 COL. MODE
0420 084A 05C3 NEXT   INCT R3          BUMP THE POINTER
0430 084C 0644        DECT R4          COUNT BYTE OUTPUT
0440 084E 130A        JEQ  OUT         QUIT WHEN DONE
0450 0850 0587        INC  R7          COUNT COLUMNS
0460 0852 0287        CI   R7,8        TEST FOR LAST COLUMN
     0854 0008
0470 0856 1301        JEQ  RSET        LAST COLUMN, START A NEW LINE
0480 0858 10EC        JMP  NMBR        OR GET DATA FOR NEXT COLUMN
0490 085A 2F05 RSET   XOP  R5,12       SEND A CARRIAGE RETURN
0500 085C 06C5        SWPB R5          AND THEN
0510 085E 2F05        XOP  R5,12       A LINE FEED
0520 0860 06C5        SWPB R5          FOR DESIRED FORMAT
0530 0862 10DE        JMP  OUT1        AND GO FOR MORE DATA
0540 0864 2F05 OUT    XOP  R5,12       RESET PRINTER
0550 0866 06C5        SWPB R5          TO A NEW LINE
0560 0868 2F05        XOP  R5,12       SO WE CAN
0570 086A 06C5        SWPB R5          PRINT THE ENDING ADDRESS
0580 086C C289        MOV  R9,R10      MAKE A SHIFT COUNTER AGAIN
0590 086E C203        MOV  R3,R8       GET THE ADDRESS
0600 0870 0BC8 SHF3   SRC  R8,12       ISOLATE A NIBBLE
0610 0872 2E08        XOP  R8,8        AND SENT IT
0620 0874 060A        DEC  R10         COUNT IT AND
0630 0876 16FC        JNE  SHF3        LOOP UNTIL DONE
0640 0878 0560        INV  @>36        RETURN TO ON-BOARD TERMINAL
     087A 0036
0650 087C 06A0        BL   @>3000      AND GO HOME
     087E 3000
0660      0800        END  STRT
ERRORS=0
```

however, you'll have to pick one output format—you can't alter it dynamically.

This program is straightforward and suits use with other TMS9900-based systems. One item, however, might prove unfamiliar, even to some TM990/189 users. At lines 120 and 640, the program modifies the data stored at location 36_H. Whenever an output function is called, the program checks this memory location; if its contents are nonzero, the output gets displayed on the on-board terminal rather than the external device. This feature allows you to use both external and internal peripherals under program control.

One other caution: The end count tests for zero in the byte counter. This test fails if you specify an odd byte count in R_2 at run time. EDN

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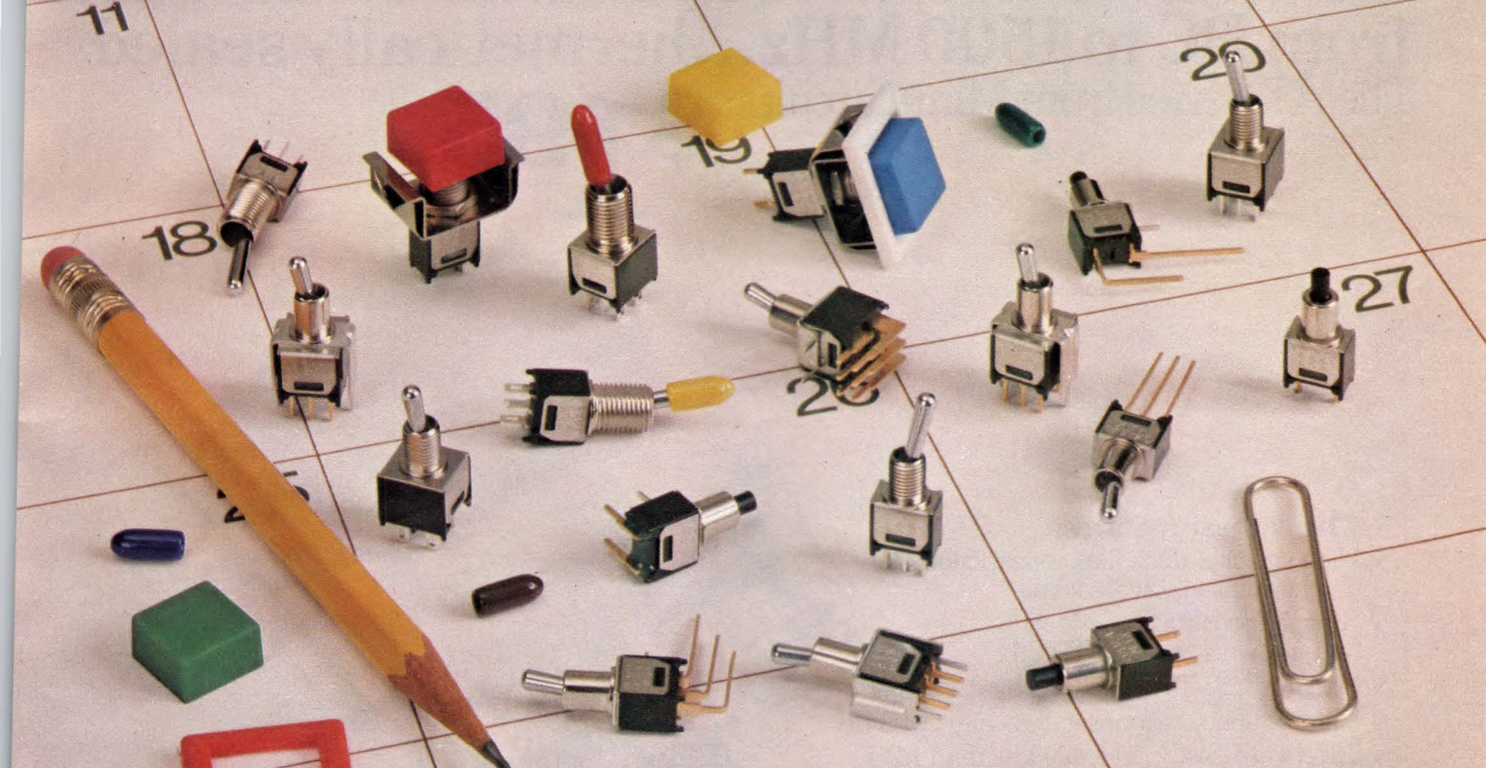

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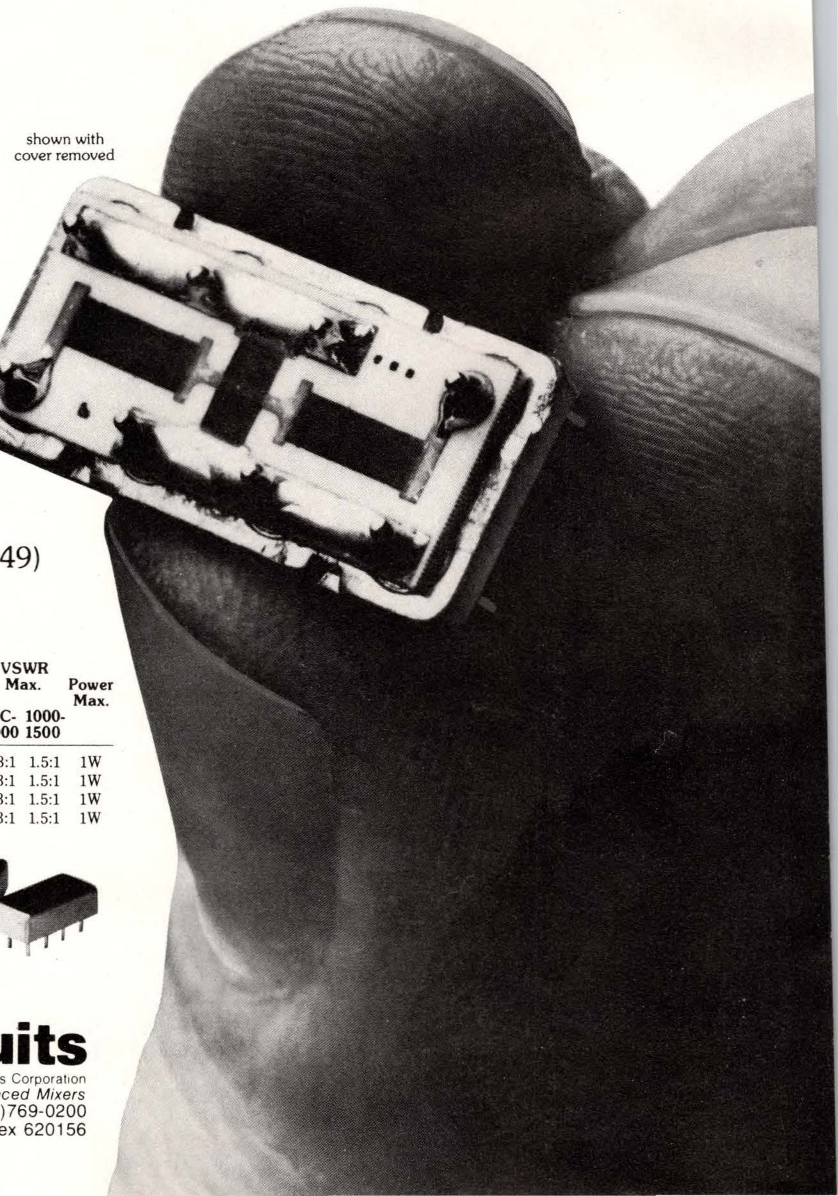
Tel: (617) 964-6400, Telex: 92-2546 • TWX: 710-335-1163

CIRCLE NO 79

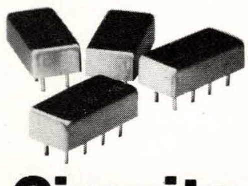
fixed attenuators

the world's lowest priced attenuators 3,6,10 or 20dB
from DC to 1500 MHz...hermetically sealed
The AT Series from Mini-Circuits **$1.95**
1000 Quantity
$3.95 (10-49)



Check these features:
- √ High stability; thick film construction in a hermetically sealed case
- √ Rugged construction: Meets requirements of MIL STD 202
- √ Miniature Size: 0.4" by 0.8" by 0.2" high
- √ Flat frequency response: Typically ±0.3 dB
- √ Excellent VSWR: typically less than 1.2:1
- √ Low cost: $1.95 (1,000 quantity), $3.95 (1-49)
- √ Delivery: From stock

Model	Attenuation, dB Nominal Value	Attenuation Tolerance from Nominal	Frequency Range MHz	Attenuation Change From Nominal Over Frequency Range, MHz		VSWR Max.		Power Max.
				DC-1000	1000-1500	DC-1000	1000-1500	
AT-3	3	±0.2dB	DC-1500	0.6dB	1.0dB	1.3:1	1.5:1	1W
AT-6	6	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W
AT-10	10	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W
AT-20	20	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1	1W



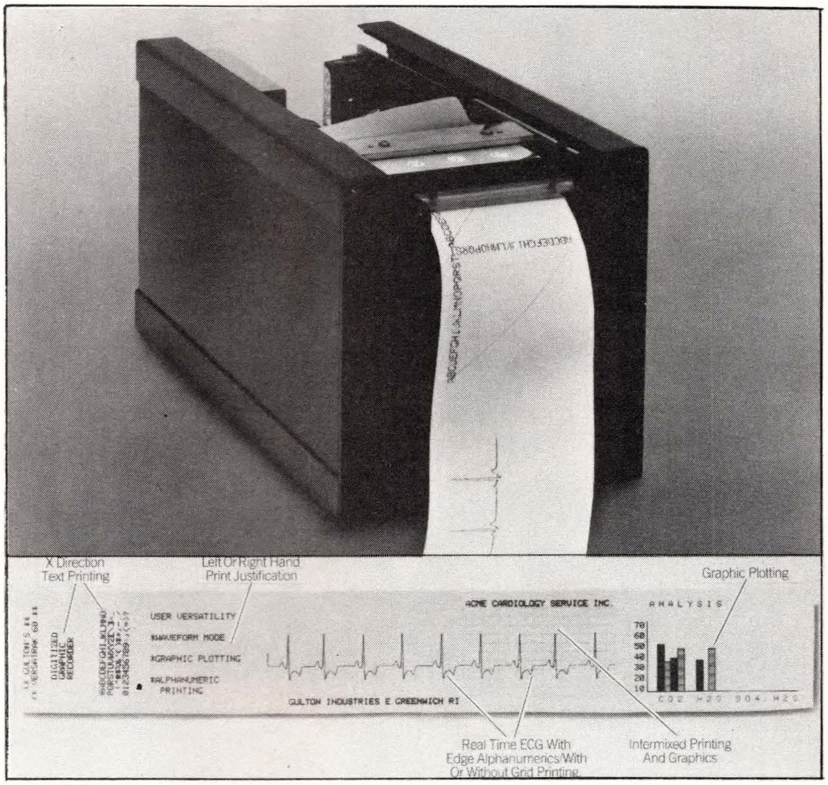
Mini-Circuits
A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
2625 East 14th Street, Brooklyn, New York 11235 (212)769-0200
Domestic and International Telex 125460 International Telex 620156

CIRCLE NO 85

Graphic/alphanumeric thermal recorder produces real-time annotated plotting

Accepting analog or digital waveform inputs or digital data and control inputs, the Versatrak-60 graphic thermal recorder provides complete information control for medical, laboratory and data-acquisition printing applications. The µP-controlled instrument features a linear-dot-array printhead that produces 240 dots across a 60-mm field on 0.25-mm centers.

On thermal graphic paper, the instrument can create a grid simultaneously with the trace or print the trace without the grid. This capability minimizes recording errors and eliminates the need for expensive pre-gridded paper.



A digitized graphic recorder, *the Versatrak-60 operates in three selectable modes that provide real-time waveform and alphanumeric printing as well as graphic plotting.*

Three display modes

The recorder operates in three selectable modes: Real-Time Waveform, Printing and Graphic Plotting. In the first, it provides selectable 5-, 25- or 50-mm/sec chart speeds or one user-controllable advance rate; grid printing with minor grid marks every 1 mm, major marks every 5 mm and tic marks every 75 mm; and 32-character left- or right - hand - margin edge printing.

Other features in this mode include choice of analog or digital waveform inputs. With analog inputs, the recorder can handle a ±250-mV FS range in a differential-balance-to-common configuration at 500 kΩ. With digital inputs, it accepts 8-bit parallel TTL-compatible signals at a 1.5-msec sampling time.

With 20-column data-logging and text orientation in the X direction and 10-column right- or left-hand-justified printing in the Y direction, the instrument's Alphanumeric mode uses an upper-case 64-character ASCII set printed in a 5×7 dot matrix. Character size runs 2.5×3.5 mm. This mode also provides user-controlled chart advance or backspace with a 3-character-line capability.

Graphic Plotting mode supplies a 30-dot-lines/sec print rate, 1- to 8-line chart advance or backspace and a 240-dot buffer for one line. In normal operation, this mode permits 1-byte individual dot addressing; in enhanced operation, two bytes specify one Y-direction line segment.

The recorder requires paper in 150-ft rolls measuring 2.75 in. wide and 2.75 in. in diameter. Front or side loading permits servicing convenience.

The 6⅛×5¾×10¾-in. instrument incorporates 3-pin analog and 15-pin digital connectors for waveform inputs and a 25-pin connector for digitized alphanumeric and graphic plotting data. It operates over 10 to 50°C and requires 95 to 135 or 210 to 250V ac power. Power consumption equals 14W typ. $1200. Delivery, 90 days ARO.

Gulton Industries Inc, Gulton Industrial Park, East Greenwich, RI 02818. Phone (401) 884-6800. **Circle No** 215

a step up in shielding technology ... Insu-shield®

Manhattan Cable's innovative new shielding, INSU-SHIELD®, is *the* definitive step-up in shielding technology. INSU-SHIELD®, through its patented and unique triple layer construction, delivers the most effective shielding in the industry today.

INSU-SHIELD® is designed with a unique aluminum/polyester/drain wire configuration which allows the drain wire to be laid *over* rather than under the foil shield in paired cables. It incorporates a thin layer of aluminum tape (foil out) bonded to a polyester film. This shield is in CONTINUOUS CONTACT with a tinned copper drain wire. An additional polyester tape is applied *over* the drain wire for the individual pairs. This technique assures TOTAL PAIR-TO-PAIR ISOLATION. INSU-SHIELD® provides maximum RFI and EMI defense.

Field proven INSU-SHIELD® represents the optimum in shielding effectiveness. INSU-SHIELD® has been acclaimed by Design Engineers for its dependability and performance reliability.

Over 5000 INSU-SHIELD® products are available in stock for immediate delivery from 16 regional warehouses. Custom assemblies and configurations can be manufactured to your exacting engineering requirements.

Data sheets and INSU-SHIELD® samples are available upon request. Contact Manhattan's Marketing Services Department at Station Plaza, Rye, NY 10580.

Manhattan
ELECTRIC CABLE CORPORATION

Telex	137-387	Cleveland	(800) 362-2915
N.J. & N.Y.	(800) 631-3528	Houston	1 (800) 392-4948
Atlanta	(800) 241-8620	Los Angeles	(800) 423-4040
Chicago	(800) 323-9022	San Francisco	(800) 227-6016

50th ANNIVERSARY

® PATENT PENDING

CIRCLE NO 86

Battery-operated IEEE-488-bus analyzer helps debug applications software

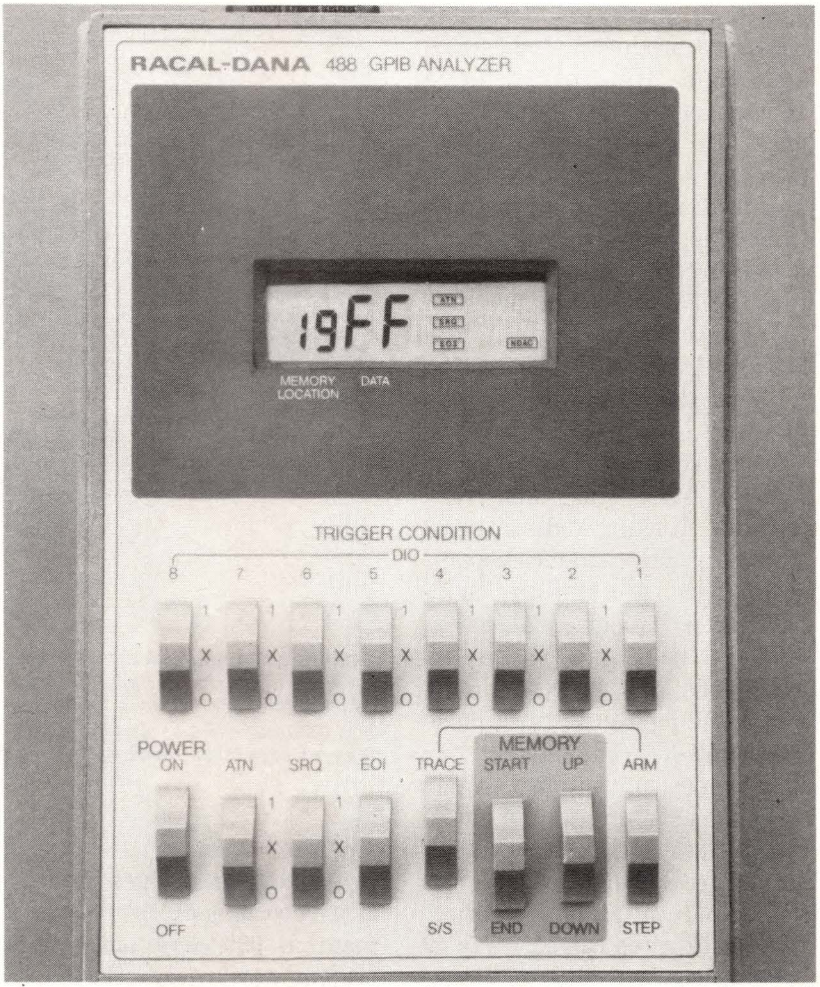
Featuring 40 words of memory and three operating modes, Model 488 bus analyzer permits monitoring of IEEE-488 systems to aid in troubleshooting applications software.

In Passive mode, the battery-operated instrument monitors bus activity and reads out the status of data input/output (DIO) lines in 2-digit hexadecimal format on its LCD. Other display capabilities include indication of memory locations in 2-digit decimal format and direct readout of instrument low-battery and trigger-arm conditions, as well as the status of bus general - interface-management and handshake lines.

In Single Step mode, the analyzer controls the bus handshake lines to provide single-step operation. And the instrument's Trace mode permits normal bus operation; trigger controls similar to those on a logic analyzer allow you to capture 40 words of bus activity.

You can specify trigger conditions on DIO, ATN, SRQ and EOI lines and locate the trigger condition at the beginning, middle or end of memory to let the instrument capture both pre- and post-trigger information. Furthermore, you can mask any lines from the trigger condition.

After triggering, the instrument lets you single-step through the captured words; moreover, you can operate the bus at full speed until a trigger condition occurs, then single-step the bus operation from that point.



Battery operation, *40 words of memory and three operating modes allow Model 488 bus analyzer to help you debug IEEE-488 systems. The LCD reads out data in 2-digit hexadecimal format and memory locations in 2-digit decimal format. And it provides direct readout of handshake- and housekeeping-line status.*

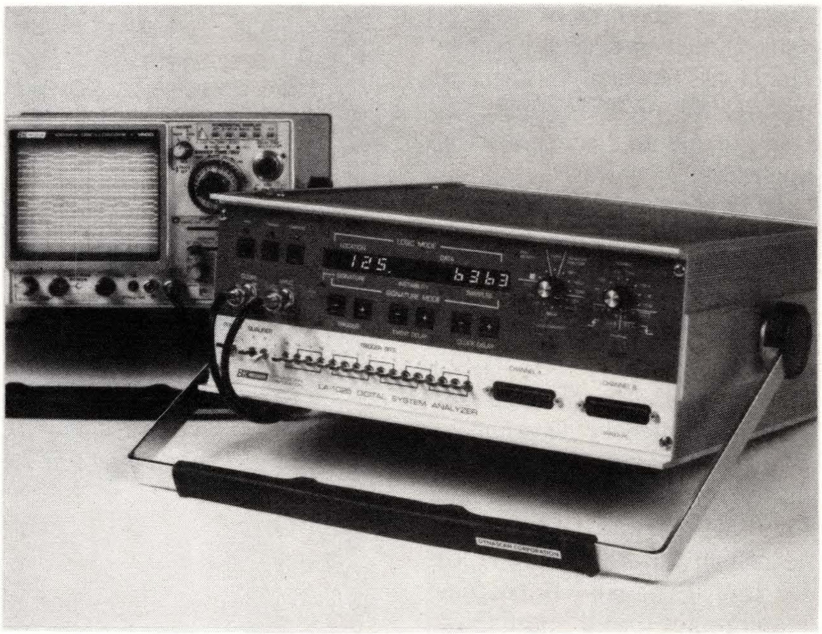
Transparent operation

Reflecting a design philosophy aimed at operation transparent to the bus, the instrument's designers incorporated battery power (four 1.5V C cells) to eliminate ground-loop problems—a potential source of system intrusion. And to further enhance its nonintrusiveness, the instrument has no controls that can modify bus data; thus, even unskilled operators can use it without risk of generating data-bus errors.

The battery operation and 2×6×8.5-in. dimensions (achievable via two custom chips) make the 2-lb instrument portable. $895.

Racal-Dana Instruments Inc, 18912 Von Karman Ave, Irvine, CA 92713. Phone (714) 833-1234. **Circle No 216**

16-channel, 20-MHz logic analyzers come with or without signature analysis



Featuring signature-analysis capability, *Model LA-1025 logic analyzer displays state data on its 12-digit LED readout or timing diagrams on a conventional oscilloscope. It contains a 16-channel×250-word memory and 18 trigger qualifiers and operates at rates as high as 20 MHz. The companion LA-1020 has the same features except for signature-analysis capability.*

Aimed at engineers designing μP-based products, Models LA-1020 and LA-1025 achieve 16-channel, 20-MHz performance. The $2475 Model LA-1025 provides signature-analysis capability that displays signatures in modified hexadecimal format; it features Continuous Signature, Unstable Signature and Signature Hold modes. The $2075 Model LA-1020 comes without the signature-analysis feature.

Both instruments present data in both state and time domains. Each model's integral 12-digit LED readout displays state data in binary, octal, decimal or hexadecimal codes. And each instrument can generate 16-channel×16-word timing diagrams, as well as clock-pulse and cursor information, for display on a conventional scope.

The instruments offer a variety of clock selections. A single front-panel control lets you choose internal asynchronous clock rates from 1 Hz to 10 MHz or external edge-selectable clocks for operation to 20 MHz.

An 18-bit pattern-recognition trigger initiates recording into each instrument's 16-bit-wide×250-word-deep memory. The 16 recording channels are fully qualifiable; the two additional qualifiers let you tailor the instrument to your application. Front-panel switches allow you to select a ONE, ZERO or Don't Care state for each of the 18 inputs.

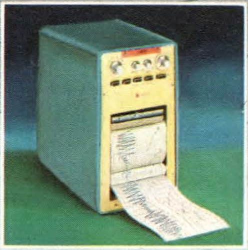
Movable trigger word

You can position trigger-word location anywhere within the 250-word memory to capture pre- and post-trigger information; recording can be delayed as many as 999 clock pulses after trigger-word recognition.

Options include a choice of TTL- or CMOS-compatible probes and 16 additional qualifiers. You can connect the event output of one analyzer to a qualifier input of a second to provide 32-channel capability at 10 MHz.

B&K-Precision, Dynascan Corp, 6460 W Cortland St, Chicago, IL 60635. Phone (800) 621-4627. **Circle No 218**

AIRPAX puts you a step ahead in drive designs for computer peripherals.

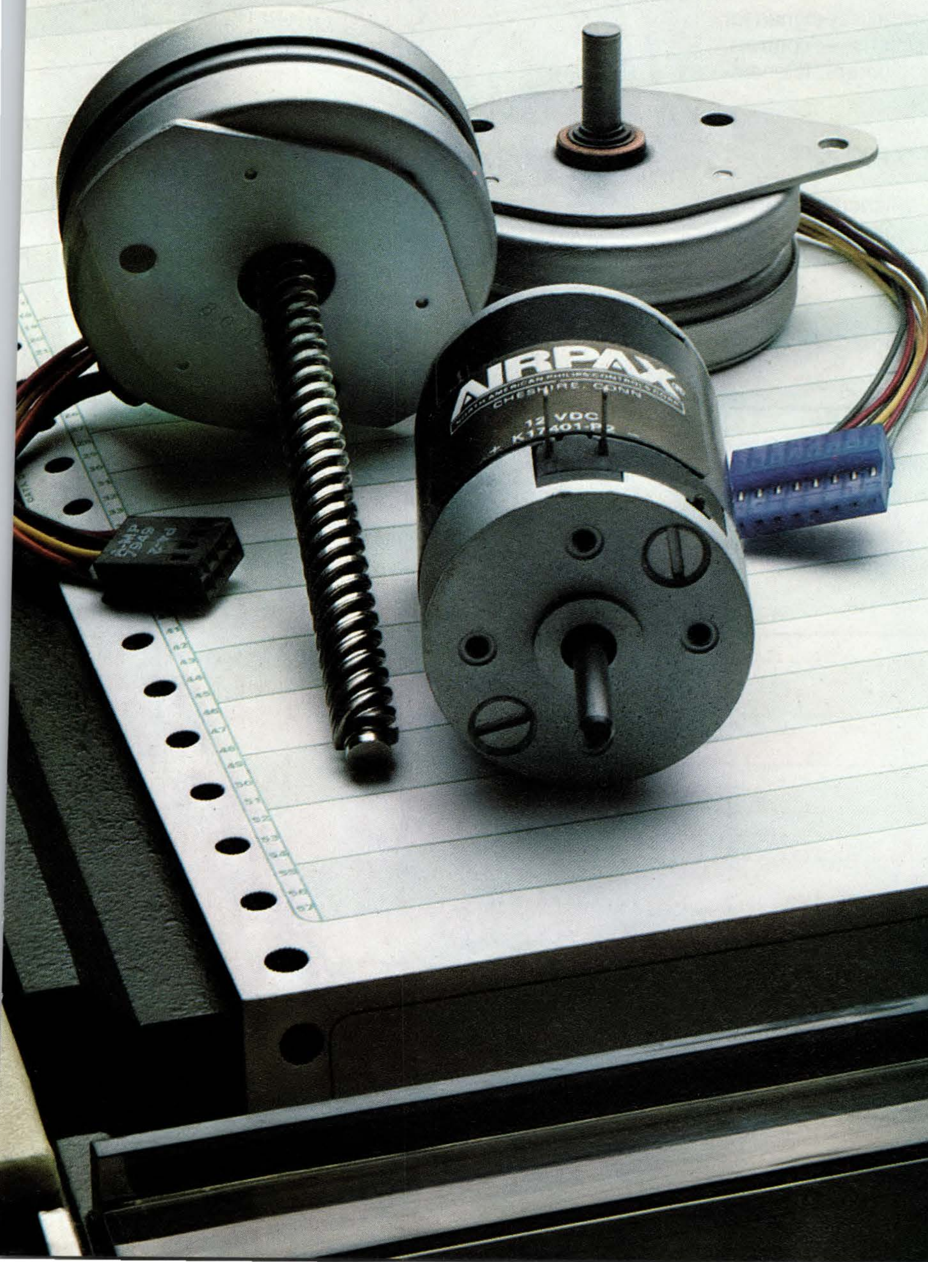


AIRPAX gives you the best performance-to-price ratios available in steppers and DC motors. They have the precision — plus ranges of voltages, torques, speeds — to suit the wide variety of drive requirements in today's computer peripherals.

Need precise positioning and fast, smooth response for memory devices? Choose an AIRPAX 82700 logic stepper motor. Unipolar and bipolar models, 5 or 12Vdc, 7.5° or 15° steps with holding torques 8 to 14 oz.-in. Their high, repeatable accuracy is ideal for floppy and mini-floppy disk drives. With lead screws, they're perfect for read/write head positioning.

In high-speed printers, Series 82700 and 82900 stepper motors serve paper advance mechanisms, smaller AIRPAX steppers are naturals for ribbon drives. And for carriage drives, select size 15 AIRPAX 17400 DC motors — 12 or 24Vdc, speeds to 5,600 rpm, stall torque 16.8 oz.-in. For outstanding performance, design your positioning or speed control servo loop around the 17400 motor.

Write for our stepper motor handbook and size 15 DC motor literature. Or call for engineer-to-engineer design assistance. AIRPAX/North American Philips Controls Corp., Cheshire Industrial Park, Cheshire, CT 06410. Phone (203) 272-0301.



AIRPAX®

NORTH AMERICAN PHILIPS CONTROLS CORP.

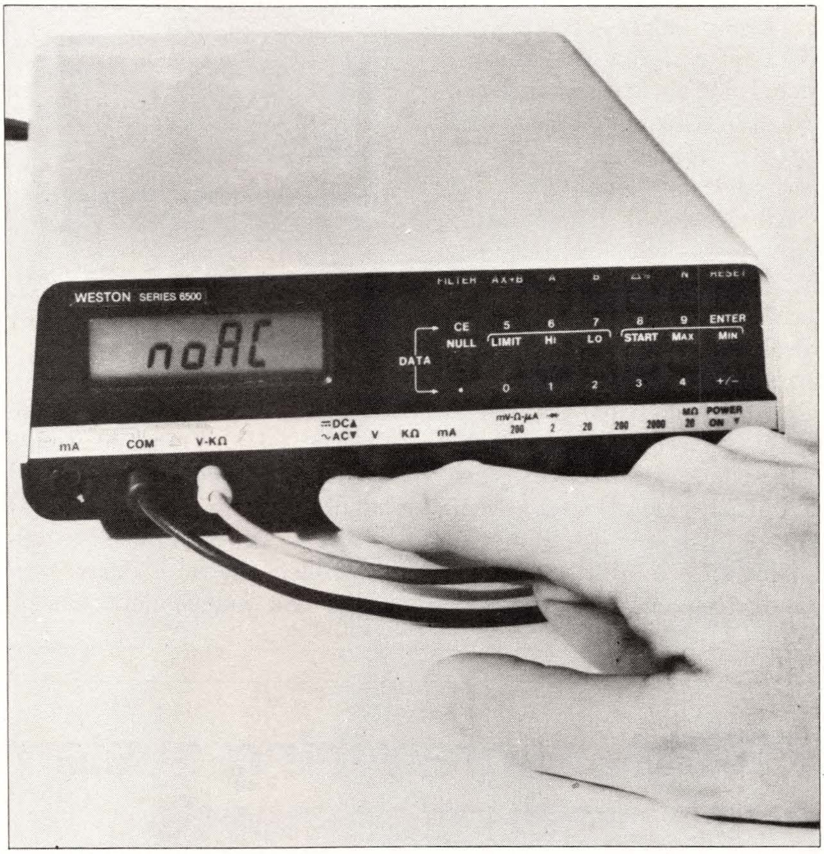
Cheshire Division

DMMs with dedicated computing functions provide prompts on 4½-digit LCDs

Series 6500 DMMs feature 4½-digit resolution, prompting capability and the dedicated computing functions often needed in DMM applications. They're aimed at what their manufacturer perceives as a gap between DMMs providing only prompting functions and those combining prompting with generalized computational programming.

