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Troubleshooting
analog circuits—Part 4

Make C programs
more portable

PLCC-to-PGA adapters

Crosspoint switch ICs

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Onboard intelligence brightens
outlook for dot-matrix
display modules



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CIRCLE NO 34

You need a partner



**When it comes
to ASICs,
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than technology
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More than a workstation, Ziatech's new ZT 1000 provides an innovative solution for many levels of factory automation.



Multi-Talented

The ZT 1000 can operate as a cell controller, a low cost PLC, and as a stand-alone controller. It can perform these tasks simultaneously with add-in intelligent control processor cards.

Trustworthy

The ZT 1000 is based on the STD Bus, designed for reliability under harsh industrial conditions.

Compatible

The ZT 1000 runs IBM PC software on Ziatech's PC-compatible single board computers, which feature IBM PC DOS and Ziatech's industrial BIOS in EPROM.

Well-Connected

The ZT 1000 comes with industrial networking options fully supported by Ziatech.

Ruggedly Handsome

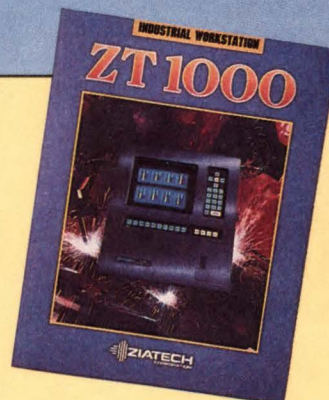
The ZT 1000 is tough enough for the factory floor. Its ½" anodized front panel meets NEMA 4/12 standards for protection from water, dirt, dust and non-corrosive liquids.

Friendly

The ZT 1000 is designed for easy operation by non-technical personnel.

In Good Company

Ziatech also offers integrated systems for rack-mounting as well as a wide selection of STD and GPIB board-level products.



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*For a free ZT 1000 brochure, including specifications, configuration guide and price list, call Ziatech today.
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VF Technology... The Bright Decision

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

GRAPHIC DISPLAY

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

DOT MATRIX MODULES

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

GRAPHIC DISPLAYS/MODULES

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

*Different Versions Available

DOT MATRIX/CHARACTER DISPLAY MODULES

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

MANY OTHER
DISPLAYS

NEW MODULES
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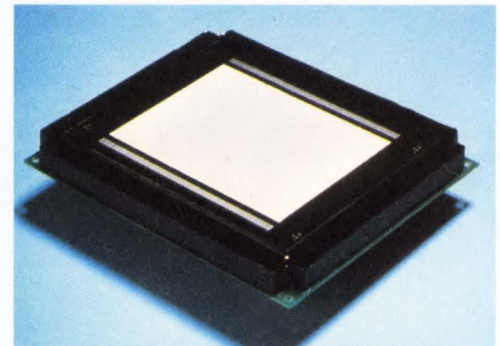
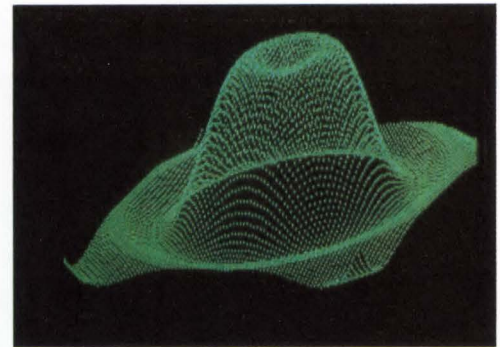


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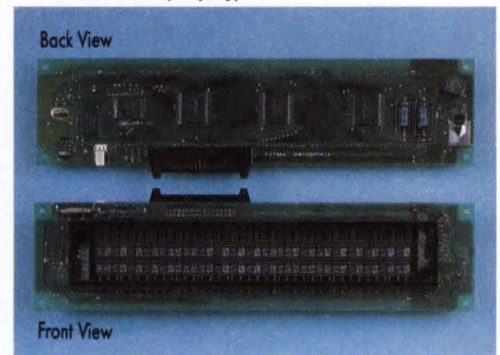
CIRCLE NO. 117



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



2 x 40 character (display)



2 x 40 character (module)

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



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

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



If you were stranded on a desert island, this is the function generator you'd want.

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Obviously, you'd need the most versatile, rugged and easiest to use function generator available.

The Model 288 programmable function generator.

It has a 2 mHz to 20 MHz output, up to 30 Vpp, that can be

balanced or unbalanced with selectable impedances from 50 to 600 ohms.

No matter what kind of equipment washed ashore, you'd be set to test it. With variable symmetry, synthesized frequency accuracy, and AM, FM, Sweep and Phase Lock modes.

You say the manual was lost in the storm? No problem. Model 288 has dedicated buttons for each mode, making it very easy to use.

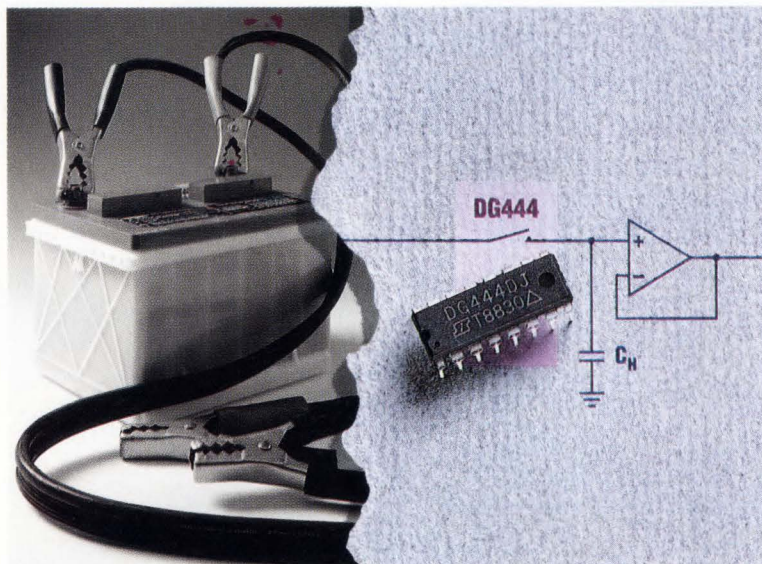
No need for a calibration lab, either. Two built-in AutoCal modes are standard.

So whether you're stuck on a desert island, or buried alive in test projects, you need the Model 288 by your side.

For more information call (619) 279-2200 today.

Circle 79 for Literature
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PERFORMANCE SPECIFICATION	METAL-GATE CMOS (DG211)	SILICON-GATE CMOS (DG444)
ON-Resistance	175 Ω	85 Ω
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Turn-ON Time	1000 ns	250 ns
Power Dissipation	20.4 mW	0.035 mW

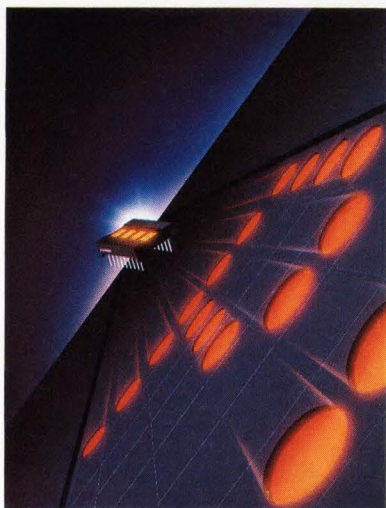
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On the cover: Dot-matrix display modules continue to be popular for a wide variety of applications. And with manufacturers incorporating different technologies and more and more onboard intelligence, the devices' future remains promising. See pg 108. (Photo courtesy Siemens)

SPECIAL REPORT

Dot-matrix display modules

108

Although most of the trade-press coverage of digital displays has concentrated on design activity involving high-resolution flat-panel devices, many applications don't need 25-line \times 80-character capability. For these applications, dot-matrix display modules suffice.—*Tom Ormond, Senior Editor*

DESIGN FEATURES

Troubleshooting analog circuits—Part 4

127

Earlier installments of this series have described a good analog troubleshooter's mindset, armamentarium of test equipment, and requisite knowledge of resistors, inductors, and transformers. Now, ace troubleshooter Pease reveals some of the secrets of an often-underestimated class of components—capacitors. And much of what you need to know to troubleshoot capacitor-related problems is not in any book—it's not even in data sheets.

—*Robert A Pease, National Semiconductor Corp*

A simple analysis helps to clarify a DSO's performance specs

147

The relationship between a digitizing oscilloscope's sample rate and the analog bandwidth of the waveforms it displays is not always obvious. In today's world, you need to understand these concepts.—*Robert A White, Hewlett-Packard*

Continued on page 7

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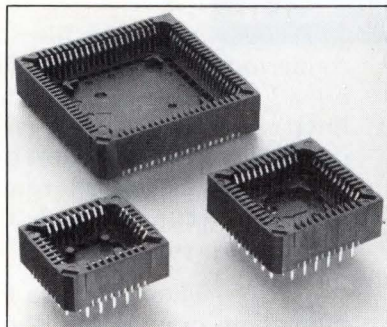
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PLCC-to-PGA adapters can provide the answer to your specific design needs (pg 63).

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Express Request 

TECHNOLOGY UPDATE

Make C programs more portable 55

It's now much easier to make your C programs widely portable to different microprocessors and computers. You can choose from a number of new compiler families that employ techniques for enhancing program portability, but you must still program with care.—Chris Terry, Associate Editor

PLCCs adapt to through-hole use 63

You no longer need to jury-rig plastic leaded chip carriers (PLCCs) to pc boards for testing or manufacturing purposes. A number of off-the-shelf alternatives promise to solve PLCC-mounting problems faster and without causing you aggravation.—Michael C Markowitz, Associate Editor

Crosspoint-switch ICs enter digital domain 75

When you hear someone refer to a crosspoint-switch IC these days, don't assume that they are speaking about an analog IC.—Anne Watson Swager, Associate Editor

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EDITORIAL

51

Many companies should be planning new products and attacking new markets. Instead, they're trying to maximize quarterly profits.

NEW PRODUCTS

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LOOKING AHEAD

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Thermal printing technique improves resolution.

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	AD840	AD841	AD842	AD843	AD844
Gain Bandwidth Min Stable Gain	400MHz 10	40MHz Unity	80MHz 2	35MHz Unity	60 to 430MHz Unity
Settling Time (10V Step)	100ns to 0.01%	110ns to 0.01%	100ns to 0.01%	110ns to 0.01%	100ns to 0.05%
Slew Rate	400V/ μ s	300V/ μ s	375V/ μ s	300V/ μ s	to 2,000V/ μ s
Quiescent Current (max)	12mA	12mA	14mA	12mA	6.5mA
Comments	HA2540 Improved Replacement	50mA min Output Current	100mA min Output Current	FET-Input, Replaces FET- Input Hybrids	Current Feedback, 2nV/ $\sqrt{\text{Hz}}$ Noise at 1kHz

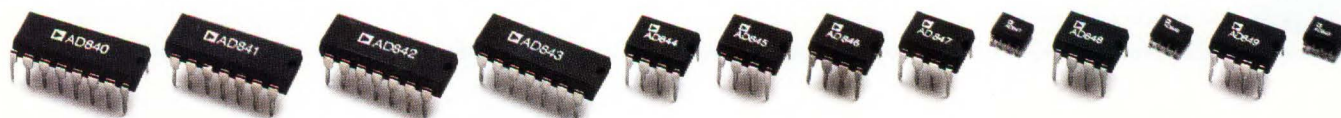
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350ns to 0.01%	100ns to 0.01%	120ns to 0.1%	100ns to 0.1%	80ns to 0.1%	Settling Time (10V Step)
100V/ μ s	450V/ μ s	300V/ μ s	300V/ μ s	300V/ μ s	Slew Rate
12mA	6mA	5.7mA	5.7mA	5.7mA	Quiescent Current (max)
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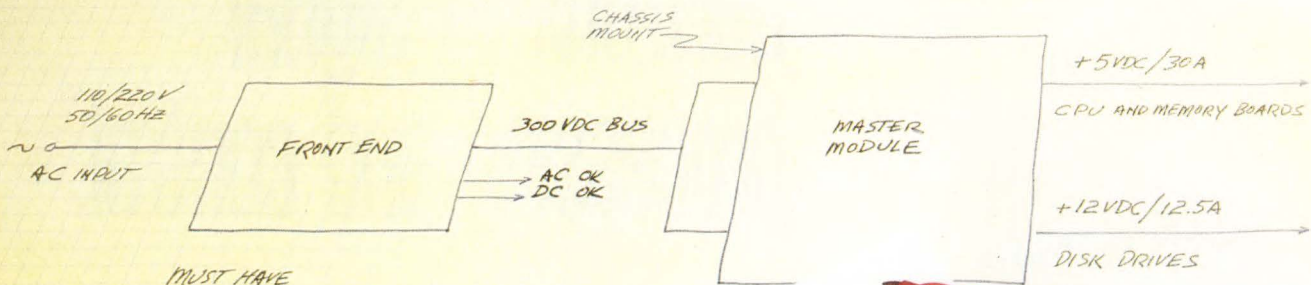
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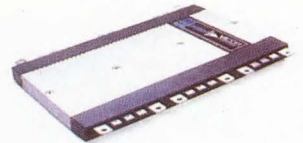
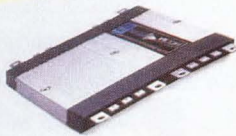
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- SEQUENCING
- 50 MHS HOLD-UP
- FCC CLASS-B
- PROGRAMMABLE OUTPUTS

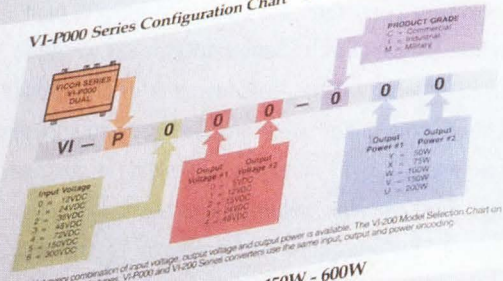
*VIC
ALSO NEED -5.2 VOLTS
AT 30 AMPS FOR THE
ECL.
CONVERTERS TO BE
CHASSIS MOUNT.
SEE ME ASAP*



Example

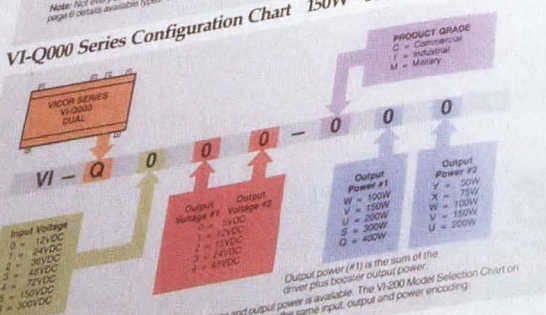
**Module Series
DC-DC Converters
Triple Output**

VI-P000 Series Configuration Chart 100W - 400W



Note: Not every combination of input voltage, output voltage and output power is available. The VI-200 Model Selection Chart on page 6 details available types. VI-P000 and VI-200 Series converters use the same input, output and power encoding.

VI-Q000 Series Configuration Chart 150W - 600W



Note: Not every combination of input voltage, output voltage and output power is available. The VI-200 Model Selection Chart on page 6 details available types. VI-Q000 and VI-200 Series converters use the same input, output and power encoding.

Configuration Steps

- 1 Select Input Voltage
- 2 Select Output Voltage 1
- 3 Select Output Voltage 2
- 4 Select Product Grade
- 5 Select Output Power 1
(Cannot exceed single module ratings for VI-200 Series drivers.)
- 6 Select Output Power 2
(Cannot exceed single module ratings for VI-200 Series drivers.)

48V: VI - P 3
+5V: VI - P 3 0 -
-12V: VI - P 3 0 1 -
Commercial: VI - P 3 0 1 - C V
150W: VI - P 3 0 1 - C V X
75W: VI - P 3 0 1 - C V X

- 1 Select Input Voltage
- 2 Select Output Voltage 1
- 3 Select Output Voltage 2
- 4 Select Product Grade
- 5 Select Output Power 1
(Cannot exceed twice module ratings for VI-200 Series drivers.)
- 6 Select Output Power 2
(Cannot exceed single module ratings for VI-200 Series drivers.)

300V: VI - Q 6
+5V: VI - Q 6 0 -
+24V: VI - Q 6 0 3 -
Industrial: VI - Q 6 0 3 - I S
300W: VI - Q 6 0 3 - I S V
150W: VI - Q 6 0 3 - I S V

- 1 Select Input Voltage
- 2 Select Output Voltage 1

24V: VI - R 1
+5V: VI - R 1 0 -
+12V: VI - R 1 0 1 -
VI - R 1 0 1 1 -

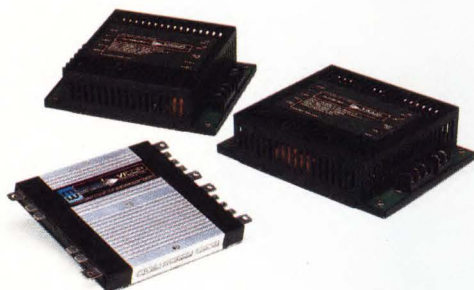
Chassis-Mount Modular Power From 50 to 600 Watts!

In single or multiple output applications, Vicor's family of chassis-mount, power building blocks provide flexible and predictable solutions to virtually any power system requirement.

Vicor's family of chassis-mount, off-line front ends, combined with the Mega and Master Module families of chassis-mount DC-DC converters, allow the power system architect to quickly and predictably customize expandable single or multiple output power systems with output power from watts to kilowatts. Modular power building blocks get you up and running in less time, at less cost, while Vicor's unprecedented levels of power density and efficiency result in less wasted space and heat.

Off-Line Front Ends

Chassis-mount front ends are available in output power ratings of 250, 500, and 750 watts and are designed for direct connection with Vicor's Mega Module and Master Module Series of DC/DC converter modules.