Prompting messages include "func," which requests a function selection; "no ac," which indicates that an ac range has been incorrectly selected for a resistance measurement; "rng," which prompts range selection; and "o.rng," which indicates an overrange condition.

Other prompts include "oflo," which indicates an undisplayable calculation overflow; and "ouch," which indicates application of voltages greater than 1050V dc or 800V ac on the 2000V range.



Operator-prompting functions *and computational capabilities useful in DMM applications highlight Weston's Series 6500 DMMs. Here, an instrument warns that the ac mode is incompatible with resistance measurements.*

Computational capabilities include a scale/offset function that applies the algorithm y=Ax+B to the measured value: You key in A and B, and the DMM displays y. This feature can, for example, turn a diode into a thermometer: The A value could represent the inverse of the incremental diode-voltage-drop change with respect to temperature, and the B entry could then compensate for the diode drop at a reference temperature.

Other computational functions include percent deviation, minimum- and maximum-reading recall, a null feature that indicates changes from a preset level and a limit function that indicates whether measured levels are higher or lower than a preset band.

Selectable filter

The instruments contain a user-selectable digital filter that's automatically disabled if measured values change at more than 2% per reading, thus providing fast display update. DC accuracy specs at 0.03% of reading+2 digits.

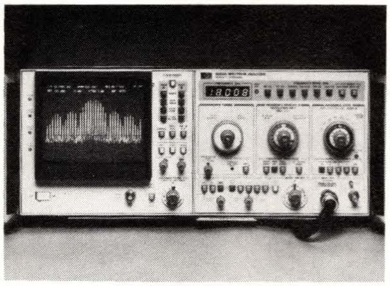
You can measure ac and dc voltages to 2000V and ac and dc current to 2A and select models that provide either average- or true-rms-responding ac measurements. Front-panel paddle switches allow you to operate the instruments without sliding them across your lab bench. From $640.

Weston Instruments, 614 Frelinghuysen Ave, Newark, NJ 07114. Phone local office.
Circle No 217

Microwave spectrum analyzer's μP control permits semiautomatic testing

Spanning the 10-MHz to 22-GHz frequency band (extendable to 170 GHz with external mixers), Model 8569A features μP control of I/O capabilities that suit it to semiautomatic production test and data logging.

An advanced mixer design that yields high sensitivity plus flat response and a stabilized local oscillator that permits high resolution combine to suit the instrument to applications ranging from wide-band displays to detailed narrow-band analysis.



Featuring 10-MHz to 22-GHz operation, *Model 8569A provides μP control that suits it to production test.*

Specifications include sensitivities of −113 dBm (at a 1-kHz bandwidth) for fundamental mixing and −95 dBm at 18 GHz, ±3-dB frequency response to 18 GHz and 80-dB dynamic range to 1.8 GHz. Dynamic range exceeds 100 dB in preselected bands.

The instrument's μP-controlled digital display provides two independent traces, each with resolution to 480 horizontal and 800 vertical points.

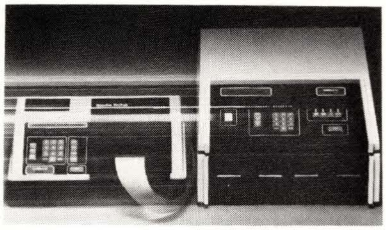
Other capabilities include digital averaging for extracting low-level signals from noise, normalization that facilitates observation of signal changes and maximum hold that allows you to monitor signal drift. The analyzer also features GPIB read/write capability.

$26,500. Optional 100-MHz comb generator, yielding 0.007% frequency accuracy through 22 GHz, $1425.

Hewlett-Packard Co, 1507 Page Mill Rd, Palo Alto, CA 94304. Phone local office. **Circle No 219**

PROM-programming system suits production needs

A PROM-programming system consisting of Model 200A data-control unit, Model 100A production programmer and a handler interface suits manufacturing applications by handling data management, programming, testing and recordkeeping.



Meeting manufacturing requirements, *Model 100A production PROM programmer and Model 200A data-control unit team up to handle programming, testing and recordkeeping chores.*

The data-control unit comes with one or two 5¼-in. disk drives—one floppy disk contains 82k bytes of 8-bit programming data—the equivalent of 41 2716-type EPROMs. You can store this data under user-specified part numbers.

Other features of the data-control unit include three RS-232C ports, which allow it to support three programmers. And when the 200A is used as a slave to a 100A, an operator can control both instruments via the 100A's front panel. (Model 200A also has an optional front panel that lets you use it with any RS-232C-compatible programmer.)

English prompts

Model 100A's features include English-language prompting messages on a 16-character display. Load, Program and Start keys initiate routine operations; an alphanumeric keyboard permits input of data-pattern part numbers. An optional foot switch facilitates manual programming of MOS PROMs that don't warrant automatic handling because of their long programming times.

Model 100A, $2750; Model 200A, $2300 to $4000; handler interface, $2100. Delivery, 6 to 8 wks ARO.

Data I/O Corp, Box 308, Issaquah, WA 98027. Phone (206) 455-3990. **Circle No 220**

	NUMBER	ORGANIZATION	TYPICAL ADDRESS ACCESS TIME	TYPICAL POWER DISSIPATION
256 Bits	TBP18S030 TBP18SA030	32 x 8	25 ns	400 mW
1K	TBP24S10 TBP24SA10	256 x 4	35 ns	375 mW
2K	TBP28L22 TBP28LA22	256 x 8	45 ns	375 mW
4K	TBP28S42 TBP28SA42	512 x 8	35 ns	500 mW
	TBP28S46 TBP28SA46	512 x 8	35 ns	500 mW
	TBP24S41 TBP24SA41	1024 x 4	40 ns	475 mW
8K	TBP28S86-60 TBP28SA86-60	1024 x 8	35 ns	550 mW
	TBP28S86 TBP28SA86	1024 x 8	45 ns	625 mW
	TBP28L86	1024 x 8	65 ns	275 mW
	TBP24S81-55 TBP24SA81-55	2048 x 4	35 ns	550 mW
	TBP24S81 TBP24SA81	2048 x 4	45 ns	625 mW

A = Open Collector; L = Low Power

Best news in recent memory: New 8K PROMs. Plus fresh redesigns. The big family from Texas Instruments.

New 8K PROMs that are speedier, that save space and power. Redesigns that significantly improve system performance. TI, a major PROM supplier, gets your day started right.

Three 8K headliners

For outstanding speed, try these TI 8K PROMs: the TBP24S81-55 and TBP28S86-60. Typical address access time: 35 ns; max address access times: 55 ns and 60 ns, respectively.

To conserve space, TBP24S81-55 comes in a 300-mil wide, 18-pin package requiring 60% less board room than the industry-standard 600-mil wide, 24-pin package.

To save power, TI's TBP28L86 8K features typical power dissipation of only 275 mW — about 50% less than TI's standard high-speed PROMs — yet is one-third faster than similar devices currently on the market.

Five banner improvements

Redesigned lower-density PROMs now offer up to 20% faster max address access times and reductions of as much as 35% in power consumption. Included are TI's popular 1K; a low power 2K; two 512x8 4Ks; the 1024x8 24-pin 8K.

Extra! Easy programming

Programming problems are fewer, costs lower with TI PROMs, since only one programming configuration is needed for all our devices from 1K through 8K.

More news in the making

On the way from TI: 16K PROM with a typical address access time of 35 ns, as well as Registered Output and Power-Down PROMs. For all the news about TI's big PROM family, call your TI distributor, or write Texas Instruments Incorporated, P. O. Box 225012, M/S 308, Dallas, Texas 75265.

TEXAS INSTRUMENTS
INCORPORATED

CIRCLE NO 89

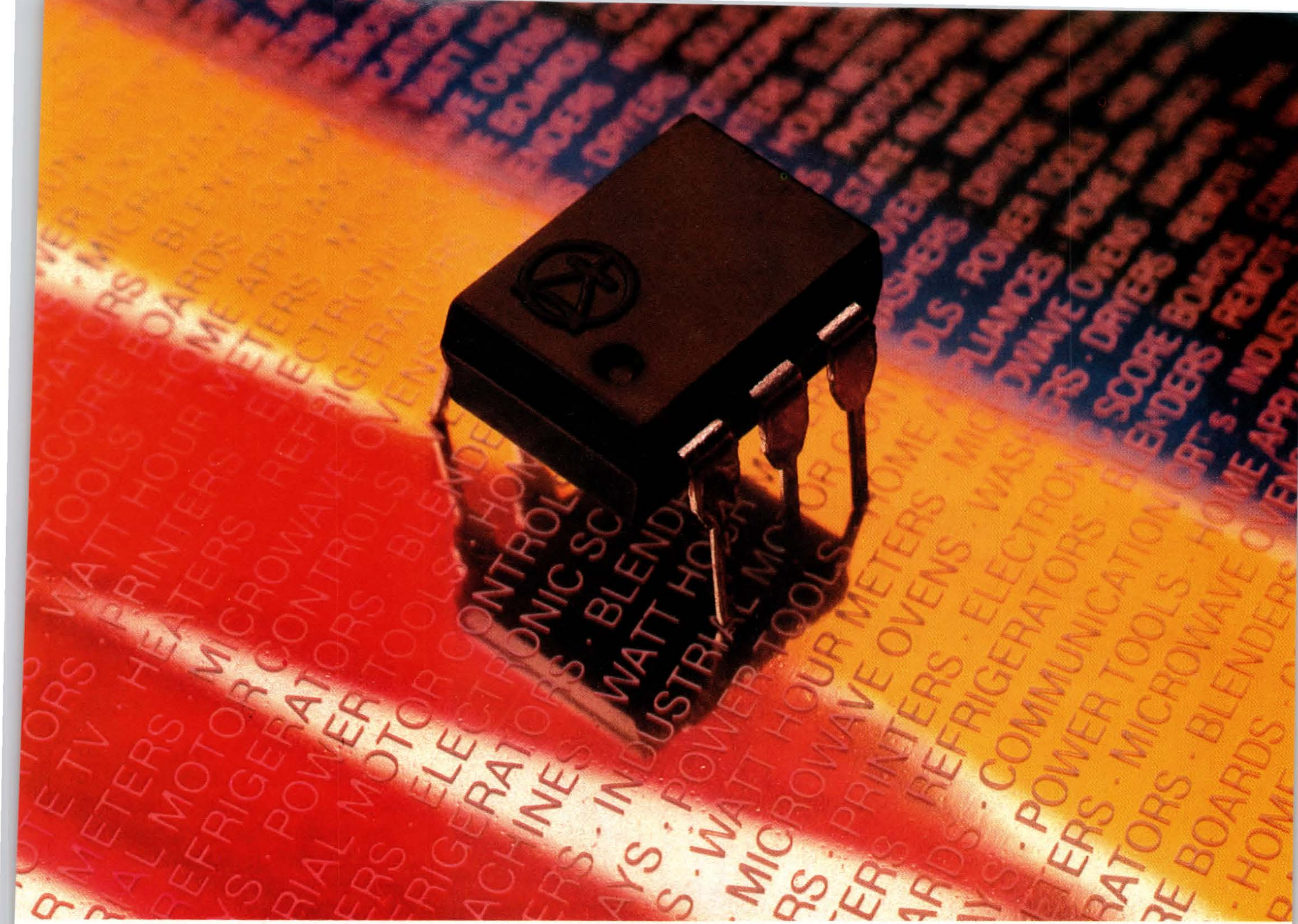
84328

New Products

INSTRUMENTATION & POWER SOURCES

μP DEVELOPMENT SYSTEM. The hard-disk Multi-AMPL multiuser prototyping/development system provides a complete set of hardware- and software-development facilities for its manufacturer's 16-bit 9900-family μPs and TM990 Series μC modules. Furnishing complete concurrent multitask operation, including compile, assemble, debug, edit and print, plus multiple-processor emulation, it also features optional PASCAL or FORTRAN, Component Software libraries and a high-level debugging test-procedure emulation language. The standard system comprises a CPU, a dual hard-disk drive, one to four 1920-character 12-in.-diagonal video display terminals with keyboard and software. Depending on the system version used, as many as eight remote users can work simultaneously at up to eight video units and terminals. Main-memory size ranges from 256k bytes (TMAM9010 version) to 320k bytes (TMAM9040). Disk storage ranges from 9.4M formatted bytes (TMAM9010) to 89.4M formatted bytes (TMAM9040). \$37,700 (TMAM9010) to \$72,900 (TMAM9040). **Texas Instruments Inc,** Box 202129, Dallas, TX 75220.

Circle No 221



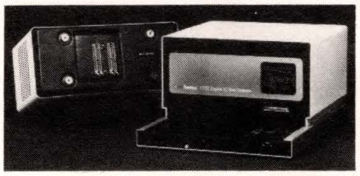
New Products

INSTRUMENTATION & POWER SOURCES

FUNCTION GENERATOR. Featuring a waveguard output-protection circuit that resets automatically after removal of an external voltage or short circuit, Model 1000A provides 20V p-p sine, square and triangle waveforms from 0.2 Hz to 3 MHz. A 1500:1 frequency-tuning range on three multiplier bands is also included. Other features include external voltage control of frequency, calibrated control-voltage output proportional to frequency and auxiliary TTL

output. $345. **Krohn-Hite Corp,** Avon Industrial Park, Avon, MA 02322. Phone (617) 580-1660. TWX 710-345-0831.

Circle No 222



IC TEST SYSTEM. An enhanced version of its manufacturer's 1732 digital-IC test system, Model 1732K is a benchtop unit for the dc parametric and functional testing of all types of digital devices. Designed for incoming inspection, it provides as many as 48 pins and employs three processors. A Z80 μP with 64k bytes of RAM controls the system and operates the CRT display. A second processor operates the magnetic-tape storage unit, and a third high-speed pattern processor applies test vectors to the device under test at rates to 2 MHz. Test vectors are stored in a pattern memory with 4k×4 bits of storage for each driver/sensor pin. Test-pattern entry is aided by a Learn mode whereby the response portion of the truth table is derived from a known-good device. Operating-system software performs a Kelvin self test for verification of contact closure on automatic handlers. From approximately $33,000 for a 16-pin unit. Delivery, 4 to 6 wks ARO. **GenRad Inc,** 170 Tracer Lane, Waltham, MA 02254. Phone (617) 890-4900.

Circle No 223

A world-class relay. New from American Zettler.

High dielectric strength. As you see here, our new AZ 690 and AZ 730 relays feature a full 8-mm spacing between coil and contacts. The benefit is a 4000-volt breakdown rating.

You get complete isolation between sensitive control circuits and switching circuits.

Meets international standards. In addition to UL and CSA approvals, these units meet the tough international standards imposed by VDE, IEC, CEE, and SEMKO.

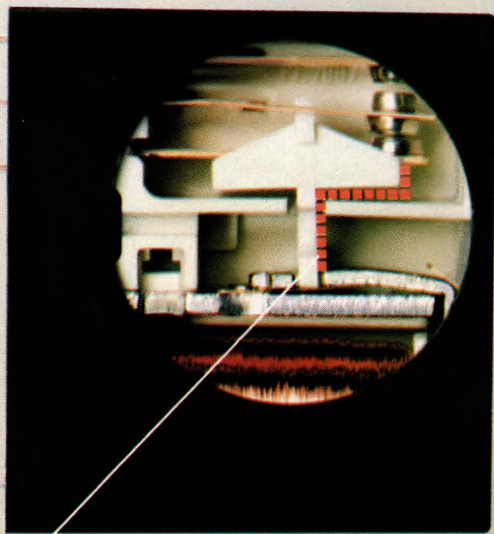
The SLIMPAK™ relay.

The THINPAK® relay.

Power switching. Available in both single-pole and double-pole arrangements, these relays switch up to 10 amps. Coils to 48 volts dc.

High-density packaging. When board space is at a premium, choose the SLIMPAK™ version. Or when low profile is important, select the THINPAK® model. Epoxy-sealed versions available.

Get all the details. Call Don Barkhurst at 714/540-4190 for samples, technical data, and a quotation on the AZ 690 and AZ 730 miniature power relays. Or write American Zettler, Inc., 16881 Hale Avenue, Irvine, CA 92714.



The path between coil and contacts is greater than 8mm. (Relay shown 2.5X actual size.)

"It's a better relay"

AMERICAN ZETTLER, INC.

CIRCLE NO 94

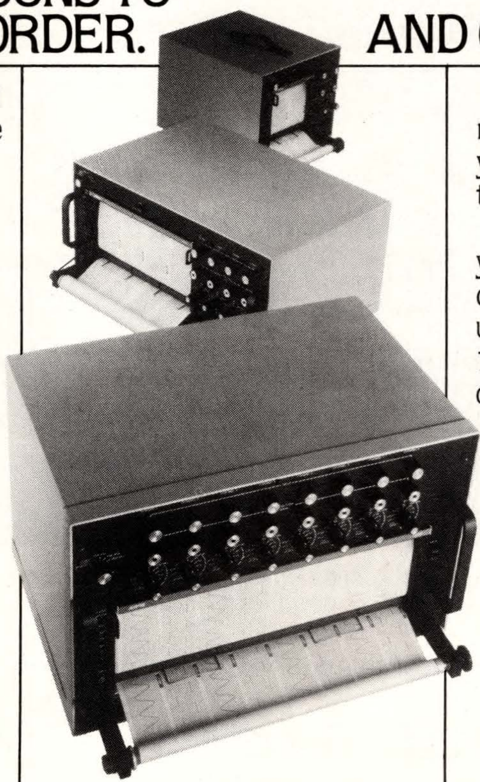
THREE NEW REASONS TO USE AN MFE RECORDER. AND ONE OLD REASON.

If you thought you'd never find the recorder you need — at a price you can afford — here's some good news from MFE:

1. We've increased our sensitivity range. Now you can record signals from 0.5mv/mm up to 5v/mm. That's a degree of sensitivity you just can't get from our competition.

2. We've added differential input so now you can isolate and display a signal as small as 25mv or as large as 250 volts, full scale across a 50mm grid.

3. We've introduced a single-channel model. So now you can choose from 1-, 2-, 4-, 6- and 8-channel recorders.



Yet even with all these improvements, MFE recorders still cost you thousands less than competitive instruments.

And of course, MFE still offers you inkless, thermal writing that's crisp and dependable. Plus an unlimited choice of speeds from 1mm per hour to 100mm per second. So you can scale your recordings for optimum resolution and paper economy.

For complete information call toll-free **1-800-258-3884.** Or write, MFE Corporation, Keewaydin Drive, Salem, NH 03079.

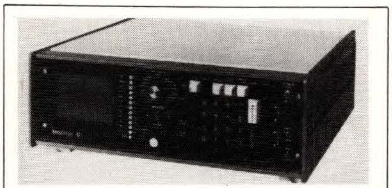
MFE

A WHOLE LOT MORE FOR A WHOLE LOT LESS.

CIRCLE NO 95

New Products

INSTRUMENTATION & POWER SOURCES

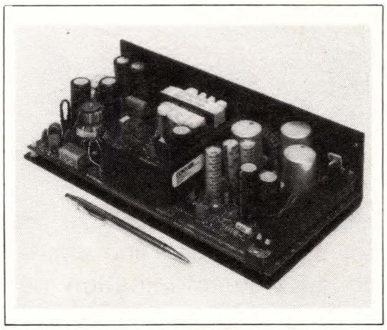


DATACOMM ANALYZER. For testing, monitoring and emulating data-communication networks, the interactive portable Monitor II simulates a variety of communications parameters at rates to 120k bps. Compatible with asynchronous, synchronous, SDLC and similar high-level data-link-control applications, it conforms to RS-232C and CCITT V.24 standards. It also features a 1-button autoprogram setup for monitoring and transmitting, a 16k-character memory (optionally 48k), a 5-in.-diagonal screen with 512-character display and byte- and bit-oriented protocol capability. Also featured are idle suppression; ASCII, EBCDIC, and hex display codes; composite video output; and a 33-key multifunction keypad for entry of user-designated control characters. $3795. **Huber Systems Corp,** Marlton, NJ 08053. Phone (609) 983-0807. **Circle No 226**

GPIB INTERFACE. Model 4380-488 connects its manufacturer's directional RF Power Analyst wattmeters to the GPIB for automatic measurement and recording of data. Typical applications include unattended periodic measurement of one to nine RF signal parameters, hard-copy printout of data-logging data, and scope, graphics-terminal or curve-plotter feed for dependent-variable display. $975. **Bird Electronic Corp,** 30303 Aurora Rd, Solon, OH 44139. Phone (216) 248-1200. **Circle No 227**

New Products

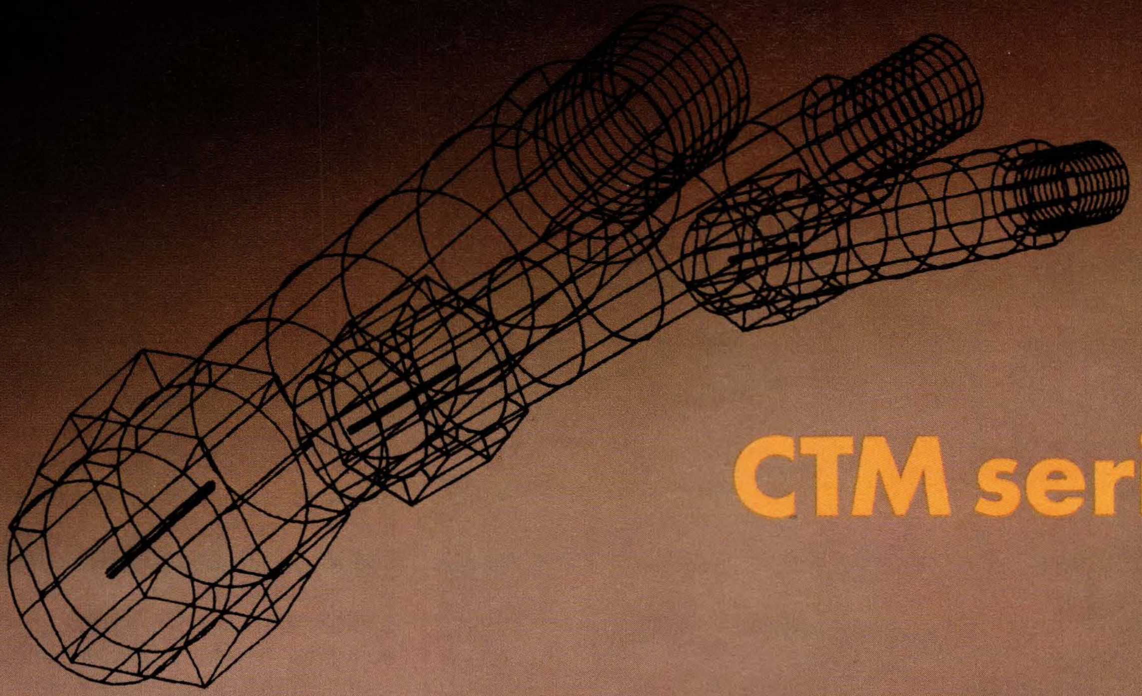
INSTRUMENTATION & POWER SOURCES



SWITCHER. Delivering 5V/25A, ±12V/4A and −5 or 24V/4A, the open-frame Model AC-200 furnishes 200W max to 50°C, derated 2.5%/°C to 70°C. Mechanically compatible with the Boschert OL-200 Series and meeting or exceeding Boschert specs, it sports an 80 to 140V/160 to 264V input-voltage range (43 to 440 Hz), plus ±3% regulation on the 5V output and ±5% on the others. All outputs are short-circuit protected, and overvoltage protection is included for the 5V output. The unit has been submitted to VDE for approval with regard to Specification 0730. $369. **Conver Corp,** 10629 Bandley Dr, Cupertino, CA 95014. Phone (408) 255-0151. **Circle No** 224

PYROMETERS. Pocket sized, these taut-band 2%-accuracy meters need no external power or batteries to cover a −200 to +2500°F range. Mirror scaled, with both Fahrenheit and Celsius readings on one scale, they provide built-in self compensation for changes in ambient temperature. An adjustable resistor on the front face eliminates the need for a fixed resistor and facilitates thermocouple changes. $115 without thermocouple. **Nanmac Corp,** 9-11 Mayhew St, Framingham Centre, MA 01701. Phone (617) 872-4811. **Circle No** 225

TUNNEL DETECTORS—BACK DETECTORS



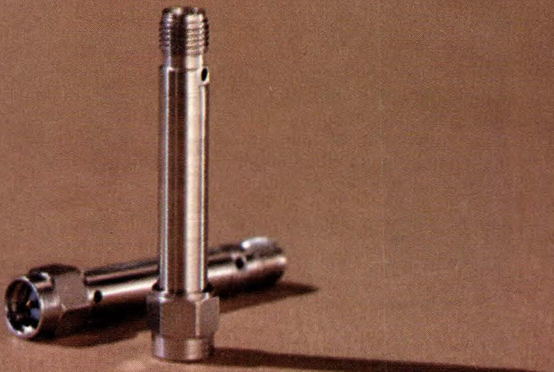
CTM series

Zero Bias
Video Impedance (100Ω typical)
Low VSWR
50mw (3 erg.) Power Handling

Productized for low cost and quick delivery
Supplied with HI-REL germanium diodes
Computer-characterized for frequency response, sensitivity and VSWR
Size: 1.60 x .25" diameter; all models
Connectors: SMA male input—female output

FREQ. (GHz)	MODEL NR.	FLATNESS (dB)	FIG. OF MERIT	TSS* (dBm)
0.5 - 4.0	CTM 2540	±0.4	90	−51
1.0 - 12.0	CTM 3112	±1.0	80	−50
2.0 - 18.0	CTM 3218	±1.0	60	−49
8.0 - 18.0	CTM 3818	±0.7	80	−50

*TSS for 2MHz VID BW; 2 dB VID. N.F.



MICROPHASE

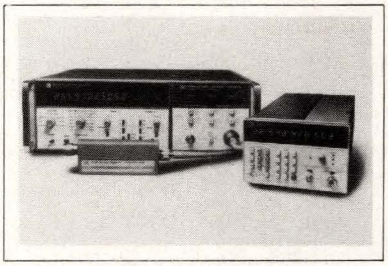
P.O. Box 1166, Greenwich, Conn. 06830
Phone 203-661-6200/TWX 710-579-2926

ENGLAND, London, Walmore Electronics, Ltd.
FRANCE, Champigny-Sur-Marne, Serrgop
GERMANY (West), Muenchen, Mikro Lambda
INDIA, Bombay, Micronic Devices
ISRAEL, Tel Aviv, Talviton Electronics
ITALY, Milano, Microelit S.R.I.
JAPAN, Tokyo, Nippon Aircraft Supply Co., Ltd.
NETHERLANDS (Belgium/Luxembourg), Gennep, Heijene B.V.
SWEDEN, Skarholmen, Amerikanska Teleprodukter

CIRCLE NO 99

New Products

INSTRUMENTATION & POWER SOURCES



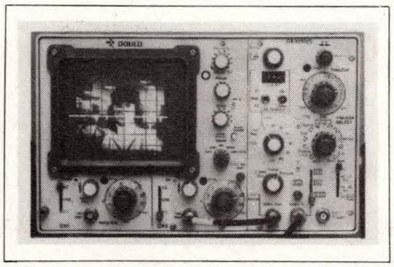
MICROWAVE LIMITER. Protecting microwave-counter input circuits against damage from excessively high signal levels to 8W cw (39 dBm) and to 100W pk pulsed (50 dBm), Option 006 operates to 26.5 GHz. Available for its manufacturer's Model 5340A, 5342A and 5343A microwave counters and Models 5356A and 5356B frequency-converter heads, it can be field installed in counters now in use. $400. Delivery, 60 days ARO. **Hewlett-Packard Co,** 1507 Page Mill Road, Palo Alto, CA 94304. Phone local office. **Circle No 228**

POWER MODULES. Rated at 250 or 375 VA, UL-listed and CSA-certified Isoreg modules protect computers from sharp voltage spikes, excessively high voltages and brownout-type voltage drops. Ferroresonant devices incorporating neither moving parts nor semiconductors, they furnish ±0.5% output-voltage stability for input voltages ranging from −25 to +15% of nominal, 0.75-pF input-to-input capacitance and 3% harmonic distortion at full load. Input cord plug, dual outlets and circuit-breaker protection on both input and output are also provided. $298 for 250-VA version; $340 for 375-VA model. **Frequency Technology Inc, TDC Div,** Box 486, Littleton, MA 01460. Phone (617) 486-3539. TWX 710-347-6974. **Circle No 229**


In the world of flat cable, new Vari-Twist™ cable really stands out.
Belden's new Vari-Twist™ twisted pair cable combines the excellent electrical characteristics of paired conductors with the fast termination of flat cable.
The 18 inch twisted portions feature opposite direction lays on each adjacent pair of conductors. This minimizes cross-talk and provides a cleaner, more reliable signal. Each two inch straight section has precise 50 mil centers to fit standard IDC connectors. And because Vari-Twist is laminated on one side only, an easier, more reliable termination can be achieved.
Best of all, you can count on Vari-Twist cable's high quality because it's made by Belden. And backed by our strong commitment to service. For more information on Vari-Twist cable or any other cables, connectors or value-added products in Belden's flat cable world, contact: Belden Corporation, Electronic Division, Central Regional Sales Office in Richmond, IN; 317-983-5200. Western Regional Sales Office in Irvine, CA; 714-833-7700. Eastern Regional Sales Office in Framingham, MA; 617-872-7846.
8-1-1
BELDEN
Coming through...
with new ideas for moving electrical energy
CIRCLE NO 101

New Products

INSTRUMENTATION & POWER SOURCES



VIDEO TEST SCOPE. The portable Model OS3350/5 TV-monitoring unit combines an NTSC (PAL version also available) 525-line waveform and picture monitor with the functions of a general-purpose 40-MHz dual-trace scope. It fits the testing and troubleshooting of TV, CATV, CCTV, video-recorder/playback and other video equipment. The timebase generator permits a line-by-line examination of 525-line waveforms or display of complete pictures. Accepting standard-level composite video signals with or without sound-in-sync signals and providing five triggering modes, the unit indicates the line examined on a 3-digit LED display. A vernier control provides triggering delays to 90 μsec, the displayed video signal can be clamped or not, and the triggering point selected can be shown as a bright-up line on the displayed TV picture. $4395. **Gould Inc Instruments Div,** 3631 Perkins Ave, Cleveland, OH 44114. Phone (216) 361-3315. **Circle No** 230

MINICASSETTE LOGGER. The portable MTL 900 suits remote data gathering, program updating and memory downloading. Each miniature cassette holds 86k bytes max at 800 bpi. System data-transfer rate specs at 2400 baud. Power is supplied through the RS-232 interface cable from the host equipment.

WHERE CAN YOU FIND STANDARD HIGH POWER 3-PHASE DC POWER SUPPLIES WITH ALL THESE FEATURES?

- High efficiency
- Low cost
- Up to 10 KW
- High performance
- Product uniformity
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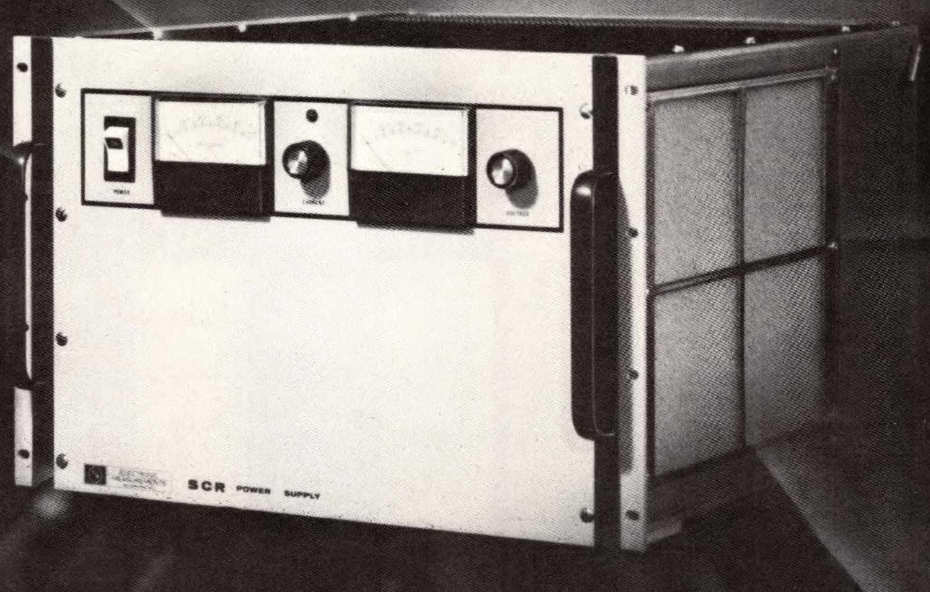


Give us your application details and we'll give you a precise power supply solution.

ELECTRONIC MEASUREMENTS INC.

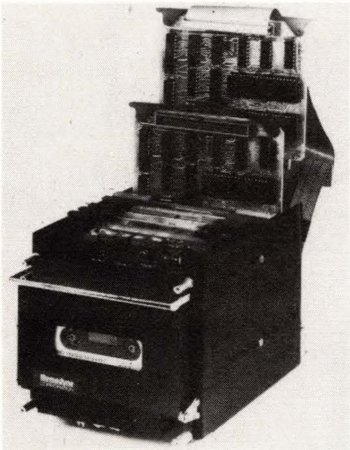
Electronic Measurements Inc.
405 Essex Road, Neptune, NJ 07753
*In NJ, AK, HI and Canada, call 201-922-9300

CIRCLE NO 188

New Products

INSTRUMENTATION & POWER SOURCES

Internal ac or battery power supplies are optional. $425. **Braemar Computer Devices,** 11950 12th Ave South, Burnsville, MN 55337. Phone (612) 890-5135. **Circle No** 231



DATA-ACQUISITION SYSTEM. Accepting as many as eight analog inputs, the Z80-based Model M80/OAS permits simultaneous controlled sampling of inputs, conversion to 12-bit binary format (plus sign bit), analysis and data storage on Philips cassettes. One converter serves each channel; the differential inputs have selectable ranges of ±500 mV to ±5V. Common mode is rejected between ±5V. Resolution equals 13 bits binary and includes overrange indication. Initiating a conversion cycle and sampling channels as programmed, the 5×5×8.5-in. unit converts values to decimal or engineering units and stores and/or transmits them over the RS-232C port. $2190 for a 4-channel system; $2535 for eight channels. **Memodyne Corp,** 220 Reservoir St, Needham Heights, MA 02194. Phone (617) 444-7000. TLX 922537. **Circle No** 232

Low-cost fiber-optic receivers satisfy varied applications

Versatile enough to serve a variety of needs, the MFOC600 and MFOD624F receivers are designed for short- to intermediate-range data transmissions.

A monolithic device housed in a 16-pin ceramic DIP, the MFOC600 accepts a detected optical signal from a PIN diode or an optical-detector preamplifier. Its outputs can be compatible with TTL and ECL as well as analog signals, accommodating data rates of 10M and 20M bps and 10 MHz, respectively.

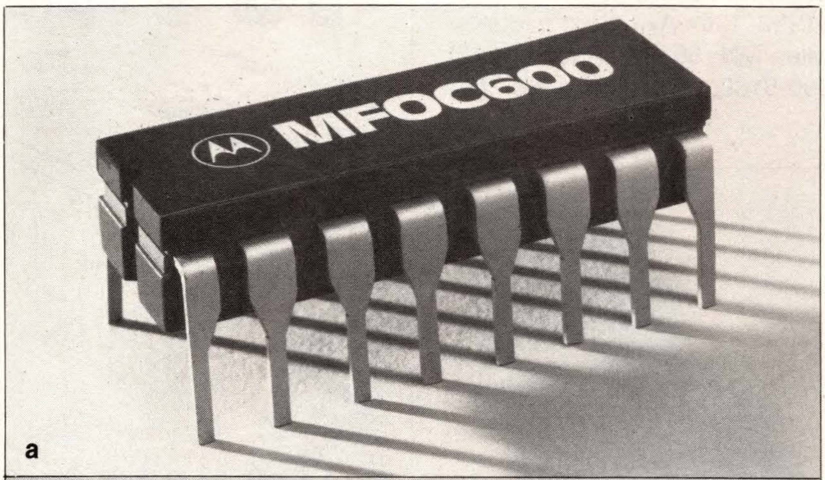
Operational data formats include NRZ, pulse-bipolar and Manchester encoding. The $18.30 receiver operates from one supply voltage and includes an AGC circuit with 20-dB dynamic range and a transimpedance amplifier for systems employing a PIN-diode input.

Uses FOAC package

Compatible with glass and plastic fibers, the $14.70 MFOD624F is a complete single-chip receiver housed in the manufacturer's FOAC package (providing an optical port with 200-μm-core fiber having 0.7 NA). It accommodates NRZ data transmissions at rates up to 500k bps.

The unit mounts in metal connector housings from AMP (227240-1) and Amphenol (905-135-5000), providing EMI/RFI protection. It operates from one 5V supply and features 20-μW sensitivity.

Motorola Semiconductor Products Inc, Box 20912, Phoenix, AZ 85036. Phone (602) 244-4556. Circle No 233



a

b

For short- to medium-length runs, *the MFOC600 receiver* ***(a)*** *offers a choice of TTL, ECL or analog outputs. The companion MFOD624F* ***(b)*** *accommodates 500k-bps NRZ data rates.*

Say goodbye to your old Analog RMS Voltmeter.

And say hello to Fluke's family of True RMS Digital Voltmeters at analog prices. The advantages of a digital voltmeter's speed and accuracy have finally come to wideband True RMS measurements. Thanks to an exclusive Fluke-designed microelectronic chip, you can now make True RMS measurements with an ease never before possible — and starting at just $1295.

Try this on your old analog meter. Each model boasts an autoranging LED display of volts (3½ digits) or dB (4½ digits) with 0.5% midband accuracy. An exclusive "dial-a-reference" feature lets you match the instrument's dBm reference to the impedance of the system you're working with. The resultant direct reading of dBm eliminates time-consuming calculations. With the relative dB feature, you can set the existing dB reading to zero establishing the input voltage level as the dB reference. Subsequent readings will be indicated as ± dB. All with ac or ac + dc input coupling.

For simplified peaking/dipping measurements, an analog meter complements the digital display. Counter and log output options are available for your system applications.

Match the model to your measurement needs. There's no compromise when buying a Fluke True RMS Voltmeter. The 8920A and 8921A boast 10 Hz to 20 MHz specifications with a 2 mV range to 2 MHz. Choose the 8920A with a BNC input or, for floating measurements to 500V, the 8921A with isolated banana jacks.

The 8922A, newest in the series, includes design enhancements for both audio measurements (with specifications to 2 Hz) and rf applications (with an 11 MHz, 2 mV range). Selectable 200 kHz filtering enhances audio performance by eliminating unwanted high frequency noise.

IEEE-488

Latch them together, then put them on the bus. Each 8920-Series Voltmeter is housed in the exclusive Fluke portable test instrument package. This system allows convenient stacking and latching of multiple instruments for unrivaled transportability. And by adding the new 1120A Translator, with appropriate instrument options, you can make your new voltmeter IEEE-488 compatible.

See how the 8920 Series measures up. For immediate response, contact the Fluke sales office or representative in your area or call:

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EDN1 6/81

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(206) 356-5400
Telex: 152662

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Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB
Tilburg, The Netherlands
(013) 673 973
Telex: 52237

- ☐ I'd like a demonstration.
- ☐ Please send me information on 8920-Series True RMS Voltmeters.
- ☐ Please send 1120A IEEE-488 Translator information.

Name

Title   Mail Stop

Company

Address

City   State   Zip

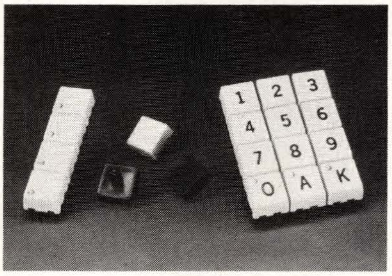
Telephone (   )   Ext.

*U.S. Prices Only

Sealed low-profile pushbutton switches accommodate wave soldering

Available in lighted and unlighted versions, 0.25-in.-square 225 Series sealed switches can be mounted directly on a pc board, then wave soldered and immersion cleaned. Their internal sealing-system arrangement reduces parts count to increase switch reliability: Life expectancy specs at 10^6 operations min.

The switches feature a short 0.025-in. travel and tactile feel. Their spst normally open contacts, available in either gold or silver finish, switch 24V ac/dc at 100 mA. Contact bounce equals 3 msec, contact resistance measures 100 mΩ max and voltage breakdown specs at 350V ac.



Compatible with wave-soldering and immersion-cleaning *assembly operations, 0.25-in.-square 225 Series pushbutton switches utilize an internal sealing system that reduces parts count to increase reliability—lifetime specs at 10^6 operations.*

Switch base and caps are high-temperature thermoplastic. White, red, gray, blue and black are standard; other colors are available. A wide choice of standard legends (epoxy inked for durability) is offered. Lighted versions employ an LED.

Maximum mounted height equals 0.3 in., and operating-temperature range spans −20 to +75°C. $0.42 for unlighted versions; $0.90 (10,000) for lighted designs.

Oak Switch Systems Inc, Box 517, Crystal Lake, IL 60014. Phone (815) 459-5000.

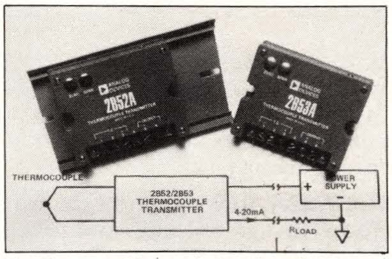
Circle No 234

Thermocouple temperature transmitters achieve 600V rms isolation

Accepting Type J, K or T thermocouple inputs, Model 2B52 and 2B53 transmitters provide cold-junction compensation and convert millivolt inputs to proportional 4- to 20-mA signals for 2-wire transmission. Both devices come factory calibrated for a specific thermocouple type and temperature range; however, you can also readily recalibrate them in the field.

The 2B52 employs transformer coupling that provides 600V rms isolation. It specs 160-dB CMR at 60 Hz. And although the 2B53 is nonisolated, it achieves similar performance.

Both models contain internal filtering by circuitry to reduce errors caused by EMI/RFI and line-frequency pickup. The internal cold-junction compensation assures ±0.1%-accurate operation over an ambient-temperature range of −30 to +85°C. Other features include open-thermocouple detection, plus response time and bias current of 0.3 sec and 85 nA and 0.1 sec and 30 nA for the 2B52 and 2B53, respectively.



Easily recalibrated in the field, *the 2B52 and 2B53 temperature transmitters achieve ±0.1% accuracy over −30 to +85°C.*

For environmental protection, the units come in metal enclosures with screw terminals for easy termination. Measuring 4×3.26×1.26 in., the cases mount on surfaces or relay racks. Power can come from an unregulated supply voltage ranging from 12 to 60V. 2B52, $160; 2B53, $114 (100).

Analog Devices Inc, Box 280, Norwood, MA 02062. Phone (617) 329-4700.

Circle No 235

How Honeywell became the optoelectronic technology leader overnight.

Simple. We acquired a high powered little company called Spectronics which turned out to be the leading innovator in optoelectronic and fiber optic technology.

They're responsible for a long list of major product developments that date back to the very beginning of optoelectronics.

At Honeywell, we feel that this product/technology base coupled with our commitment to its future development will result in the industry's most exciting and progressive source for optoelectronic and fiber optic expertise.

So if you have any questions we can shed our newly acquired light on, give us a call. We may have become the leader overnight, but that leadership represents years of innovation.

Either write Honeywell Optoelectronics Division, 830 East Arapaho Road, Richardson, Texas 75081 or call (214) 234-4271.

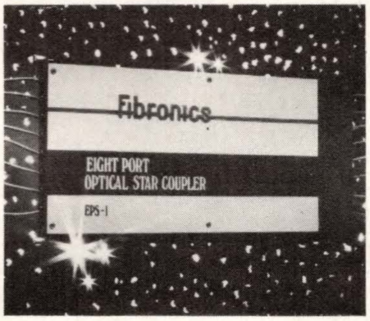
Honeywell

OPTOELECTRONICS

CIRCLE NO 105

New Products

COMPONENTS & PACKAGING



STAR COUPLER. Furnishing 16 connection points (eight input fibers optically coupled to all eight output fibers), the 8-port Model EPS-1 permits a remote computer or central processor to link with as many as seven terminals or peripherals using graded-index optical fibers. A totally passive device, it provides typical excess loss of 5 dB and can be supplied wtih 50-, 62.5- or 100-µm-core graded-index pigtails. The eight input and output 50-cm-long pigtails accommodate connectors or direct fiber splicing. The coupler is also available with installed connectors. Approximately $700. Delivery, 6 wks ARO. **Fibronics Ltd,** 655 Concord St, Framingham, MA 01701. Phone (617) 879-7071. **Circle No** 236

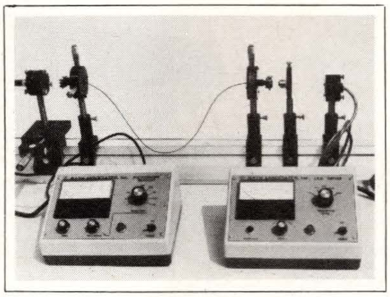
F-O MULTIPLEXER. A 16-port fully protected unit, Model LDM-9500 multiplexes as many as 16 RS-232C data channels in asynchronous or synchronous formats for full-duplex transmission over a pair of optical fibers. Providing transmission-system protection (including the fiber-optic cable), with a redundant hot-standby transmission system, it automatically switches on the backup system if any of the high-speed components fail or a fiber breaks during transmission. Asynchronous data rates span dc to 19.2k bps; synchronous rates, dc to 64k bps. Other features include transmission to 2 km, diagnostic and visual indicators, and full RS-232C handshaking capability. $6000 per end. **Valtec Corp,** 99 Hartwell St, West Boylston, MA 01583. Phone (617) 835-6082. TLX 920355. **Circle No** 237

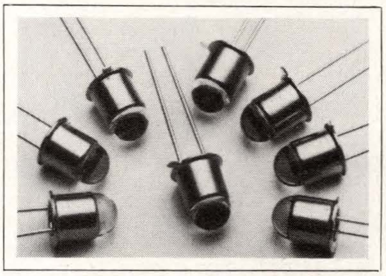

Augat topples the low-cost socket myth.
THE MYTH: Augat makes only expensive, precision-machined DIP sockets.
THE FACT: Augat offers a complete line of DIP sockets, including low-cost production sockets—at the lowest prices in the industry.
Furthermore, when we tested our 200 Series Low-Cost Sockets against leading competitors', ours actually exhibited greater withdrawal force and lower insertion force. In addition, corrosive atmosphere testing revealed no increased contact resistance—indicating gas-tight performance. Augat 200 Series Low-Cost DIP Sockets feature:
• Beryllium copper, copper alloy or gold inlay contact materials
• Shock and vibration resistance
• MIL-S-83734 approval (Beryllium, Tin, & Gold)
• Low profile construction
• Closed bottom design
• Packaged in tubes for automatic insertion.
• From 8-40 pins
Plus, the best mechanical and electrical characteristics.
Don't be fooled by the myth. Specify 200 Series Low-Cost Sockets from Augat—and get all the real advantages.
For more information, contact your nearest Augat distributor, or write Augat, Inc., 33 Perry Avenue, P.O. Box 779, Attleboro, MA 02703. Tel: (617) 222-2202. TWX: 710.391.0644.
AUGAT®
Augat interconnection products, Isotronics microcircuit packaging, and Alco subminiature switches.
CIRCLE NO 107

New Products

COMPONENTS & PACKAGING

F-O MEASURING SYSTEM. Furnishing precise, repeatable measurements of attenuation and numerical aperture of fiber-optic fibers 90 μm through l mm in diameter, the S-1700A Optical Fiber Parameter Measurement System comes in modular form on an optical bench. Measurements are possible at as many as five user-selectable wavelengths. $2750. Delivery, 4 to 6 wks ARO. **Math Associates Inc,** 6 Manhasset Ave, Port Washington, NY 11050. Phone (516) 944-7050. **Circle No** 238

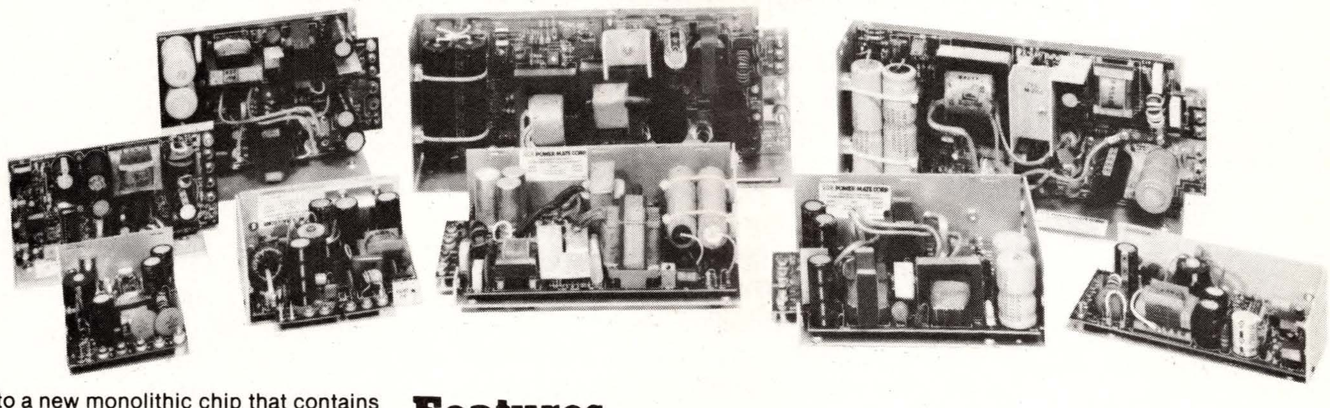




IR-LED LAMPS. Solid-state Models E10 and E12 furnish a 15- and 6-mW output, respectively (at forward voltage of 1.7V and forward current of 100 mA), from centered GaAs chips and optical-quality lenses. Total radiation is restricted to a narrow emission band of 20°. Peak emission wavelength specs at 940 nm (I_F=50 mA) with spectral bandwidth of 50 nm at 50%. Higher output is possible in pulsed mode. Model E10, $1.86; Model E12, $1.72 in hermetic TO-18 package. **Gilway Technical Lamp,** 165M New Boston St, Woburn, MA 01801. Phone (617) 935-4442. **Circle No** 239

KEYBOARD. The solid-state intelligent Model CP-4550 features serial output, n-key rollover, automatic repeat and custom codes. With a life-cycle-test rating >100 million cycles, the capacitive unit utilizes its manufacturer's line keytops, carries a 2-yr warranty and provides full μP capabilities. $45 (OEM qty). **Cortron,** 400 W Grand Ave, Elmhurst, IL 60126. Phone (312) 279-9110. TWX 910-254-0154. **Circle No** 240

ECONO/SWITCH
THE SWITCHER COST BREAKTHROUGH YOU'VE BEEN WAITING FOR!



nks to a new monolithic chip that contains regulation, modulation and a protective uitry, Power/Mate now offers top quality tching regulated power supplies at a frac- of the cost of conventional switchers. In ny cases even less than the cost of quality ar supplies.

ypical parts count is reduced 20% for a ch higher MTBF...well over 50,000 hours... n a one year warranty to back it up. Reli- ility is greatly improved by use of computer- ed "worst-case analysis," individual testing every IC and semiconductor, and a compre- nsive burn-in program.

The new ES Series boasts well over one watt tput per cubic inch, 70-80% efficiency and a ns holdup time.

But the big news is dollars per watt, a break- ough achieved through advanced design d manufacturing techniques. Power/Mate's Series switchers set the new standards for ue and performance in switching power pplies for years to come.

Features.

- Brownout protection.
- Overvoltage protection.
- Overload protection.
- Short circuit protection.
- Reverse polarity protection.
- Soft start protection.
- UL and CSA recognized.
- Convenient 3-surface mounting.
- Convection cooled.
- Remote sensing.
- Optional logic inhibit.
- Advanced EMI filtering.

Specifications.

AC Input. 85-132 and 170-264 VAC, 47-440Hz.
DC Output. See charts.
DC Output Adjustability. ±10%.
Regulation. Line ±0.1% + 1mV within AC limits specified above. Load ±0.1% + 1mV from no load to full load.
Noise and Ripple. 50mV peak-to-peak max., 20Hz to 200KHz.
Efficiency. 70 to 80%.
Transient Response. Recovery to 1% in 300 microseconds for a 50 to 100% load change.
Remote or Local Sensing. Provision included for improved overall regulation.
Overload and Short Circuit Protection. Solid state short circuit protection. Automatic electronic current limiting circuit limits output current adjustable between 105% and 125% of unit rating, thereby providing protection for the load as well as the supply. Units cannot be damaged by prolonged short circuits.
Overshoot. No voltage spikes on turn-on, turn-off or power failure.
Logic Inhibit Function—Optional. A command signal between 4.5 and 5.5V referenced to (—) negative sense terminal will inhibit the DC output. May be used for control, sequencing or maintenance.
Overvoltage Protection. Built-in, fixed.
Energy Storage Time. The output voltage will remain within regulation for a minimum of 16 milliseconds after loss of AC input power (from nominal line voltage).
Polarity. May be either positive, negative or floating up to 300 volts DC.
Soft Start. Provides input current limiting at turn-on.
Parallel Operation. Units may be paralleled for increased output current. Consult factory.
Long-Term Stability. 0.1% for 8 hours after 20 minute warm-up.
Ambient Operating Temperature. Continuous duty from 0°C to 71°C. Full rating from 0°C to 50°C, derate linearly to 60% of rating at 71°C.
Storage Temperature. −20°C to +85°C.
Quality Control. In accordance with MIL-I-45208

S-C Series $85.

MODEL	VOLTS	AMPS
ES-5C	5	3
ES-12C	12	1.5
ES-15C	15	1.2
ES-24C	24	0.75
ES-28C	28	0.65
ES-36C	36	0.5

ES-D Series $89.

MODEL	VOLTS	AMPS
ES-5D	5	6
ES-12D	12	3
ES-15D	15	2.4
ES-24D	24	1.5
ES-28D	28	1.3
ES-36D	36	1.0

ES-E Series $99.

MODEL	VOLTS	AMPS
ES-5E	5	10
ES-12E	12	5
ES-15E	15	4
ES-24E	24	2.5
ES-28E	28	2
ES-36E	36	1.5

ES-F Series $149.

MODEL	VOLTS	AMPS
ES-5F	5	20
ES-12F	12	10
ES-15F	15	8
ES-24F	24	5
ES-28F	28	4
ES-36F	36	3

S-G Series $189.

MODEL	VOLTS	AMPS
ES-5G	5	30
ES-12G	12	15
ES-15G	15	12
ES-24G	24	8
ES-28G	28	7
ES-36G	36	5

ES-H Series $229.

MODEL	VOLTS	AMPS
ES-5H	5	45
ES-12H	12	22
ES-15H	15	18
ES-24H	24	12
ES-28H	28	10
ES-36H	36	8

ES-J Series $269.

MODEL	VOLTS	AMPS
ES-5J	5	60
ES-12J	12	30
ES-15J	15	25
ES-24J	24	16
ES-28J	28	14
ES-36J	36	10

Case Sizes

ES-C	4.13"x3.25"x1.68"
ES-D	6.12"x3.24"x1.75"
ES-E	4.62"x4.88"x2.00"
ES-F	7.10"x4.88"x2.75"
ES-G	8.60"x4.88"x2.75"
ES-H	10.60"x4.88"x2.98"
ES-J	12.00"x4.88"x3.13"

PTIONS: Crowbar up to 8 Amps $8, greater than 8 Amps $16. Add Suffix V to Model No. Cover $6. Add Suffix C to Model No. Logic Inhibit $8. Add Suffix I.