FRONT END SELECTION CHART

MODEL	OUTPUT POWER		
	250W	500W	750W
VI-FKE6-CUX	✓		
VI-FKE6-COX		✓	
VI-FKE6-CMX			✓

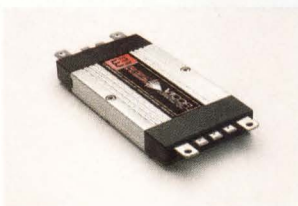
OPERATING PARAMETERS (ALL MODELS)			
NOM	INPUT VOLTAGE (VAC)		
	LOW	HIGH	TRANSIENT (1 SEC)
110	90	135	150
220	180	270	300

Strappable to provide operation from 90 VAC to 270 VAC lines, the front ends feature conducted EMI/RFI filtering to VDE/FCC A & B, 50 msec holdup, active in-rush limiting and a BUS-OK status output. An opto-isolated AC-OK output is provided for advance warning of DC BUS dropout due to AC line failure.

DC/DC Converter Modules

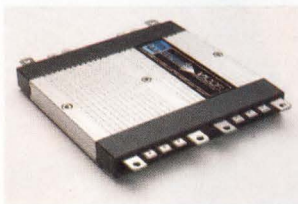
Vicor's Mega Module and Master Module Series of single and multiple output DC-DC converters provide the power system designer with a cost effective, high performance, off-the-shelf solution for applications that might otherwise require a custom supply. These modules incorporate standard VI-200 Series converters in a rugged, chassis-mount package.

Single Output



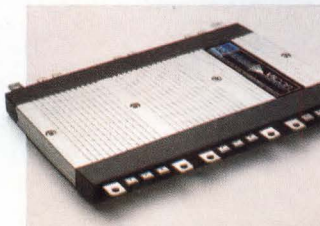
- Single output available from 50 to 200 watts.
- 2.5" x 4.9" x 0.62".

Single and Dual Outputs



- Single output available from 100 to 400 watts
- Dual outputs from 50 to 200 watts each
- 4.9" x 4.9" x 0.62".

Single, Dual and Triple Outputs



- Single output available from 150 to 600 watts.
- Dual outputs with the first output from 100 to 400 watts, and the second output from 50 to 200 watts.
- Triple outputs from 50 to 200 watts each.
- 7.3" x 4.9" x 0.62".

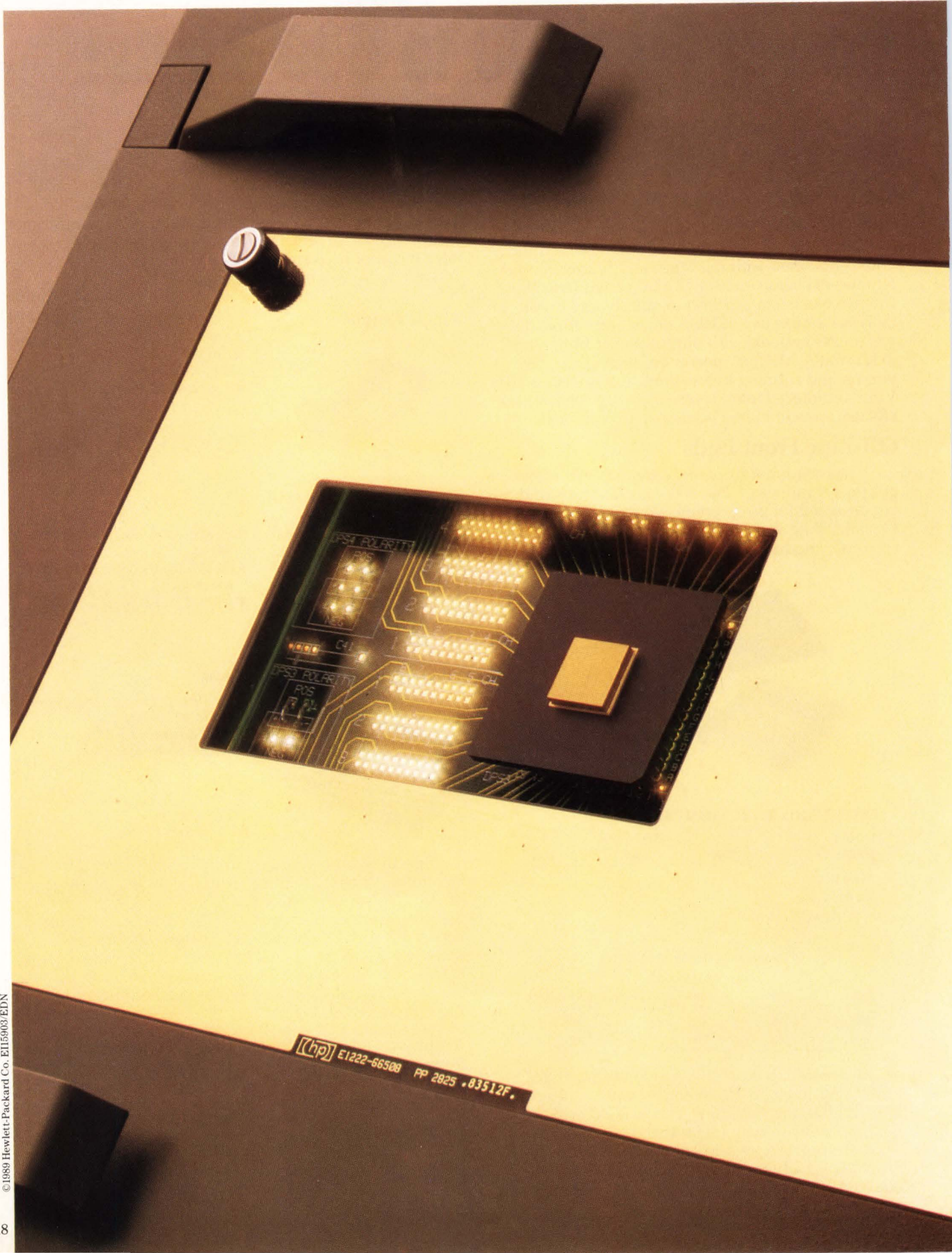
Specify your configuration by picking any combination of Vicor's standard output voltages (5, 12, 15, 24, 48 VDC) at the power levels you need. Vicor does the rest. If standard output voltages don't meet your needs, Vicor can provide semi-custom outputs anywhere in the range of 2 to 100 VDC! For complete details and applications information, please refer to the Mega Module and Master Module sections of the Vicor Product Catalog.

To Receive A Complete Catalog, Including Information On Vicor Products, Applications And Accessories, Call Vicor Today At (508) 470-2900, or write to 23 Frontage Road, Andover, MA 01810.



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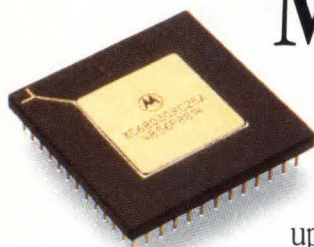


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408-253-5933

NEWS BREAKS

EDITED BY JOAN MORROW

CURRENT-LOOP RECEIVER HAS $\pm 40V$ COMMON-MODE INPUT RANGE

Using the monolithic RCV420 current-loop receiver IC, you can convert a floating, 4- to 20-mA analog signal to a ground-referenced 0 to 5V analog signal with an accuracy of better than 0.1% of full scale. The device, from Burr-Brown (Tucson, AZ, (602) 746-1111), accepts signals within a common-mode signal range of $\pm 40V$ while introducing no more than 1.5V of drop in the signal loop. It also features an 86-dB common-mode rejection rating. Plastic- and ceramic-packaged versions of the receiver cost \$4.50 and \$7 (100), respectively.—Steven H Leibson

ENHANCED DRAM-CONTROLLER FAMILY MATES WITH 25-MHz μ Ps

National Semiconductor Corp (Santa Clara, CA, (408) 721-5943) has boosted the speed of its DP8420 family of dynamic-RAM controllers and has added features to the devices. The new devices, designated by an "A" suffix, will operate with μ Ps running at clock rates as high as 25 MHz, which represents a 25% increase in speed in comparison with the company's earlier parts. The dual-ported DP8422A handles dynamic RAMs as large as 4M bits, and the single-ported DP8421A and DP8420A accommodate 1M- and 256k-bit devices, respectively. All three dynamic-RAM controllers incorporate address latches, bank-select logic, a programmable wait-state generator, and a refresh counter.

In addition, the chips support memory interleaving, burst- or nibble-mode dynamic-RAM access, and page-or static-column-mode access. The company sells the DP8422A, DP8421A, and DP8420A for \$23.50, \$17.97, and \$12.50, respectively.—Steven H Leibson

6M-WHETSTONES COPROCESSOR ANNOUNCED FOR 68020/68030

The Abacus-3168 numeric coprocessor from Weitek Corp (Sunnyvale, CA, (408) 738-8400), when teamed with a Motorola (Phoenix, AZ) 25-MHz 68030, is expected to deliver 6M Whetstones (double-precision) and 1.5M-flops Linpack (double-precision) performance. The coprocessor consists of a full floating-point multiplier, an ALU, and a divide/square-root unit. Green Hills Software Inc (Glendale, CA) provides compiler support for the C, Fortran, and Pascal languages.

Although Weitek won't be offering samples of the IC until July, samples of daughter boards that are hardware and software compatible with the IC will be available for shipment in April. The 25-MHz Abacus-3168 daughter boards cost \$995 (100). The vendor expects to price the 25-MHz, 121-pin IC at \$499 (2500).—Doug Conner

VHDL TOOLS TO BE INTEGRATED WITHIN A POPULAR EDA SYSTEM

Mentor Graphics (Beaverton, OR, (503) 626-7000) has announced an implementation of IEEE-STD 1076, or the VHSIC hardware description language (VHDL), that integrates a VHDL analyzer and interactive source-code debugger with the graphical interface and database of the company's existing design tools. The product, System 1076, will also feature a graphical editor for architectural design. This complete design system will permit you to mix VHDL models with other modeling methodologies in your designs and let you execute VHDL models directly in Mentor's QuickSim logic simulator.

NEWS BREAKS

The architectural graphical editor, due in the second release of the software, will automatically generate code that describes VHDL connectivity when blocks are selected for inclusion in a design. A templating editor will speed the entry and editing of text. Prices for the System 1076 will start at \$24,900, though the ability to run a compiled VHDL model will be a free enhancement for any of the vendor's Idea workstations. The first release of System 1076 is scheduled for the third quarter of 1989; the second release is scheduled for early 1990.—Michael C Markowitz

1M- AND 2M-BIT HYBRID SRAMs AND EEPROMs FIT IN 32-PIN DIPs

Hermetically sealed, 32-pin DIPs house White Technology Inc's (Phoenix, AZ, (602) 437-1520) family of 128k \times 8-bit and 256k \times 8-bit hybrid static RAMs and EEPROMs. The ceramic DIPs are 0.6 in. wide. The static RAMs feature 120-nsec access times; the EEPROMs feature 150-nsec access times. Deliveries of all devices will start in April. The 128k \times 8-bit (WS-128K8-120CM) and the 256k \times 8-bit (WS-256K8-120CM) static RAMs cost \$275 and \$506 (100), respectively. The 128k \times 8-bit (WE-128K8-150CM) and 256k \times 8-bit (WE-256K8-150CM) EEPROMs cost \$1200 and \$2280 (100), respectively. The "M" suffix on these part numbers denotes military versions of these devices and a -55 to +125°C operating-temperature range. The company also offers commercial-temperature (-40 to +85°C) versions of the four devices.

—Steven H Leibson

8-BIT, 9-TAP FIR FILTER ACHIEVES 40-MHz DATA RATE

The L64243 digital FIR filter from LSI Logic Corp (Milpitas, CA, (408) 433-8000) operates at 40-MHz data-throughput rates and integrates nine taps, each consisting of a multiplier and an accumulator. Therefore, it has an aggregate speed of 360 million operations/sec (each operation takes the form "a=a*b+c"). Two on-chip multiplexers allow you to configure the device as a 1-dimensional, 9-tap filter for signal-processing applications or as a 2-dimensional, 3 \times 3 filter for image-processing applications. The device accepts 8-bit data and coefficients in either unsigned or two's complement formats, and it has a 20-bit output to prevent loss of precision. Coefficients enter the device through one 8-bit port, but the tap coefficient registers are double-buffered, so you can load new coefficients at a leisurely rate and then activate all of them simultaneously. The 20-, 30-, and 40-MHz versions of the FIR filter cost \$117.80, \$247.50, and \$272.50 (100), respectively.—Steven H Leibson

Stay Generations Ahead in Video/RF 12-Bit ADCs

When it comes to the industry's highest performance 12-bit, 10 MSPS converters, TRW LSI can keep you out front. Whatever your data acquisition problem, TRW LSI's THC1200 Series provides the solution.

Take the THC1201: It's completely self-contained, including track/hold and all timing circuitry. Signal in, data out, all in a 46-pin hermetic DIP. Standard $\pm 1.0\text{V}$ input range, $\pm 15\text{V}$ and $\pm 5\text{V}$ supplies, TTL interface and synchronous data output make this the easiest part of your system design.

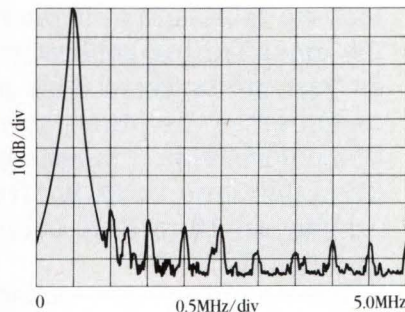
Really cramped for space? Try the THC1202. You get the same leading-edge performance as the THC1201, but in a 40-pin package that's 40% smaller. And, as an extra bonus, you can dump that -15V power supply. And accommodate bipolar or unipolar input signals. That's not all...

If you have signals down in the mud, our THC1200 is the solution. It offers a full scale input range of ± 167 millivolts. That means you won't need that extra low-

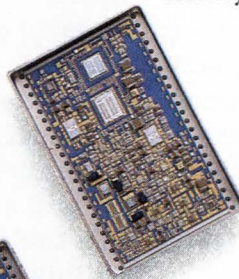
noise gain stage. But, the whole world doesn't speak softly, so the THC1200 has a gain switch that gives you a $\pm 2.5\text{V}$ input range. That's a gain shift of 15X, extending the dynamic range by over 23dB.

Need more? Give us a call. We have many other leading-edge conversion products on the drawing board. Or we'll do one just for you.

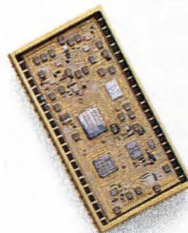
Even if you have already solved your 12-bit acquisition problem, talk to us. Remember, we guarantee full-spec performance. Plus, we can show you how to save time, space, power and money — and obtain multiple-source security without a redesign.



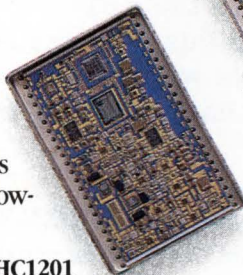
Part Number	Analog Input Range (V)	Package Style	Area (Sq. In.)	Power (W)
THC1202	± 1.0	40-Pin DIP	2.3	5
THC1201	± 1.0	46-Pin DIP	3.8	5
THC1200	± 2.5 and ± 0.167	46-Pin DIP	3.8	9



THC1200



THC1202



THC1201

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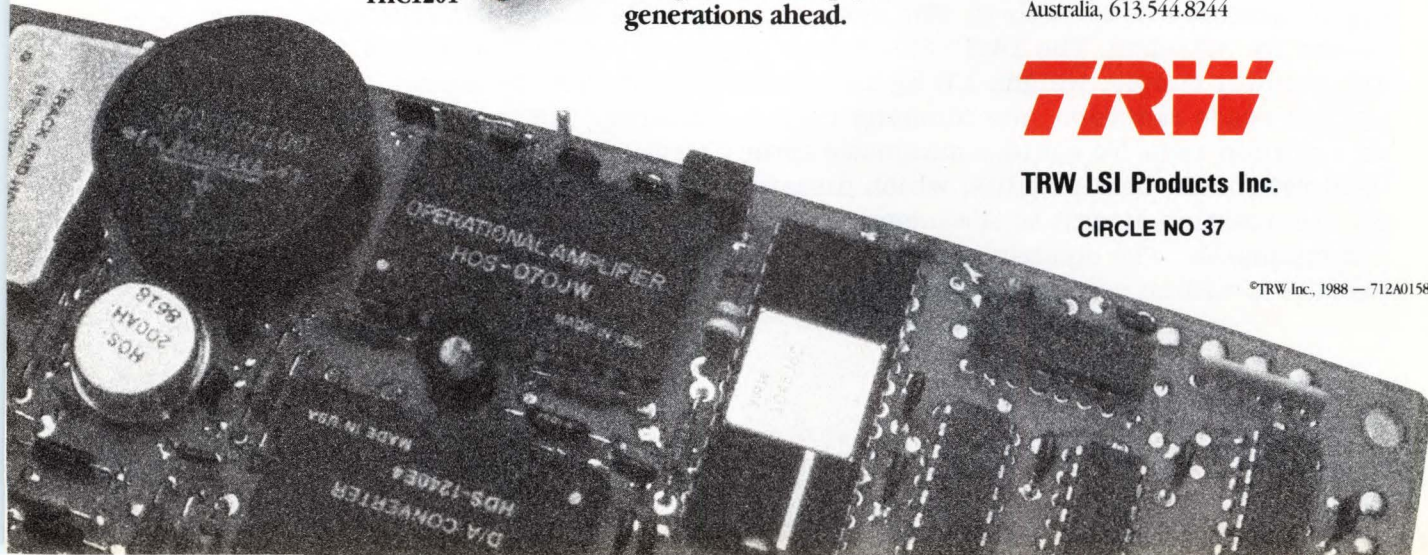
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Tokyo, 3.487.0386; 3.461.5121;
Taipei, 2.751.6856;
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CIRCLE NO 37

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NEWS BREAKS: INTERNATIONAL

COLOR-VIDEO CONTROLLER INTERFACES TO TV SETS OR MONITORS

The IMS-G300 color video controller from Inmos Ltd (Bristol, UK, TLX 444723; in the US, Colorado Springs, CO, (719) 630-4000) can drive a variety of video displays ranging from TV sets to high-resolution color monitors. The device, which is packaged in an 84-pin pin-grid array or quad flatpack, incorporates a 256×24 -bit color look-up table, a 32-bit pixel data port, three 8-bit video D/A converters, a programmable video timing generator, and a phase-locked loop. The 32-bit pixel port can operate as four multiplexed 8-bit ports, which allow the device to access video RAM at one-quarter the pixel rate. In this mode, the color look-up table allows you to display 256 colors from a palette of 16 million colors. Alternatively, you can enter 24-bit pixel data and route it directly to the D/A converters; this scheme enables you to display all 16 million colors simultaneously.