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New Products

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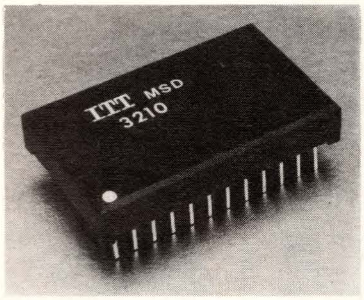
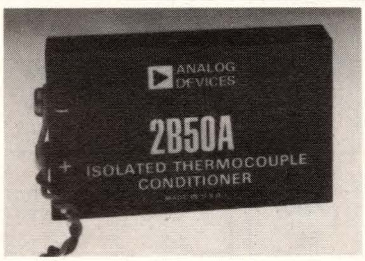
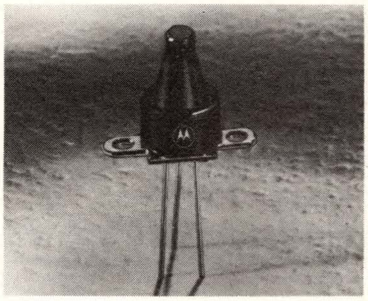


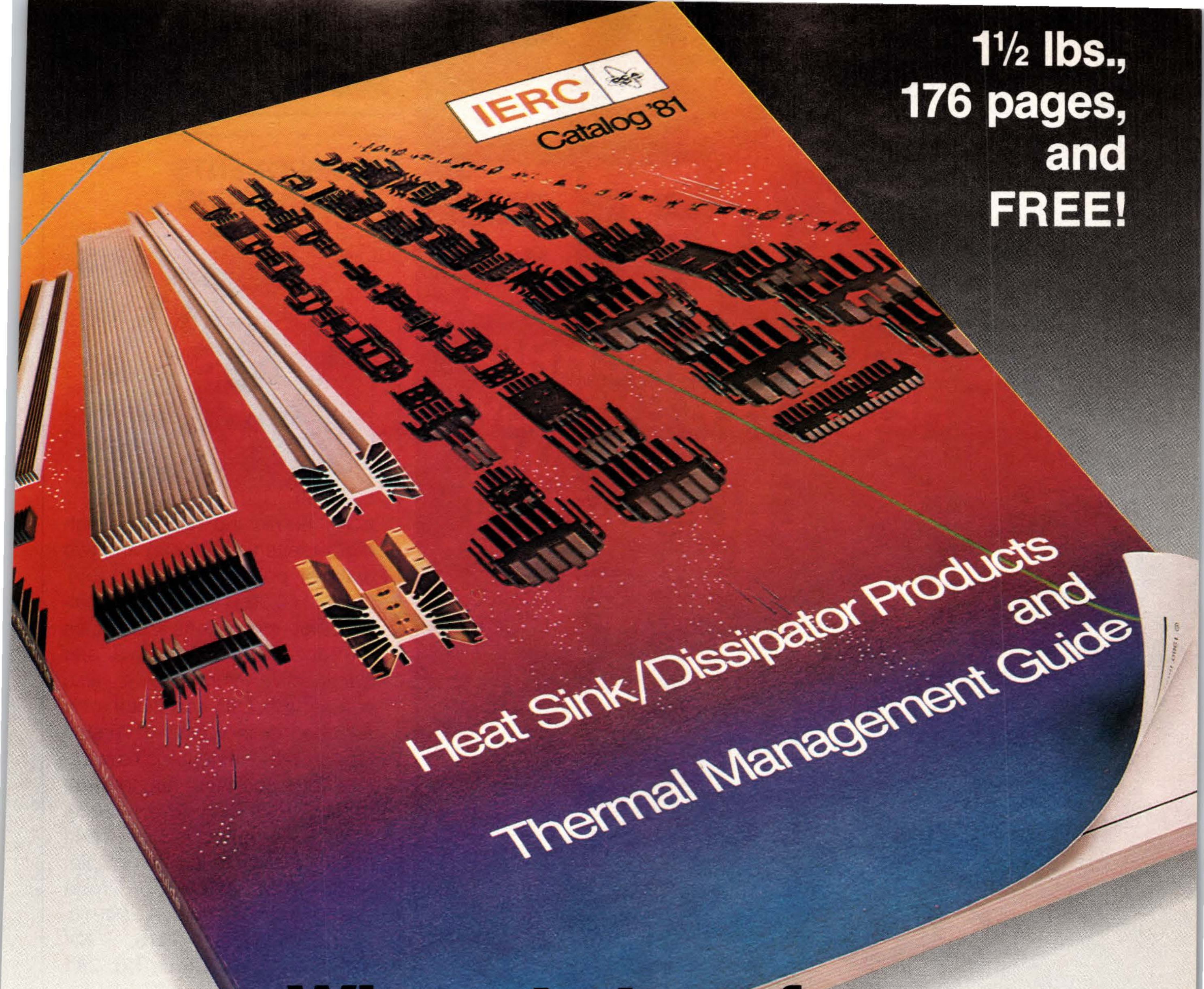
DTMF TONE RECEIVER. Model ITT 3210 combines CMOS/LSI and thick-film hybrid technologies in a unit measuring <0.8×1.3 in. A complete DTMF receiver, it requires only addition of a 3.58-MHz crystal, accepts standard DTMF signals from differential or single-ended sources and produces either a binary or a binary-coded 2-of-8 code on its 3-state outputs. Also featured are single-supply operation; good dial-tone rejection, signal-to-noise ratio and speech immunity; and a wide dynamic range and adjustable sensitivity. $65. **ITT North Microsystems Div,** 700 Hillsboro Plaza, Deerfield Beach, FL 33441. Phone (305) 421-8450. TLX 512329. **Circle No** 243



THERMOCOUPLE CONDITIONER. Featuring pin-programmable cold-junction compensation, Model 2B50 also provides input protection, filtering, isolation and screw terminals for direct connection of Type J, K, R, S, T, E and B thermocouples. Key specs include ±1500V pk (continuous) transformer isolation (input to output), 160-dB min common-mode rejection at 60 Hz, ±1-μV/°C max input offset drift (B grades) and linearity error of ±0.01% max (B grades). A-grade devices furnish input offset drift of ±2.5μV/°C max and ±0.025% max linearity error. Meeting IEEE Standard 472-1974:SWR for transient voltage protection, the unit provides 220V rms (continuous) input protection and a user-adjustable input span of ±200 to ±5 mV. 2B50A, $86; 2B50B, $103 (100). **Analog Devices Inc,** Box 280, Norwood, MA 02062. Phone (617) 329-4700. **Circle No** 244



F-O EMITTERS. GaAlAs emitter LEDs that approach the output capabilities of Burrus diodes, MFOE107F and -108F operate at 820 nm, are packaged in their manufacturer's plastic ferrule case and include heat-sink spreaders. Power output selected in 3-dB ranges specs at 700 to 1400 μW (MFOE107F) and 1100 to 2200 μW (MFOE108F). Both devices have a 200-μm 0.5-NA glass-core optical port and are compatible with AMP (P/N 227240-3) or Amphenol SMA connectors (P/N 905-135-5000). MFOE107F, $24.75; MFOE108F, $27.50. Delivery, <8 wks ARO. **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-4556. **Circle No** 245



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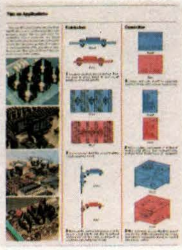
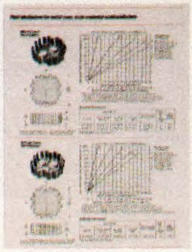

Tips on applications


Indexed by thermal resistance, board area


Charts, tables, ordering information

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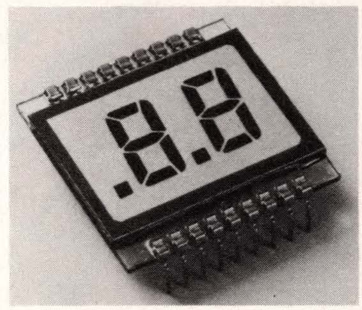

LCD. Furnishing two ½-in.-high digits (seven segments) and two decimal points, the 1.2×1.2-in. Model FE1901 suits channel-indicator applications and comes in transmissive, reflective and transflective versions. It also comes with DIP connector pins attached or in a pinless version for use with elastomeric connectors. Two operating-temperature ranges (−20 to +55°C, −20 to +80°C) as well as red, blue and green readouts are available. $8.65 (100). **AND,** 770 Airport Blvd, Burlingame, CA 94010. Phone (415) 347-9916. TWX 910-374-2353. **Circle No 241**

F-O DATA LINK. A fiber-optics evaluation module, the GR-1 system features TTL-compatible dc to 10M-bps operation, integrated monolithic pc-board-mounted receiver and transmitter, 5m of 100-dB/km-attenuation glass fiber with polished connectors and complete evaluation-module specifications. The transmitter furnishes 880-nm min peak wavelength, 40-nm max spectral bandwidth and minimum NA of 0.17. The receiver features 10.5-mA max output current and 0.42 NA (typ). The system operates from a 5V supply. $50. **Fairchild Optoelectronics,** 464 Ellis St, M/S 4-315, Mt View, CA 94042. Phone (415) 962-5011. **Circle No 242**

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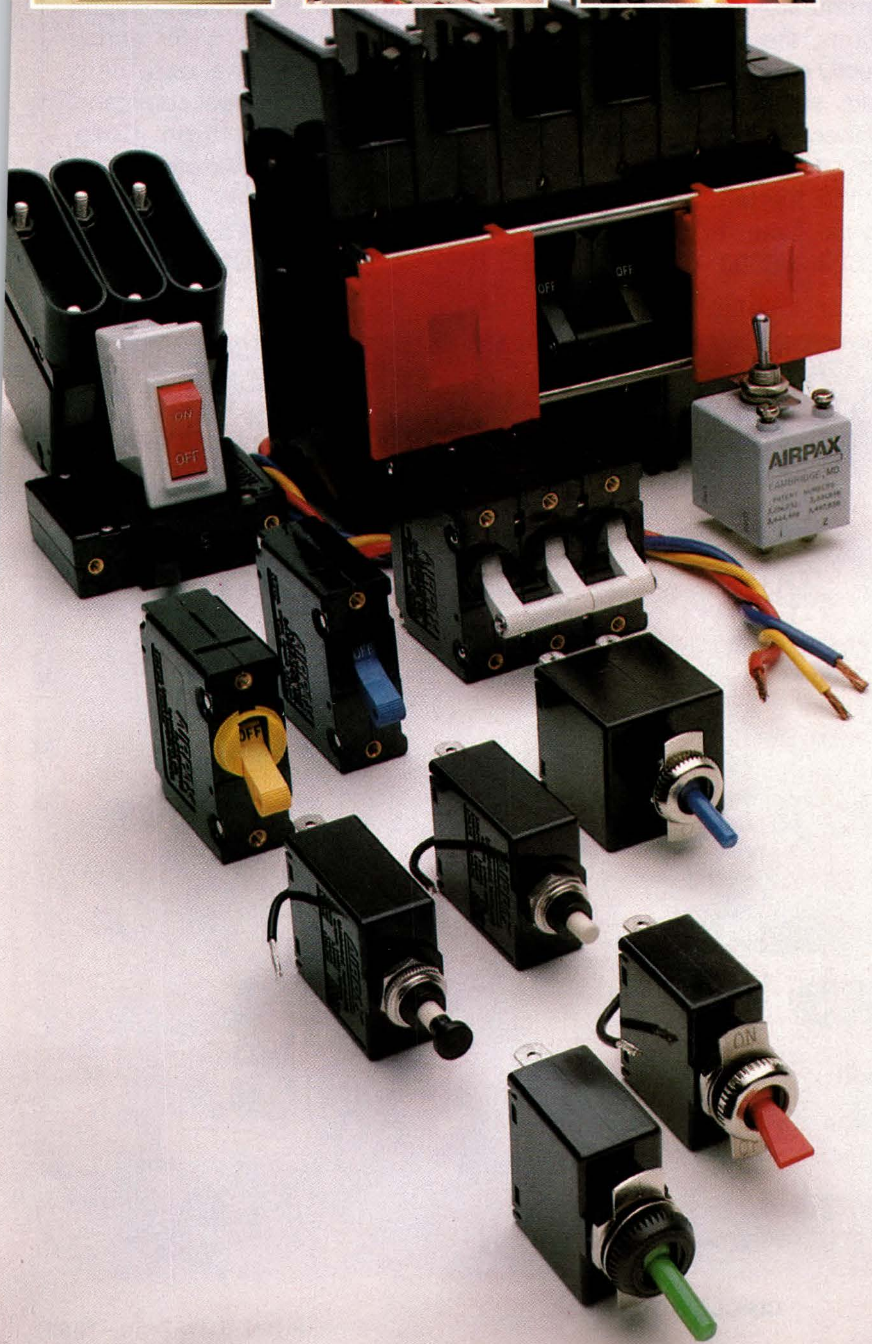

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New Products

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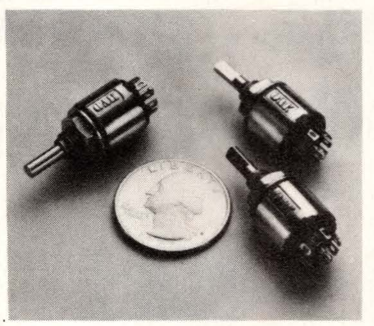
F-O CABLE. Pifax S-220 Type 30, a dual-channel multimode step-index 200-μm-diameter silica-core cable, provides an optical fiber clad with a hard plastic that can directly attach to connectors. Key specs include 35-dB/km typ attenuation at 670 nm (30 dB/km typ at 820 nm), 0.42 NA (typ), core refractive index of 1.46 and rise time (10 to 90%) of 7 to 8 nsec/0.2 km (based on RCA C30133 test conditions). The 600-μm-diameter fiber comes in a 2600-μm-diameter outer jacket. $3.90 per metre (100m). **E I DuPont de Nemours & Co Inc,** Polymer Products Dept, Wilmington, DE 19898. Phone (302) 774-7850. **Circle No** 302



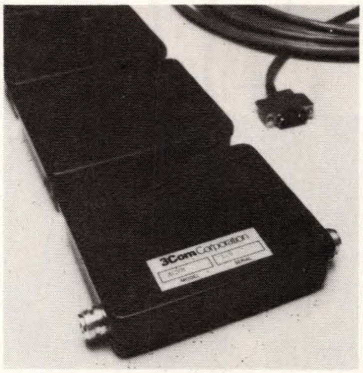
ROTARY SWITCH. Series 500 is a ½-in.-diameter rotary unit that exceeds MIL-S-3786 requirements. Also suiting civilian communications-system applications, the sealed unit mounts directly on a pc board and can be wave soldered and immersion cleaned. $4.50 (1000) for single-pole, 10-position version. **Oak Switch Systems Inc,** Box 517, Crystal Lake, IL 60014. Phone (815) 459-5000. **Circle No** 303

DISTORTION SUPPRESSOR. Suppressing harmonic distortion at the output of D/A converters used for reconstructing digitized audio signals, the modular Model MP1926 keeps distortion well below 0.005% (−81 dB) over 20 Hz to 20 kHz. Noise specs at −115 dB. The unit's 3.4-μsec time-constant response eliminates slewing problems while providing full-power response to audio signals, according to the company. Requiring approximately 0.1W, the unit handles a power-supply range of ±8V to ±15V and is controlled by one externally supplied mode-select command. $39 (100). **Analogic Corp,** Audubon Rd, Wakefield, MA 01880. Phone (617) 246-0300. TWX 710-348-0425.

Circle No 304

New Products

COMPONENTS & PACKAGING



ETHERNET TRANSCEIVER. Meeting Xerox, DEC and Intel Chapter 7 Physical Layer specifications for Ethernet compatibility, this 10M-bps transceiver features front-end circuitry that tolerates coaxial-cable transients. It also supports controller time-domain-reflectometer functions for use in Ethernet cable maintenance and comes with standard N Series connectors for coupling to the coaxial-cable network. \$550 (2), including 50-ft transceiver cable. **3Com Corp,** 3000 Sand Hill Rd, #1, Menlo Park, CA 94025. Phone (415) 854-3833. **Circle No** 246

RELAYS. Providing UL and CSA ratings to 5A for applications requiring multipole double-throw switching, Class 67 devices come in dpdt through 8pdt configurations, have 3 or 5A silver gold-clad bifurcated or nonbifurcated contacts and handle 6 through 110V dc or 6 through 115V ac control voltages. Other coil voltages or currents are also available. Packaged in a polycarbonate dust cover, the relays furnish plug-in/solder-type and printed-circuit terminals. From \$5.50. **Magnecraft Electric Co,** 5575 N Lynch Ave, Chicago, IL 60630. Phone (312) 282-5500. TWX 910-221-5221. **Circle No** 247

You can't buy a better frequency counter than our new 6001.

Even if you spend $300 more.

Count the extra range. The extra precision. The dollars you save. And you understand why, at $489,* our new Model 6001 650 MHz Precision Frequency Counter offers you more value than those of other leading manufacturers.

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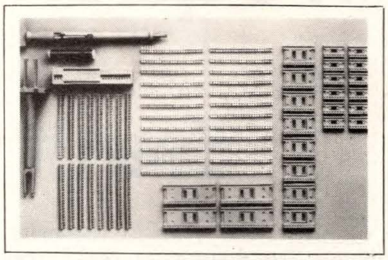
COMPONENTS & PACKAGING

BREADBOARD SYSTEM. You can use the expanded Scotchflex breadboard system to fabricate plugs and connectors accommodating 8- to 40-conductor sockets. Plug and solder strips come in 24-contact sizes but can be snapped off with the supplied tool for smaller sizes. The modular strips can be stacked end to end or side by side. Standard kits provide 24 24-contact plug strips 16 24-contact solder strips and dual 16- to 40-pin sockets with

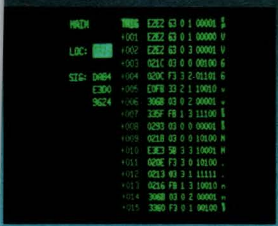


S-shaped beryllium-copper contacts. Optional kits add an SBC-8010-, Motorola M6800-, S-100- or Zilog Z80-equivalent μP board. A universal breadboard tool comes standard; an optional self-feeding wiring tool permits insertion of two wires in each U-contact. Standard kits, \$80; μP-board kits, \$110 to \$135. **3M Co,** Box 33600, Saint Paul, MN 55133. Phone (612) 733-9214. **Circle No 248**

TRIMMERS. With TCRs of ±5 (Model 1285) and ±15 ppm/°C (Model 1280) over −55 to +125°C, these ¾-in. Accutrim precision units provide a 26-turn adjustment screw that can be set to any value within 0.05%. Setting stability is >0.1% under shock and vibration conditions. Also featured are 10-nsec rise time and standard resistance values from 10Ω to 20 kΩ. Resistance tolerance equals ±10%, with ±5% tolerance also available. Model 1280, \$3.44; Model 1285, \$7.99 (100). **Vishay Intertechnology/Resistive Systems Group,** 63 Lincoln Hwy, Malvern, PA 19355. Phone (215) 644-1300. **Circle No 249**

Logic Analysis System

The *PI*-540 packs virtually every measurement function you'll need in a single, easy-to-use instrument.



Advanced State Section

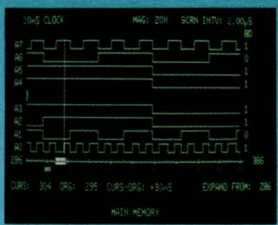
Up to 40 channels. Display data in hex, octal, decimal, binary and ASCII. Includes powerful qualification features, branch analysis, and 16 levels of triggering.

$7,300 (Base price)

Mnemonic Display

Dedicated μP probes with disassembly simplify software development tasks. *PI*-540 can accommodate 3 resident disassemblers.

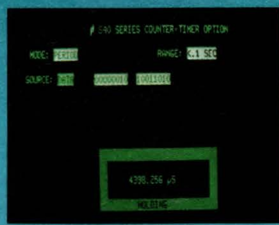
$950



50 MHz Timing Section

Independent, 8-channel, 1000-word timing analyzer with 5 ns glitch capture. Also provides 5 state display formats.

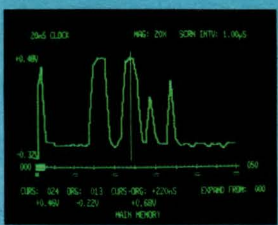
$9,500 (State and timing)



Performance Monitoring

100 MHz counter/timer measures hardware and software execution times. Includes industry standard signature analyzer.

$950



Waveform Recording Section

50 MHz and 1000 samples. Waveform can be linked to other analysis sections for tracing analog and digital interactions.

$11,250 (State, timing, and waveform)

RS-232 Serial Testing

Model 70 probe converts *PI*-540 into powerful serial communications analyzer. Receive, edit, and transmit messages at rates up to 19.2 K b.

$550

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The *PI*-540 resides in the expandable System 5000 mainframe. RS-232 and IEEE-488 interfaces are available.

For additional information circle no. 118

For demonstration circle no. 125

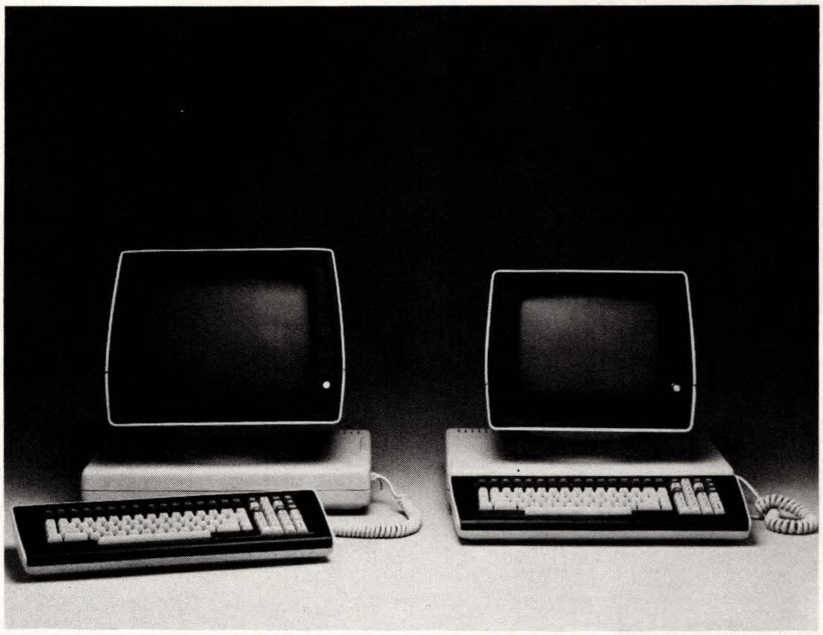
Modular terminals let OEMs add value

Series 8000 intelligent terminals consist of three basic building-block modules: CRT (12 or 15 in.), logic unit and keyboard. This modular design allows OEMs to configure a variety of terminal systems.

These configurations can be easily accomplished without specialized tools. For example, OEMs can easily exchange 12- and 15-in. CRTs, and the detachable keyboards plug in via a simple cable.

The green-phosphor CRTs mount on ball joints to fit on top of the 2.75-in.-high logic box; they provide up to 20° of tilt and 60° of swivel for maximum operator comfort. The manufacturer has located power for both the CRT and logic within the CRT housing and offers the CRT with nonglare surfaces in a variety of optional phosphors, including white and amber.

Additionally, the video modules handle an 80×24-character display, forming a 7×9 character in a 10×10 cell. The standard character generator supports 128 symbols, with 224 optional. Moreover, the video module features dim, reverse, underscore, blink, blank and double-width characters on a per-row basis.



For OEMs that need flexibility in custom applications, *Zentec's Series 8000 modular intelligent terminals include a video module (12- or 15-in. monitors), a logic module and a detachable keyboard module.*

Keyboard options

Like the CRT monitor, the Model 8401 keyboards meet ergonomic requirements for operator confort; they're canted to 11° and incorporate sculpted keys. The keyboards employ an Intel 8048 μP, attach via a 4-ft spiral cord and sport a full typewriter keyboard plus a 14-key numeric pad, 12 special-function keys and 16 general-function keys.

The third module in the Series 8000 is the 8201 logic box. This 18.5-in.-wide×14-in.-deep box can accommodate as many as three snap-in logic boards, allowing OEMs to develop their own logic to support the terminal.

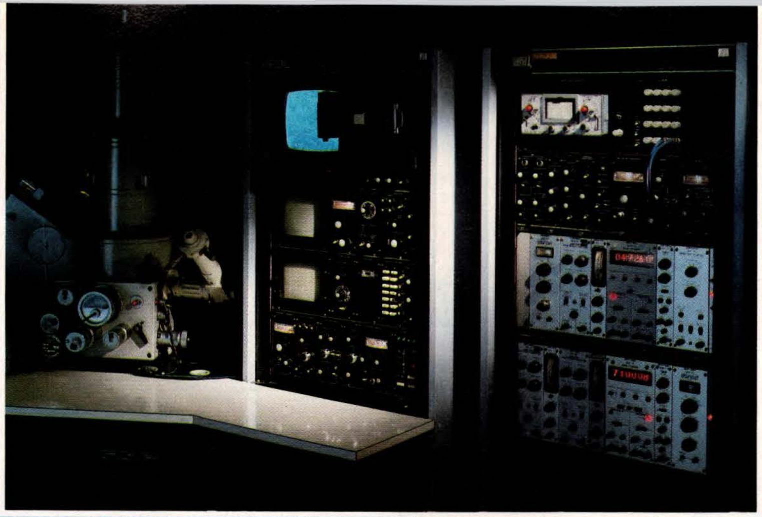
However, in the standard configuration, the logic box uses the Intel 8085A μP and can support up to 8k of PROM with the Intel 2716 or 16k with the Intel 2732. The standard configuration comes with 16k of RAM, but it can expand to 32k or 64k.

Communication occurs via a Zilog SIO, which supports RS-232C, 20-mA current loop, async, byte sync and bit sync protocols, with switch-selectable transmission rates ranging from 100 to 19.2k baud.

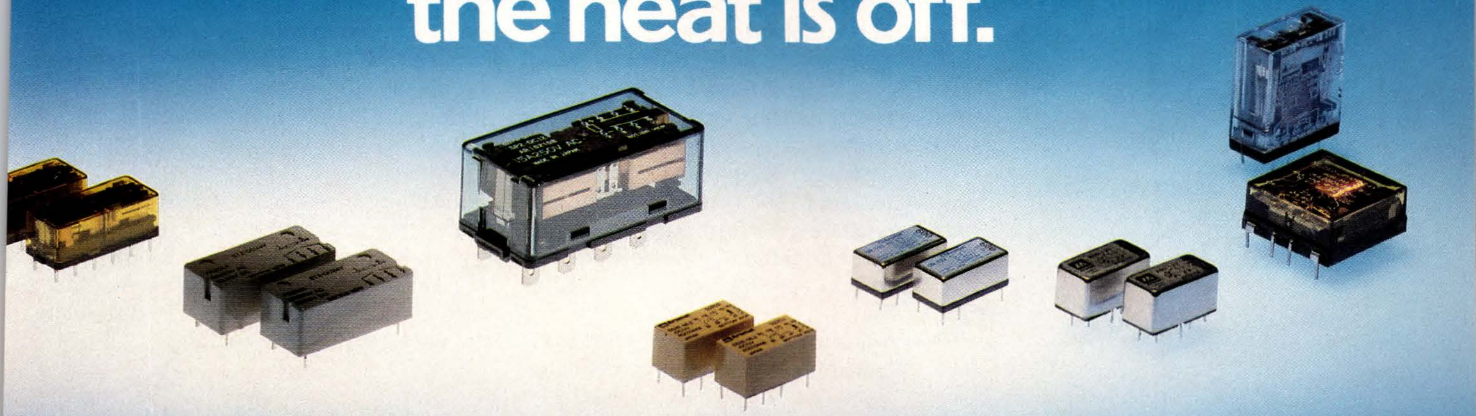
The terminal's manufacturer explains that designers can pick and choose the modules desired, thus reducing on-hand inventories. $826 (100) for a μP, 16k RAM, 8k ROM and communications controller; $448 and $777 for the 12- and 15-in. CRT modules, respectively; $266 for the standard typewriter-style detachable keyboard. Deliveries planned for July.

Zentec Corp, 2400 Walsh Ave, Santa Clara, CA 95050. Phone (408) 727-7662.

Circle No 251



Good news for control and instrumentation: the heat is off.



New Aromat Polarized Relays.

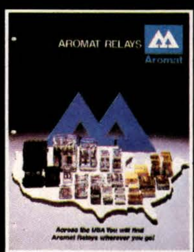
These extraordinary low input/high output relays have latching capability: energy is not required to keep them activated.

The result is less energy and no heat–thus very low thermal EMF.

Aromat Polarized Relays work on electronic PC boards at higher ambient temperatures, can be mounted in higher densities, and have a longer life. These relays are ideal for applications such as:

- Temperature controls
- Energy management systems
- Process controls
- Instrumentation
- Industrial controls

This chart gives basic details. But for the complete and extraordinary story on Aromat relays, contact your local Aromat representative, or write today for your free copy of this catalog.



	Contact Arrangement	Nom. Operating Power	Contact Rating
DS	2A/2C/4C	360mW	2A@30VDC
SE	2A,2B/4A	192mW	4A@250VAC
ST	1A,1B/2A	110mW	8A@250VAC
SP	2C/4C	300mW	1/2HP@125/250VAC
R	1C	150mW	1A@20VDC
DR	1C	70mW	1A@20VDC
NC	2C/4C	360mW	5A@125/250VAC

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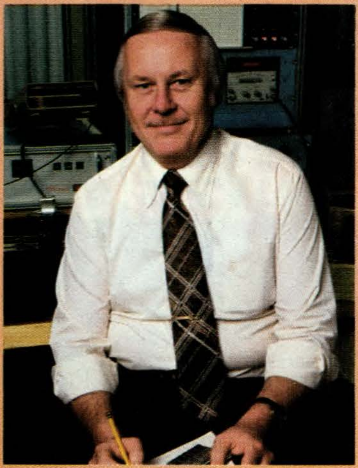

James E. Koncel, Manager, Research and Development, Bodine Electric Company

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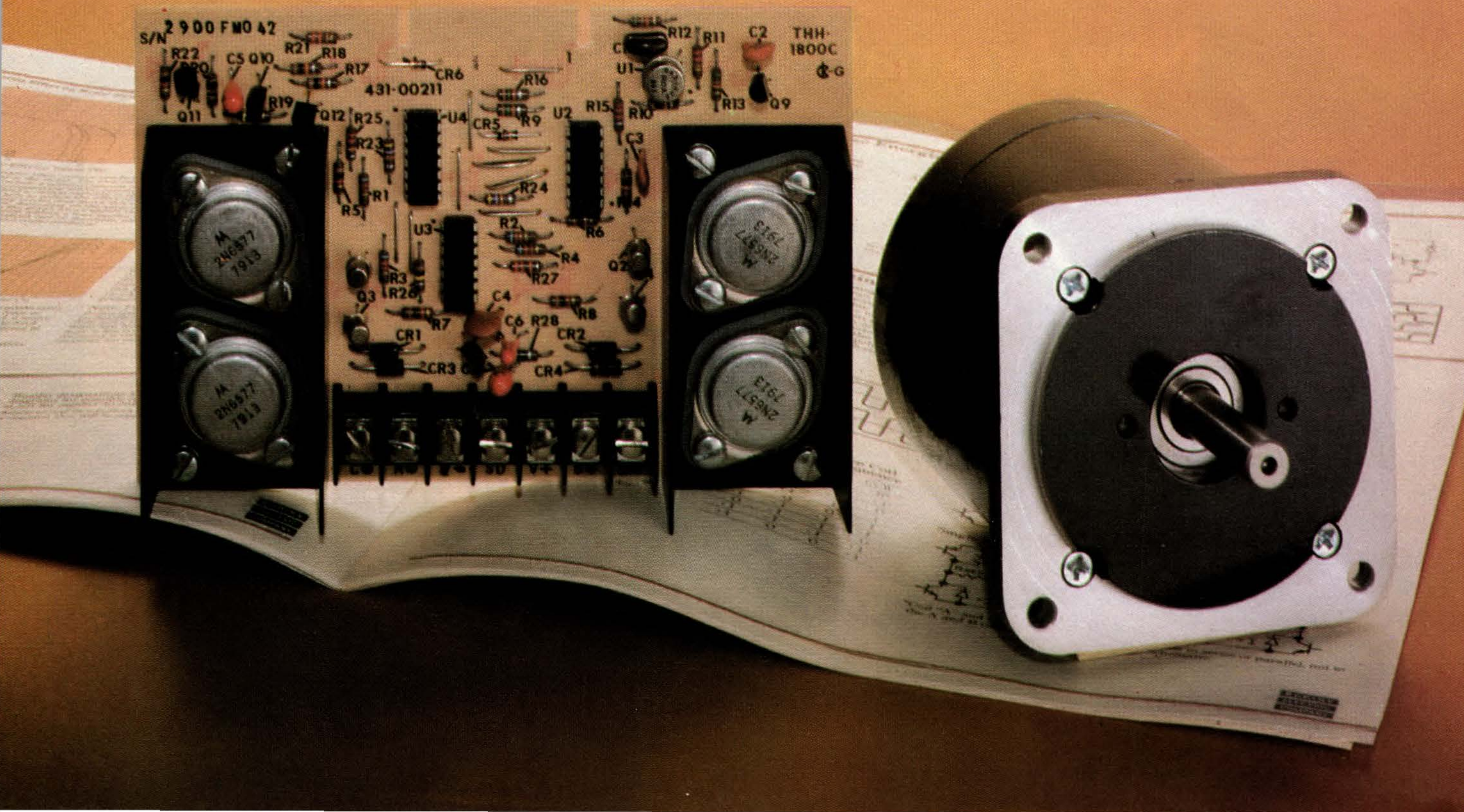
"Full disclosure doesn't stop there, however. We include a scope photo of single step response for every motor and step mode—showing the exact effect of choosing half-step or wave drive. Separate families of error-free-start-stop curves and slew curves accurately predict slow speed performance and traverse time with various inertias.

"We also show separate families of static torque curves at various current levels, for *every* motor and winding. This means as much as ten times greater accuracy than a 'typical' curve in predicting friction, spring, and weight-load position error effects.

"We think we've made stepper application easier." Write today or ask your Bodine representative or distributor for our free 48-page stepper system catalog. You'll find all the information you need to make the very best choice—Bodine.

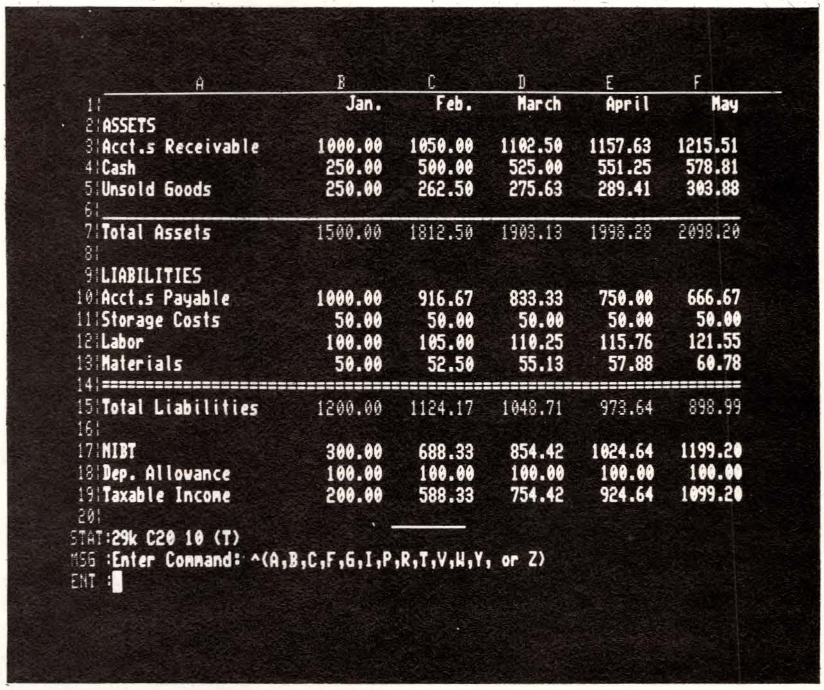
CIRCLE NO 120



CP/M-compatible electronic worksheet accommodates any terminal

An aid to nonprogrammers and a flexible information-handling tool, the SuperCalc electronic worksheet quickly handles row/column calculations and aids in the development of statistical data. This software package simplifies its user's tasks by permitting single-keystroke command and data entry and allowing automatic user-defined movement to the next data or cell location.

A user can display data in individually modified column widths and with numeric options. In appropriate terminals, highlighting and low-intensity displays implement protected fields.



CP/M compatible, *the SuperCalc electronic worksheet handles column/row data, performs calculations on any cell and lowers display intensity for protected fields.*

Menu-driven commands

To increase SuperCalc's usability, menus guide a user to the correct command. Errors—unrecognized keyboard entries—are diagnosed by toggling the terminal's bell; entering a question mark then produces detailed explanation of the problem.

With single keystrokes, a user can replicate any block of the worksheet, or one previously saved, in any worksheet portion. The user can also replicate formulas and their current values.

Accepts many terminals

The package is designed to work in concert with the popular Digital Research CP/M operating system. Additionally, it supports any terminal currently available.

The first time you use SuperCalc, its installation portion runs to customize the package to your terminal configuration. The process usually involves choosing your terminal's name from a menu, but you also get the option of installing the software in an unlisted terminal. With this latter option, SuperCalc prompts for information on cursor addressing, control and escape codes, plus attributes such as low-intensity fields.

The package will be available by mid-July for $295, which includes a CP/M-formatted diskette and a manual with a quick-reference card. Preprogrammed templates ($100) for various applications are also available, as are OEM licensing agreements.

Sorcim Corp, 405 Aldo Ave, Santa Clara, CA 95050. Phone (408) 727-7634. **Circle No** 253

NEXT TIME

EDN's June 24 issue will feature a Special Report on CMOS—envisioned by many industry experts as the premier processing technology of the 1980s and now exploding into a variety of new product areas. Other highlights include articles on

- Designing with current-mirror ICs
- Implementing a color-graphics processor
- Understanding the recently amended patent law
- Using digital techniques in signal-processing applications

. . . and much more. Also look for Technology Update stories on CAD/CAM developments and laser technology, plus our regular Design Ideas, A Question of Law and μC Design Techniques departments. You can't afford to miss this issue!

EDN: Everything Designers Need

Information-handling software packages meet growing retrieval needs

Created to turn a personal computer into a powerful intelligent worksheet, four generic software packages, dubbed VisiPlot, VisiTrend, VisiDex and VisiTerm, provide such capabilities as arithmetic functions, plotting and graphing and financial or statistical analysis.

The packages—currently configured to operate on Apple computers—are visually oriented and require no special programming skills. Additionally, they demonstrate commonality of command structure.

Versatile data plotting

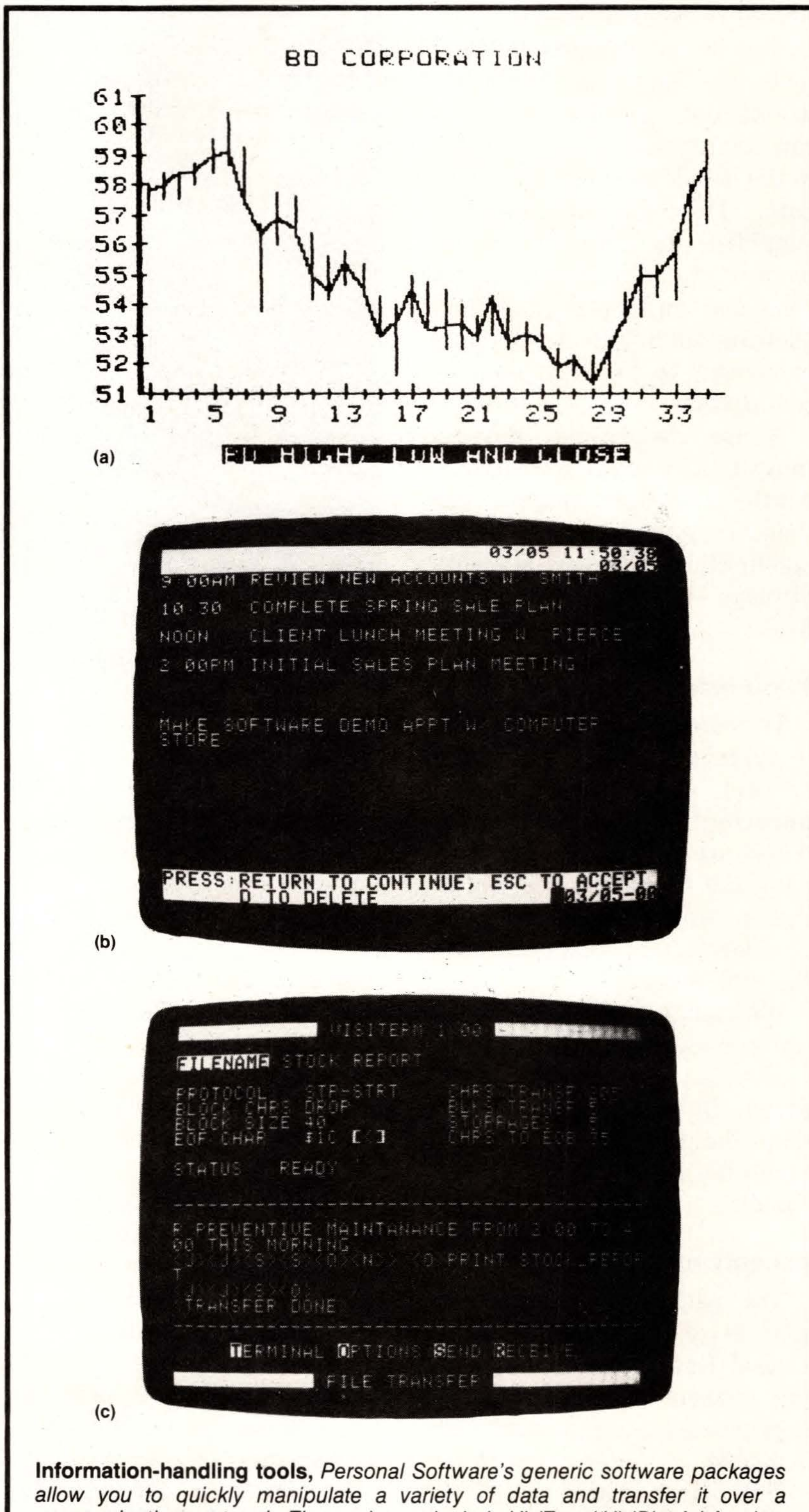
The VisiPlot package produces high-resolution graphs and charts in six formats and colors without user programming intervention. It can use either numerical data entered directly or data generated from the manufacturer's popular VisiCalc program.

Typically, VisiPlot produces several plots, including bar graphs (cumulative and side by side), time-series line plots, area charts, pie charts, Hi-Lo charts and scatter charts. A total of 645 data points can reside in memory at one time, and as many as 150 data points can appear on one graph.

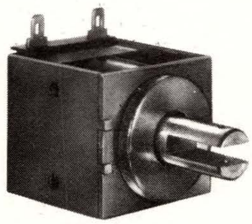
As an added feature, users can print plots via either the Apple Silentype thermal printer, the Integral Data Systems Paper Tiger Models 440 and 445 or daisy-wheel printers with graphics capability.

A combined approach

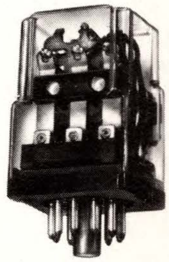
Combining the power of VisiPlot with a forecasting program, VisiTrend/VisiPlot speeds time-consuming and



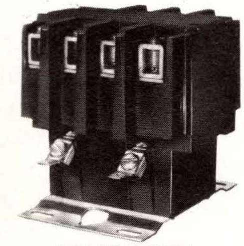
Information-handling tools, *Personal Software's generic software packages allow you to quickly manipulate a variety of data and transfer it over a communications network. The packages include VisiTrend/VisiPlot* **(a)** *for data analysis, VisiDex* **(b)** *for storing and rapidly retrieving dissimilar information and VisiTerm* **(c)** *for communications capability.*



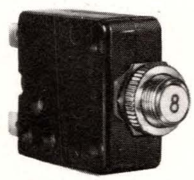
SOLENOIDS.
This box frame S3H is designed for smooth, pull-on-operate actuation. Its molded coil cover provides excellent coil and terminal protection. Intermittent and continuous duty cycles available for AC or DC.



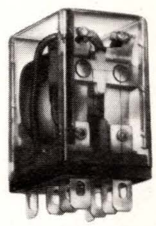
NEW KRPA.
This new, low-cost version of the famous KRP relay features a clear dust cover and octal-type plug termination. 5 and 10 amp contacts are available in arrangements up through 3 form C. UL recognized.



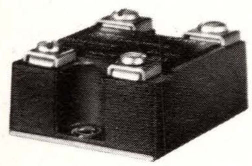
DEFINITE PURPOSE CONTACTORS.
The P30 and P40 series switch motor loads up to 30 and 40 amps at 600V AC or resistive loads up to 40 and 50 amps at 600V AC. Three and four pole models are available.



CIRCUIT BREAKERS.
This W58 thermal is the inexpensive alternative to fuses. Contacts "snap" open and reset button extends when breaker trips. From 0.5 through 35 amps. UL & CSA.



GENERAL PURPOSE RELAYS.
Save space with the compact, ruggedly constructed K10 series. 2 form C contacts rated 13 amps at 120V AC (resistive), 10 amps at 277V AC or 28V DC (resistive). UL and CSA.



SOLID STATE RELAYS.
This ECM hybrid is packaged in a .875" high, screw terminal enclosure. Reed-triggered triac switches 120 and 240V AC loads from 0.75 through 40 amps. Potted and non-potted versions are UL recognized.

P&B isn't just relays.

Circuit breakers, solenoids, solid state relays, time delays, definite purpose contactors—now they're all designed and manufactured to meet the same high standards Potter & Brumfield has set for general purpose and power relays. And since they're P&B components, they're all available off-the-shelf from leading distributors backed by P&B's sizeable factory inventory. Potter & Brumfield Division AMF Incorporated, 200 Richland Creek Drive, Princeton, IN 47671. 812/386-1000.

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CIRCLE NO 121

complex calculations such as descriptive statistics and multiple-linear-regression analysis. Because the software works in tandem with VisiPlot, calculation results can be displayed graphically. And like VisiPlot, VisiTrend can accept data from either direct keyboard input or files previously created by VisiCalc.

Types of trend analysis VisiTrend handles include trend-line forecasting, data transformations, cumulative-total data values, fitted- and residual-series generation, moving averages, smoothing (line of best fit), lead/lag and percent change. This latter function could suit OEMs who must keep a constant watch on trends in pricing and parts availability.

Electronic card file

The third program in the series, VisiDex, provides a way to do what everyone thinks a personal computer should do: store and provide rapid retrieval of masses of unrelated information. This package permits users to enter information on a CRT in free-form fashion or according to user-defined fill-in formats.

Typical applications include tickler files, mail lists, memos and virtually anything else you now do on paper. As many as 36 6-letter key words can be defined for any record, thus permitting multiple access to the data.

VisiDex also contains a calendar that facilitates retrieving information by date. And if the host Apple has an on-board clock, the program can automatically purge information on a given date or time or generate a user reminder. Furthermore, data can be sorted by key word, numeric order or date for later printout.

Communications tie-in

The final package in the series, VisiTerm permits the transfer of disk-file information over the phone. This terminal package works with files created by the other packages and includes features such as single-key macro definitions, an ability to match host systems and scrolling.

The four packages are available now for the Apple II or II+ on 5¼-in. soft-sector (16-sector configuration) floppy diskettes. VisiPlot, $179.95; VisiTrend/VisiPlot, $259.95; VisiDex, $199.95; VisiTerm, $149.95.

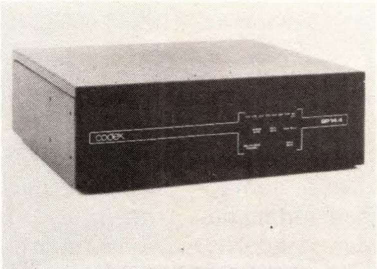
Personal Software Inc, 1330 Bordeaux Dr, Sunnyvale, CA 94086. Phone (408) 745-7841. **Circle No 254**

Signal-processing modem handles 14.4k-bps data rates

System designers requiring data rates greater than 9600 bps can add a building block to their arsenal: the SP 14.4 modem. It can transport data at 14.4k bps using a novel signal-processing architecture rather than a µP implementation.

The modem's signal structure employs hexagonal packing on a triangular grid and a patented data-transparent internal error-correction mechanism. Compared with rectangular grid structures, this one provides greater immunity to line impairments such as noise and phase jitter.

Current 9600-bps modem applications can upgrade to the SP 14.4 and add two channels of digitized voice without incurring additional circuit costs. And in certain applications requiring statistical multiplexers, this modem decreases the number of required high-speed links.



Utilizing novel data-rate, signal-processing and error-correction mechanisms, *the SP 14.4 modem achieves a 14.4k-bps data rate.*

The SP 14.4 serves point-to-point applications with or without a 6-channel buffered multiplexer—an option that permits combinations of two to six inputs with a wide variety of data rates.

The modem also finds use in network-control and -management systems. Reports transmitted by it to the central site can alert operators of deteriorating conditions, permitting corrective action. $9950. Delivery, starting in November.

Codex Corp, 20 Cabot Blvd, Mansfield, MA 02048. Phone (617) 364-2000. **Circle No 255**

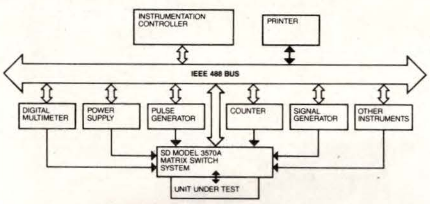
THE BETTER BUSSER.

SYSTRON DONNER's IEEE-488 INSTRUMENT CONTROLLER.

A dedicated controller is more efficient, easier to use.

It's Systron Donner's Model 3522—nicknamed the IEEE-488 Busser II. It controls instruments. Pure and simple. It speaks the language of IEEE-488. With precisely the right controls and features. Things such as special IEEE-488 function keys. And BASIC as the programming language. And a large, easy-to-read fluorescent display. And a standard teletypewriter keyboard. And simplified program storage. On and on.

Which means the 3522 is *not* one of those big general-purpose desk-top computers with horsepower you don't need. (And extra cost and complexities you don't want.)



And half the price.

With the 3522 you pay only for instrument controlling. And the computations normally required for test and measurement applications. So the price is only $1995 —including PROM reader/programmer. Which means a 50% savings—or more—compared with those desktop computer "controllers."

And that means, now you can automate a lot more testing, a lot more economically. And with a lot less trouble.

Easy-to-change programs.

With the 3522, you store programs in simple, plug-in cartridges. To change programs, just plug in a different cartridge. And you can erase/reprogram cartridges whenever you wish.

SD: a supermarket of IEEE-488 instruments.

We've got you covered in IEEE-488: Frequency counters. Signal generators. Digital multimeters. Pulse generators. Power supplies. DC voltage source. Matrix switch. We've even got a Model 3520 Controller if you don't quite need all the memory and software of the 3522.

Call Systron Donner.

Getting more information is easy. Just call us or send in the coupon. We'll rush you *complete product* literature—along with a list of our representatives in your area.

CIRCLE NO 122

SYSTRON DONNER EDN 61081
INSTRUMENT DIVISION/IS2

2727 Systron Drive, Concord CA 94518
Phone: (415) 671-6630
TWX: 910-481-9479

Dear Systron Donner,
Better instrument control at half the price? I'm interested!

- ☐ Rush me complete literature on the 3522 Controller, including a description of the software instructions. Also fill me in on your other instrumentation:
- ☐ Frequency Counters
- ☐ Signal Generators
- ☐ Digital Multimeters
- ☐ Pulse Generators
- ☐ Power Supplies
- ☐ Other: ____________

Name ____________

Title ____________

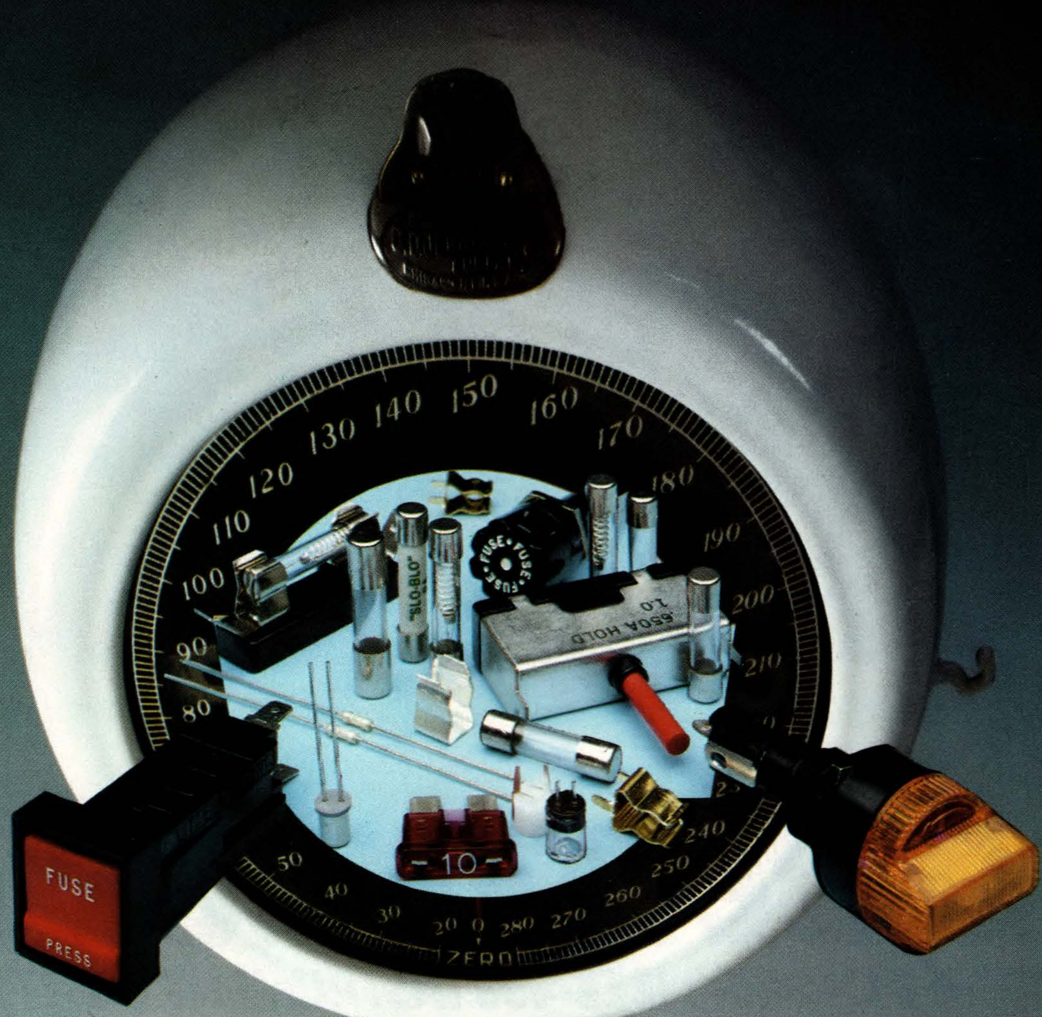
Company ____________

Address ____________

City/State/Zip ____________

Prices listed are U.S. domestic. All prices and specifications subject to change without notice.

SYSTRON DONNER
Member THORN EMI Group


FUSE
PRESS
"SLO-BLO"
10
ZERO

New Products

COMPUTERS & PERIPHERALS

COMPUTER SYSTEM. Model 5 microsystem combines the HP 1000 L Series μC, dual 270k-byte mini-floppy disk drives, a CRT and a keyboard. It supports a variety of HP 1000 software, including two real-time operating systems. The RTE-L is an execute-only system for as much as 64k bytes of memory; RTE-XL is an expanded-memory operating system for as much as 512k bytes, providing full program-development capabilities. Both are multiuser and multitasking. Available languages include HP PASCAL, FORTRAN, assembler or BASIC. Optional software includes the manufacturer's Distributed Systems Network software for a computer-network link and IMAGE/1000 for database management. Graphics peripherals and the manufacturer's GRAPHICS / 1000 - II software with 3-dimensional capabilities are also supported. From <$10,000. Delivery, 8 wks ARO. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone local office.
Circle No 256

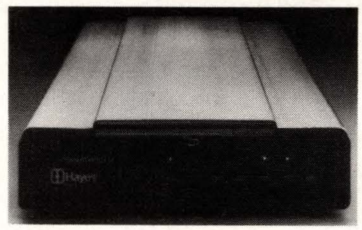
DISPLAY TERMINAL. A nonventilated unit with keyboard for interaction with remote devices,

New Products

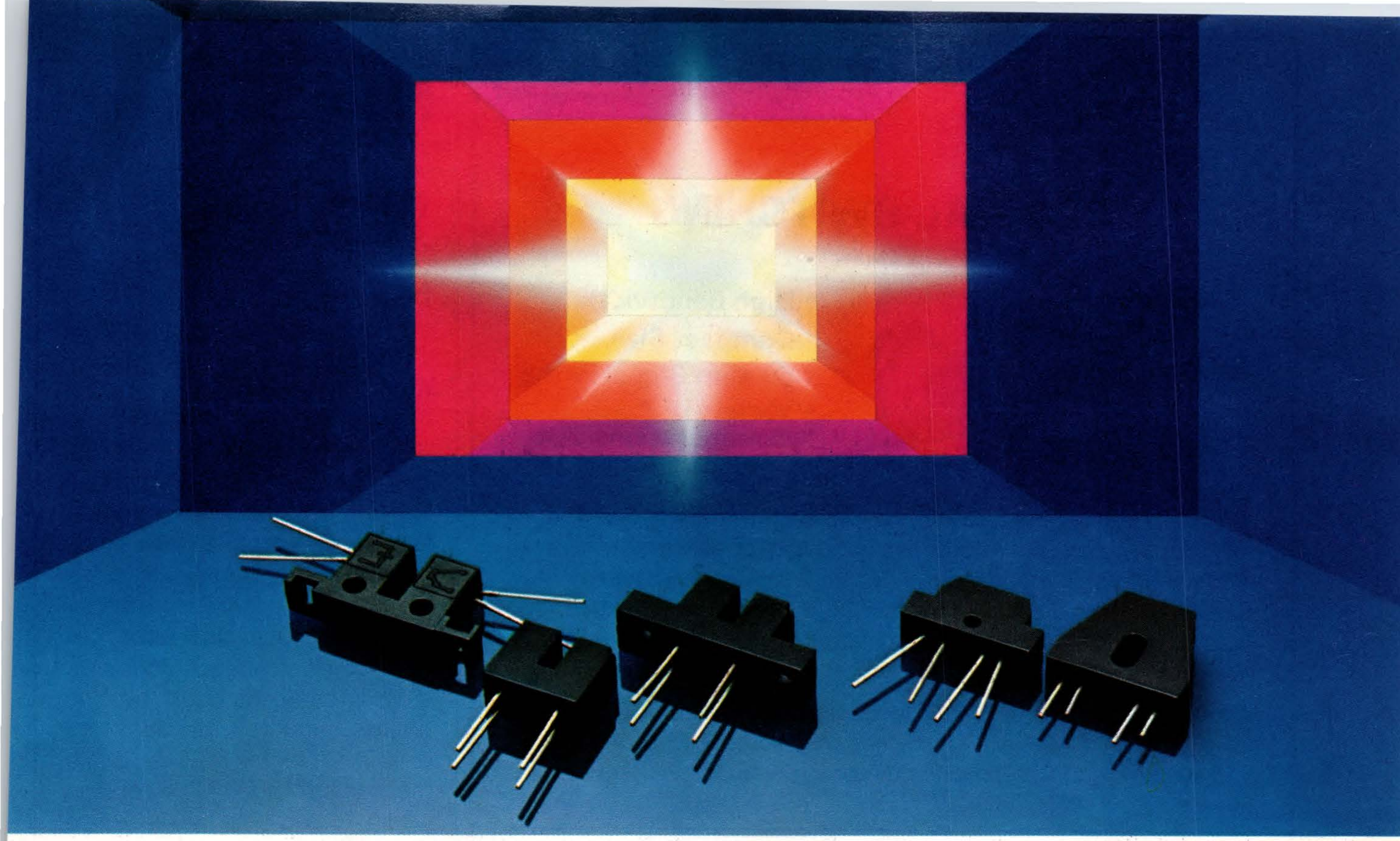
COMPUTERS & PERIPHERALS

Model 4815 is designed for use in hostile environments with wide shifts in ambient temperature (to 50°C) and noncondensing relative humidity (to 95%). Its Noryl structural-foam enclosure meets general NEMA 12 specifications (dust tight, drip tight). Covered and sealed with a membrane, the keys can be operated using thick work gloves and provide tactile and audio feedback. Other standard features include self test, 12-in.-diagonal 80-characters-per-line display with full ASCII character set and addressable cursor, switch-selectable 100- to 9600-baud operation and repeating numeric and cursor control keys. $3550. Delivery, 45 days ARO. **Xycom Inc,** Box 984, Ann Arbor, MI 48106. Phone (313) 429-4970. TWX 810-223-8153.

Circle No 257



MODEM. An FCC-approved direct-connect device for use with RS-232C-compatible computers or terminals, Smartmodem can be program controlled by ASCII strings in any language. Analyzing and executing commands and responding by sending result codes, which can be English words or decimal digits, it provides autodial and autoanswer capabilities. Touch-Tone or pulse dialing modes can combine within a command, with pulse-mode signals accessing a PBX and Touch-Tone dialing an outside number after the second dial tone is received. An audio monitor and automatic redial are also provided. $279, including power pack and modular telephone cable. **Hayes Microcomputer Products Inc,** 5835 Peachtree Corners East, Norcross, GA 30092. Phone (404) 449-8791. **Circle No** 258



Good reasons to switch. More bright ideas from TI Opto.

Thirteen devices. Five packages. Low-cost I/R emitter/detectors replace mechanical switches with reliable, solid-state components.

If you're still using mechanical switches, switch. If you're experiencing problems caused by ground loops and induced common mode noise in your analog and digital applications, switch. If you're looking for solid-state reliability, cost-effectiveness and off-the-shelf availability, switch.

Design in any one of TI's infrared (I/R) optical switch products for use in either the transmissive or reflective mode for sensing applications such as shaft encoders, sector sensors, level indicators, line finders, batch counters, beginning/end table indicators.

Reflective applications

Optical switches for these applications consist of a high-efficiency gallium arsenide LED and a silicon phototransistor in a molded plastic package. The photosensor responds to the emitted radiation from the LED *only* when a reflective object is within the sensor's view. For optimum PC board mounting ease, these switches are available in two package designs: Specify TIL139 or TIL149.

Transmissive Applications

Eleven devices, each consisting of a high-efficiency gallium arsenide LED and a silicon NPN phototransistor or photo Darlington, in a molded plastic housing, in a variety of pinouts to meet the demands of all your design requirements. The switch housing gap provides you with a means of interrupting the signal with tape, cords, shaft encoders or other opaque materials, thereby switching the output transistor from an ON to an OFF state. Specify as follows: TIL138, TIL143, TIL144, TIL147, TIL148, TIL158, TIL159, for high-speed switching. TIL145, TIL146, TIL160, TIL161, with photo Darlington output.

100-piece pricing*

TIL138, TIL139, TIL149	$1.52
TIL141, TIL146, TIL159, TIL161	$1.79
TIL143, TIL145, TIL158, TIL160	$1.99
TIL147 (Hermetic application)	$6.81
TIL148 (Hermetic application)	$4.94

Optical switches from TI. Available now at your nearest field sales office or authorized distributor.

Bright ideas — getting brighter all the time.

In addition to optical switches, TI's growing opto line includes:

- Visible LEDs
- Opto-couplers
- Single-digit displays
- Multi-digit displays
- Hermetic displays
- Fiber optic assemblies

TI Opto. Offering the highest quality devices across the complete product spectrum. A full line from one of the industry's largest Opto suppliers. A supplier with a firm commitment to innovative, cost-effective Opto products.

More bright ideas keep coming from TI Opto. You can find out about them by sending for your free copy of the Optoelectronics Master Selection Guide. Write to Texas Instruments Incorporated, P.O. Box 225012, M/S 308, Dallas, Texas 75265.

*U.S. OEM price, subject to change without notice
Distributor prices may vary.

TEXAS INSTRUMENTS
INCORPORATED

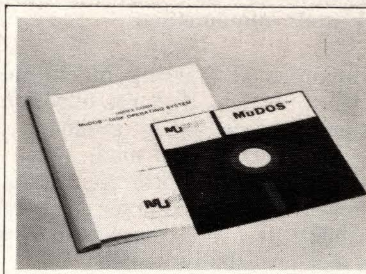
CIRCLE NO 128

81526

New Products

COMPUTERS & PERIPHERALS

DISK DRIVE. This 5¼-in. Winchester disk drive furnishes 11,000-power-on-hrs MTBF, 6.38M-bytes-per-drive unformatted capacity, 170-msec average access time and 5M-bps data-transfer rate. With two 5¼-in. disks per drive, information can be written and stored on all four sides. The drive includes a spindle mechanism, stepper motor and head assembly with four read/write heads and drive electronics located on two pc boards mounted beneath the disk. An integral fail-safe brake mechanism stops disk rotation within 15 sec. The disk's sealed head-to-disk interface protects against external contaminants. $1490. **Texas Instruments Inc,** Box 202145, M/S H-574, Dallas, TX 75220. Phone (713) 373-1050. **Circle No 259**



OPERATING SYSTEM. MuDOS CP/M-compatible operating system can be used with its manufacturer's Net/80 and Exp/80 network slave processors, can be customized to any Z80-based hardware configuration and replaces CP/M, MP/M and CP/Net. Using the Z80's extra registers and instructions to speed processing of operating-system calls, it provides 6-times-faster program loading than CP/M and 3- to 5-times-faster file-processing functions. A buffer manager, a totally re-entrant file manager and

The only 100 MHz scope that gives you three vertical input channels... Kikusui just had to do it better.

Three vertical input channels, two trigger views and an "add/differential" trace. That's what you get with KIC's new 100 MHz KIK-scope. Use the third channel as an extra data channel, as an additional signal in an x-y display, or for a host of other applications. There's almost no limit to the versatility that this third channel adds to your scope. And, it's included at no extra cost in our new Model 6100.

The Model 6100 is comparable to TEK's Model 465B and HP's 1742 but displays more traces (six compared with three), and offers more screen brightness, more flexibility, greater simplicity of operation and a two-year warranty that substantially reduces the second year cost of ownership. The Model 6100 also features an auto-dynamic focus circuit for clear, sharp pictures and a metal housing that minimizes RFI interference.

Now for the surprising news: Despite all the extra features, the 6100 costs less than either the TEK or HP scopes.

For versatility of operation, an alternate trigger permits viewing a very wide range of non-synchronous signals. For simplicity of operation, a level-lock on the trigger level control for both A and B channels activates a peak-to-peak detector that automatically sets trigger level and triggers without operator intervention.

Rugged and compact, the 6100 is completely modular. Like all KIK-scopes, the construction is on plug-in boards that are supported by a board swap-out program that assures fast maintenance turn-around and minimum down-time.

And, just to give you a little added assurance, your KIK-scope comes with a 30-day "satisfaction-or-your-money-back" guarantee.

This new 100 MHz KIK-scope along with eleven other models for engineering labs, field service and production line applications, is described in our new brochure. Write for it. It's free.

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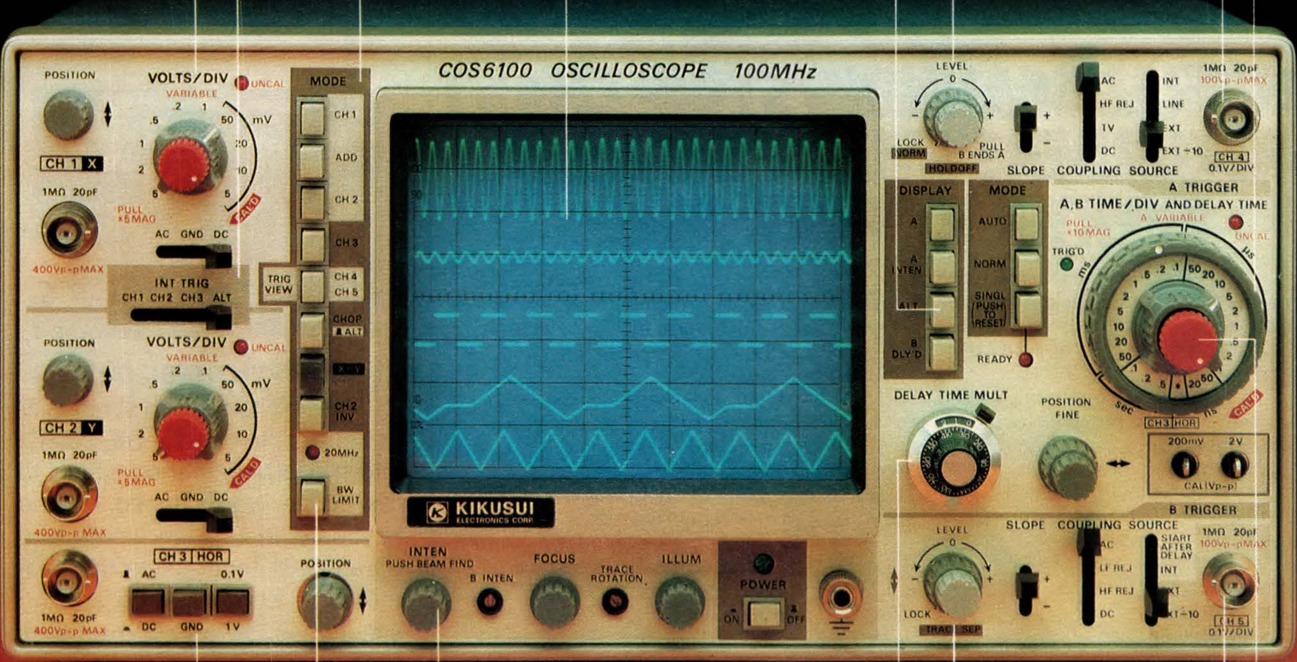
CIRCLE NO 131



New Products

COMPUTERS & PERIPHERALS

optional multiple-print queueing capability are also available, as is automatic concurrent print spooling. The software supports disk files to 67M bytes and drives to 2000M bytes and performs read-after-write verification of each disk-update operation. $300 to $750 on diskette, depending on configuration. **Musys Corp,** 1451 E Irvine Blvd, Suite 11, Tustin, CA 92680. Phone (714) 730-5692. TWX 910-595-1967.

Circle No 260

WINCHESTER SYSTEM. Providing 41.6M bytes of memory (20.8M bytes per drive), the 5¼-in.-high WINC-08 emulates the RL02 cartridge drive and is partitioned into two logical sections so that each drive looks like two RL02 units. Software transparent to DEC operating systems, it comprises two pc-board assemblies. The μP-based intelligent formatter/controller can handle two Winchester drives and is housed with the disk drives; the host-computer interface adapter comes as a dual-width card for LSI-11 users or as a quad-width card for PDP-11 systems. Error-correcting-code capability identifies and corrects errors of as many as five continuous bits anywhere in a disk sector. $8445 for one drive, power supply, controller and interface card. Delivery, 8 wks ARO. **Advanced Electronics Design Inc,** 440 Potrero Ave, Sunnyvale, CA 94086. Phone (408) 733-3555.