The on-chip phase-locked loop generates appropriate video clocks from a 6- to 9-MHz external clock source. The timing generator can free-run or synchronize to an external synchronization signal. It can also produce separated or composite synch outputs and an interlaced or noninterlaced video output. You can program the IMS-G300 with any suitable μ P. Engineering samples of the device are available for \$175. Production parts cost \$101.14 (1000).—Peter Harold

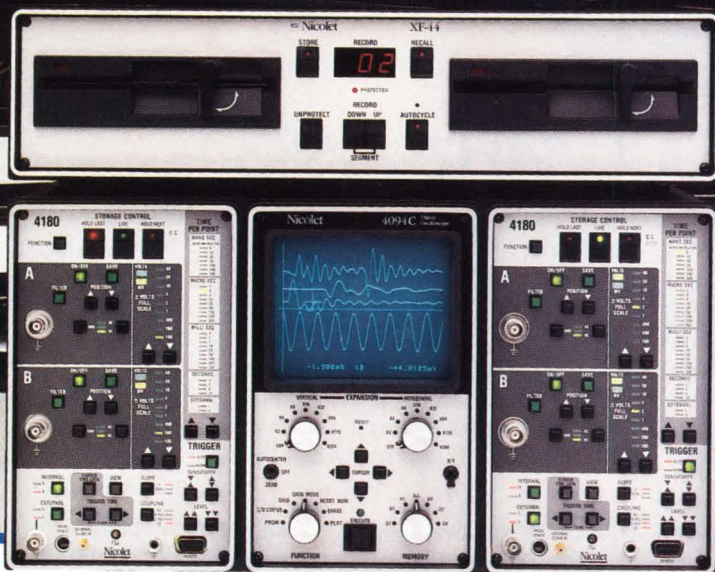
COMMAND LANGUAGE CONTROLS INTELLIGENT PERIPHERALS

Targeted for use in backplane bus systems, the Clip control language allows you to control intelligent peripheral boards by using high-level commands. The language, which was developed jointly by Arcom Control Systems Ltd (Cambridge, UK, FAX 0223-410457) and British Telecom's Microprocessor Systems Div (Ipswich, UK, FAX 0473-642824), uses English-language-type commands, which are processed by a resident interpreter on each peripheral board. The language includes commands that allow you to interrogate and pass data between a CPU and an intelligent peripheral. Both companies will provide suitable interpreters with their STE Bus boards. Although the language is currently implemented in STE Bus products, it is suitable for use in other computer systems. The two companies will retain the copyright, but the specification will be supplied for a nominal charge (£15) to anyone interested in using it.—Peter Harold

SPACEWORTHY COMPUTER HAS AUTOMATIC ERROR CORRECTION

Mitsubishi has developed a high-reliability computer for use in outer space, according to Japanese news reports. The system can quickly detect and eliminate errors caused by radiation. The $14.5 \times 20 \times 7.8$ -cm computer, which consists of three boards and a power supply, weighs 1.6 kg and consumes only 7W. To harden the computer against space radiation, the company used a gate array that can withstand as much as 1 million rads. To achieve automatic error detection and correction, the company used redundant data circuits, which discard bad data, and connected an additional error-correction circuit to the memory. The computer can execute 200,000 to 300,000 commands/sec. The company is currently developing a version that will be able to execute 1 million commands/sec.—Joanne De Oliveira

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Nicolet also has four software packages available which allow you to transfer, display and manipulate 4094 data on your PC. There are also over 100 disk-downloadable programs available for the 4094.

■ External Control

With programs like Waveform BASIC, you can even create your own custom programs for data manipulation and external control of the 4094C. IEEE (GPIB) and RS232 interfaces are included for easy communications with a PC.

■ Programming Support

Nicolet's application support can make all the difference. Our application engineers are a phone call away and are always ready to help you.

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Tough enough to meet full MIL-specs, capable of operating over a wide -55° to $+100^{\circ}\text{C}$ temperature range, in a rugged package... that's Mini-Circuits' new MAN-amplifier series.

The MAN-amplifier's tiny package (only 0.4 by 0.8 by 0.25 in.) requires about the same pc board area as a TO-8 and can take tougher punishment with leads that won't break off. Models are unconditionally stable and available covering frequency ranges 0.5 to 1000 MHz, NF as low as 2.8 dB, and power output as high as +15 dBm.

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

Internally the MAN amplifiers consist of two stages, including coupling capacitors.

A designer's delight, with all components self-contained. Just connect to a dc supply voltage and you are ready to go.

The new MAN-amplifiers series...
another Mini-Circuits' price/performance breakthrough.

MODEL	FREQ. RANGE (MHz)	GAIN dB		MAX. OUT/PWR†	NF	DC PWR	PRICE
	f_L to f_U	min	flatness††	dBm	dB (typ)	12V, mA	\$ ea. (10-24)
MAN-1	0.5-500	28	1.0	8	4.5	60	13.95
MAN-2	0.5-1000	19	1.5	7	6.0	85	15.95
MAN-1LN	0.5-500	28	1.0	8	2.8	60	15.95
◇MAN-1HLN	10-500	10	0.8	15	3.7	70	15.95
*MAN-1AD	5-500	16	0.5	6	7.2	85	24.95

††Midband $10f_L$ to $f_{U/2}$, ± 0.5 dB †dB Gain Compression ◇Case Height 0.3 in.

Max input power (no damage) +15 dBm; VSWR in/out 1.8:1 max.

*Active Directivity (difference between reverse and forward gain) 30 dB typ.

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setting higher standards

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CIRCLE NO 44

C118 REV. E

SURFACE MOUNT MIXERS



\$3.30
(1,000 qty)

The opportunity for automated, low-cost assembly is a key benefit of surface-mount technology, but is often wiped out by the high price of surface-mount components. Now, Mini-Circuits offers a new series of mixers to meet the pricing demands of SMT... only \$3.30 in 1,000 quantity (\$3.95 ea. in quantity of 10)... at a cost even lower than most conventionally-packaged mixers.

The SCM-1 spans 1 to 500MHz and the SCM-2 covers 10 to 1,000MHz. Housed in a rugged, non-hermetic 0.4 by 0.8 by 0.3 in. high (maximum dimensions) plastic/ceramic package. Spacing between connections is 0.2 in. The mixer is offered with leads (SCM-L) or without leads (SCM-NL) to meet a wide range of pc board mounting configurations.

Each SCM is built to meet severe environmental stresses including mechanical shock/vibration as well as temperature shock. The operating and temperature storage range is -55°C to +100°C. Each SCM, designed and built to meet today's demanding reliability requirements, carries Mini-Circuits' exclusive 0.1% AQL guarantee of no rejects on every order shipped (up to 1,000 pieces).

When you think SMT for low-cost production, think of Mini-Circuits' low-cost SCM mixers.

SPECIFICATIONS (typical)	SCM-1L SCM-1NL	SCM-2L SCM-2NL
	(L=with leads) (NL=no leads)	(NL=no leads)
FREQ. RANGE (MHz)		
LO, RF	1-500	10-1000
IF	DC-500	5-500
CONVERSION LOSS (dB)		
Midband	6.3 dB	6.5 dB
Total Range	7.5 dB	8.0 dB
ISOLATION (dB)	(L-R)(L-I)	(L-R)(L-I)
Low-Band	60 45	45 35
Mid-Band	45 40	35 30
High-Band	40 35	25 20
PRICE	\$3.30 (1000 qty) \$4.25 (1-9)	\$4.15 (1000 qty) \$5.45 (1-9)

Units are shipped in anti-static plastic "tubes" or "sticks" for automatic insertion.

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CIRCLE NO 58

C 115 REV. B

Tandem's powerful NonStop VLX™ computer systems are packed with proprietary technology. Including bi-polar and

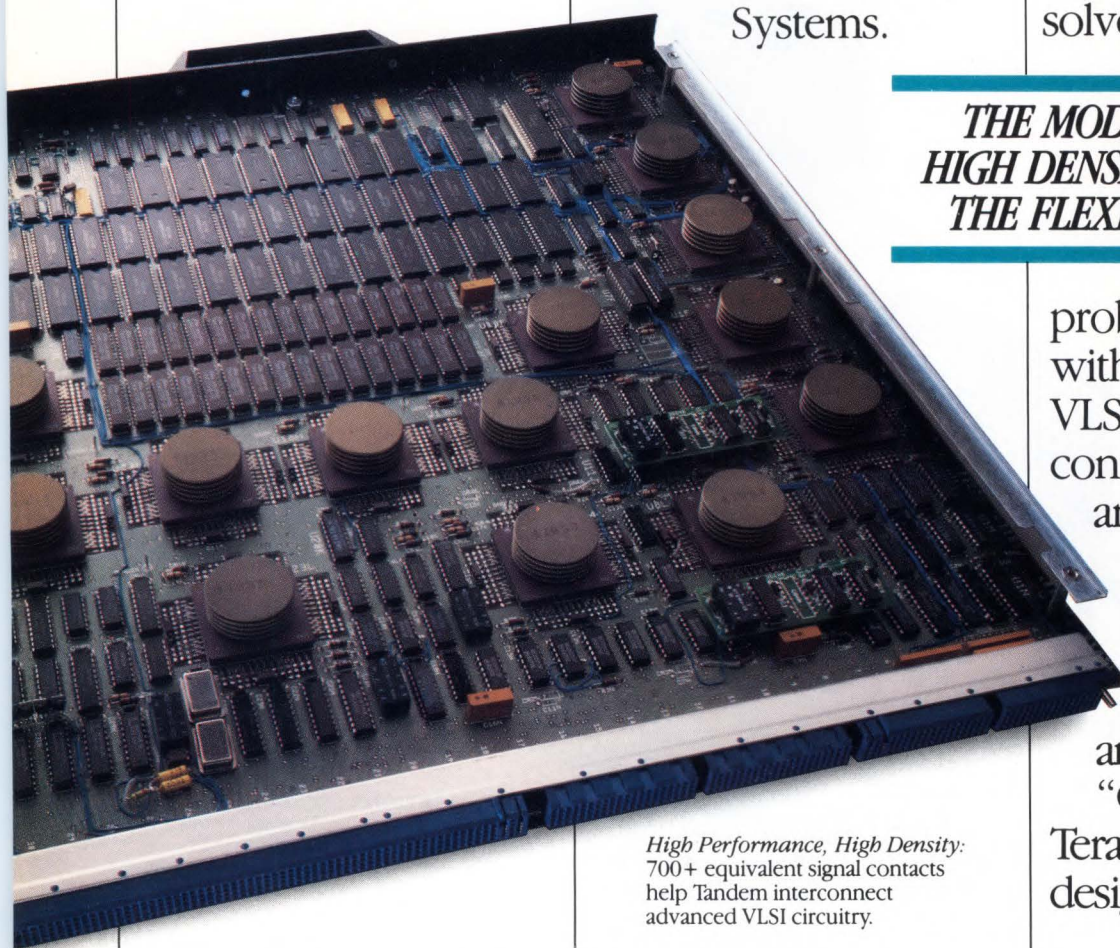
CMOS gate array logic designed with Tandem's own CAD system. When it came to connecting it all, however, Tandem chose to

rely on interconnection specialists: Teradyne Connection Systems.

"We needed connection technology every bit as sophisticated as our VLSI technology," says Larry Laurich, V.P. of the Transaction Systems Division at Tandem. "And Teradyne's High Density Plus™ backplane system solves many of the

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High Performance, High Density: 700+ equivalent signal contacts help Tandem interconnect advanced VLSI circuitry.

problems associated with interconnecting VLSI. Everything from controlled impedance and low inductance to preserve signal integrity, to high contact density and solid power and ground returns."

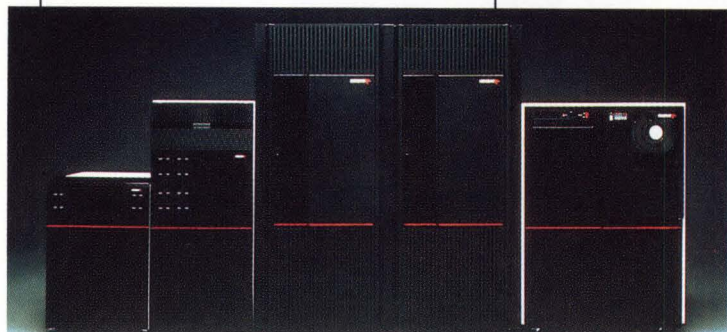
"On top of all that, Teradyne's modular design provides the

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flexibility we need to tailor our backplanes to each application."

Now, nearly 1,000 backplane systems

choice should be Teradyne, too. To find out how we



The Tandem NonStop VLX™ system.

later, is Tandem still completely sold on Teradyne's High Density Plus? "We made the right choice with Teradyne. And we look forward to working with Teradyne to meet future interconnection requirements."

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Automatic Component Rename				✓
Data Migration				✓
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Prices and features are those available at time of publication, 1/89.

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SIGNALS & NOISE

SCSI spec allows 5M-byte/sec transfer rate

Maury Wright's article on SCSI host adapters (EDN, September 1, 1988, pg 59) perpetuates a common myth when it states the maximum SCSI transfer rates. Maury quotes the SCSI specification (ANSI document X3.131-1986) as setting maximum transfer-rate limits of 1.5M bytes/sec in asynchronous mode and 4M bytes/sec in synchronous mode.

In fact, the SCSI specification never directly sets the transfer rate, but rather specifies delays such as setup, hold, and skew. The 55-nsec setup time is the only SCSI timing specification that limits asynchronous information transfer, and cumulative delays equal a minimum of 180 nsec for the synchronous mode. If theory were borne out in practice, asynchronous mode would be faster than synchronous mode!

Transfer rates in working systems are limited by a host of factors, but typically, asynchronous mode is slowed dramatically by the fourfold effect of cable propagation delay. In this mode, each byte is transferred with a 4-edge handshake and waits during the cable propagation delay each time. The oft-quoted 1.5M bytes/sec is a pessimistic estimate even for a 6m cable with today's protocol controllers.

The maximum synchronous mode rate that SCSI allows could be calculated from 1/180 nsec, resulting in about 5.56M bytes/sec, but a practical maximum is about 5M bytes/sec, allowing for guard bands on the 90-nsec assertion and negation periods specified for the request and acknowledge signals.

SCSI-2, scheduled to be forwarded for public review at the December 1988 ANS X3T9.2 SCSI Committee meeting, contains Fast SCSI, a method of doubling the synchronous-mode transfer rates. A caution, however: This mode has been tested only with the differential-transceiver option. You

shouldn't expect to obtain these rates from protocol chips containing single-ended transceivers—yet.

Jim Schuessler

*SCSI Committee member
National Semiconductor Corp
Santa Clara, CA*

Learning English doesn't deny foreign heritage

I totally agree with Jon Titus's opinion in the editorial "Let's make it English" (EDN, October 13, 1988, pg 53). My grandparents immigrated to the United States during the 1920s and did not know one word of English. They felt it was their duty to learn English and to become active members of the community. They learned English with the help of their relatives and friends, and by reading the local newspapers. They were very proud of their heritage and never felt as though they lost any part of it by learning to speak English.

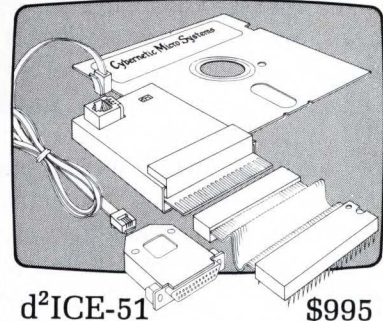
Both of my grandparents held respectable jobs. My grandfather retired from the Erie Lackawanna Railroad after 35 years of service, and my grandmother worked part-time as a custodian at Alfred University for many years. When I was growing up, my grandparents would tell me stories about their lives in Germany. My grandmother would translate old German tales into English for me, and it was an experience that I will never forget.

*Chuck Faisst
Avon, NY*

Foreign competition isn't necessarily unfair

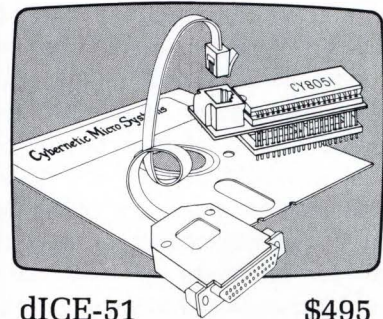
Having been raised in a laboratory where the consensus was that only HP equipment was good enough for us, I was very interested to read that HP was offering a unique scientific/engineering calculator, and I bought it soon after. Immediately,

Low Cost 8051 Tools



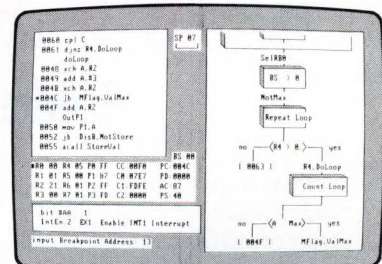
d²ICE-51 \$995

This Real-Time ICE is the lowest cost and smallest sized full speed 8051 in-circuit emulator. Full access to hardware I/O. Includes all debugging features of Sim and DICE below. Fits in shirt pocket.