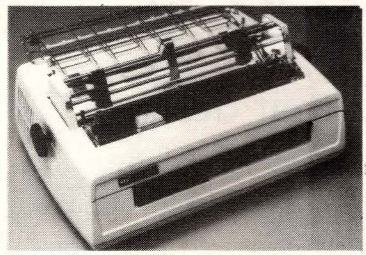
Circle No 261

SPEECH SYNTHESIZER. Type-'N-Talk text-to-speech synthesizer permits an RS-232C-interfaced personal computer to reproduce words typed on the keyboard in English words and phrases. Without using the host memory, words can be spoken simultaneously as soon as they are typed, and the 750-character buffer can hold them until the user prompts the computer to speak in phrases or sentences. The phonetic speech is heard

COMPUTERS & PERIPHERALS

through the user's loudspeaker. The system can also furnish a software-generated display of phonetic codes, storable in the host's memory. $345. **Votrax,** 500 Stephenson Hwy, Troy, MI 48084. Phone (313) 588-0341.
Circle No 262

PRINTERS. Letter-quality character printers, the seven units in the Spinwriter 7700 Series operate to 55 cps, use 27% fewer parts than their 5500 Series predecessors and utilize digital head-positioning techniques. MTBF is estimated at >2500 hrs. Key features include dual-pressure roller assembly and 3-roller bail; a variety of



user-installable forms-handling options, 115/230V ac universal power supplies and enhanced diagnostic self test. Terminal models furnish an optional word-processing feature that permits creation of graphs, plots and bold-face printing. OEM units, from $1254; terminal models, from $2170 (100). Delivery, 30 to 60 days ARO. **NEC Information Systems Inc,** 5 Militia Dr, Lexington, MA 02173. Phone (617) 862-3120.
Circle No 263

GRAPHICS SOFTWARE. For the manufacturer's HP 1000 family of real-time computers, GRAPHICS/1000-II software includes two packages: a device-independent Graphics Library (DGL) and an Advanced Graphics Package-3D (AGP-3). Requiring minimal space, DGL is a 2-dimensional package permitting the use of different graphics peripherals, controlled by a common set of commands without programming changes. Requiring DGL for operation, AGP-3 is a 3-dimensional package providing interactive communication with graphics peripherals. Based upon the CORE Graphics System of the ACM SIGGRAPH Graphics Standard Planning Committee, the software suits applications involving data-display charts,

SNAP-SHOTS

SPR-100
6/15/40/75/100/150/200/300 Amps AC

SPR-200
6/15/40/100/300 Amps AC
150/300/600 Volts AC

SPR-300
6/15/40/100/300 Amps AC
150/300/600 Volts AC
25Ω Mid-Scale

SPR-300CL
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EXP-300
6/15/40/100/300 Amps AC
100-150/200-300/400-600 Volts AC
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SPR-311
1.5/5/15/50/150 Amps AC
150/300/600 Volts AC
25Ω Mid-Scale

THE AWS SNAP 8's FROM A FAMOUS FAMILY OF INSTRUMENTS

Meet the AWS Snap 8 family. It's made up of six different models and each is specifically designed to handle a variety of job requirements. We know there's one that can handle yours.

Take the SPR-300 for example. Grand-daddy of the Snap 8 series and still undisputed leader in Snap-Around versatility. The "300" equips you for all of your daily troubleshooting needs. From testing low current (6 Amps AC FS) to servicing big systems drawing 300 Amps AC, the SPR-300 does it all. It can also read to 600 Volts AC and has a 25Ω mid-scale. Other AWS Snap 8's are available for measurements as low as 1.5 Amps AC FS and have expanded voltage ranges for even greater accuracy.

To get the whole picture on the entire family of AWS instruments, call your distributor today or contact A.W. Sperry Instruments Inc., 245 Marcus Blvd., Hauppauge, N.Y. 11787, 800-645-5398 Toll-Free (N.Y., Hawaii, Alaska call collect 516-231-7050).

A.W. SPERRY INSTRUMENTS INC.
The Measurable Advantage.

CIRCLE NO 137

New Products

COMPUTERS & PERIPHERALS

dynamic display graphics for monitoring process-control systems and interactive design graphics for computer-aided drafting, mapping and design. DGL, $2000; AGP-3, $4000. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone local office.
Circle No 264

COMPUTER SYSTEM. A CP/M system based on the Mostek/Pro-Log STD Bus μC family, XM800 combines a 16-slot card cage plus terminal mother board, 5-output power supply (linear or switching) and dual 8-in. floppy-disk drives in an 11×17.5×22-in. enclosure. A wide range of peripheral and I/O cards is available; double Eurocard and Multibus versions will be available later this year. $3995 for system including five STD Bus cards, 64k dynamic RAM, dual disk drives and CP/M 2.2; without drives, software and cards, $995. **Xitex Corp,** 9861 Chartwell Dr, Dallas, TX 75243. Phone (214) 349-2490.
Circle No 265

MICROCOMPUTER SYSTEM. Software compatible with all DEC PDP-8 minicomputers and VT-78 DECstation equipment, the 4-MHz PCM-12 employs a binary instruction set identical to the PDP-8's and provides a 64k-word memory capacity. The mainframe sports an all-aluminum cabinet, tilt-up card cage with 18-card capacity, heavy-duty linear power supply and built-in pushbutton-activated bootstraps for both RX01 (single-density) and RX02 (double-density) floppy disks, RK05-type hard disk, TU-58 DECtape and

SIEMENS

Siemens Zener Diodes.
World's Finest Quality. Made in Arizona.

For over a decade, Siemens has been noted for the most reliable zener diodes on the market–offering Hi-Rel and MIL-Spec components designed to support your equipment under the most difficult conditions. Siemens reputation for highest-quality zeners has been built through state-of-the-art semiconductor technology in manufacturing, testing and documentation procedures.

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It all helps explain why Siemens zener diodes were selected for so many space and military programs. Among them: Voyager, Pioneer/Venus, Comsat, Trident, Poseidon, AWACS, Polaris, and Telsat.

And Siemens' broad commercial line offers one source for virtually all zener diode needs–from 250 mW devices up through 50 W devices. Specific family types within these lines range from 1.8V through 200V. All designed, manufactured, and 100% tested to provide highest-quality support to your end product.

For further information, return the coupon to Siemens Corporation, Components Group, Iselin, NJ.

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Siemens Corporation, Box 1000, Iselin NJ 08830.
Please send zener information. I am especially interested in
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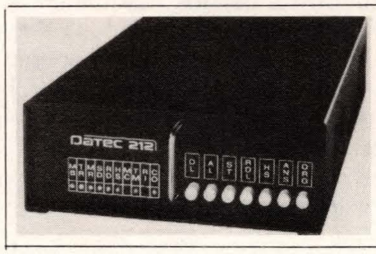
New Products

COMPUTERS & PERIPHERALS

paper tape. Optional plug-in modules include seven memories, four serial or parallel I/O modules, floppy- and hard-disk controllers and paper-tape, audio-cassette and printer interfaces. \$815 (10); plug-in modules, \$200 to \$300. **PC/M Inc,** 6800 Sierra Ct, Dublin, CA 94566. Phone (415) 829-8700. TWX 910-389-6890. **Circle No 266**



MODEM. A 300/1200-bps unit, Model 212 furnishes full- or half-duplex transmission and reception over 2-wire dial-up networks or 2-wire leased or private-line systems. At 0 to 300 bps, it operates in binary FSK format and is compatible with Bell 100 modems or acoustic couplers. The 1200-bps mode uses a DPSK character-asynchronous or bit-synchronous format; at 1200 bps, the unit is compatible with Bell 212A modems. Answer and Originate buttons on the front panel allow switching from data to voice and back to data communications without relinquishing the phone line. Other features include unrestricted use with Key-Phone systems, seven test modes, optically isolated DAA and test-pattern generator/analyzer. \$795 for stand-alone unit; \$695 for rack-mounting card. Delivery, 30 to 45 days ARO. **Datec Inc,** 300 E Main St, Carrboro, NC 27510. Phone (919) 929-2155. **Circle No 267**

"With my group your nickel buys 86 years of PC experience—every time."

"For 10 years my group has had just one objective: to answer customer questions the first time they call.

"You could say that with 86 years of experience in the 'front end' of my group we ought to have all the answers. But the reason we can goes far deeper than that.

"My group is totally organized to make sure we can do business on your nickel. You won't have to wait for us to call you back with an answer.

"We've got full control...

"Last year our group made 97% of our shipments on time. An average we maintain consistently, year after year.

"We can do it because each product group at Photocircuits Glen Cove has its own manufacturing organization dedicated to the needs of its customers. We literally control our own production. Our groups are kept small, so that we know exactly what our customers need. And we each have our own production capability to do it. No wonder we can give answers the first time you call.

"Delivery date changes are not kept secret...

"With this kind of control, we never find out on shipping day that the plant had a problem weeks ago. If it affects the customer, my group lets the customer know the same day.

"Tooling right—right from the start...

"If our 86 years of experience have taught us one thing, it's that a job that starts right, runs right.

"The way Photocircuits tools up makes sure a job runs right the first time. As soon as we get your blueprints, art masters and specifications, we analyze them for possible problems that could cause delays later on.

"When you realize that my group tools at least one new job a day, and our deliveries run so well, you can be sure we're tooling right—right from the start.

"Recently, for a new customer requiring qualification samples, Photocircuits was the only vendor that met specs the first time.

"Less than 1% returns...

"Today, overall, my group runs with less than 1% returns. Since much of our product is made for telecommunications, a market place with stringent demands on quality, you know there is no compromise in customer requirements."

Warren Wagner, Product Group Manager, center, with 29 years of experience, flanked by his group: Nick DeJesu (17 years), Barbara Poit (14 years) and at right, Gene Knecht (26 years).

The complete Photocircuits Glen Cove story.

Warren Wagner's product group is just one of four Photocircuits teams, all specialists in two-sided PTH boards, delivering quality and service. Our new brochure describes our complete manufacturing capability and product group structure.

For this brochure and the name of our sales representative in your area, write Photocircuits Glen Cove, New York 11542. Or call (516) 448-1059. A division of Kollmorgen Corporation.

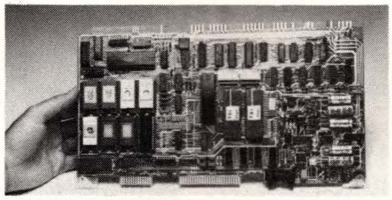
Photocircuits
Glen Cove

CIRCLE NO 141

Speech-synthesizer board enlivens computer output

If you want your computer to do some fast—or even slow—talking, connect it to the Speech 1000 board. Incorporating a linear-predictive-coding system, the board stores approximately 200 sec of speech at a 2200-bps encoding rate or 300 sec at slower rates. The resulting digitized speech sounds nearly as natural as the original, according to the manufacturer.

You can use the available 458k-bit memory to store any number of words, phrases or sentences. The board also comes with seven 28-pin memory-device sockets.



Featuring large vocabulary capacity, *high-fidelity speech and 3-way interfacing, the Speech 1000 synthesizer board allows computers to generate recorded voice responses.*

Depending on vocabulary size, you can choose standard 16k-, 32k- or 64k-byte EPROMs, ROMs or RAMs. Customized vocabularies, however, with individualized voice type, dialect, foreign language or inflection cost $50 per word.

The Speech 1000 provides 3-way interfacing via an RS-232C serial port, a TTL parallel port or a plug-in Multibus interface. A simple command protocol permits the host to download a sequence of commands and word pointers that specify and enunciate the recorded message, freeing the host from constantly servicing interrupts or polls. $1200.

Telesensory Speech Systems, 3408 Hillview Ave, Palo Alto, CA 94304. Phone (415) 856-TALK. **Circle No 268**

Unleashing the most powerful minicomputer ever designed.

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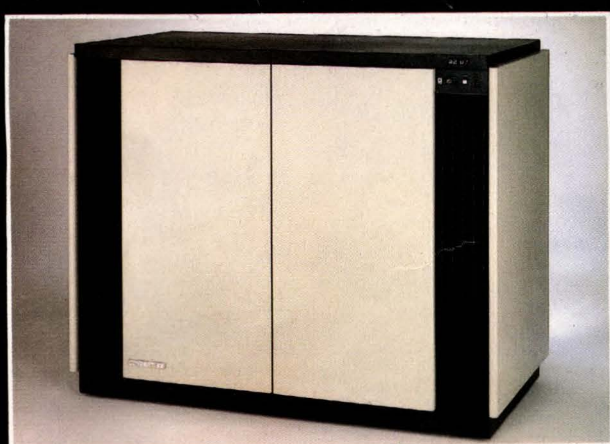
A minicomputer so far ahead of any other that the numbers speak for themselves:

Whetstone 1	3604 Whets(x1000)
Whetstone 2	2249 Whets(x1000)
Real-Time Simulation	22.4 Seconds



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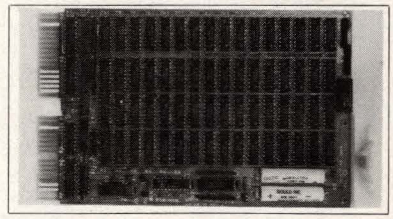
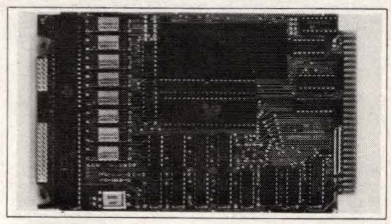
CIRCLE NO 144

New Products

COMPUTER-SYSTEM SUBASSEMBLIES



MEMORY BOARD. A 16k-word add-in CMOS unit for the DEC LSI-11 backplane, the dual-height Model 1816CMOS uses 450-nsec memory chips, provides NiCd-battery backup and includes a recharger. Although maximum retention time is a function of battery voltage and temperature, the worst-case figure equals 64 hrs. The card decodes an 18-bit address and allows 16k words to start on any 4k boundary. Switches, accessible when the board is plugged in, permit write protection of any 4k-word block. $1995; depopulated 8k version, $1795. Delivery, 60 days ARO. **ADAC Corp,** 70 Tower Office Park, Woburn, MA 01801. Phone (617) 935-6668. TLX 949329.
Circle No 269



μC BOARD. Providing sockets for 8k to 32k bytes of ROM and EPROM and 64k bytes of dynamic RAM, the 4-MHz Z80 MCPU-800 STD Bus card requires no Wait states when used with the on-board RAM and 350-nsec-access-time ROMs. 16k blocks of RAM and ROM can be selectively enabled or disabled by software via a memory-map port and its associated bipolar PROM. A com-

The Great Gap

The Gap is a new series of 3C8 pot and EC cores developed to help solve the design problems of the innovative power supply engineer designing switched-mode power supplies using flyback techniques.

The inductance factors of these new cores have been standardized to specific A_L values covering a range of effective permeabilities optimized for flyback applications.

Standard A_L values have also been established for output choke requirements, preventing saturation while providing maximum impedance to AC ripple current.

For more information on The Great Gap, Speak to The Specialists.
If we can't help you, chances are nobody can.

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Division of Amperex Electronic Corporation, Saugerties, New York 12477
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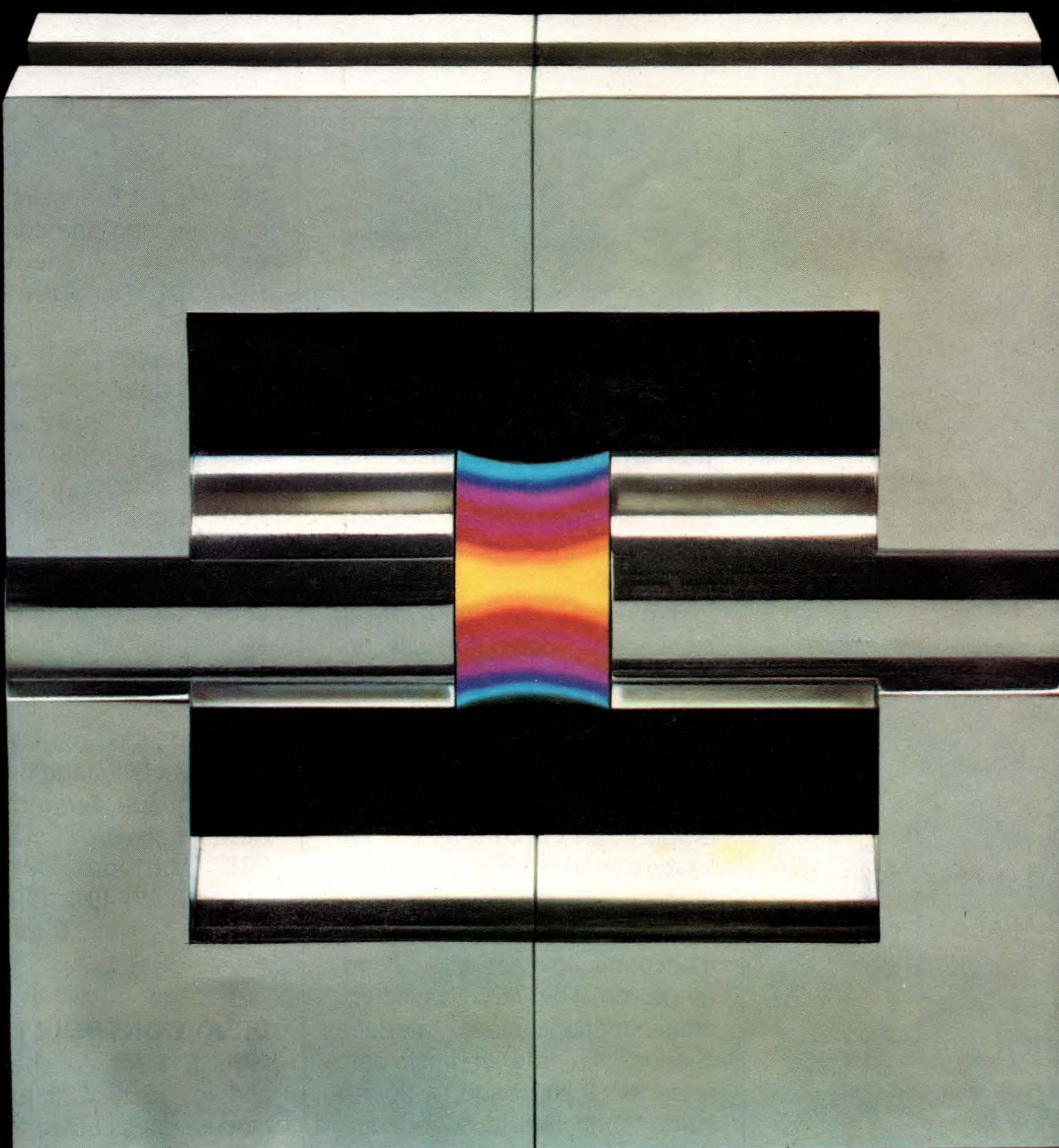


A North American Philips Company

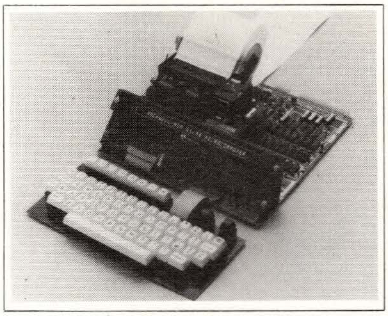
CIRCLE NO 147

New Products

COMPUTER-SYSTEM SUBASSEMBLIES

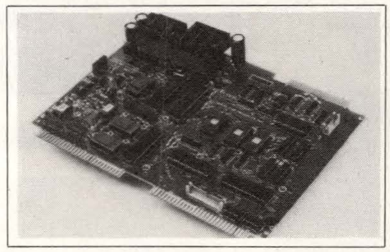
pletely programmable serial port furnishes software-controlled bit rates of 30 to 56k baud; eight bits for modem or terminal control; and even, odd or no parity-bit generation. The 8255A parallel interface can be configured as 24 I/O bits, two 8-bit ports with handshaking or a bidirectional bus interface with handshaking. \$1175 with 64k bytes of RAM; 16k-byte version, from \$675. **Miller Technology,** 16930 Sheldon Rd, Los Gatos, CA 95030. Phone (408) 395-2999.

Circle No 270



μC SYSTEM. Featuring 48k max of RAM, 32k max of ROM or EPROM and system address expansion to 131k bytes, the Aim-65/40 system consists of four modules: an R6502-based single-board computer with on-board expansion to 64k bytes of memory, a printer with full-graphics 280×n dot-matrix and 40-column alphanumeric modes, a 40-character alphanumeric display and a full-ASCII-set keyboard with user-assignable function keys. 6-level priority-interrupt logic and six 16-bit multimode timers are provided, as is an RS-232C asynchronous-communications interface channel with programmable data rates to 19,200 baud, a 20-mA current-loop interface and dual audio-cassette interfaces. Two user-definable 8-bit parallel ports with handshake control and an 8-bit serial shift register are included. Three additional programmable 8-bit parallel ports interface to keyboards, displays and printer modules. \$1795 for system with ROM-resident software; μC module, \$1195. Delivery, 90 days ARO. **Rockwell International,** Box 3669, Anaheim, CA 92803. Phone (714) 632-2321.

Circle No 271

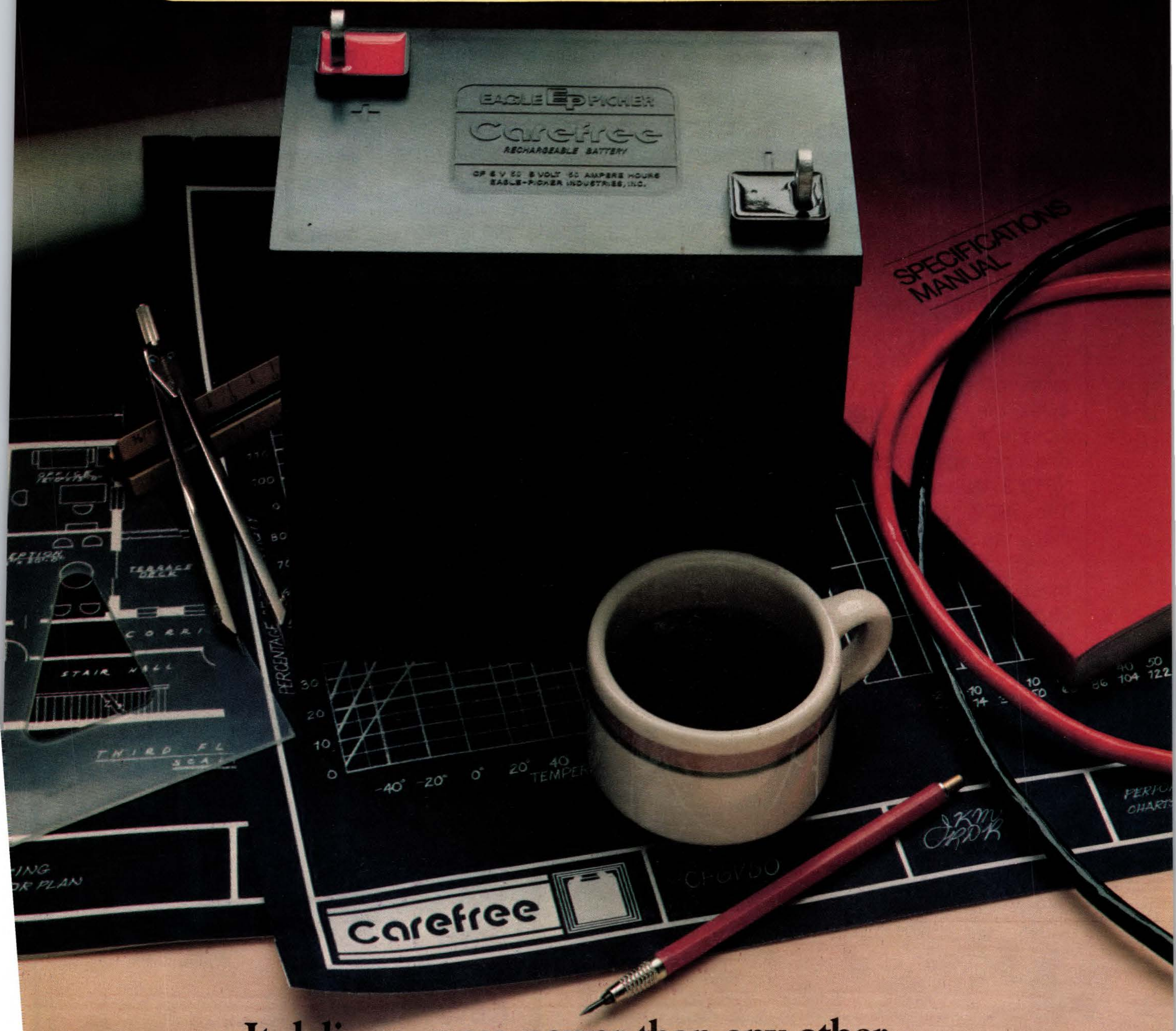


I/O MODULE. Linking a variety of monitoring and control devices to any computer using RS-232C (or RS-423) lines, Model SL-800M furnishes eight analog inputs (12-bit resolution), digital inputs and digital outputs and a 115/230V ac power supply. Options include two analog outputs (12-bit resolution) and differential analog inputs. With the RS-423 communications interface, the 9×12-in. board can be located as far as 4000 ft from the host; as many as 96 units can be daisy chained on the same serial line. You can program the module in any high-level language or in assembly language. From \$995 (100). **Serial Lab Products Inc,** Box 766, Marlboro, MA 01752. Phone (617) 481-1684.

Circle No 272

DISK CONTROLLERS. The iSBC 215 for Winchester disks and the iSBC 220 for storage-module drives utilize their manufacturer's 8089 I/O processor for DMA and controller intelligence.

Introducing the new Carefree® CF6V50.



It delivers more power than any other totally maintenance-free battery in the world.

For emergency lighting systems, UPS systems or anything requiring reliable, stand by power, the new CF6V50 is the optimum power source.

Instead of relying on several smaller batteries arranged in series, one CF6V50 does it all . . . including delivery of 100% capacity on the critical first cycle.

Moreover, the CF6V50 is just one of over 40 Carefree® batteries. They're the maintenance-free rechargeables that fit more space and power requirements than any other batteries in the world . . . from the 6V½AH to the 6V50AH.

Nominal Capacity @ 68° F

20 Hour Rate (2.5 amperes to 5.25 volts)	50 ampere hours
10 Hour Rate (4.5 amperes to 5.10 volts)	45 ampere hours
5 Hour Rate (8.0 amperes to 4.95 volts)	40 ampere hours
1½ Hour Rate (18.0 amperes to 5.25 volts)	27 ampere hours
1 Hour Rate (26.0 amperes to 4.50 volts)	26 ampere hours

Physical Size (± .05 inches):

Length	Cover 7.42	Base 7.24 inches
Width	Cover 4.51	Base 4.40 inches
Height		7.42 inches
Height (including terminal)		8.32 inches
Volume (excluding terminals)		237 cubic inches
Weight		21.5 pounds

Carefree®

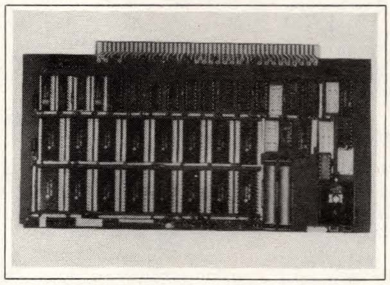
CIRCLE NO 149

Eagle-Picher Industries, Inc. *Commercial Products Department* P.O. Box 130, Seneca, MO 64865 (417) 776-2256 TWX 910-774-4533

New Products

COMPUTER-SYSTEM SUBASSEMBLIES

Programming is simplified through use of memory-based parameter blocks that permit multiple-disk operations using linked-list techniques. The iSBC 215 accommodates as many as four 8- or 14-in. 4.5M- to 26.7M-byte (formatted) Winchester drives from various manufacturers, handles >100M bytes of storage, provides 4M bytes max of optional backup storage on a removable medium and conforms to the proposed X3T9.3 ANSI standard interface. The iSBC 220 interfaces as many as four SMD-compatible drives, providing 12M to 2.4G bytes of storage. The iSBX 218 Multimodule board and iSBC 208 Multibus board control as many as four single- or double-density, single- or double-sided 8- and 5¼-in. diskette drives. iSBC 215, $2000; iSBC 220, $2500; iSBX 218, $540; iSBC 208, $1065. **Intel Corp,** 5200 NE Elam Young Parkway, Hillsboro, OR 97123. Phone (503) 640-7147. **Circle No 273**

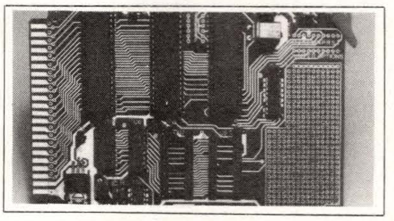


MEMORY MODULES. For S-100-bus systems, the CMOS RAM Models CMEM-32K (32k bytes of memory), -16K (16k bytes) and -8K (8k bytes) feature a software-programmable write-protect window permitting changes in parts of the program or selected data without risk of accidentally writing over protected data. When a power drop is detected, the boards generate an interrupt, enabling the battery-backup system to store data before the main power supply fails. Providing 250-nsec access time, the units run in 4-MHz systems with no Wait states. Other features include 8- or 16-bit data transfers and extended memory addressing through 24-bit address lines. $1095 for CMEM-32K; $895 for CMEM-16K; $695 for CMEM-8K. **Dual Systems Control Corp,** 1825 Eastshore Hwy, Berkeley, CA 94710. Phone (415) 549-3854. **Circle No 274**

New Products

COMPUTER-SYSTEM SUBASSEMBLIES

MEMORY BOARD. Compatible with the Motorola Exorciser bus and Micromodules, the Pachyderm uses 16k dynamic RAMs to furnish 64k to 250k bytes of storage including parity. With 5 or 12V battery-backup capability, a fully populated 256k system draws 8W in Standby mode. A PROM implements fixed memory mapping in increments of 2k for the lower 64k of memory. The transparent refresh system employs a Cycle Salvaging circuit that utilizes unused memory cycles to implement refresh operations, reducing by two-thirds conventional cycle-stealing memory's refresh time, according to the company. From \$795 for 64k×9 version to \$1980 for 256k×9. **Novex Inc,** 19717 Meredith Dr, Derwood, MD 20855. Phone (301) 840-8575. **Circle No 275**



SINGLE-BOARD COMPUTER. Featuring a 6802 8-bit μP and as much as 8k bytes of ROM or EPROM, Model SBC681 provides expansion sockets for adding 1k bytes to its 128 bytes of on-board RAM. Also included are a 6821 PIA and/or a 6522 VIA. The VIA contains an 8-bit shift register and two programmable 16-bit timers in addition to two parallel ports. On-board jumpers select processor-interrupt connections and ROM size; a crystal-controlled clock provides 1-MHz operation. The 4.5×6.5-in. board operates from a 5V regulated supply or from 8V with optional on-board regulator. \$89.95 (100). Delivery, stock to 6 wks ARO. **Industrial Micro-Systems Inc,** 189 Hitchcock Rd, Southington, CT 06489. Phone (203) 628-4844. **Circle No 276**

ADD-IN MEMORY BOARDS. For LSI-11/23 systems, MEM11-128 and -64 use 64k dynamic RAMs to provide 256k (128k×16) and 128k (64k×16) of storage, respectively. The dual-width cards plug directly into the Q-bus backplane; their first and last addresses are


HOURS
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D-C MICROAMPERES
DEGREES F
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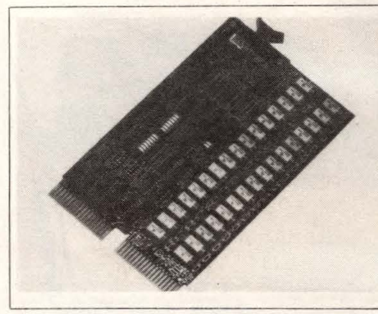
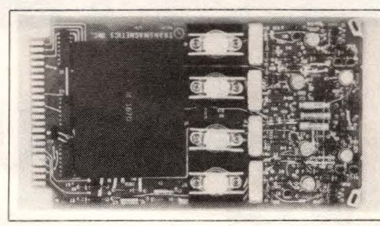
New Products

COMPUTER-SYSTEM SUBASSEMBLIES



DIP-switch selectable in 1k-word increments. DIP switches also permit enabling of memory in the 4k-word I/O area in 1k-word increments. Options include byte parity generation and error detection and 22-bit address recognition. MEM11-128, $2990; MEM11-64, $2390; with parity option, $3240 and $2540, respectively. **Andromeda Systems Inc,** 9000 Eton Ave, Canoga Park, CA 91304. Phone (213) 709-7600. TWX 910-494-1248. **Circle No** 277



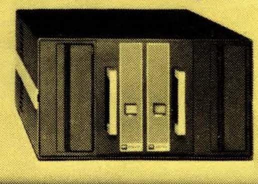
D/S CONVERTERS. B1670 Series synchro drivers accept 14 bits of data into internal registers and position as many as three Size 11 torque receivers with ±4′ accuracy. Switching the receivers through a 180° step, they are protected against short circuits and synchro-load malfunctions. Low-power TTL input registers permit the units to be parallelled and multiplexed. An integral damping feature is included. $715 (small qty). **Transmagnetics Inc,** 210 Adams Blvd, Farmingdale, NY 11735. Phone (516) 293-3100. **Circle No** 278

EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number for additional information from manufacturers.