DICE-51 \$495

This reduced-speed in-circuit 8051 debugger provides full access to I/O but will not run real-time. With the same user interface features as Sim8051 below, DICE-51 generates execution profiles during reduced speed execution. (CMOS and MIL also available.)



Sim8051 \$395

This software Simulator/debugger allows 'no-circuit', debugging of 8051 code on IBM-PCs. All Cybernetics 8051 debug tools offer multi-window source code displays, symbolic access to data, single key commands, breakpoints, trace, full speed and single step execution, execution profiler, and more.

Other 8051 tools include:

Cross Assembler	\$195
8751 Programmer	\$195-\$345
Debugger Demo Disk	\$ 39



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CIRCLE NO 1

SIGNALS & NOISE

I found that the 128k bytes of memory praised in the press reviews is mainly ROM, and only 2k bytes is available to the user. When you use the IFTE statement, the stack fills up so fast that after a limited number of loops, there is no memory left. I have not yet found a way to limit the number of stack levels. The handbook laconically tells you to delete programs or expressions in memory in this case, which is little comfort, particularly because no card reader is available.

In short, I am somewhat disappointed with my 28C, but I was infuriated to read in EDN's January 7, 1988, issue that HP is now offering a new version of the 28C that has 32k bytes of user memory. I must conclude that for my \$235 I have been serving as one of the "scientists and engineers that make the 28C for scientists and engineers," and I am supposed to spend another \$235 to (maybe) get what I want.

I hope you agree that this type of practice is one of the reasons that people prefer Japanese calculators: They're less expensive and more responsive to the needs of the customer. Japanese competition should not just be dismissed as unfair.

F Muller

*NATO HAWK Management Office
Rueil-Malmaison, France*

YOUR TURN

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

Address correction

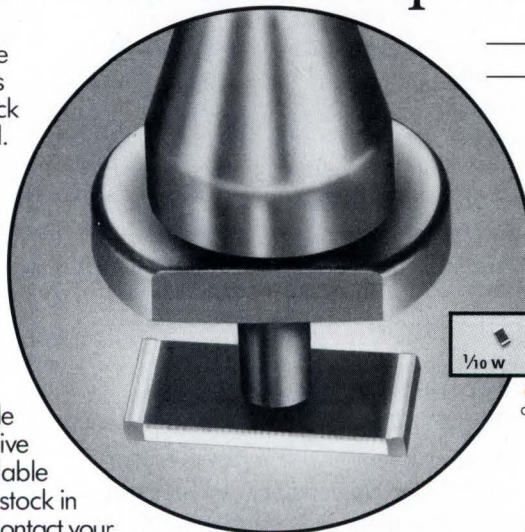
The article "PC-resident analog-I/O cards" by Bill Travis (September 15, 1988, pg 150) listed an incorrect address and phone number for the Markenrich Corp. The company's correct address and phone number are as follows:

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Commercial:	Power: 1/10, 1/8, 1/4, 1/2, 1 watt; Value: 3Ω - 22 Meg.; Tol.: ± .5%-20%; T.C.: ± 100, 200, 300 PPM/°C.

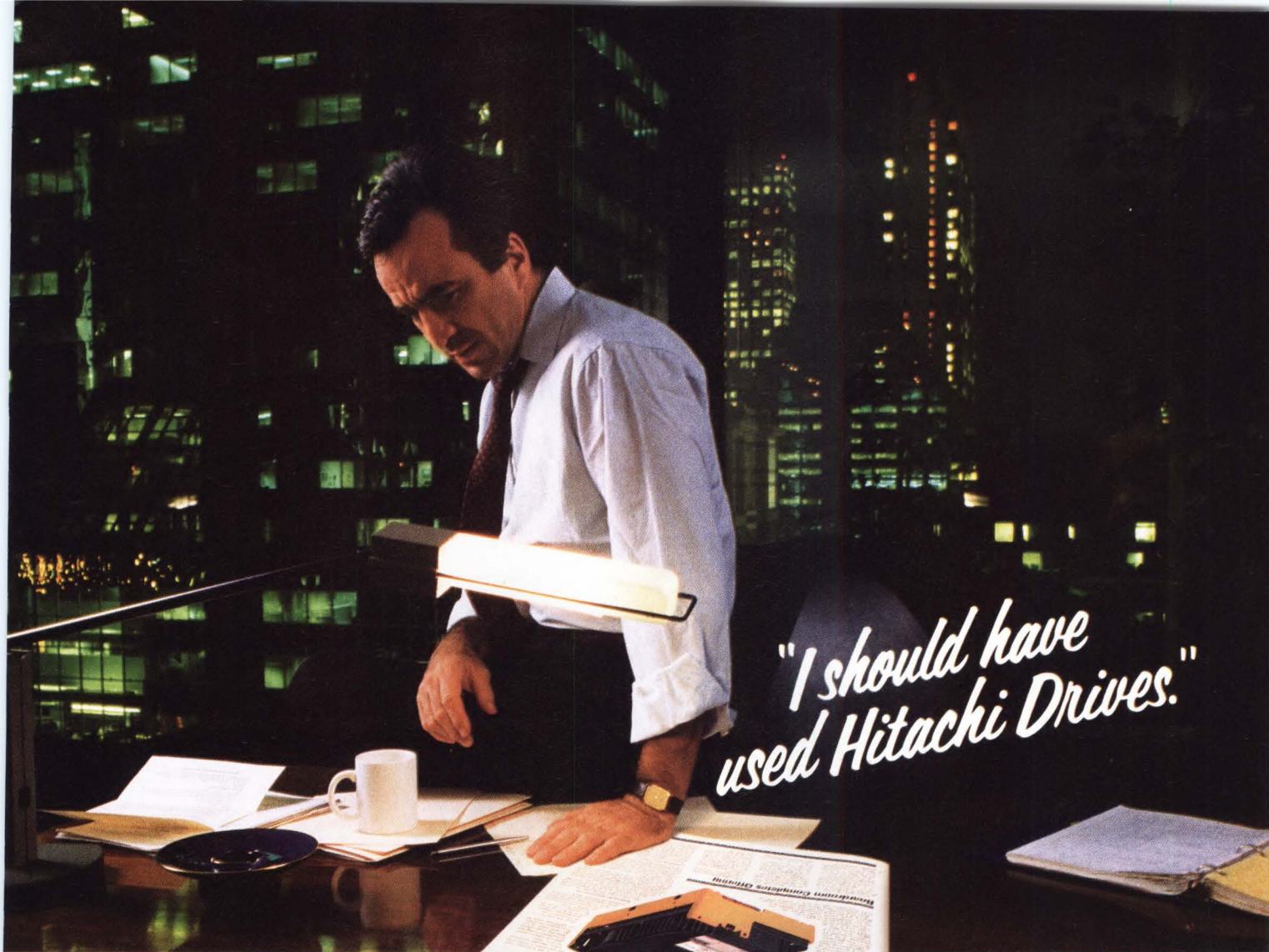


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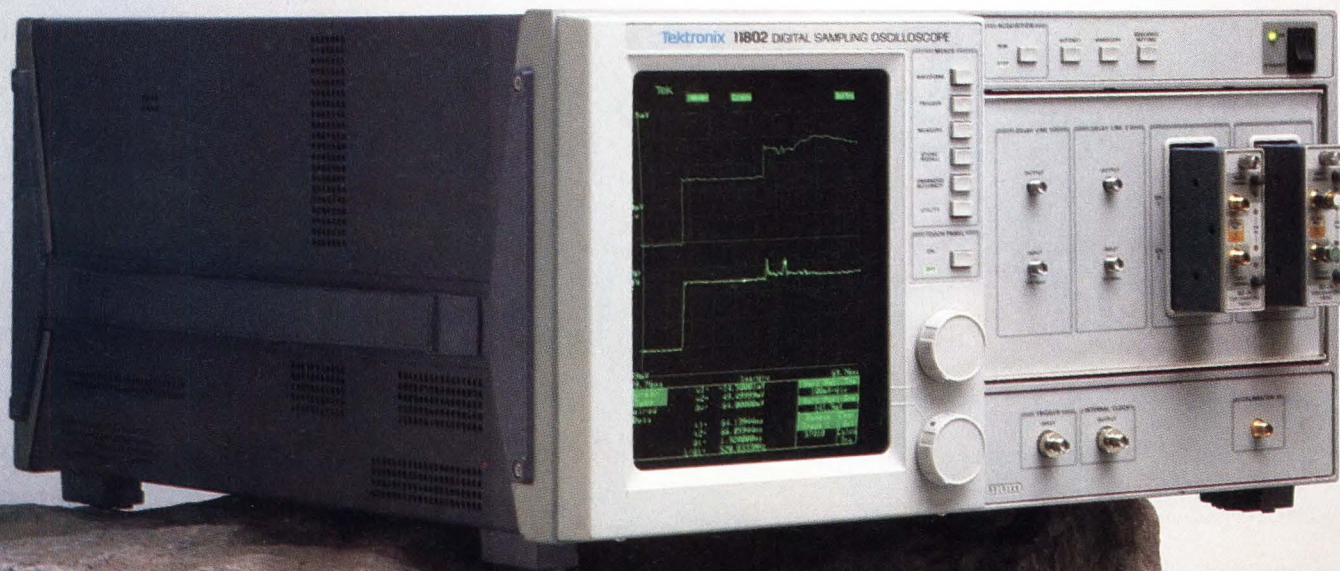
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CIRCLE NO 120

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► *Channelled array:*

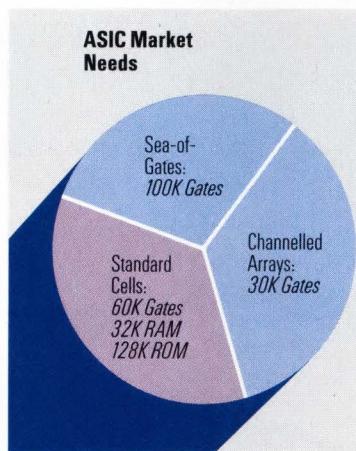
new 1.2 μ channelled arrays provide speed in the subnanosecond range together with a logic density of up to 30,000 usable gates.

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CALENDAR

Selling in Japan and the Pacific Rim: New Developments and New Strategies (seminar), Washington, DC. Electronic Industries Association, 1722 Eye St NW, Washington, DC 20006. (202) 457-4930. February 21 to 22.

The Computer-Aided Software Engineering Symposium (CASES), Dallas, TX. Elizabeth C Barnaby, Digital Consulting Inc, 6 Windsor St, Andover, MA 01810. (508) 475-6990. February 21 to 23.

Power Supply Design Seminar, Tampa, Orlando, and Fort Lauderdale, FL; Huntsville, AL. Unitrode Corp, 580 Pleasant St, Watertown, MA 02172. (617) 926-0404. February 21 to 24.

Semiconductor User and Applications Industry Conference, San Francisco, CA. Dataquest, 1290 Ridder Park Dr, San Jose, CA 95131. (800) 624-3282. February 27 to 28.

Digital Signal Processing, Single-Chip DSP Processors, Development Systems—Theory, Designs and Applications (seminar), Anaheim, CA. Dr Amnon Aliphas, DSP Associates, 18 Peregrine Rd, Newton, MA 02159. (617) 964-3817. February 27 to March 1.

Comcon Spring '89 (34th IEEE Computer Society International Conference), San Francisco, CA. Kenichi Miura, Fujitsu America, 3055 Orchard Dr, San Jose, CA 95134. (408) 432-1300. February 27 to March 3.

Commercially Available Reduced-Instruction-Set Computer Processors (seminar), Anaheim, CA. Dr Amnon Aliphas, DSP Associates, 18 Peregrine Rd, Newton, MA 02159. (617) 964-3817. March 1 to 3.

Systems Engineering for Integrated Hardware/Software Applications (short course), Los Angeles,

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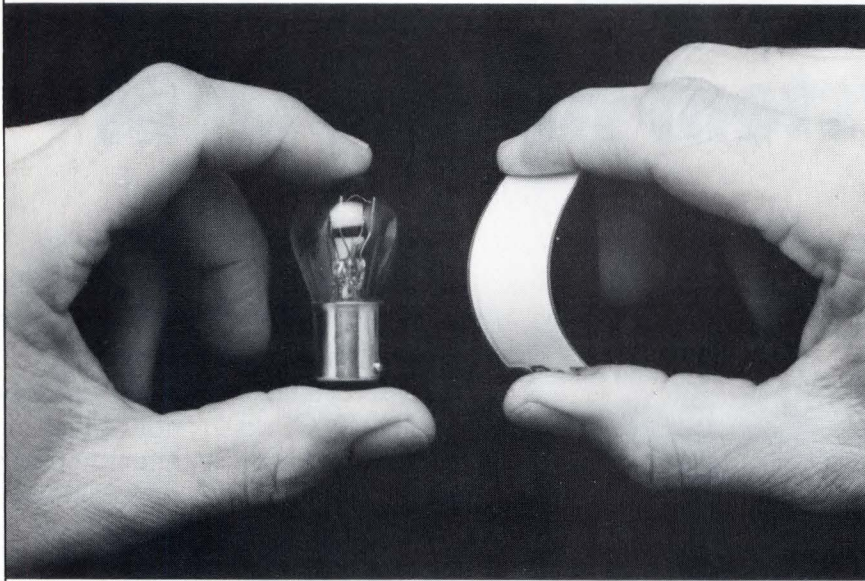
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CIRCLE NO 4

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Half of all EDN's
articles are staff-written.

EDN

CALENDAR

CA. John Valenti, Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (231) 417-8888. March 7 to 10.

The Executive Forum on Supercomputing, San Jose, CA. Pat Westly, Westly Enterprises, 3697 S Court, Palo Alto, CA 94306. (415) 494-7115. March 9 to 10.

APEC '89 (IEEE Applied Power Electronics Conference and Exposition), Baltimore, MD. Trey Burns, Data General Corp, 4400 Computer Dr, E213, Westboro, MA 01580. (508) 870-9182. March 13 to 17.

C Programming Workshop, Seattle, WA. Specialized Systems Consultants Inc, Box 55549, Seattle, WA 98155. (206) 527-3385. March 13 to 17.

Modern Electronic Packaging (seminar), San Diego, CA. Technology Seminars Inc, Box 487, Lutherville, MD 21093. (301) 269-4102. March 20 to 22.

DCA Forecast to Industry (seminar), Tyson Corner, VA. Janie Herring, AFCEA NOVA Chapter, The BDM Corp, 7915 Jones Branch Dr, McLean, VA 22101. (703) 848-6944. March 27 to 28.

IBM Personal Computer Interfacing for Scientific Instrument Automation (workshop), Blacksburg, VA. Linda Leffel, Donaldson Brown Center for Continuing Education, Virginia Tech, Blacksburg, VA 24061. (703) 961-4848. March 27 to 29.

1989 Technical Symposia on Aerospace Sensing, Orlando, FL. The International Society for Optical Engineering (SPIE), Box 10, Bellingham, WA 98227. (206) 676-3290; in Europe: SPIE, Koblenzer Strasse 34, D-5300 Bonn 2, West Germany. (49228) 361546. TWX 172-283-747. March 27 to 31.

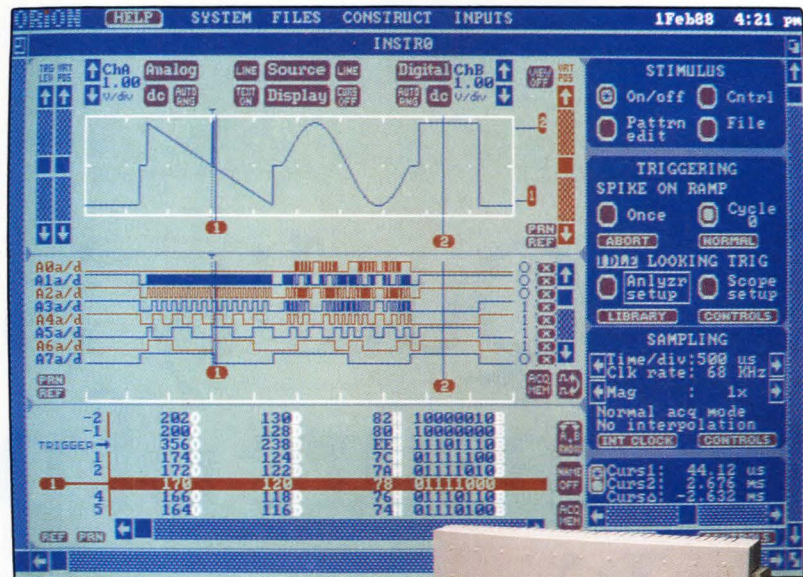
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OmniLab display demonstrates capture of an imbedded analog glitch (in top trace) with time-aligned presentation of the waveform's digitized bit values (center) and numeric states.



of rare events like metastable states, bus contentions, missing pulses, and buried noise glitches.

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Scale Factor:	5 mV/div to 10V/div	Synchronous Clocking:	0 to 34 MS/s
	in 1-2-5 sequence	Acquisition Memory:	4K samples (16K, 64K optional)
Record Length:	4K (16K, 64K optional)	Disassembly Options:	Over 150 microprocessors
ANALOG STIMULUS		DIGITAL STIMULUS	
Output:	8mV to 8 V peak-to-peak, 8 bit	Outputs:	24, 74F tri-state drivers
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Clocking:	34 S/s to 34 MS/s	Timing:	34S/s to 34MS/s
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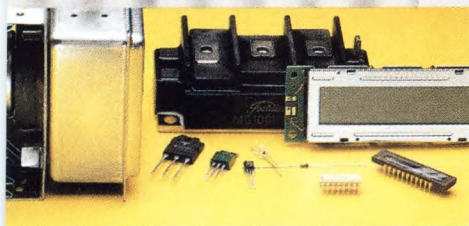
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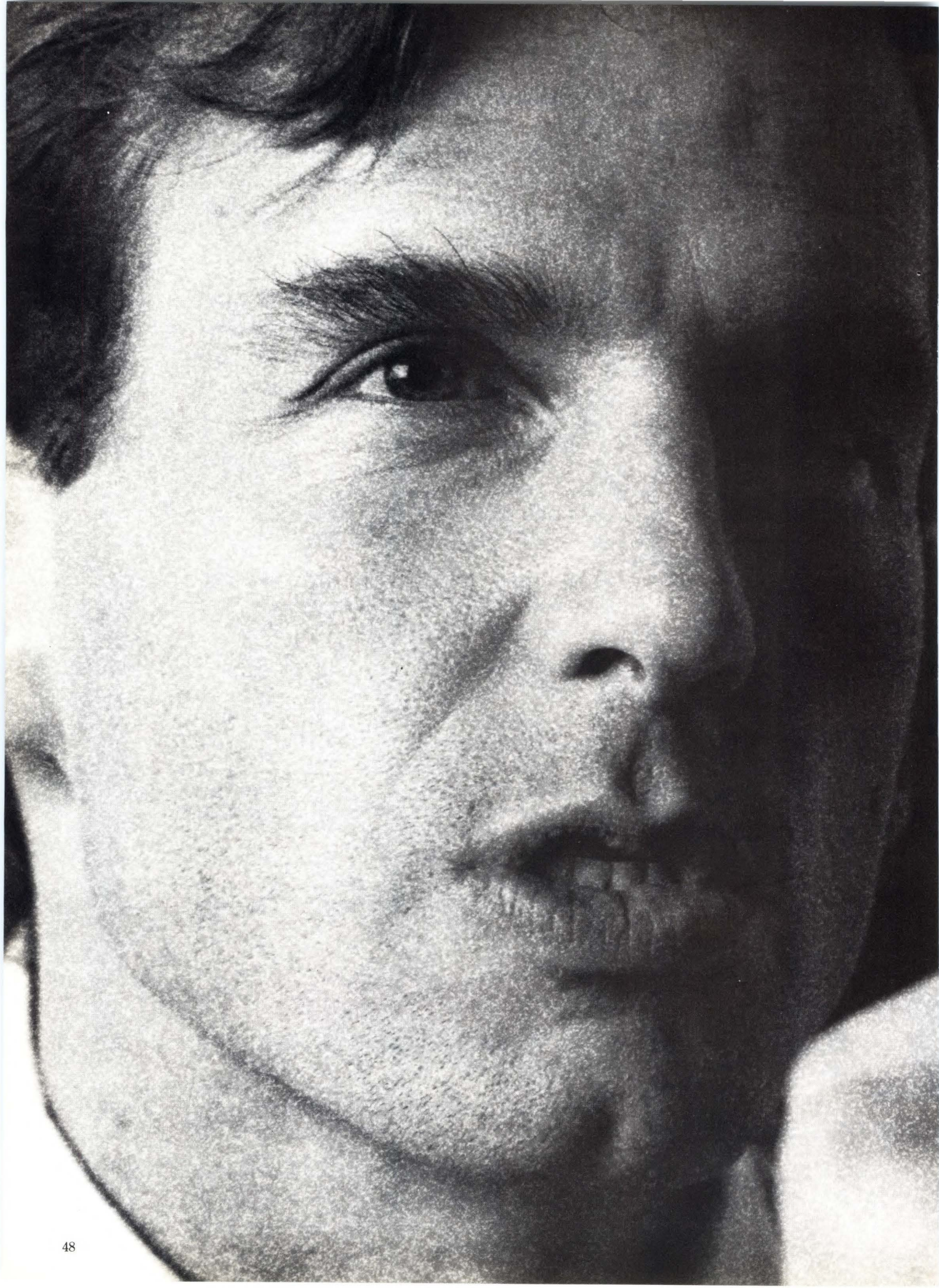
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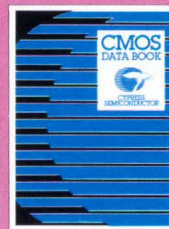
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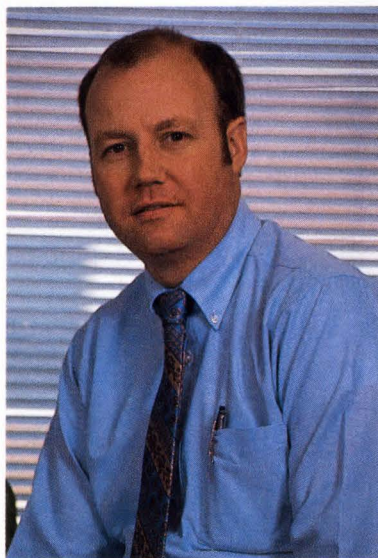


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EDITORIAL

Manage innovation, not money



In a capitalistic economy, every seller tries to maximize his profit, but within the last 20 years, we've lost sight of many long-term goals—competitiveness, new technologies, research, and development—and concentrated on making quick profits instead. Today, over 75% of the chief executive officers polled by *Research & Development* magazine agree that we're concentrating too much effort on short-term goals.

As a result, we're not spending enough time or money on developing the next generation of technologies, which in turn leads to a new generation of advanced products. Instead, managers waste time trying to please shareholders by increasing stock prices, improving quarterly profits, and staving off takeover attempts. The need for more innovators is crucial, yet the path to fame and fortune seems to require an MBA instead of a degree in engineering or science. The job market reinforces this view. Although engineers develop the products that keep a company in business, they usually earn less than the managers who track quarterly results.

Managers aren't always short-term thinkers. These days, they must face the considerable long-term corporate debt they've accumulated, either while leading a takeover fight, or while repulsing one. But many of them would be aghast at the suggestion that an equivalent amount spent on R&D could have made their present position much stronger.

Many managers ignore long-term investments in R&D, thinking that the best way to develop new products is to buy companies along with the technologies they've developed. Such an approach is risky. R&D acquisitions often stifle creativity within the acquiring company, and they reduce loyalty, too. After all, why should an employee pour his effort into an underfunded and unappreciated R&D effort if the company is willing to spend a great deal of money quickly to acquire technology elsewhere?

Getting people to renew their concentration on long-term goals—innovation, research, development, competitiveness—is a long-range goal itself. But we'll get there faster if we take managers' minds off the need to make a short-term profit. We need a national change in attitude, and there are several things we can do.

First, we can make stocks appeal only to long-term investors. Making investors hold their shares for six months before they're allowed to vote at stockholders' meetings might be a way to start. Also, we could make any stock sold within six months of its purchase subject to a 20% profit surcharge. Eliminating quarterly reports would also help. Detailed financial reports issued at 18-month intervals could take their place.

Second, you can tell the people who invest your money—in retirement funds, mutual funds, investment plans, etc.—that you want your money invested for long-term growth, not quick income. If they can't or won't comply, start looking for an investment outlet that believes in the long-term potential of our technical industries.

Now, you may be inclined to think that solving this problem is up to somebody else. Considering the vagaries of the stock market, you'd rather invest *your* money for short-term profit, thank you, and let somebody else worry about getting the US back on the track of technological innovation. Let me suggest that that attitude is the one that got the US into this mess in the first place. Solving the problem is going to be up to all of us. The managers and CEOs of large companies aren't going to change their methods until the stockholders stop demanding quick profits.

Ultimately, everybody who participates in the economy will be better off if US investors support long-term growth. Waiting for long-term goals to come to fruition is a mature attitude, it's true, and such attitudes are none too popular these days. But maybe it's time we grew up.

Jon Titus
Editor



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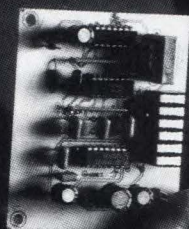


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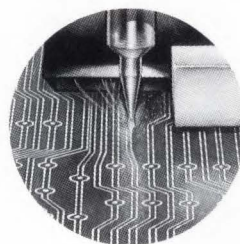
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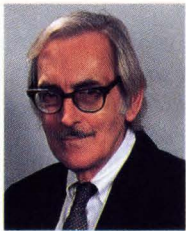
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Make C programs more portable



Merely writing your programs in C doesn't guarantee they'll be portable. New compiler families and techniques can help, but you must still program with care.

Chris Terry,
Associate Editor

It's now much easier to make your C programs widely portable to different microprocessors and computers. First, you can choose from a number of new compiler families that employ techniques for enhancing program portability. Then, you can take certain programming precautions to minimize the amount of recoding you need to do to target programs for different machines.

The C programming language was originally used only in Unix systems that ran on VAX computers. Today, however, C compilers exist for almost every known CPU architecture, and the operating system doesn't have to be Unix. The machines all have different instruction sets and different ways of storing and manipulating data.

Further, users of C programs are increasingly demanding that those programs be portable to many different machines. It's not as easy as you might think to make a C program portable,

because some features of the language work in an implementation-dependent manner. It's often necessary to recode portions of programs that manipulate pointers, for example, which may be interpreted differently by the various compilers.

If you want your C programs to run reliably on many different machines, you need to pay a great deal of attention to how you use some of these implementation-dependent features. NonUnix systems, for example, may have very different ways of interpreting the status code associated with something as simple as the `exit()` system call.

Fortunately, helpful standards are emerging in some areas—the interim Federal Information Processing Standard, based on the National Bureau of Standards P1003.1 standard, is an example. Other documents, such as the X/Open Portability Guide (XPG), can also assist you in programming for portability. Version 3 of the XPG will encom-



Illustrations by Bruce Gilfoy

TECHNOLOGY UPDATE

Make C programs portable

pass the Posix 1003.1 standard, and if you conform to the XPG guidelines, your C software will work properly on any machine manufactured by any member of the X/Open group.

Cross-development considerations

If you're designing software for embedded systems, you'll probably do all your development work on a host computer, such as a workstation or a machine of the IBM PC/AT or PS/2 class. Software vendors offer many cross-development packages for these hosts; typical examples come from Intermetrics, Avocet Systems, and Archimedes Software.

For any specific programming language, each of these vendors supplies a family of cross-compilers, cross-assemblers, linkers, and symbolic debuggers that use the same building blocks for the machine-independent processes, supplemented by machine-specific building blocks that match the particular host and target machines. You have to order the package for a particular host and target machine, but if you're developing an application for embedded systems of several different architectures, the building blocks that the packages have in

common ensure that much of your application will be directly portable—you'll only have to recode the target-specific portions. If you're using a single host, the cost of such recoding will be minimal. Intermetrics' compilers for the PC/AT, for instance, cost \$1000 each. Similar assemblers cost \$800 each, and debuggers sell for \$1500 each. Avocet's prices are even lower—its C cross-compiler for PCs and compatibles costs \$895; its macroassemblers cost from \$349 for 8-bit targets to \$750 for a 68030 target μ P.

Archimedes Software concentrates on C cross-development tools for microcontrollers such as Intel's 8051 and 8096 families, Motorola's 6301 and 6811 families, Zilog's Z80 and Z180, and Hitachi's 64180. To increase program portability, the Archimedes compilers use the Kernighan and Ritchie language definition (Ref 1) with extensions that are compatible with the proposed ANSI standard for C. In addition, the company's "float" data type conforms to the IEEE 32-bit single-precision format.

Another feature that makes for portability relates to the extensions. In order to enable the extensions, you have to use a special compiler option (you add "-e" to the

command line). To ensure that a program will be portable, you can check your source code to see if you used the "-e" option. If so, you can take away the extensions and modify the associated code to adhere strictly to the Kernighan and Ritchie standard; it will then be completely portable. The Archimedes compilers start at \$995 for a PC-hosted compiler; other tools from this vendor include symbolic debuggers and the Simcase series of simulators.

Retargetable compilers

If you're designing system software for a completely new reduced-instruction-set computer (RISC) or bit-slice architecture that requires microcode, you may be able to use a retargetable compiler—that is, a compiler that first generates output in an intermediate language, and then uses files containing a definition of the target machine to translate the intermediate language to executable code and optimize it for the target machine.

Portability of code is built into such compilers, because when you start development, you use the definition files to modify not only the compiler, but all of the associated tools such as the linker, symbolic



debugger, and simulator. The value of such a retargetable tool set is that it lets you generate optimized microcode for the target system, yet retain the advantage of writing in high-level code. Further, you can generate microcode for any machine for which you can create appropriate definition files. For example, you could use the tool set to create software for a machine that uses RISC processors in parallel and has a bus width of 100 or more bits. The project would consume only a fraction of the time that it would take to develop the program in microcode.

Quantitative Technology's Software Foundry is the only user-retargetable tool set of this kind that is currently available, largely because of the difficulty of making the optimizing functions, simulator, and symbolic debugger retargetable. Retargetable cross-compilers have been available for mainframes for several years, but complete tool sets have not. The Software Foundry costs \$50,000 for workstations and \$90,000 for VAX machines.

Yet a third aid in writing portable C programs is the interpreter. An interpreter is especially valuable in developing a prototype quickly. If your objective is to use an algo-

rithm correctly or to develop a user interface, you don't want to have to worry about bookkeeping issues. While you're still learning to understand the algorithm or interface, you can tolerate the slow execution time of an interpreter, because it allows you to make corrections quickly and to rerun the program without going through the tedious edit-compile-link-run cycle. Once you've got the program working correctly, you can use your compiler facilities to tune the program and optimize it for the target processor.

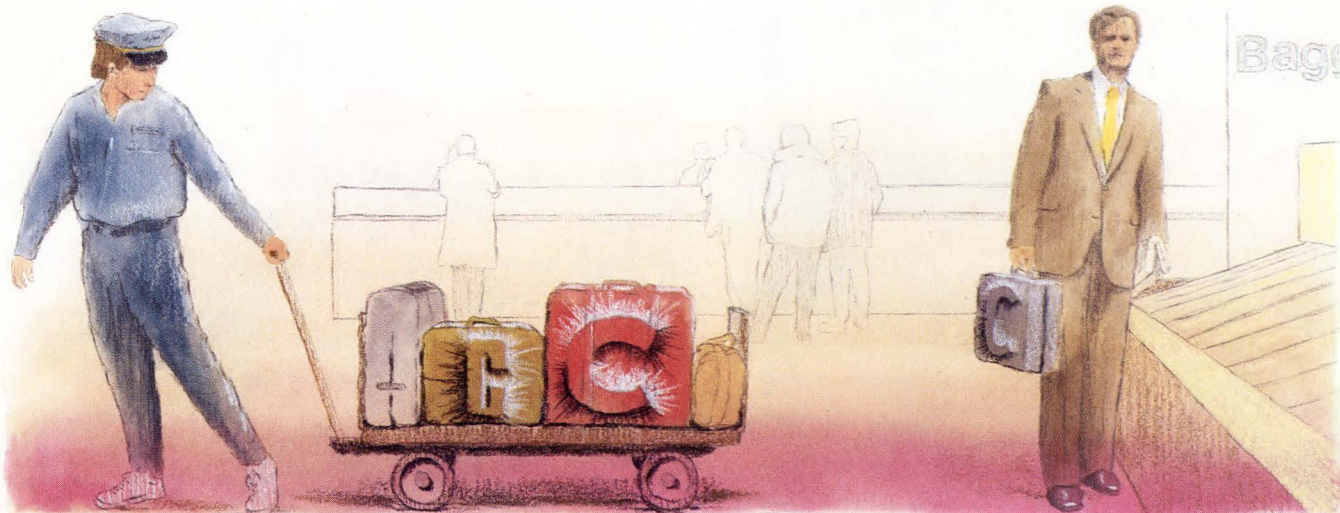
Some interpreters are intended for only one type of system—a personal computer or a workstation, for example—and work only with a particular compiler. Other interpreters, however, are available for several different types of machines and their compilers.

Typical of the single-machine packages are Borland International's \$99.95 Turbo-C and Microsoft's \$99 Quick-C, both of which include incremental compilers. The packages run on the IBM PC family of computers, and they also work with Microsoft's C compiler version 5.0. They are designed to take advantage of the segmented architecture of Intel's 8086 μ P family. Catalystix's Safe C is a package that con-

tains a stand-alone interpreter and a number of analytical utilities. It runs under a variety of operating systems, including MS-DOS, VAX/VMS, and Unix. The interpreter produces identical results, regardless of the type of host, so the programs you develop with this package are usually completely portable. Prices range from \$1000 to \$8000, depending on the host machine.

C sees a byte stream

An innate feature of C is that it views a file and I/O operations as nothing more than a stream of bytes. This viewpoint has a number of advantages: It hides the distinction between binary files and text files from programs that don't need to interpret the data in the files, and it frees the programmer from having to specify dozens of parameters in order to, say, use the **open()** function to open a file. Moreover, the I/O interface for a byte stream is very simple. On the other hand, stream-based I/O destroys all clues to individual read or write operations—and in some applications it's necessary (or at least desirable) to retain such clues. In general, stream-based I/O is an inappropriate model for files that are primar-



TECHNOLOGY UPDATE

Make C programs portable

ily record based (such as database files), yet the **stdio** functions alone don't handle record-based files well. You should familiarize yourself with the other I/O models so that you can pick the most appropriate one for your project. You may even have to create your own library of I/O functions to handle the data-intensive domains common in graphics, database, and CAD applications.