Sprint 68 Microcomputer



CONTROL COMPUTER DEVELOPMENT SYSTEM
6800 MPU, serial I/O, 48K RAM, dual 8" drives, WIZRD multitasking DOS, editor, assembler, 12K BASIC, all for $3995.

OPTIONS
C, PL/W, PASCAL, FORTRAN, EROM programmer, analog I/O, parallel I/O, 488 GPIB interface, CMOS RAM/battery, power fail detect/power on reset

WINTEK

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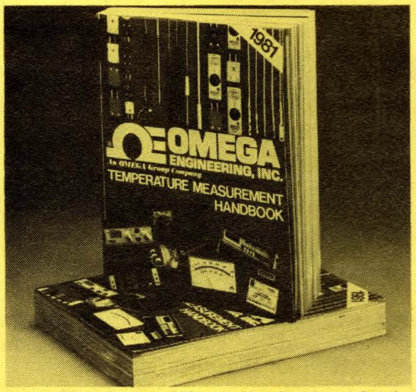
317-742-8428

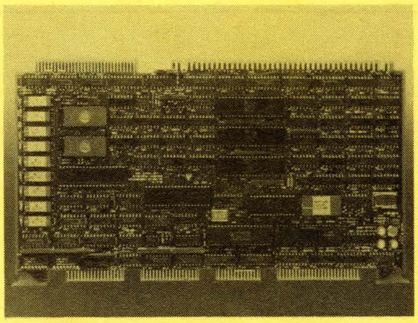
CIRCLE NO 157



A new 1981 full-color, 360-page Handbook and Catalog of Thermometry covers OMEGA temperature measurement and control products. Color-illustrated guide details over 10,000 items. It features a full line of new hand-held digital thermometers, a special section on temperature data acquisition systems, and a new 20-page section on industrial thermowells. Handbook section has many useful reference tables and important technical data.

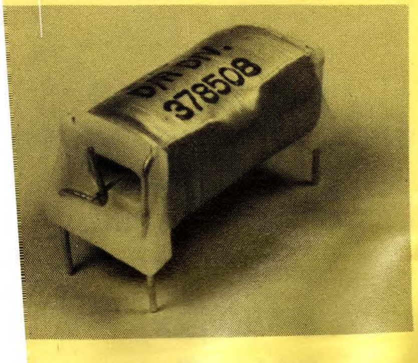
OMEGA Engineering, Inc.
Box 4047
Stamford, Ct. 06907
Telephone 203-322-1666

CIRCLE NO 158



Heurikon presents the MLZ-91A with Z80A CPU, floppy controller, winchester and streamer I/F, DMA, AM9511 math chip, GPIB I/F, 32K/64K RAM with parity, 2 ROM sockets, 2 RS232 ports (RS422/423 option), 4 counter/timers, 20 bit Intel Multibus, Bi-directional bus I/F, memory mapping RAM, I/O map, user defined LEDS and dip switch positions, CP/M and MP/M operating systems. **Heurikon Corporation,** 3001 Latham Drive, Madison, Wisconsin 53713. (608) 271-8700.

CIRCLE NO 159

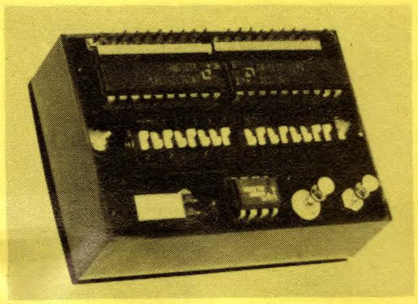


SENSITIVE RELAYS

uglas Randall Division *makes reed relays* special instrument, control systems and ephone applications. *The one pictured oper-* from less than 5milliwatt signals. It has cing capable of withstanding 3500VRMS ween the switch and coil to meet telephone interface requirements.

Douglas Randall Div./Kidde, Inc.
203/599-1750
6 Pawcatuck Avenue
Pawcatuck, Connecticut 02891

CIRCLE NO 160



16 CHANNEL LOGIC COMPARITOR MODULE

Model C16 compares 16 TTL level signals against user set DIP switches. Upon a true comparison, an active low TTL output signal is produced and a LED is lit. The C16 can trace software execution, trigger a scope, halt a processor, etc. Multiple units can be cascaded. Complete with test leads and case for $179. For further information, please call or write:

Lane Digital
P.O. Box 303
Nipomo, CA 93444
(213) 325-7155

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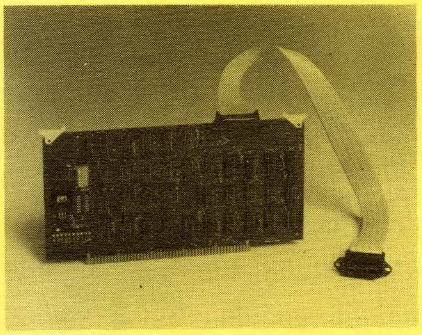

S-100 to IEEE-488 INTERFACE

THE P&T-488 INTERFACE BOARD lets your S-100 computer be a talker, listener, or controller on the IEEE-488 instrumentation bus. Software packages allowing high level language access to the 488 bus are available for CP/M, CDOS, North Star DOS/BASIC, as well as for direct assembly language programming. Price of the P&T-488, assembled and tested with one of the software packages, is $450. Additional information is available from: **PICKLES & TROUT**, PO Box 1206, Goleta, CA 93116. Phone: (805) 685-4641.

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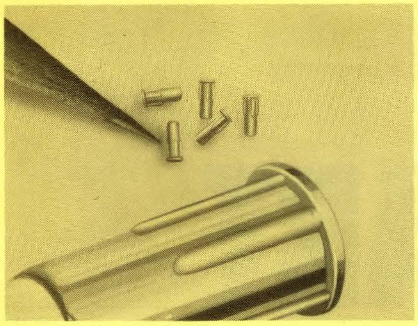

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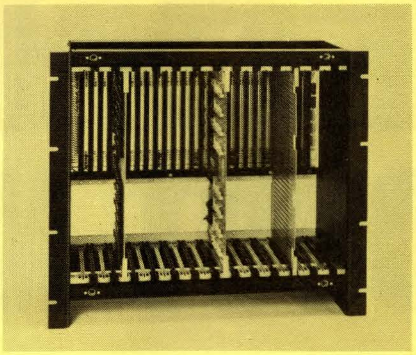

RACK MOUNT MULTIBUS™ CAGES

Now you can assemble Multibus systems for rack mounting applications with a minimum of mechanical design effort. The 15.75" high units are available with up to 26 card slots complete with backplane and power supply connections. Multibus™ Intel Corporation.

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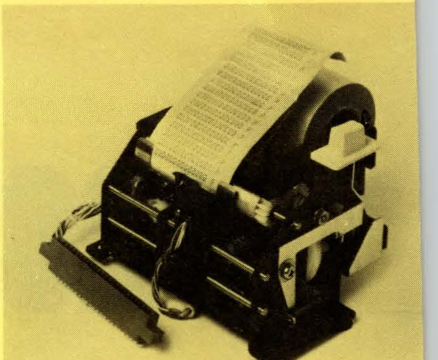

FAST RELIABLE DISCHARGE PRINTER DC-1606B/DC2106D prints 16 or 21 column alphanumerics in a 5 x 7 dot matrix format. It's MTBF is 3.0 millions lines on 2.25" paper costing about ¾ cent per foot. Just 3.8" H x 5.4" W x 5.5" D, it is as low as $120 in 100 quantity. Other printers with interface electronics available. **HYCOM, 16841 Armstrong Avenue, Irvine, CA 92714 (714) 557-5252.**

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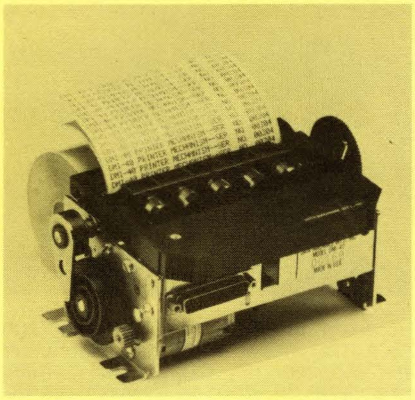
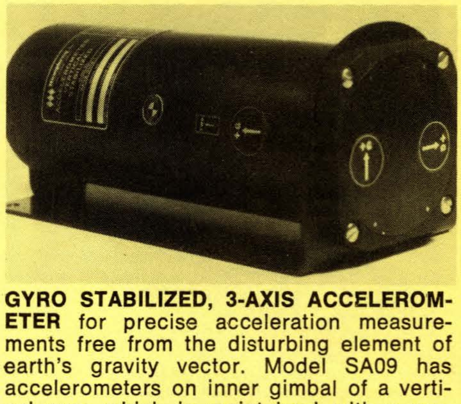


12v DC PRINTER—40 COLUMN—IMPACT

Extremely simple and rugged low cost dot-matrix impact line printer designed for portable, mobile and wide temperatures. Speeds to 120 LPM. Cassette ribbon. Multiple copy. PATENTED SOLENOIDS. Limited graphics. The 12 volt controller has 96 char set and takes parallel or RS-232 inputs to 9600 baud. Mechanism rated from −20°C to +60°C. **DATA MACHINES INT'L, INC.** (A Sub. of Telxon Corp.), Ghent Square, Bath, OH 44210. (216)-666-6789.

CIRCLE NO 166



GYRO STABILIZED, 3-AXIS ACCELEROMETER for precise acceleration measurements free from the disturbing element of earth's gravity vector. Model SA09 has accelerometers on inner gimbal of a vertical gyro which is maintained with a verticality within ±0.2° of local gravity. Wirewound potentiometers provide continuous pitch and roll outputs. Angular freedom of ±85° pitch and 360° continuous roll. 3.13" x 10.0" long, 3.5 pounds. **AC/DC. Humphrey, Inc., 9212 Balboa Ave., San Diego, CA 92123. (714) 565-6631 3-AXIS ACCELEROMETER**

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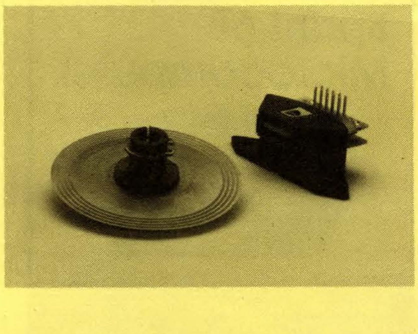

A DRC breakthrough in encoder technology, incorporated into our new Series 560 Modular Optical Incremental Encoders, allows operation at gaps of .03" ± .02". This insensitivity to gap variations means fast, easy integration for volume production applications. These low-cost encoders are available in resolutions to 500 cycles/revolution with sinesoidal or TTL output. Get more information today.

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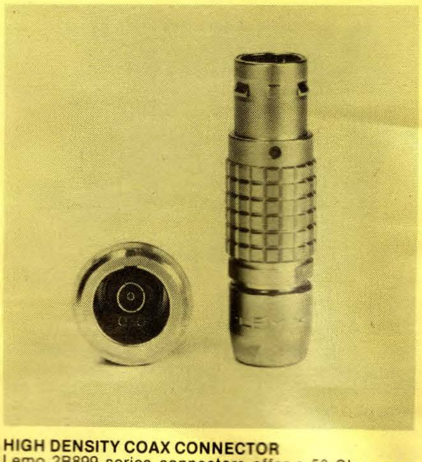

HIGH DENSITY COAX CONNECTOR

Lemo 2B899 series connectors offer a 50 Ohm coax contact suitable for RG-174 and 2 signal contacts, all in a compact, high-quality package. Quality workmanship and a matte chrome *plated finish* complement any high density front panel. This connector is expressly designed for front panel connectors to active probes containing IC's and requiring a combination of coaxial and signal contacts. **Lemo U.S.A. Inc.,** Box 6626, Santa Rosa, CA 95406; 707/523-0600.

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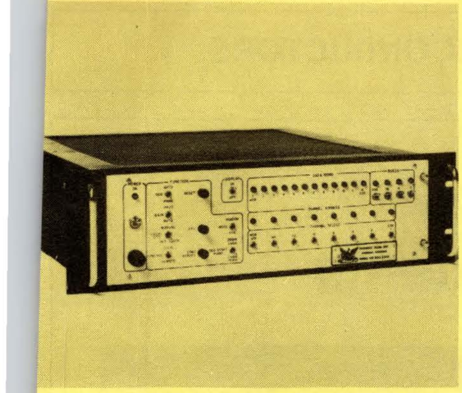

(DAS 8000 SERIES)

S 8000 ADAPTS TO ALMOST ANY INPUT SIGNAL RRENTLY IN USE. 8000 series A/D data con- ters offer automatic or programmed gain selec- with 11 binary ranges from ±10 millivolts to 0.24 volts full scale. In automatic ranging mode, n ranges effectively provide system with a ary floating point capability. The data word (12 ary bits) is combined with the range data (4 ary bits) for a 16 bit output word. Overall namic range: 132 db. **PHOENIX DATA INC., 3384 Osborn, Phoenix, AZ 85017. PH (602) 278-8528.**

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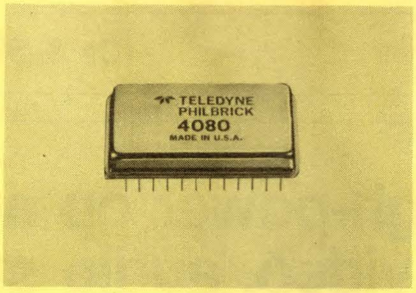

FASTEST 12 BIT VOLTAGE D/A CONVERTERS. The 4080 Series of 12 bit voltage output DACs are fully three times faster than nearest competitor. 10V step settles to ±0.02%FSR (±2mV) in 250nsec max. True 12 bit performers. Integral linearity error guaranteed less than ±½LSB. Monotonicity guaranteed over entire operating temperature range. TTL compatible, standard 24 pin DIP, 6 output ranges, ±15V supplies. Power consumption—900mW max. Units available for −55°C to ±125°C operation screened to 883. $229/100's. Prototype quantities available from stock.

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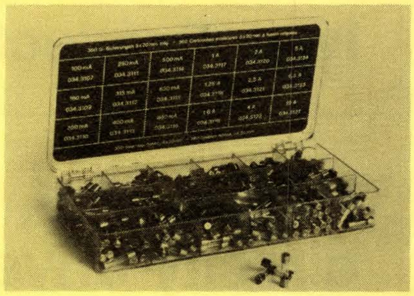

INTERNATIONAL FUSE KITS

International fuse kits contain 18 different values of 5 x 20 mm fuses that comply with IEC 127, are SEMKO and BEAB approved, and satisfy all requirements of VDE, SEV and other international test agencies. Two selections are available: one is composed of quick-acting and the other of time-lag fuses. These kits are designed specifically for R & D labs and maintenance and repair operations. **Panel Components Corp.,** Box 6626, Santa Rosa, CA 95406; 707/523-0600.

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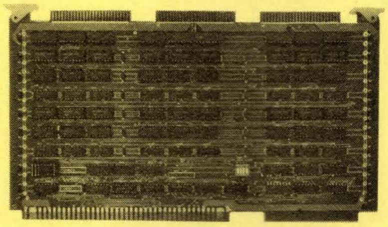

I/O EXPANSION BOARD

The SBS-520 I/O Expansion Board with 72 TTL I/O lines features high-speed operation, low-power consumption, diagnostic capability and direct interface to many solid-state I/O module systems. All I/O drivers, buffers and terminators are provided and burned-in as a system for 100 hours.

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FAST 8048 BASED EPROM TESTER & DUPLICATOR screens marginal or damaged EPROMs as they are programmed. Simply touch the AUTO PROG key and the UPP-2700 will TEST-PROGRAM-VERIFY and TEST sixteen 2708's in less than 130 seconds! All EPROMs from 2704's thru 2732's may be both tested and programmed using plug-in firmware modules. Find out why 3 out of 4 manufacturers who try it buy it. Call the OAE HOTLINE (213) 240-0080 or TELEX 194773—**OLIVER ADVANCED ENGINEERING, INC.,** 676 W. Wilson Ave., Glendale, CA 91203.

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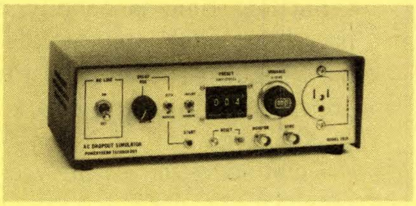

AC DROPOUT SIMULATOR

Model 1810 simulates line voltage dropouts that are fully adjustable from 0-500 cycles duration at 50/60 Hz. Timing is controlled by a zero-synchronized preset counter and calibrated delay for optimum accuracy and resolution. Handles 15A loads at 125 Vac. Test power supplies, µP-based systems and other ac-operated equipment affected by power line disturbances. **Powertrend Technology,** 3139-G Los Feliz Drive, Thousand Oaks, CA 91362. (805) 496-2945.

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High-speed, high-power op amp directly drives video, audio systems

Your first look at the 1461's 14-pin DIP gives you a clue that this op amp is different: The package is all metal and has hold-down ears for heat-sink mounting.

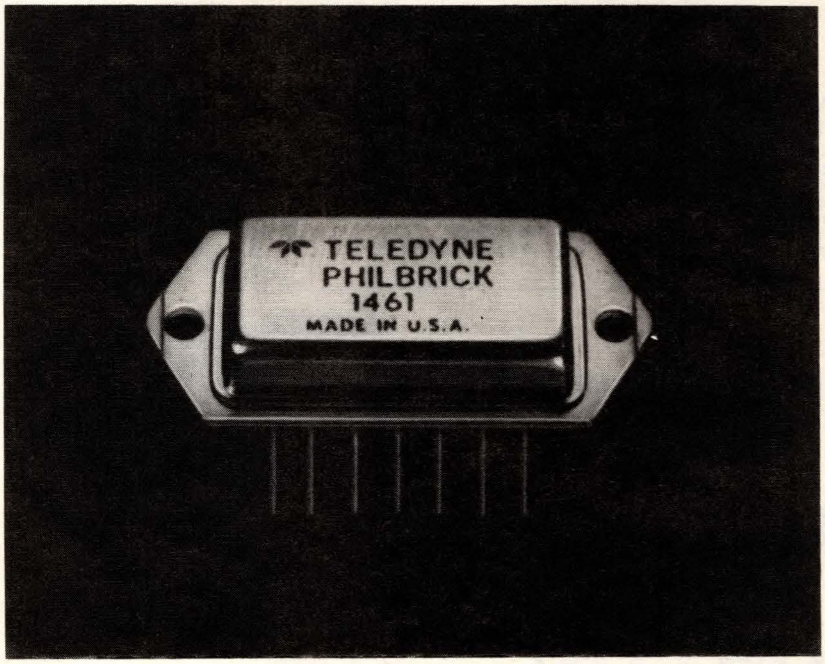
Employing a VMOS output stage, the hybrid device can deliver a ±30V output swing with ±600-mA max current into virtually any imaginable load—capacitive or inductive. It can function, for example, as a driver for CRT deflection yokes or complementary power-bipolar or FET audio-output stages. When driving a 100-μH yoke, it can achieve 2- to 3-μsec settling times for a 0.5A step.

The 1461 runs rapidly and quietly with a gain-bandwidth product of 1 GHz typ and a unity-gain bandwidth of 15 MHz typ. When operating as a unity-gain follower (compensation capacitance equals 30 pF), it furnishes a 150V/μsec typ slew rate; when running wide open, 1200V/μsec is typical.

Settling time is equally impressive: A 25V step settles to 0.1% in 500 nsec (typ), and a 10V step reaches the same 0.1% level in 400 nsec.

Quiet operation is achieved by employing an FET input stage, providing typical noise specs of 4.5 μV p-p (0.1 to 100 Hz), 1.5 μV rms (100 Hz to 10 kHz) and 6 μV rms (10 kHz to 1 MHz). A bipolar stage between the input and power-output stages provides the device's typical 115-dB open-loop gain.

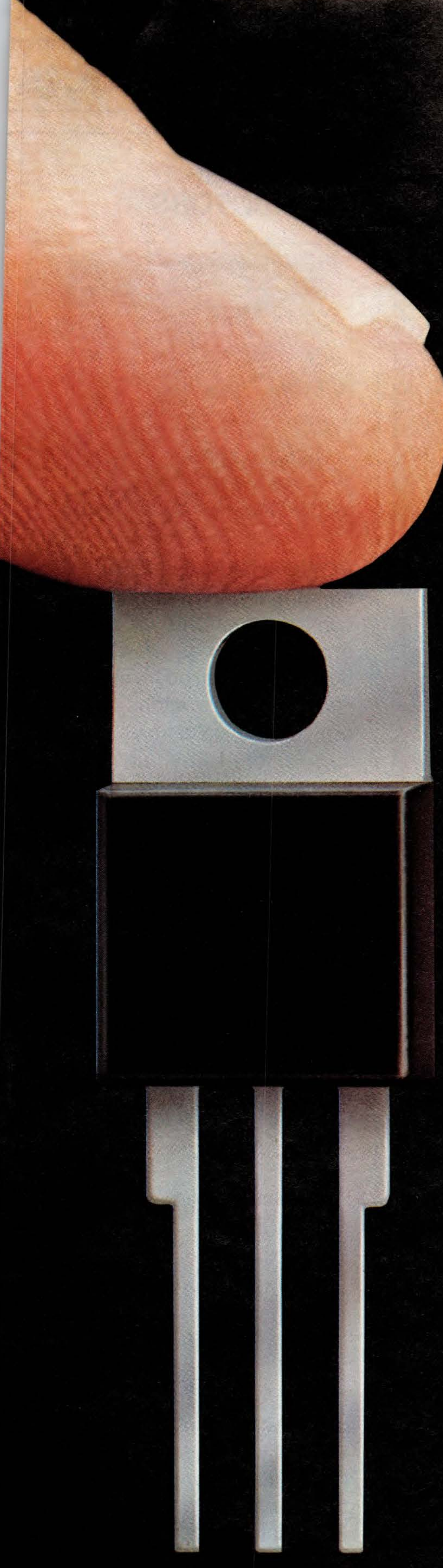
Two operating-temperature-range versions are available: The 1461 meets its specs over a 0 to 70°C span; the 1461-83 (MIL-spec) device handles −55 to +125°C requirements. $129 to $147 (100).



Combining ±30V, ±600-mA output capability and 1-GHz gain-bandwidth product, *Model 1461 op amp furnishes a typical input noise of 1.5 μV rms from 100 Hz to 10 kHz.*

Teledyne Philbrick, Allied Dr at Rte 128, Dedham, MA 02026. Phone (617) 329-1600.

Circle No 279



A Power Transistor That Won't Shock You

2,500 Volt (RMS) Isolation

When isolation is required for a transistor in a TO-220 package, you've probably been shocked to learn that as much as 10 extra parts are necessary in order to isolate the device from the mounting surface. Teccor now offers an internally isolated "T-TIP Series" transistor that requires no additional insulating parts. What's more, there are no complicated mounting procedures that can cost you time and money on the assembly line, or at the test and rework station.

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Teccor also offers SCR's and triacs with the same isolation features. And as a major power semiconductor manufacturer, we assure you that our products will be readily available when and where you want them.

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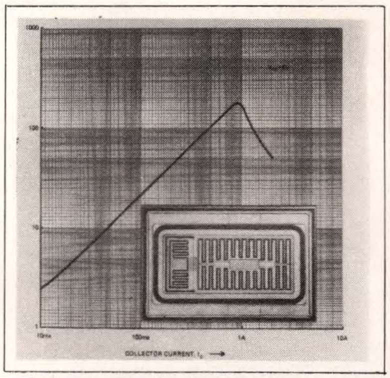
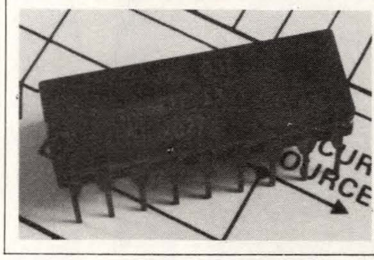
New Products

ICs & SEMI-CONDUCTORS



POWER DARLINGTONS. Featuring collector currents of 2A continuous and 4A pk and V_{CEO} and V_{CBO} ratings of 400V and 500V min, respectively, PD-4 npn power Darlingtons provide a dc current gain (h_{FE}) of 200, $V_{CE(SAT)}$ of 1.20V at 1A and typical switching speed of 2 μsec. Operating and storage temperatures span −50 to +150°C. The 100×150-mil monolithic chips are gold backed for eutectic mounting with aluminum pads on top for wire bonding. From $4.05 (100). Delivery, 6 to 8 wks ARO. **Dionics Inc,** 65 Rushmore St, Westbury, NY 11590. Phone (516) 997-7474.
Circle No 280

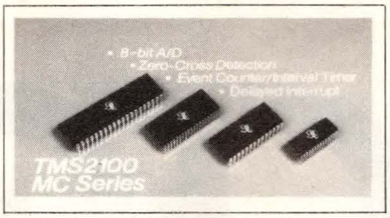


DAC. A 10-bit IC with sign-magnitude coding, DAC-210 provides 1.5-μsec settling time and nonlinearity over full temperature range as low as ±0.075% FS. Containing an output amplifier, reference, logic-controlled polarity switch and ladder-network switches, it's directly

New Products

ICs & SEMI-CONDUCTORS

compatible with TTL and DTL and interfaces with CMOS devices. By applying an external reference signal to the reference input (instead of shorting the reference output to the reference input), you can use the unit as a 2-quadrant multiplier. Maximum zero-scale offset voltage over the full temperature range specs at ±0.06% FS (for A and E versions); maximum bipolar full-range voltage symmetry, 40 mV (for all except G versions). $9.50 to $66; DAC-210AX (−55 to +125°C operation, ±0.75% FS maximum nonlinearity), $55. **Precision Monolithics Inc,** 1500 Space Park Dr, Santa Clara, CA 95050. Phone (408) 246-9222. TWX 910-338-0528.
Circle No 281



SINGLE-CHIP μCs. Furnishing the same architecture and instruction set as other TMS1000-family μCs, units in the TMS2100 Series incorporate an 8-bit A/D converter, 8-bit interval timer, zero-crossing detector, software-programmable delayed interrupt, on-chip oscillator and bidirectional I/O port and suit industrial and appliance-control applications. 2k bytes of on-chip ROM and 512 bits of RAM are also provided. The TMS2100 and -2170 feature a 4-bit input port, 4-bit bidirectional port, analog input and 8-bit output port. The TMS2100 has seven and the TMS2170 six individually addressed output latches. The TMS2300 and -2370 provide two 4-bit input ports, a 4-bit bidirectional I/O port, two analog inputs and an 8-bit output port; the TMS2300 has 15 and the -2370 14 individually addressed output latches. The TMS2170 and -2370 also furnish a high-voltage interface with pull-down to directly drive vacuum-fluorescent displays. $3.25 to $4.50 (OEM qty). **Texas Instruments Inc,** Box 202129, Dallas, TX 75220. Phone (214) 995-6611.
Circle No 282

CMOS ROM. MCM65516, organized as 2048 bytes, is designed for use in multiplex bus systems. Operated at 5V, the -43 version achieves an access time of 430 nsec; the -55, 550 nsec.

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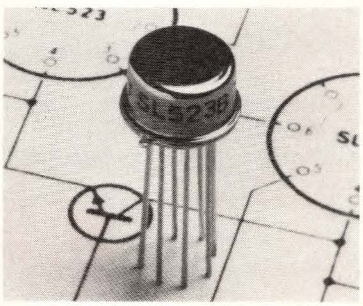
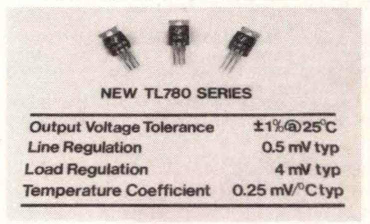
Current requirements equal 30 mA max active and 50 μA max standby. Compatible with CMOS μCs that share address and data lines, the unit features mask programmability of pins 13, 14, 16 and 17. Pin 17 provides active-HIGH, active-LOW or MOTEL (MOTorola, intEL) operating modes, furnishing direct compatibility with Motorola 6800 or Intel 8085 μPs. From $16.60 (550-nsec access time) in plastic to $25.65 (100) (430 nsec) in ceramic. **Motorola Semiconductor Products Inc,** 3501 Ed Bluestein Blvd, Austin, TX 78721. Phone (512) 928-6660. **Circle No 283**



LOG IF AMPLIFIER. A dual wide-band logarithmic amplifier that can be directly coupled into cascaded stages, SL 523 is available individually or in matched sets of eight stages. Suiting use in successive-detection log IF strips for radar and ECM and IFF transponders, and pin compatible with SL 521 devices, the SL 523 provides a small-signal gain of 24 dB. When supplied in matched sets, each unit's gain is matched to 0.75 dB at 60 MHz; the units track each other's gain characteristics. Upper cutoff frequency (−3 dB) specs at 120 MHz min; lower cutoff, 15 MHz max. Other specs include detected video-output signal of 1.8 mA min (with 0.5V rms input voltage), 6V dc operation, and typical maximum RF output voltage of 1.2V p-p. $29; matched sets of eight, $348 (100). **Plessey Semiconductors,** 1641 Kaiser Ave, Irvine, CA 92714. Phone (714) 540-9979. **Circle No 284**

LOGIC-ARRAY CIRCUITS. Featuring improved power-dissipation and speed specs, commercial Series 20 devices reduce supply current from 225 to 180 mA on PAL16L8, -16R8, -16R6 and -16R4 medium PAL registered circuits for performing sequential functions. Speed specs at 35 nsec max, 25 nsec typ. Propagation delay time has been reduced from 40 to 35 nsec in small PAL devices, performing combinatorial functions (except for the PAL16C1, which continues to operate at 40 nsec). Available units range from an octal 10-input AND/OR gate array to a quad 16-input registered AND/CARRY/OR/XOR gate array. All provide programmable 3-state outputs, registers with feedback and variable I/O pin ratio. Small PALs, $8.35 in plastic, $12.20 in ceramic; medium PALs, $20.83 in plastic, $25 (100) in ceramic. **Monolithic Memories Inc,** 1165 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 739-3535. TWX 910-339-9229. **Circle No 285**



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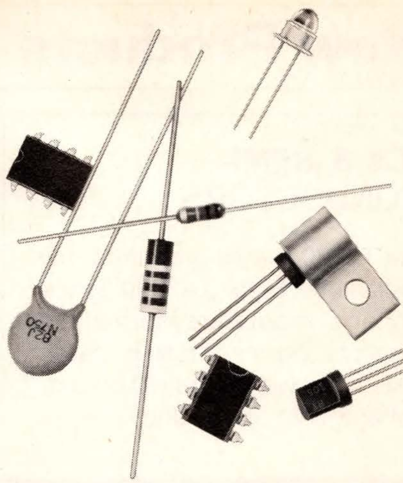

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This optoelectronic switch is a complete system in a single, 3-lead clear plastic TO-92 package. It includes a silicon photodiode, low-level amplifier, Schmitt trigger, output driver, and voltage regulator. The ULN-3330Y switch is designed for ON-OFF light applications where passing objects break a light beam (to 3 kHz or 180,000 rpm). It is also useful for operation at a precise light level and is recommended for applications where a light threshold sensor is required. This low-cost switch features an internal latch to provide hysteresis and eliminate chatter or hunting. An open collector output driver will switch 50 mA at 15 V.

*In production quantities. Less than 20% the cost of anything comparable.

For Engineering Bulletin 27480 write to: Technical Literature Service, Sprague Electric Company, 491 Marshall St., North Adams, Mass. 01247.

For application engineering assistance, write or call Sprague Electric Company, Semiconductor Division, 115 Northeast Cutoff, Worcester, Mass. 01606. Telephone 617/853-5000.

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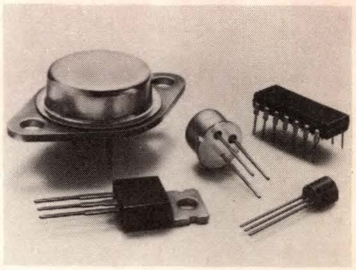

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Carefully weigh advantages, disadvantages of patent versus trade-secret protection

David Pressman, Attorney at Law
San Francisco, CA

If you want to safeguard valuable information, an invention or manufacturing process from competitors, making it a trade secret can provide significant protection, as the first two articles in this series have pointed out. However, there is an alternative to the trade-secret route: patent protection. Despite their obvious advantages, though, patents have serious limitations and thus might not be the best method of protecting your important information or inventions from misappropriation or misuse. This last of three articles, therefore, examines the strengths and weaknesses of the patent process as an alternative to trade secrecy.

To patent or not to patent

Most designers are surprised to learn that they often can realistically choose between two modes of protection for important information or inventions. Both trade-secret protection and the patent process, however, can effectively safeguard creative works. And as indicated in the first article in this series, it's just as practical to sue and recover damages against a person who misappropriates a trade secret as it is to sue and recover damages against a patent infringer.

Unfortunately, you can't have your cake and eat it too. When you create information or a process applicable to trade-secret protection, you must choose definitively between keeping it a trade secret or patenting it: The two modes of protection are incompatible. The word "patent," in fact, means "open" in its original sense. And US patents, when issued, contain a full description of the invention and are printed, published and distributed widely by the government. Thus, it would be impossible to keep information a trade secret and also patent it.

Law limits prepatent commercial use

But why couldn't you keep trade-secret-protected information under wraps for many years, use it to produce a product or deliver a service, and then, if the information seems likely to be discovered, patent it and obtain an additional 17 yrs of protection? The reason you can't is simple: The law forbids it. Section 102(b) of the patent law states:

"A person shall be entitled to a patent unless...the invention...was in public use or on sale in this country more than 1 yr prior to the date of the application for patent in the United States..."

This provision means that once you use your invention commercially, either to produce a product or to perform a service, you must file a patent application within 1 yr of that activity. If you file it later than a year from the product's first commercial use, your patent application will be refused if the US Patent and Trademark Office learns of your commercial activity.

Furthermore, even if you do manage to obtain a patent under these circumstances and sue for infringement, a court would declare your patent invalid (and possibly subject you to other penalties) if the infringing party can show that you engaged in the early commercial activity specified in the 1-yr rule. Moreover, you could additionally be held liable for perjury: The patent application's written oath contains a statement taken from Section 102(b).

In any case, you shouldn't wait a year from a product's first commercial use to file a US patent application. Certain other countries, lacking the US's 1-yr grace period, require that a patent application (including the corresponding US application) be filed before an invention is commercially exploited at all.

One other possibility deserves mention. If you're not ready or able to exploit your invention commercially and prefer patent protection over trade secrecy, you can apply for a patent and still keep your invention secret. How? By not using it commercially for the 1 to 3 yrs (or longer) that it takes for the Patent Office to rule on your application. Then if the Patent Office refuses your patent, it will continue to keep your unsuccessful patent application secret indefinitely, permitting you to institute trade-secret protection.

Consider trade secrets' advantages over patents

What, then, is the best method of protecting an important invention, a manufacturing process or information? Most knowledgeable people place a

very high value on the advantages that trade secrecy confers and hence *generally* advise taking the trade-secret and not the patent route when an invention or process can be protected that way. Why? Consider trade secrets' advantages over patents.

First, a trade secret affords *the possibility of perpetual protection.* Whereas a patent's protection lasts only 17 yrs and is not renewable, trade-secret protection lasts as long as the pertinent information is kept secret. And with a trade secret, *the expense, time, and effort expended on the patent process is eliminated.*

Even a simple patent application currently costs approximately \$1000 to \$1500 to prepare and file using a patent attorney; at least \$500 more is required to process the application through the Patent Office. Furthermore, under the new, recently enacted patent law, maintenance fees will be imposed 3½, 7½ and 11½ yrs after a patent is granted. (See EDN's next issue for an article on the law's provisions.)

In addition to these costs, a substantial amount of time is required to consult with a patent attorney and supply him with the necessary information. Moreover, you'll usually have to spend additional time discussing how broad to make the scope of your patent—an important decision in the patent-application process.

With trade-secret-protected information, on the other hand, you save all of this time and expense. Only minimal expense and routine precautions are required to keep important information protected—precautions probably already in use for other types of sensitive data.

Patents can disclose important data

As a further advantage, you can keep critical details confidential with trade-secret protection. In contrast, as a condition of the patent process, you must disclose the "best mode" you're aware of for making and using your invention, including all the critical details necessary to enable one skilled in the art to make and use the invention successfully. And when your patent is issued, all of this information is published and circulated for your competitors to see.

Furthermore, they can use the information freely—provided they don't infringe your patent during its 17-yr term, and without any restriction after the 17-yr term expires. Requiring you to disclose details of your invention is actually the *raison d'etre* of the patent law; in exchange for this disclosure, the state rewards you with a 17-yr monopoly on your invention.

An additional trade-secret advantage is that *you receive protection without risk.* In applying for and obtaining a patent, however, you run the risk that the Patent Office might refuse your application or that even if you obtain a patent, the courts will hold it invalid. Such rejection usually occurs because your invention is not sufficiently differentiated from the prior art, or because of a host of other factors, including failure to disclose sufficient detail, violating the aforementioned 1-yr rule concerning commercial use or failure to name the proper inventors. All of these risks, though, are generally absent on the trade-secret route.

Circumventing a patent by designing around it

Additionally, *no possibility of "designing around" an invention or manufacturing process exists* when it's protected as a trade secret. In contrast, once a patent is issued, it's published with one or more "claims"—carefully crafted sentence fragments that tell the public the scope of your invention. Anyone is free to study the patent and circumvent the protection it affords by designing around its claims and their equivalents.

This situation, moreover, is more likely to occur if the claim drafter (usually your patent attorney or agent) did a poor job by not making the patent's claims as broad as possible. With a trade secret, however, no claims or other details of the invention are ever published for potential competitors to design around and exploit.

Finally, *trade secrets afford protection to nonpatentable information.* To qualify for a patent (and to have it held valid under a court test), your invention must constitute a significant improvement or development over the prior art; in legal terms, it must be considered "unobvious" to those skilled in the art to which it pertains. And some courts additionally hold that it must produce "unusual and surprising results." However, no such severe tests are required of a trade secret; as the first article in this series pointed out, only secrecy and some minimal degree of novelty must be shown.

Trade-secret protection is not infallible

Alas, all of these advantages of trade secrets over patents don't come without some limitations. Furthermore, patents can provide protection that trade secrets cannot. And unfortunately, *trade-secret protection suits only a relatively small percentage of inventions.* Thus, the only classes of inventions that can generally be effectively kept secret in commercial use are chemical formulas, manufacturing processes and performance techniques (such as laser-light-show projection techniques). And as the first article in this series pointed out, if information about a process or product is discoverable by reverse engineering, anyone is generally free to copy the product or process, provided no patent infringement occurs. In that case, then, a patent provides superior protection.

A further problem with trade secrets is that *they provide no protection against an independent discoverer.* Thus, if someone discovers or duplicates your trade secret legitimately—as, for example, by an independent act of invention—you have no legal recourse against such an act. In this respect, a patent offers much broader protection: It remains valid both against independent creators and copiers.

Trade-secret protection additionally requires that *strict secrecy measures must be established and maintained.* Once information is to be protected, therefore, its secrecy must be preserved by limiting employee access, using special employer/employee agreements and employing locks, "confidential" stamps and other measures. Furthermore, failure to take such measures and prove their use to a court subjects a trade secret to loss of protection. A patented invention, on the other hand, can be published and used freely without any loss of protective rights.

Insolvency can prevent recovery of damages

Trade secrets additionally run the *risk of loss to an insolvent thief.* If someone should misappropriate your trade-secret information, you of course have a full right to sue and recover damages and have the court order the thief to cease using your information. But what if the person involved has no assets or has gone out of business after revealing your invention to the world? And what if he sells or reveals your information to an innocent manufacturer, who in good faith tools up and begins to use your trade secret before you discover the loss?

In such cases, your rights against the insolvent thief become useless. Moreover, you might not be able to stop the innocent user from exploiting your invention or recover damages against such a user, as you could with a patent.

Another trade-secret limitation is that *they are more difficult to base lawsuits on and enforce* than patents. While a patent must initially be *presumed valid* when brought into court, information considered a trade secret must be *proven* to actually constitute a trade secret under the legal criteria for trade-secret protection (see the first article in this series), and the precautions taken to protect it must be shown in effect. Furthermore, some form of theft, misappropriation or improper derivation of your trade secret must be proven before any suit for trade-secret misappropriation can proceed.

Although patents don't enjoy the prestige they once had, they still are impressive documents. Owning one thus entitles you to a handsome document from the government, under seal and with a fancy ribbon attached. And the patent itself, and the fact that it has passed a rigorous test in the Patent Office, commands almost universal respect. A trade secret, on the other hand, is not accorded any of these accoutrements, *has passed no government test and hence is considered fair game by all potential copiers.*

Which route to take?

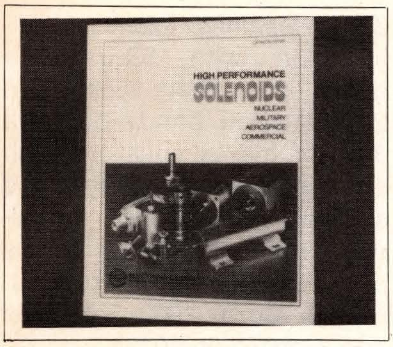
Adding up the pluses and minuses of patent versus trade-secret protection can prove difficult. But if you have information, an invention or a manufacturing process that you feel can be protected and kept secret as a trade secret and that you estimate won't likely be discovered independently for at least 17 yrs, most experts advise protecting it as a trade secret rather than taking the patent route.

In the final analysis, then, trade secrets provide the significant advantages of perpetual protection, the relative absence of cost or risk and fact that you don't have to let your knowhow be published for all your competitors to see and utilize. But whatever course you take in protecting your invention, using the information contained in these three articles can help you provide the highest degree of protection. **EDN**

(Ed Note: You're invited to send questions on aspects of the law that might form the basis of future articles (or comments or questions on published articles) to EDN's editorial office, c/o the Question of Law editor.)

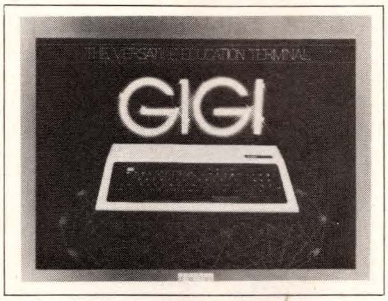
David Pressman, JD, BSEE, received the Juris Doctor degree from George Washington University and a BSEE from Penn State University. A member of Eta Kappa Nu and Sigma Tau, he is registered to practice before the US Patent and Trademark Office, is a member of the California and Pennsylvania Bar Associations and is on the Board of Directors of the California Inventors Council. Formerly a field engineer at Philco-Ford Corp, a patent examiner with the US Patent Office and a patent attorney for Philco-Ford, Elco Corp and Varian Associates, Pressman is currently in private practice specializing in patent law. He is also the author of *Patent It Yourself!—How to Protect, Patent and Market Your Inventions* and a lecturer in patent, trademark and copyright law at San Francisco Community College.

Literature



Solenoids' design and operating features
A 24-pg handbook describes linear high-performance solenoids, detailing force-stroke curves, coil resistances, recommended voltages and maximum permissible ON times for either continuous- or cyclic-duty devices. It provides tips for solenoid selection for several applications and examines contact protection. A glossary concludes the brochure. **Electroid Corp,** 45 Fadem Rd, Springfield, NJ 07081. **Circle No** 296

Applications for subminiature connectors
A 60-pg catalog details D subminiature rectangular connectors for use in aircraft, missile and ground-support systems. It includes 75 photographs, eight cutaways and 70 drawings of Original-D, Burgun-D, Golden-D, Royal-D, Hermetic-D, Filter-D and Mas/Ter-D devices. Catalog D-15 also provides drawings of contact arrangements, cross-reference charts for part numbers, tables of shell and mounting dimensions, electrical data and ordering instructions, as well as accessory data, voltage/current ratings, and panel-mounting and tools/assembly instructions. **ITT Cannon Electric,** 666 E Dyer Rd, Santa Ana, CA 92702. **Circle No** 297

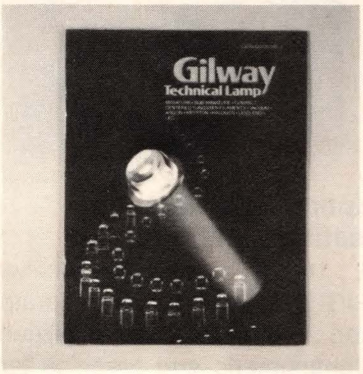


Educational-terminal features, options
A 14-pg brochure describes GIGI (general imaging generator and interpreter), an intelligent alphanumeric and graphics terminal that operates with a variety of color and black-and-white video monitors. It discusses the terminal's GIGI BASIC, text and graphics editors, multiple-character sets, data-plotting package and other options. Specs on display characteristics, user-defined memory, environmental factors, input power and communications capability for the educational-applications terminal conclude the booklet. **Digital Equipment Corp,** 444 Whitney St, Northboro, MA 01532. **Circle No** 298

Resistor-network specs, capabilities
A brochure describes a line of thick-film resistor networks and chip resistors, displaying standard network configurations including DIP, SIP and flatpack styles with molded, coated and sandwich-type construction. It examines models qualified to

Literature

MIL-R-83401 as well as chip resistors that meet MIL-R-55342. Finally, it lists resistance values maintained in stock as well as standard circuits available for pull-up, pull-down, pulse-squaring, dual-line-termination, current-limiting, impedance-balancing and other applications. **Dale Electronics Inc,** 2300 Riverside, Norfolk, NB 68701. **Circle No** 289



Illuminating lamp capabilities

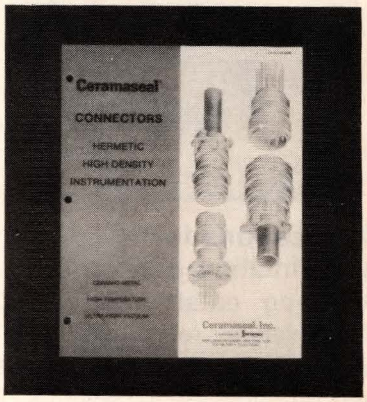
With 16 pgs of mechanical, electrical and optical specs, Catalog 156 details technical lamps. For each unit, it specifies color temperature, filament type and size, atmosphere, intensity, voltage, current, life in hours, glass quality and configuration, and filament position. A product index is included. **Gilway Technical Lamp,** 165M New Boston St, Woburn, MA 01801. **Circle No** 290

Meeting your fiber-optic-cable needs

A kit-type folder offers specification sheets detailing the company's fiber-optic cables. Cable types covered include Series 2200 and 2210 step-index designs with 200- and 300-μm-core plastic-clad fibers; Series 2260, which utilizes 100-μm-core glass-clad partially graded-index fiber; and BitLite Series 2261, featuring tubeless construction with 50-μm-core graded-index fibers supplying a 200-MHz-km bandwidth and 8-dB/km max attenuation. Each sheet provides cable cross sections, dimensions, optical-power and attenuation graphs and available configurations. **Belden Corp,** 2000 S Batavia Ave, Geneva, IL 60134. **Circle No** 291

Data on comm-network monitoring

Detailing state-of-the-art unattended - communications - network surveillance, automatic alarms and reconfiguration capability, an 8-pg brochure also describes the latest hardware available to automatically supervise communications networks. It examines how to automatically detect faults at the central communications center and quickly correct them. **Digilog Network Control Div,** Babylon Rd, Horsham, PA 19044. **Circle No** 292

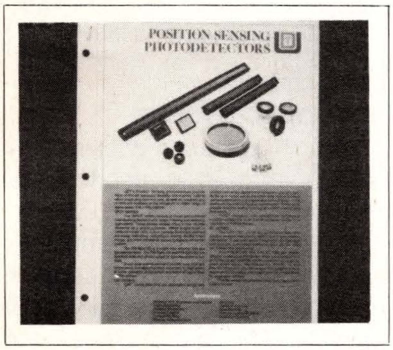


Connecting in hostile environments

Catalog 8008 describes a line of ceramic/metal high-density instrumentation connectors. It examines units available with 10 or 20 conductors per connector, developed for use in severe environments; diagrams detail

Literature

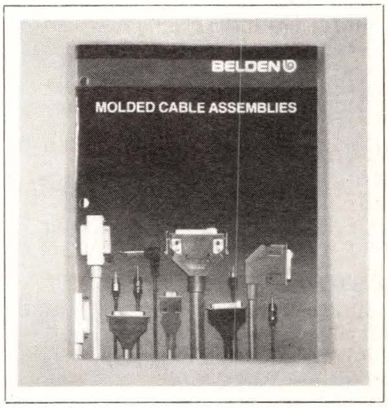
device construction. The 6-pg booklet also highlights two accessories for the vacuum-side conductors used in the units: push-on crimp-type contacts and ceramic spacers. **Ceramaseal Inc,** New Lebanon Center, NY 12126. **Circle No** 299



Using position-sensing photodetectors

A 6-pg brochure highlights a line of position-sensing photodetectors. It presents data on 11 models in three series—the SPOT Series of bi- and quadrant cells for nulling and centering applications, the LSC Series for continuous position sensitivity over a wide dynamic range and the SC Series providing X- and Y-axis position information. Spec charts, performance graphs, responsivity curves, typical schematic hookups and dimensional drawings complete the brochure. **United Detector Technology,** 3939 Landmark St, Culver City, CA 90230. **Circle No** 300

Custom-designing cable assemblies



A 28-pg catalog describes design-it-yourself molded cable assemblies for interfacing data systems, peripherals, instrumentation and controls. It also details shielded and unshielded standard products, including 9- and 37-position RS-449, 15- and 50-position RS-422A and RS-423A, 25-position RS-232C and 24-position GPIB lines. Specifying hints and checklists simplify selection. **Belden Corp,** Interconnect Systems Operation, 105 Wolfpack Rd, Gastonia, NC 28052. **Circle No** 301

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Literature

Characteristics of low-profile keyboards

Data sheet 1-0066C describes 55 low-profile keyboards and provides specs, drawings, dimensions and output-code diagrams. The 6-pg brochure also covers key arrays, key and frame configurations, mounting configurations and environmental-protection factors. **The Digitran Co,** 855 S Arroyo Parkway, Pasadena, CA 91105.

Circle No 293

Tips for using optoelectronic units

In more than 400 pgs, a manual discusses solutions to common problems in the application of fiber-optic systems, optocouplers, emitters/detectors and digital bar-code systems, and optoelectronic displays and lamps. It also examines photometry/radiometry, contrast enhancement in displays, reliability of optoelectronic components and mechanical handling of optoelectronic units. Circuitry and software examples are provided. Each major section covers the theory of a particular technological area, the theory behind products designed to service needs in that area and practical solutions to technical problems encountered. \$27.50. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304.

INQUIRE DIRECT

Data details fiber-optic system

A 4-pg brochure defines the HDC Interface, a standardized fiber-optic system. It includes 10 color photos of the compatible cable/connector/diode hardware used in high-density, single or multichannel applications and provides data on materials, performance outline dimensions, and termination tooling and instructions on ordering components. Drawings detail outline dimensions and a mounting pattern. **ITT Cannon Electric,** 666 E Dyer Rd, Santa Ana, CA 92702.

Circle No 294

Choosing and using solid-state relays

Applications data for solid-state relays fill a 20-pg catalog. Graphs plot surge current against time, load characteristics and input current and voltages. Dimensional drawings and spec charts accompany text detailing output-switch protection and troubleshooting techniques. **Magnecraft Electric Co,** 5575 N Lynch Ave, Chicago, IL 60630.

Circle No 295

Books

Op-amp text emphasizes practical designs

***Operational Amplifiers**, by Jiri Dostal. 488 pgs; $85.50 (hardcover); Elsevier Scientific Publishing Co, 52 Vanderbilt Ave, New York, NY 10017, 1981.*

If you're looking for the best up-to-date book on practical op-amp applications, you might not think to find its author in Czechoslovakia. But that's the home of Jiri Dostal, whose *Operational Amplifiers* reaches an impressive new level of completeness and good intuitive sense—building, of course, on earlier texts by Philbrick Research, Burr-Brown, James Roberge, John I Smith and others.

Dostal reviews the classical and conventional studies of operational amplifiers, explaining the theory and practice of how to make amplifiers work well and stably. He also provides excellent insights into why resistors and capacitors do such a good job of facilitating analog circuit design when activated with an op amp.

The section on op-amp testing is a particularly fine example of practical engineering. Where else are you told to "place a 30×40-cm shielding copperclad board on the bench" and prepare "to ground yourself"? Indeed, the rules Dostal summarizes would prevent 90% of all linear-IC testing problems if thoughtfully followed.

The translation into English is in good idiomatic American (kudos to translator Ing Karel Kieslich); the engineering jargon and phrasing fall comfortably on the ear. You'd hardly guess that American English isn't the author's native language. (Actually, analog electronics is his language!)

To be sure, this book does contain a few glitches. For example, most Teflon capacitors have a temperature coefficient of −102 ppm/°C—not +200 ppm/°C as stated. Also, Dostal claims that "it seems almost impossible to switch microvolt signals by an FET switch; the temperature differences on the silicon chip should be below 0.001°C." But such low temperature differentials do exist in modern IC op amps, devices that produce less than 0.5 μV of noise.

Another minor point: In Fig 3.24, Dostal says that op amps stabilized by shunt damping are rare, yet Harris Semiconductor employs this stabilization technique in most of its amplifiers.

Finally, although Dostal covers FET-input op amps quite well in general, he doesn't mention the newest IC FET-input models—a minor oversight because the design discussions apply equally well to discrete, hybrid or IC devices.

Except for these few small (nit-picking?) negatives, the first 451 pgs of this book are quite good—full of useful, general engineering information. The next 8 pgs (Chapter 14), however, make Dostal's work a *must* for any good library. This chapter contains a compact bible of well-founded advice for analyzing, developing and manufacturing high-performance analog circuits. Dostal provides some excellent insights here—most of which have never before appeared in books or magazine articles. Then the discussion gets better yet: The 3-pg section on troubleshooting is absolutely priceless.

Most textbooks on analog circuit design totally ignore troubleshooting techniques; they seem to pretend that if you ignore the subject, the need for it will disappear. But all designers know that in reality Murphy's Law remains unbroken, and Dostal proves that there are logical, innovative approaches to solving devilish problems. Even "old dogs" will learn a few "new tricks" from this section. And beginners in the analog art will gain considerable wisdom by studying the ingenious techniques distilled from years of struggling with balky circuits.

Dostal's attitude toward analog design can perhaps be summarized by his comment on the bottom of pg 157: "Troubleshooting should resemble fencing rather than wrestling!" Bravo!

Every op-amp engineer or enthusiast will enjoy reading this book.—***Robert A Pease***

NEXT TIME

EDN's June 24 issue will feature a Special Report on CMOS—envisioned by many industry experts as the premier processing technology of the 1980s and now exploding into a variety of new product areas. Other highlights include articles on

- Designing with current-mirror ICs
- Implementing a color-graphics processor
- Understanding the recently amended patent law
- Using digital techniques in signal-processing applications

. . . and much more. Also look for Technology Update stories on CAD/CAM developments and laser technology, plus our regular Design Ideas, A Question of Law and μC Design Techniques departments. You can't afford to miss this issue!

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617-536-7780

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RETRACTION

It was mistakenly reported in the May 13th issue of EDN that NCR was closing plants in Ohio and Delaware. Production from the former NCR plant in Delaware was moved to a new facility in South Carolina which was built to expand NCR's development and production of systems for the supermarket and food distribution industries. No plant was closed in Ohio; only a small group of engineers headquartered there was transferred to the new South Carolina facility. It is regretted that this error occurred.

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Circle No. 5004 (on page 271 of **EDN**)

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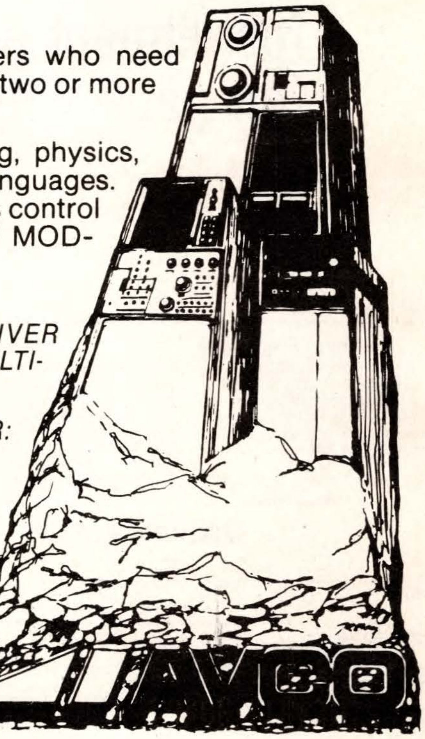

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Looking Ahead: Trends and Forecasts

High space R&D costs ground US firms

Despite the Space Shuttle's recent successful flight, US electronics firms are not rushing to fabricate exotic new alloys or ultrapure semiconductors in the nearly gravity-free environment of space.

The obstacle? Cost. Rental of the Space Shuttle's cargo bay—approximately the size of a railroad boxcar—will cost as much as $35 million next year; the Spacelab that goes in it adds another $13 million. And additional costs would be incurred by the development of special machinery for microgravity manufacturing.

Success, however, in developing a new product would be even more expensive: Large-scale production in space might require an additional space station.

Another problem inhibiting US firms: US-government tax credits are not available for R&D, in contrast to Japan and West Germany.

Thus, while US companies currently plan only a few materials - processing - research experiments, the West German government has made downpayments on two Spacelab missions, and the Japanese government has expressed serious interest in one.

SPACE SHUTTLE/SPACELAB MATERIALS-PROCESSING-IN-SPACE RESEARCH

	MISSION
MATERIALS-SOLIDIFICATION EXPERIMENT	SHUTTLE, MID-1984
VAPOR CRYSTAL GROWTH SYSTEMS, FLUIDS EXPERIMENT	SPACELAB 3
ZERO-GRAVITY COMBUSTION FACILITY	SPACELAB, MID-1980s

SOURCE: TRW/DEFENSE & SPACE SYSTEMS GROUP

F-O-components market to top $1.06B by 1990

Fueled by rapidly expanding telecommunications applications, the US fiber-optic-components market will grow at an average annual rate of 49%, reaching $375 million by 1985 and topping $1.06 billion by 1990.

And spurred by sensor fibers' 44% and integrated optical circuits' expected 46% average annual growth rate over the period, US fiber - optic-component production will also exhibit a healthy rate of growth. Rising from last year's $2.39 million figure, it should pass the $58 million mark by decade's end, predicts Gnostic Concepts Inc (Menlo Park, CA).

Production of the special sensor fiber employed primarily in high - accuracy interferometry-based gyroscopes will reach a $16.80 million level by 1990. And the development of fiber-optic sensor systems (EDN, October 5, 1980, pg 254) should create demand for the integrated optical circuits now under development.

Although military and other government applications currently represent the largest fiber-optic-component applications segment with 37% of total consumption, commercial telecommunications' application share will accelerate rapidly from last year's 21% level to 43% by 1990. Computer and industrial applications will also rise rapidly over the period. Government/military use, however, will drop to 20% of total end use by that date, says Gnostic.

In related developments:

- Export opportunities will open up for US manufacturers for computer, consumer and other nontelecommunications fiber-optic-component applications. But foreign firms will offer strong competition in domestic emitter, hybrid transmitter and receiver, coupler and connector markets.
- Viewing fiber optics as the key to expansion of digital-electronic-system exports, the Japanese government plans to invest $70 million in fiber-optics research over the next 6 yrs.

US FIBER-OPTIC-COMPONENT PRODUCTION
($ MILLION, % OF TOTAL PRODUCTION)

	1980		1985		1990		AVERAGE ANNUAL GROWTH
CABLE	$0.47	20%	$1.85	10%	$7.88	14%	33%
TRANSMITTER MODULES	0.60	25%	5.28	29%	10.79	18%	34%
RECEIVER MODULES	0.41	17%	2.30	12%	3.15	5%	22%
CONNECTORS	0.16	7%	1.90	10%	6.29	11%	44%
SENSING FIBERS	0.43	18%	4.69	25%	16.80	29%	44%
INTEGRATED OPTICAL CIRCUITS	0.31	13%	2.46	14%	13.54	23%	46%
TOTAL	**$2.39**		**$18.47**		**$58.44**		**38%**

SOURCE: GNOSTIC CONCEPTS INC

Material for this page developed from *Electronic Business* magazine and other sources by Jesse Victor, Assistant/New Products Editor, and Joan Morrow, Assistant Editor.

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  4.75" × 2.60" × 2.22" (ZHL Models)
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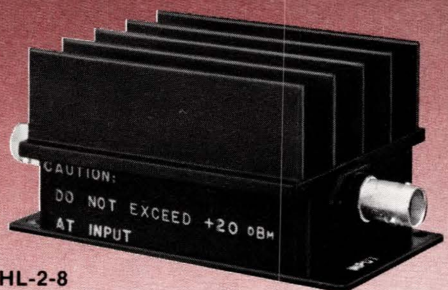

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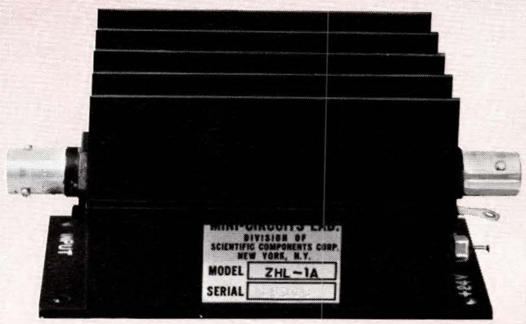
So from the table below, select the ZHL model for your particular application now ... we'll ship within one week!



ZHL-1A

MODEL NO.	FREQ. MHz	GAIN dB	GAIN FLATNESS dB	MAX. POWER OUTPUT dBm 1-dB COMPRESSION	NOISE FIGURE dB	INTERCEPT POINT 3rd ORDER dBm	DC POWER VOLTAGE	DC POWER CURRENT	PRICE $ EA.	PRICE QTY.
ZHL-32A	0.05-130	25 Min.	±1.0 Max.	+29 Min.	10 Typ.	+38 Typ.	+24V	0.6A	**199.00**	**(1-9)**
ZHL-3A	0.4-150	24 Min.	±1.0 Max.	+29.5 Min.	11 Typ.	+38 Typ.	+24V	0.6A	**199.00**	**(1-9)**
ZHL-1A	2-500	16 Min.	±1.0 Max.	+28 Min.	11 Typ.	+38 Typ.	+24V	0.6A	**199.00**	**(1-9)**
ZHL-2	10-1000	15 Min.	± 1.0Max.	+29 Min.	18 Typ.	+38 Typ.	+24V	0.6A	**349.00**	**(1-9)**
ZHL-2-8	10-1000	27 Min.	±1.0 Max.	+29 Min.	10 Typ.	+38 Typ.	+24V	0.65A	**449.00**	**(1-9)**
ZHL-2-12	10-1200	24 Min.	±1.0 Max.	+29 Min.*	10 Typ.	+38 Typ.	+24V	0.75A	**524.00**	**(1-9)**

Total safe input power +20 dBm, operating temperature 0° C to +60° C, storage temperature −55° C to +100° C, 50 ohm impedance, input and output VSWR 2.1 max.
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