Macros require special care

If you intend to optimize code for maximum execution speed rather than minimum size, you'll probably make liberal use of the C preprocessor to define macros. Upon compilation, these macros generate fast inline code, but because each call to a macro generates the same amount of code, the program size will naturally increase. However, you should take certain precautions to ensure that your macro will always work the way you intended.

Unix consultant Ken Arnold suggests four basic guidelines for using the preprocessor correctly (**Ref 2**). First, he notes, you should be aware that not all preprocessors will tolerate a space between the “#” sign and the directive. Using the space makes for more readable code, but if you're writing for differ-

ent compilers on different machines, it's safer to omit the space.

Second, Arnold advises that you use parentheses liberally around the parameters that you pass into and out of a macro. An incoming parameter may consist of a fairly complex expression whose built-in operators could change the precedence of the operators in your macro.

Third, you should be sure to remember that the macro definition does *not* include the terminating semicolon. If you erroneously terminate a macro with a semicolon, you may find that the expansion drops an extra semicolon into the middle of an expression, with the result that the compiler will evaluate some parameter twice (and you have no way of knowing ahead of time which one will be affected).

Further, says Arnold, you should be aware that some compilers can't deal with “newline” symbols that occur in the middle of a macro invocation. This limitation is not present in the newer compilers, but if you're writing for portability and to make your code easy for others to use, avoid such potentially troublesome constructions—you can't know what evil still lurks in the hearts of other people's compilers.

Ken Arnold remarks, finally, that

although the preprocessor can be used to make code “readable and robust,” careless use of it can produce “the most unreadable pieces of code known to humanity.”

When you're planning new applications, consider the availability of the Xenix operating system for 80386-based machines, which can run programs in either 16- or 32-bit mode. Microsoft and AT&T are co-operating to merge Xenix 386 and Unix System/V Release 3.2 into a Merged Product (MP) that will embody all the existing 80286 and 80386 executable formats common to Unix and Xenix on the 80386. The product will allow all existing 80286- and 80386-based applications to run on any 80386-based machine.

In the long run, Microsoft and AT&T plan to establish and support a binary standard that will allow all conforming programs to run on all 80386-based Unix machines. This standard will include a superset of the current Xenix System/V 386 program interface, but will *not* include system-call extensions that are peculiar to Xenix. If you're planning new applications, and would like them to be source-code-compatible with this proposed binary standard, you should avoid these Xenix-specific extensions (for a full list of them, see **Ref 3**).



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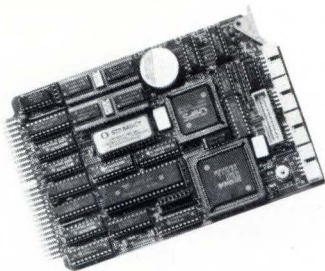
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t_s	4.0 ns	4.5 ns
t_{co}	6.5 ns	7.5 ns
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f_{max2}^*	165 MHz	150 MHz
Inputs	Outputs	Product Terms
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Make C programs portable

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

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Here's a final caution: Don't assume that any function in your favorite compiler's library is "standard"—in other words, don't assume it will be present in other libraries or that, if it is, it will work in exactly the same way for any machine. The only universal functions are those that are defined (or at least described) in the Kernighan and Ritchie manual. Beyond those, the number and types of functions in the library are a function of the compiler vendor's generosity. Even when the ANSI X3J11 proposal becomes a formal standard, it will mandate only a "minimal" standard library—additional functions may be offered at the discretion of the compiler vendor.

Obviously, the more functions you have in your library, the less code you'll have to write. But to ensure that your programs will be portable, you'll have to make sure that the library functions you use don't depend on any machine-specific characteristics to operate properly.

In recent years, compiler writers have adopted the convention of using an underscore as the first character of the name of any variable or function that the compiler uses. If you avoid using a leading underscore when you name your variables and functions, you'll run less risk of duplicating an unfamiliar name that's in your library. **EDN**

References

1. Kernighan, Brian W, and D M Ritchie, *The C Programming Language*, Prentice-Hall Inc, Englewood Cliffs, NJ, 1978, 1988.
2. Arnold, Ken, "Fun with the Pre-processor," *Unix Review*, April 1988, pg 73.
3. Dunsmuir, Martin, "Programming Considerations in Porting to Microsoft Xenix System V/386," *Microsoft Systems Journal*, January 1988, pg 31.

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PLCCs adapt to through-hole use



You no longer need to jury-rig plastic leaded chip carriers (PLCCs) to pc boards for testing or manufacturing purposes. A number of off-the-shelf alternatives promise to solve PLCC-mounting problems faster and without causing you aggravation.

Michael C. Markowitz,
Associate Editor

Surface-mount technology (SMT) purports to offer advantages over traditional through-hole designs. Because SMT gives you access to both sides of a pc board and features smaller components, it provides superior component density and lower manufacturing costs. Further, it allows greater use of automation, which can improve reliability and yields, and SMT packages' shorter lead lengths decrease inductance, thereby providing better high-frequency performance. As a result, some IC manufacturers supply devices—such as many of the IBM EGA, VGA, and PC chip sets—only in surface-mount packages such as the PLCC.

Not everyone or every design can benefit from this move to SMT, however. The migration can cause certain problems, and the clever solutions you come up with may be very time consuming. For example, if you're designing a pc board for in-house manufacturing and your company doesn't have surface-mount capability, you may need to jury-rig a way to use a surface-mount-only device.

Or maybe you've designed your board and built several prototypes but don't yet have enough stock of a particular surface-mount device to test all of the boards. Perhaps you want to perform incoming inspection on the PLCC IC while risking minimal damage to the device or your supply.

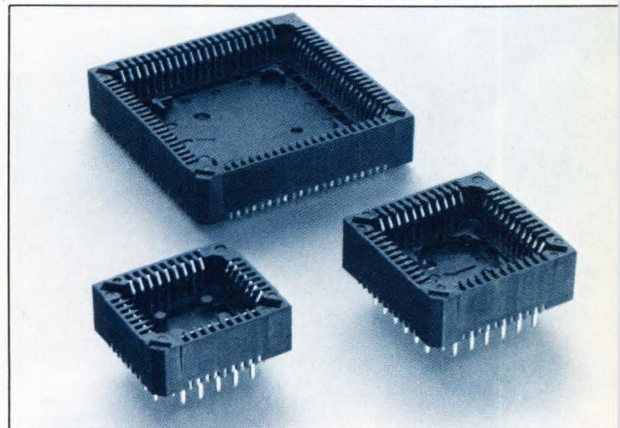
If you're building a breadboard or a prototype, you certainly don't want to solder the connections; each circuit modification would require desoldering and resoldering, which would place stress on the component leads and possibly cause heat damage to the chip.

Alternatively, perhaps you've designed and built a densely populated board, and then you find a problem with a surface-mount device. The nature of SMT devices makes probing difficult: Once you find the relatively hard-to-reach test point, you must struggle to avoid shorting two leads, yet maintain contact while you read the meter.

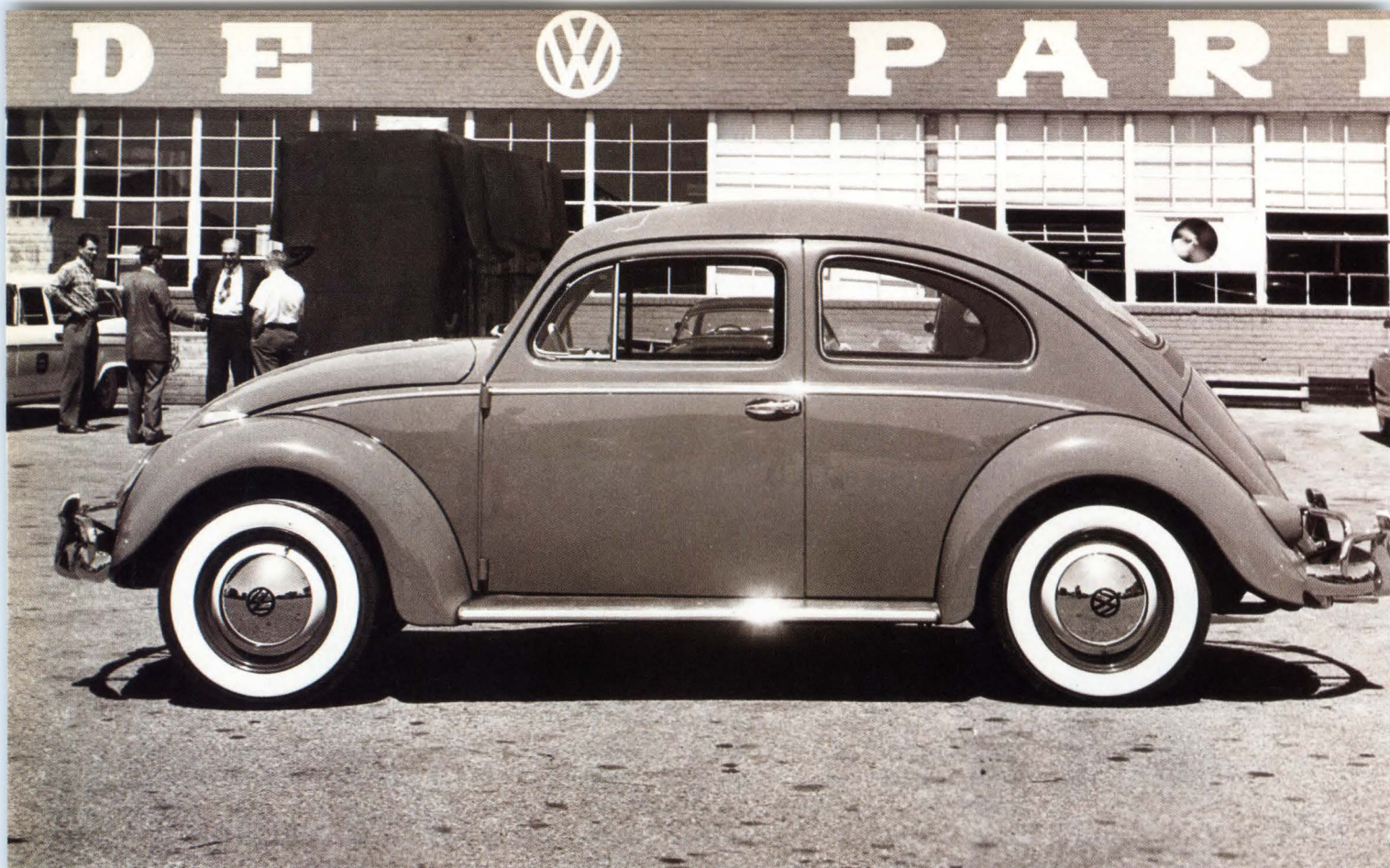
Sockets let FSEs fix boards

Perhaps your SMT board is large and expensive and contains diagnostic routines that can trace a fault to a particular device. Using a PLCC socket would allow a field-service engineer (FSE) to replace the bad component at the customer's site.

Here's another possible scenario: If you've selected a particular programmable device and either a bug or a technological change requires that you reprogram the part *after* you've shipped products to your customers, what do you do? A socketable PLCC adapter could solve the problem.



A kink in each contact locks the PLCCs into these AMP sockets and prevents the packages from popping free.



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TECHNOLOGY UPDATE

PLCC adapters

In response to the needs of designers, manufacturers have jumped into the market with a class of components which, for want of a better name, can be called PLCC-to-PGA adapters (Table 1). In one or another of their various incarnations, these adapters may provide the answer to your design needs and save you from having to resort to a kluge.

Simple PLCC sockets (see box, "What makes an IC socket?") can serve in many applications, though

for some uses, other types of adapters or sockets may be more appropriate. In the realm of surface-mount to through-hole converters, simple PLCC sockets are the least expensive alternatives, so they're the most appealing for high-volume, low-margin applications.

Although you can obviously use the sockets to alter surface-mount devices for through-hole service (for example, if your company only has through-hole manufacturing capability), they could perform just as

easily in other capacities. When you're using sockets as test or burn-in fixtures, their insertion-force requirements are one source of concern; you'll want to minimize the risk of damaging the leads when you insert and remove the device. The other primary drawback to using the sockets as burn-in or test fixtures is their limited operating-temperature range—most are not specified to operate at typical burn-in temperatures. Simple sockets do offer an appropriate solution to the problem of field repair, however.

Most simple sockets offer closed-bottom designs to prevent solder bridging or wicking—a capillary action that draws solder up into the socket. In addition, all of these sockets feature a notch that lets you insert a chip-removing tool, and each package has standoff on the bottom that facilitate cleaning after you've soldered the package to the pc board.

Finally, be aware that JEDEC standards allow a range of package sizes, so you need to make sure that the PLCC you're using fits the socket you choose. Most manufacturers build their sockets to accommodate the entire range of JEDEC packages. Understand too, that the insertion-force spec offered here is only a guide provided by manufacturers for a PLCC of unstated size.

AMP's HPT (high-pressure tin) series of PLCC sockets utilizes a positive-locking phosphor bronze contact design to prevent SMDs from popping out of the sockets. Because of the locking mechanism, the typical insertion force for the 84-pin socket is, at 60 lbs, higher than that of most other sockets. Like most simple sockets, the HPT sockets exact a penalty of about 10% of the package size. Too, most simple sockets spec 200g average normal force between the socket contacts and the PLCC leads.

A similar socket type is available

TABLE 1—REPRESENTATIVE PLCC ADAPTERS

MANUFACTURERS	PRODUCT	APPLICATIONS	AVAILABLE SIZES	COST
ADVANCED INTERCONNECTIONS	PLCC ADAPTERS TO WIRE-WRAP PANELS	A, B, E	20, 28, 44, 52, 68, 84, 100, 124	84-LEAD, \$19.43
	PLCC ADAPTERS	B, D, E	20, 28, 44, 52, 68, 84, 100, 124	68-LEAD, \$18
AMP	HPT SERIES	A, D	20, 28, 44, 52, 68, 84	68-LEAD, \$1.25 (100,000)
ANTONA	ANC-9000	B	20, 28, 44, 52, 68, 84	68-LEAD, \$49
AUGAT	DENSEPAK	A, B, E	16, 20, 28, 44, 52, 68, 84	84-LEAD, \$15 (500)
BURNDY	CHIPAK	A, D	20, 28, 32, 44, 52, 68, 84	68-LEAD, \$1.68 (25,000)
EMULATION TECHNOLOGY	CONVERT-A-SOCKET	C	20, 28, 32, 44, 52, 68, 84	20-LEAD, \$215
	ADAPT-A-POD (GENERIC)	B, C	20, 28, 44, 52, 68, 84	20-LEAD, \$160
GLOBAL SPECIALTIES	SURFBOARDS	B	20, 28, 44, 68, 84	84-LEAD, \$39.95
ITT CANNON	LCS SOCKETS	A, D	32, 44, 52, 68, 84	68-LEAD, \$1.77 (5000)
J M NEY	TEST AND BURN-IN SOCKETS	C	18, 20, 22, 28, 32, 44, 52, 68, 84	84-LEAD, \$19.87 (1000)
METHODE	SURFACE-MOUNT CHIP-CARRIER SOCKETS	A, D	28, 32, 44, 52, 68, 84	84-LEAD, \$1.25 (10,000)
	LEADED-CHIP-CARRIER ADAPTER PLUGS	B	28, 32, 44, 52, 68, 84	68-LEAD, \$34 (25)
PRECICONTACT	SERIES PLCC SOCKETS	A, D	68, 84	68-LEAD, \$2.10 (5000)
ROBINSON NUGENT	PLCC-68-PT	A, D	68	68-LEAD, \$1.99 (1000)
SOCKET EXPRESS	PLCC ADAPTER	B	44, 68, 84	84-LEAD, \$40.35

NOTES:

A=THROUGH-HOLE SOCKETING OF SMT DEVICE
 B=PROTOTYPING
 C=TESTING
 D=FIELD REPAIR
 E=REPROGRAMMABILITY

TECHNOLOGY UPDATE

PLCC adapters

from Precicontact. These sockets require an insertion force of about 24 lbs (11 kg) for a 68-lead socket. The contacts are of copper alloy and the tin-lead plated leads extend 0.122 in. below the bottom of the package; a good rule of thumb is that you need 0.2 in. per wire-wrap connection.

The Chipak is a PLCC socket from Burndy that has tin-alloy plated beryllium-copper contacts. Its lead-length is 0.120 in. The insertion force for the Chipak sockets is 12 oz per contact.

You can also procure simple sockets from vendors such as Methode, Robinson Nugent, and ITT Cannon. Methode's versions offer a socket with phosphor bronze contacts; the 84-pin socket requires an insertion force of 30 lbs max. A 68-lead PLCC socket from Robinson Nugent has phosphor bronze contacts and a low profile (0.383 in.).

Cannon's copper-alloy contact

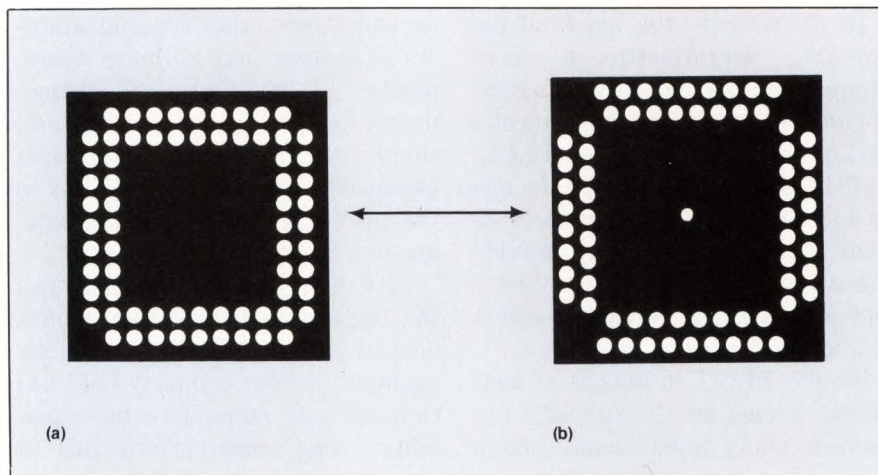


Fig 1—PGA sockets come in two varieties. In-line, 0.1-in.-center sockets (a) seem to find more use in production environments; staggered 0.1-in.-center sockets (b) are used more often in burn-in fixtures. The historical reason for the existence of staggered-contact sockets (that they make trace routing easier) is no longer an issue.

sockets are also low-profile models. The 68-pin socket has an insertion-force requirement of under 12 lbs. Cannon offers the socket in both in-line and staggered-contact versions (Fig 1); the manufacturer claims the staggered-contact type is more

prevalent in the Far East than in the US.

Although these simple sockets make it relatively easy to use PLCC-packaged devices on through-hole boards, the sockets' short leads aren't generally suitable

What makes an IC socket?

Because many PLCC adapters utilize PLCC sockets, it's valuable to understand how these sockets work. They come with stamped-and-formed contact springs that are made of beryllium copper, phosphor bronze, or copper alloy. Beryllium copper contacts, the most expensive, have the best spring characteristics over the widest temperature range (-65 to $+125^{\circ}\text{C}$), so they're best suited for military and computer applications. For industrial purposes, phosphor bronze offers good spring characteristics over a moderate temperature range (-65 to $+105^{\circ}\text{C}$) at moderate cost. Copper-alloy contacts are best suited for commercial purposes; their spring characteristics work over a limited temperature range (-40 to $+85^{\circ}\text{C}$), and they are the least expensive of the contact-spring alternatives.

Socket contacts are always plated; usually in gold, tin, or a tin-lead alloy. When you put two dissimilar metals in contact, you create a galvanic differential—essentially a battery—that hastens corrosion of the contact area. Therefore, because most ICs have tin- or tin-lead-plated leads, it's a good idea

to use either tin or tin-lead alloy as the plating material for the socket. A word of caution, however: Tin contacts can grow crystalline whiskers that may cause shorting problems, so the contacts should be made either of reflowed tin or of tin-lead alloy.

You should also make sure that the insulating material (often plastic) that makes up the socket's body has a UL 94V-0 flammability rating. Additionally, you should inquire as to the operating-temperature rating of the socket. The hygroscopic (water-absorbing) characteristics of the socket are also critical. When many insulators, such as plastic, absorb water, their electrical resistance can drop, causing leakage problems.

Finally, the socket's size and shape should fit into the space you've allotted on your pc board. Standoffs on the socket will keep the socket off the board and allow you to remove solder flux with cleaning fluid after you've completed the assembly. Another feature that's helpful in a square socket, such as a PLCC socket, is an orientation mark that indicates how you should insert the IC.

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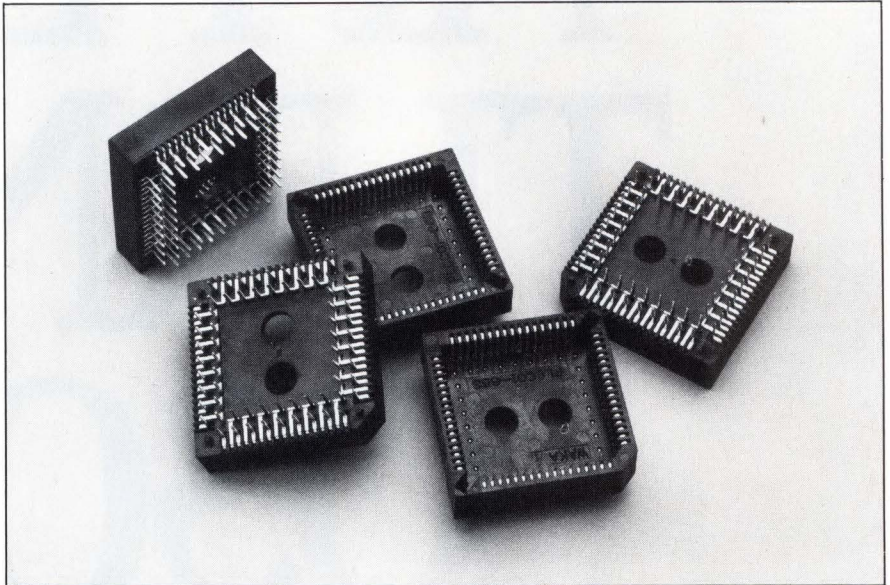
PLCC adapters

for development work. Prototyping and breadboarding with surface-mount components can be difficult to impossible unless you have some way of mounting the IC while maintaining interconnection flexibility at the same time. You can use a number of products to obtain this flexibility before committing the designs to production.

Adapters from Antona, for example, take the form of a simple socket mounted on a small pc board. Traces on the board carry the I/O signals between the PLCC and the labeled wire-wrap posts mounted on the pc board. To provide access for a logic probe, Antona seats the numbered wire-wrap posts so that a short segment extends above the pc board's surface. On the other end, the tin-plated pins extend 0.6 in. beyond the prototype when you use a 0.062-in. card. Standard adapters that hold PLCCs having 20 to 84 pins are available from stock at a cost ranging from \$18 to \$58. The company has a 100-pin adapter under development.

A similar adapter is available from Socket Express. In addition to having wire-wrap posts, all of these adapters have numbered nubs protruding from the socket side to facilitate probing. Methode, too, offers a similar part that lets you insert PLCC devices in high-density or universal prototyping boards. It features an onboard, pin-side ground plane for noise reduction. The 68-lead part comes in versions with 0.3- and 0.1-in. spacing.

Another approach to breadboarding or prototyping conveniently sidesteps the problem of trying to wire-wrap a surface-mount device. Global Specialties' Surfboards are PLCC sockets that mount on a pc board by means of two nondestructive, solderless breadboarding strips. Traces on the pc board connect the socket to the strips; numbers on the pc board show which



Because the contacts are exposed at the tops of the sockets, you can easily probe the surface-mount packages in these Precicontact sockets.

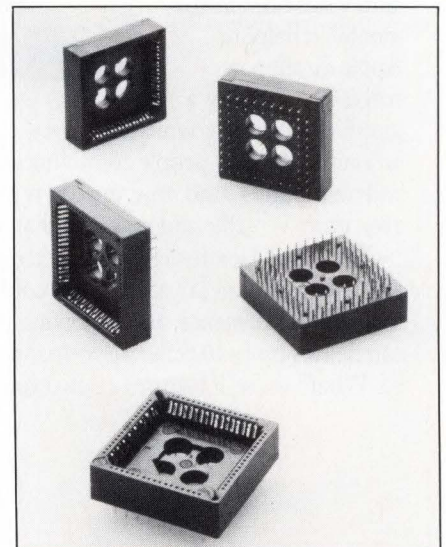
PLCC pin you're trying to wire. Making modifications is as simple as moving a wire from one location on the breadboard strip to another. The Surfboards come with a lifetime guarantee.

Testing sockets' LIF requirements

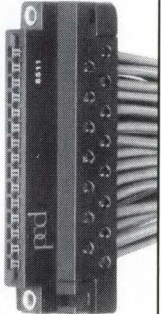
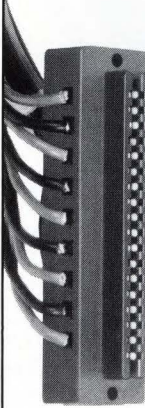
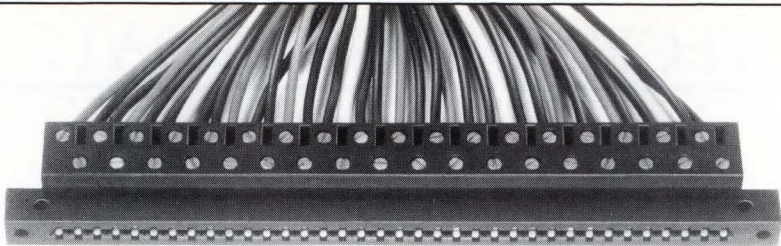
After you've developed your design and are ready to concern yourself with producing and testing the circuit, you should consider using sockets that function best in these capacities. The small-footprint test and burn-in sockets from J M Ney allow you to build dedicated burn-in fixtures for your PLCC-populated circuit boards. The test and burn-in sockets—made of glass-fortified polyphenylene sulfide with beryllium copper contacts—are specified to operate at temperatures as high as 150°C. With upgrades of both the contact material and the socket plastic, the sockets can operate to 200°C. The sockets have open tops that allow "dead-bug" loading (loading the device with the leads up), which lets you more easily probe the PLCC. The sockets require an insertion force of 40g per contact—about 6 lbs for a 68-lead PLCC. The

normal force between the socket and the package leads is nominally 45g per contact. Each of the sockets has a staggered-contact footprint.

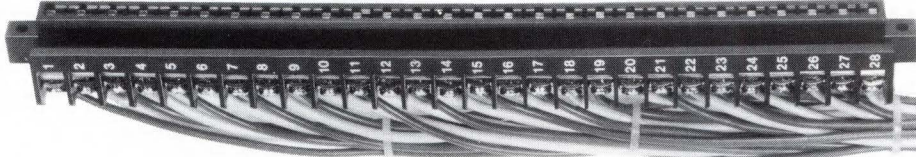
The Convert-A-Socket from Emulation Technology converts production sockets to test/burn-in sockets or vice versa. These sockets, made from two pc boards in a sandwich arrangement, come in many different configurations, in-



A closed-bottom design prevents solder bridging or wicking on these sockets from Burndy.



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Make smarter connections

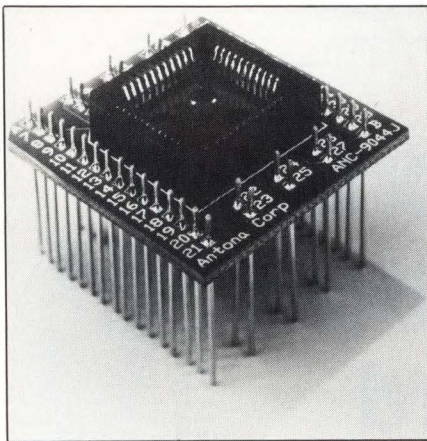
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TECHNOLOGY UPDATE

PLCC adapters



For development work, adapters (such as this one from Antona) offer a temporary home for a PLCC package and long terminal posts for wire wrapping.

cluding PLCC-to-PGA adapters. You can request versions that convert from PGA, PLCC, or LCC (leadless chip carrier) to PGA, LCC, PLCC, or staggered-row PGA configurations. Additionally, you can specify a custom-wired

board to modify the converter pin-out. The sockets are available in both in-line and staggered footprints. For test applications, you should specify the ZIF (zero insertion force) version; for production purposes, the LIF (low insertion force) socket is more appropriate. Though the manufacturer suggests the sockets for use as burn-in sockets, they're rated to operate only to 125°C, which severely restricts their application in that area.

Emulation Technology's Generic Adapt-A-Pod is useful for converting emulator pods to accept devices having different pin counts. Like their cousins, the Convert-A-Sockets, the Adapt-A-Pods are two pc boards that can create an interface between a PLCC-, LCC-, or PGA-configured emulator pod and PGA, LCC, or PLCC sockets.

Although it's often useful to convert a design from surface-mount



Development tools with a twist are these adapters from Global. They socket a surface-mount package and let you make connections to the part by using solderless breadboarding strips.

to through-hole technology, such conversion may not solve all your test, manufacturing, and repair problems. Consider, for example, an EPROM that needs to be repro-

For more information . . .

For more information on the PLCC-to-PGA adapters discussed in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Advanced Interconnections
5 Energy Way
West Warwick, RI 02893
(401) 823-5200
FAX (401) 823-8723
TWX 910-240-3454
Circle No 700

AMP Inc
Box 3608
Harrisburg, PA 17105
(800) 522-6752
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Antona Corp
1643½ Westwood Blvd
West Los Angeles, CA 90024
(213) 473-8995
Circle No 702

Augat Interconnection Products Group
33 Perry Ave
Attleboro, MA 02703
(508) 222-2202 ext 2403
TWX 710-391-0644
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Burndy Corp
Richards Ave
Norwalk, CT 06856
(203) 838-4444
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Emulation Technology Inc
2368B Walsh Ave, Bldg D
Santa Clara, CA 95051
(408) 982-0660
FAX (408) 982-0664
TLX 981866
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Global Specialties
Box 1405
70 Fulton Terrace
New Haven, CT 06505
(800) 345-6251
In CT, (800) 445-6250
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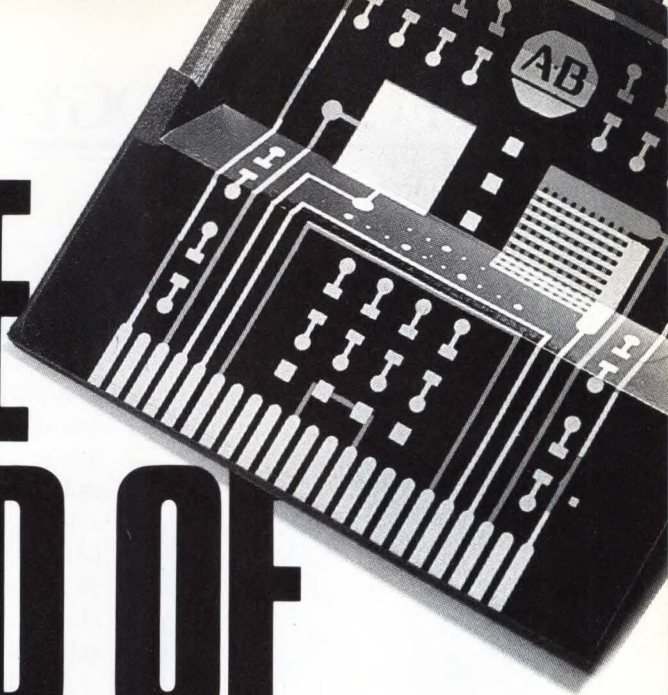
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Backplane Div
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Chicago, IL 60656
(312) 867-9600
Circle No 709

Precicontact Inc
835 Wheeler Way
Langhorne, PA 19047
(215) 757-1202
Circle No 710

Robinson Nugent
800 E Eighth St
New Albany, IN 47150
(812) 945-0211
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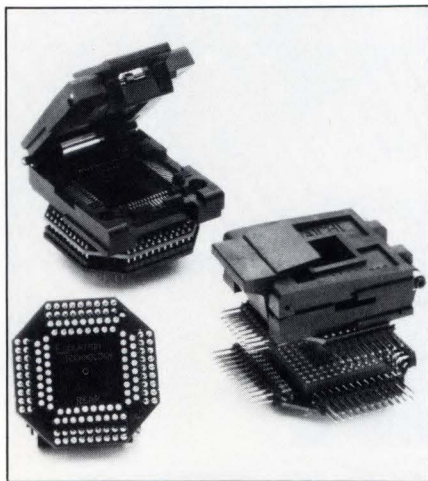


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TECHNOLOGY UPDATE

PLCC adapters



This 2-pc-board sandwich with a socket on top is Emulation Technologies' Convert-A-Socket. It's available in a standard pin configuration or can be customized to your specification.

grammed after it's connected to a board. You can't reprogram the device while it's still connected to your system, and, unless both your programmer and your system boards have PLCC sockets, you'll have trouble mounting PLCCs on them. Two solutions directly address the need to move surface-mount PLCCs quickly between two circuits.

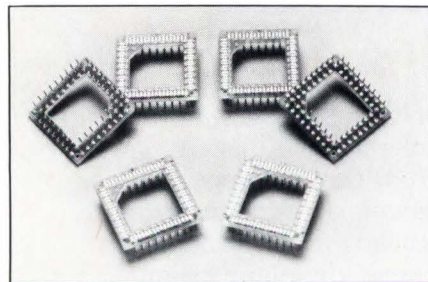
First, you could use a pc board that has leads to which you mount your PLCC package. Densapak is a pc-board adapter from Augat that comes either in a surface-mount socketed version into which you drop your PLCC, or as an SMD-ready board to which you solder the PLCC. You can insert the adapter

in a motherboard via numbered through-hole pins. Densapak is primarily intended for adapting PLCCs to universal-pattern pc boards with 0.3-in.-center through holes. The Densapak adapter typically comes without a socket; however, you can also purchase an adapter/socket pair for about \$2 to \$8 more than the cost of the socket alone. Advanced Interconnections sells a similar adapter.

Another adapter from Advanced Interconnections allows you to surface-mount a PLCC part directly to a daughter board that's only slightly larger than the PLCC itself. You can then plug the adapter into a PGA socket to connect the device to your circuit board. If you need to reprogram the chip, simply unplug the adapter, plug it into your programmer, and reprogram and replace the chip. Advanced Interconnections will solder your chips to the adapter for an additional \$1.80.

Depending upon your particular application, you can find numerous solutions for your PLCC-mounting problems. In fact, many PLCC-socket manufacturers offer similar solutions for the frustrations caused by other surface-mount packages. These off-the-shelf products can spare you the four or five hours you'd spend in the shop building a kluge as well as the hour or two you'd need to test and debug it.

EDN



If you surface-mount a PLCC directly to an Advanced Interconnections adapter, such as the ones shown, you can easily move the device and adapter from socket to socket for test, reprogramming, or repair.

Reference

Leibson, Steven H, "IC-socket innovations keep pace with improvements in packaging technologies," *EDN*, September 19, 1985, pg 61.

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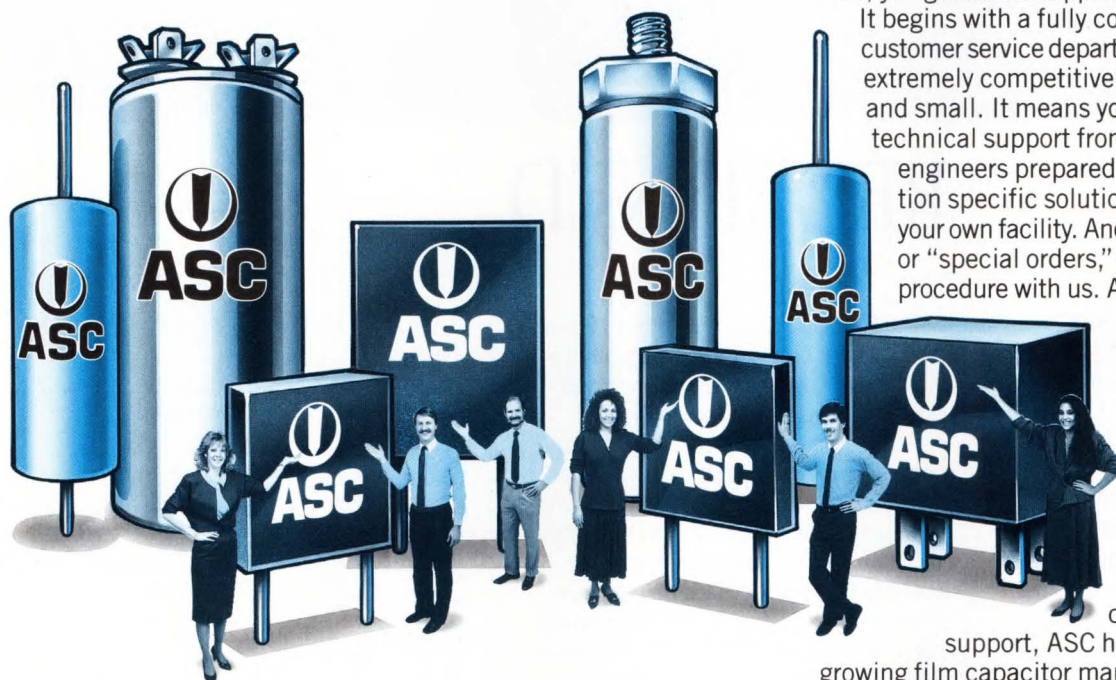
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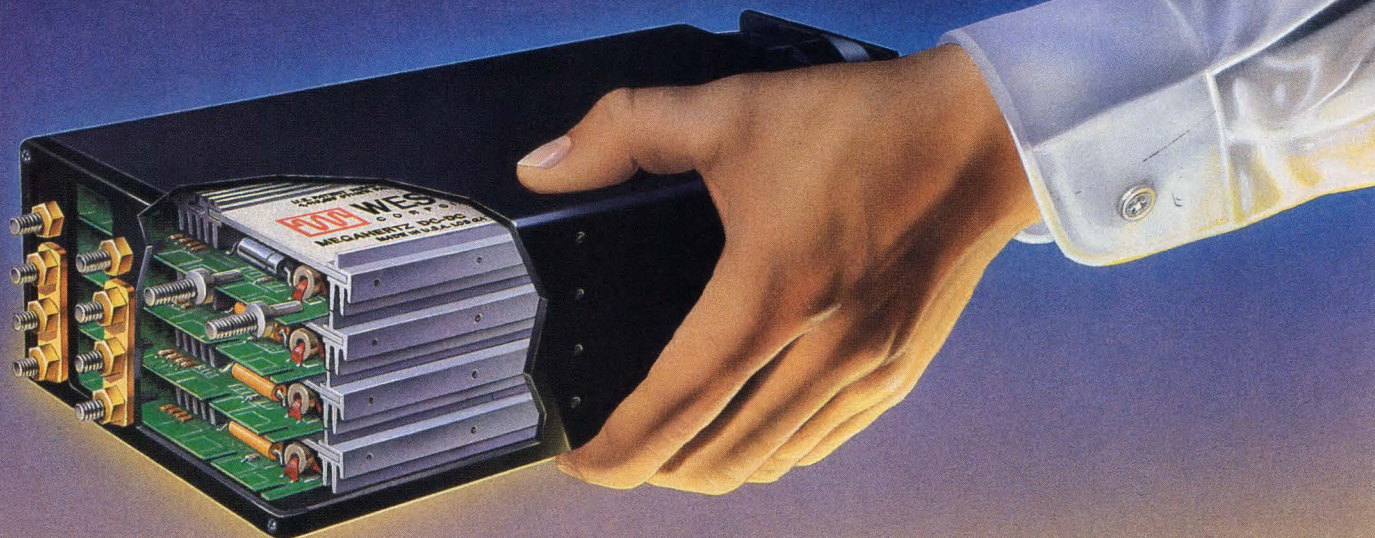
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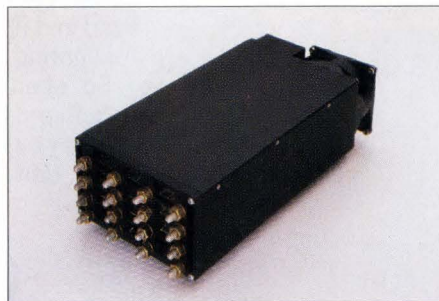
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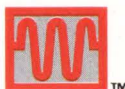
Other features include outstanding electrical performance; UL, CSA, VDE safety agency approval (in process); variable speed fan option for low ambient noise environments and 3 phase or DC input options. Indeed, with unprecedented power density, versatility and new features, the StakPak redefines power packaging. Please contact Westcor for a data sheet, pricing and additional information.




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Model	Output Voltage (VDC) and Maximum Current (amperes) per Channel				
	#1	#2	#3	#4	#5
Single Output					
SP1-1801	2 @ 240				
SP1-1802	5 @ 240				
SP1-1803	12 @ 100				
SP1-1804	15 @ 80				
SP1-1805	24 @ 50				
SP1-1806	28 @ 42				
SP1-1807	48 @ 25				
Dual Output					
SP2-1801	2 @ 120	5 @ 120			
SP2-1802	5 @ 120	5 @ 120			
SP2-1803	5 @ 120	12 @ 66			
SP2-1804	12 @ 66	12 @ 66			
SP2-1805	15 @ 53	15 @ 53			
Triple Output					
SP3-1801	5 @ 180	12 @ 16	12 @ 16		
SP3-1802	5 @ 150	12 @ 33	12 @ 16		
SP3-1803	5 @ 180	15 @ 13	15 @ 13		
SP3-1804	5 @ 150	15 @ 26	15 @ 13		
Quad Output					
SP4-1801	5 @ 150	12 @ 16	12 @ 16	5 @ 30	
SP4-1802	5 @ 150	15 @ 13	15 @ 13	5 @ 30	
SP4-1803	5 @ 150	12 @ 16	12 @ 16	24 @ 8	
SP4-1804	5 @ 150	15 @ 13	15 @ 13	24 @ 8	
Five Output					
SP5-1801	5 @ 120	12 @ 16	12 @ 16	5 @ 30	24 @ 8
SP5-1802	5 @ 120	15 @ 13	15 @ 13	5 @ 30	24 @ 8

Total output power may not exceed 1200 watts for any model, single or multiple output. Lower power StakPak models are available. Please contact the factory.



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CIRCLE NO 92

Crosspoint-switch ICs enter digital domain



Crosspoint-switch ICs are easiest to separate along those old familiar lines: analog vs digital.

Anne Watson Swager,
Associate Editor

When you hear someone refer to a crosspoint-switch IC these days, don't assume that they are speaking about an analog IC. Certainly the most common type of crosspoint, or crossbar, switch is the analog one, but new digital crosspoint switches are emerging that provide efficient ways to switch or reroute digital data.

In general, these programmable switches connect one of many inputs to one or more outputs. Initially, crosspoint-switch ICs were developed to replace electromechanical switches (relays) in electronic telephone-switching systems such as key exchanges—systems with 20 to 30 lines—and PBXs (Fig 1). However, the applications for these devices are no longer limited to telephone networks. You'll be surprised to find them in unexpected places such as parallel-processing, industrial-control-

routing, and data-communications systems.

In the telecommunications field, analog switches are still more cost effective for key-exchange systems, but digital switches are becoming more and more popular for larger systems. For instance, some digital crosspoint switches have characteristics that make them particularly well suited for communication networks such as ISDN (Integrated Services Digital Network). In addition, the need for higher-speed devices to serve fiber-optic communications applications has also spawned high-frequency digital switching systems. In describing crosspoint-switch ICs, it's easiest to separate them along those old familiar lines: analog vs digital.

Analog crosspoint switches consist of an array of analog switches fabricated on one IC. What distinguishes a crosspoint switch from other analog switches or multiplexers is its matrix architecture

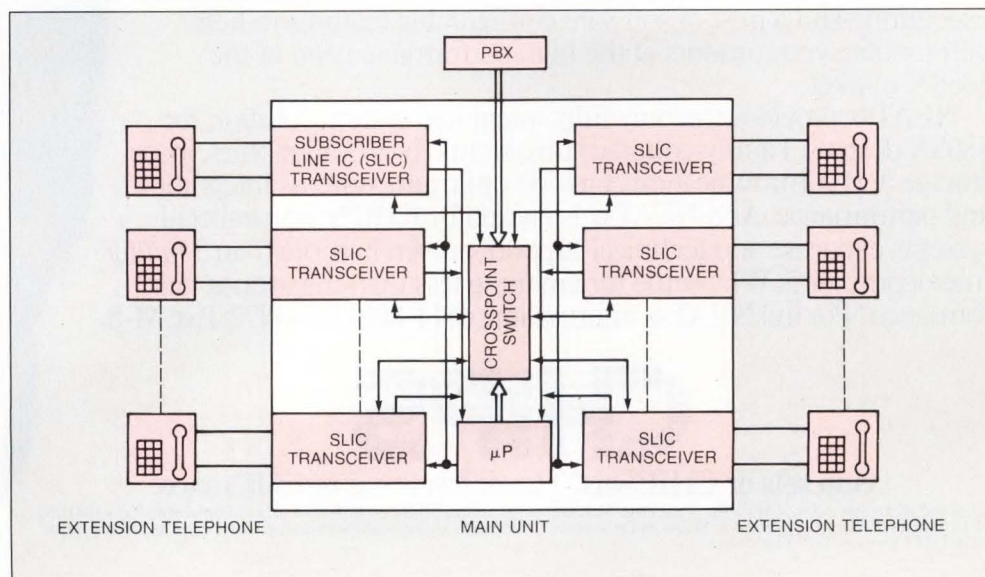


Fig 1—Crosspoint switches are typically found in telephone switching systems such as PBXs. They provide the switching flexibility necessary to connect multiple lines going to multiple destinations (diagram courtesy NEC Electronics).



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TECHNOLOGY UPDATE

Crosspoint-switch ICs

(Fig 2a). The block diagram of the NEC μ PD22100C 4×4 crosspoint switch includes the basic building blocks that all analog crosspoint switches have in common: the switch array itself, an address decoder, and the control memory or latches. For any $n \times m$ crosspoint switch, n equals the number of inputs, m equals the number of outputs, and the IC consists of n times m distinct switches.

You'll find IC array sizes ranging from 4×4 to 16×8 , with 16 to 126 switches per IC, respectively. The size of the package depends on the array size; Table 1 lists crosspoint switches that reside in packages as small as 14-pin DIPs all the way up to 40-pin DIPs and 44-pin PLCCs. Although most switches are manufactured in CMOS, SGS Thomson's M079, M089, and M093 are NMOS. Some of the arrays are symmetrical—that is, they have an equal number of inputs and outputs—but others are not. Some are designed to switch balanced telephone lines; examples are the $2 \times 2 \times 2$ M079 switch and Raytheon's $4 \times 4 \times 2$ RC4444.

Programming an analog crosspoint switch is quite straightforward. The procedure varies only

slightly from IC to IC. The timing diagram for the NEC μ PD22100C is representative of a switch's programming requirements (Fig 2b). To turn a particular switch on, you must first select that switch's address by applying the corresponding logic levels to the address inputs. You then specify a closed switch by applying a high logic level to the Data In line while you hold the Strobe line high.

Because analog crosspoint switches are designed primarily to deal with analog voice signals, not high-frequency or low-level analog signals, their performance specs can't compete with devices intended for precision switching. It is the analog crosspoint switch's unique architecture, rather than its specific performance characteristics, that makes it useful.

Nonetheless, the salient specs for crosspoint switches are the same as those for analog switches in general. As you might expect, the specs of most concern to designers are on-resistance (R_{ON}), crosstalk, frequency response, and the maximum analog signals you can pass through the switch (V_{P-P}). One specification that is unique to analog crosspoint-switch ICs (and oth-

ers containing multiple switches) is ΔR_{ON} . This spec represents the variation in R_{ON} between switches in the same IC package.

Specs have wide variation

The analog crosspoint switches' specifications vary widely from switch to switch and from manufacturer to manufacturer. The specs are particularly difficult to tabulate or compare because each manufacturer uses a different set of test conditions. Table 1 is intended to give you a general idea of the range of some available products and their characteristics. You should realize that most of the manufacturers listed make more than one crosspoint-switch type. When choosing an analog crosspoint switch, you should consult each individual product's data sheet, and determine the switch's performance under your anticipated circuit conditions.

Fortunately, you can deduce some rules of thumb about the switches' specs. For instance, the R_{ON} of each switch in a package varies depending on operating conditions such as temperature, power-supply voltage, and input-signal level; R_{ON} increases as temperature increases and as supply voltage de-

TABLE 1—REPRESENTATIVE ANALOG CROSSPOINT-SWITCH ICs

VENDOR	PART NO ¹	ARRAY SIZE	PACKAGE STYLE	TYP R_{ON} (Ω)	TYP ΔR_{ON} (Ω)	MAX ANALOG INPUT (V_{P-P})	CROSSTALK (AT $f=1$ kHz UNLESS OTHERWISE SPECIFIED)	PRICE ² (1000)
HARRIS (FORMERLY GE SOLID STATE)	74HC22106	8×8	28-PIN DIP	64 AT $V_{CC}=4.5V$	25 AT $V_{CC}=4.5V$	$V_{CC}/2$	-110 dB ($V_{IN}=2V_{P-P}$)	\$4.13
MITEL	MT8812	8×12	40-PIN DIP OR 44-PIN PLCC	70 AT $V_{DD}=10V$	10 AT $V_{DD}=14V$	V_{DD}	-90 dB ($V_{IN}=2V_{P-P}$)	\$5.10
NEC	μ PD22100C	4×4	16-PIN DIP	80 AT $V_{DD}=12V$	18 AT $V_{DD}=12V$	V_{DD}	-110 dB AT $f=0.1$ kHz (V_{IN} NOT SPECIFIED)	\$0.95
SGS THOMSON	M3494	16×8	40-PIN DIP OR 44-PIN PLCC	40 AT $V_{DD}=10V$	6 AT $V_{DD}=10V$	8	-95 dB ($V_{IN}=1V_{P-P}$)	\$5.50
SILICON SYSTEMS	78A093A/B	12×8	40-PIN DIP OR 44-PIN PLCC	28 AT $V_{DD}=12V$	15 AT $V_{DD}=12V$	6	-97 dB ($V_{IN}=1V_{P-P}$)	\$5.93

NOTES:

1. ALL THE SWITCHES LISTED ARE MANUFACTURED IN CMOS TECHNOLOGY.
2. PRICES LISTED ARE FOR DIP PACKAGES.

TECHNOLOGY UPDATE

Crosspoint-switch ICs

creases. Most manufacturers quote R_{ON} for at least three voltage levels—typically 5, 10, and either 12 or 15V. You can't easily generalize about the effect of input-signal levels on R_{ON} ; this relationship is sometimes nonlinear and also depends on the supply voltage.

A switch's frequency response depends on the peak-to-peak level of the analog-signal inputs; the larger the signal, the lower the bandwidth. With input signals of around 2 V_{P-P}, most switches have a response of approximately 40 to 50 MHz.

Of course, you aren't restricted to using only analog data with analog switches. You can certainly switch digital data through analog switches as long as you take into account the lowpass-filtering effect of R_{ON} and the parasitic capacitance, and as long as you ensure that your TTL or CMOS signals don't exceed the switch's maximum V_{P-P}. Some analog crosspoint switches specify that their inputs are TTL or CMOS compatible. Finally, don't forget about the ΔR_{ON}

spec; it signifies that the filtering of each digital signal line will be slightly different.

Now consider digital types

The newer digital crosspoint switches, like the analog switches, are available in a variety of matrix sizes. In general, they are larger and more highly integrated than their analog counterparts. For instance, Sierra Semiconductor makes a 32×32 digital switch, and SGS Thomson makes a 256×256 switch array. As is true of analog crosspoint switches, digital switches require you to load a value into a register to specify the I/O-channel connection.

One distinction between analog and digital crosspoint switches is that the digital types are not bidirectional. The digital switches have dedicated inputs and outputs, as opposed to the analog types' simple resistive connection. The architecture of the digital switches includes internal building blocks such as input registers, multiplexers, and output buffers.

The digital switches do have certain features in common. For instance, most digital crosspoint switches are nonblocking: They allow you to connect any input to any output, even if that input has already been assigned to another output. Many have 3-state outputs that allow you to cascade multiple ICs to create large switching matrices.

Digital types vary

Each digital switch does have its own particular attributes, however. Digital switches exhibit differences in architecture, programming features, timing requirements, and speed. In addition, some switches are designed to be compatible with a specific communication protocol. It's best to consider a digital crosspoint switch according to the application that it serves.

If your application requires a general-purpose digital crosspoint switch, the recently announced Sierra Semiconductor SC11320 monolithic CMOS 32×32 switch IC may suit your needs. The SC11320 has a straightforward digital architec-

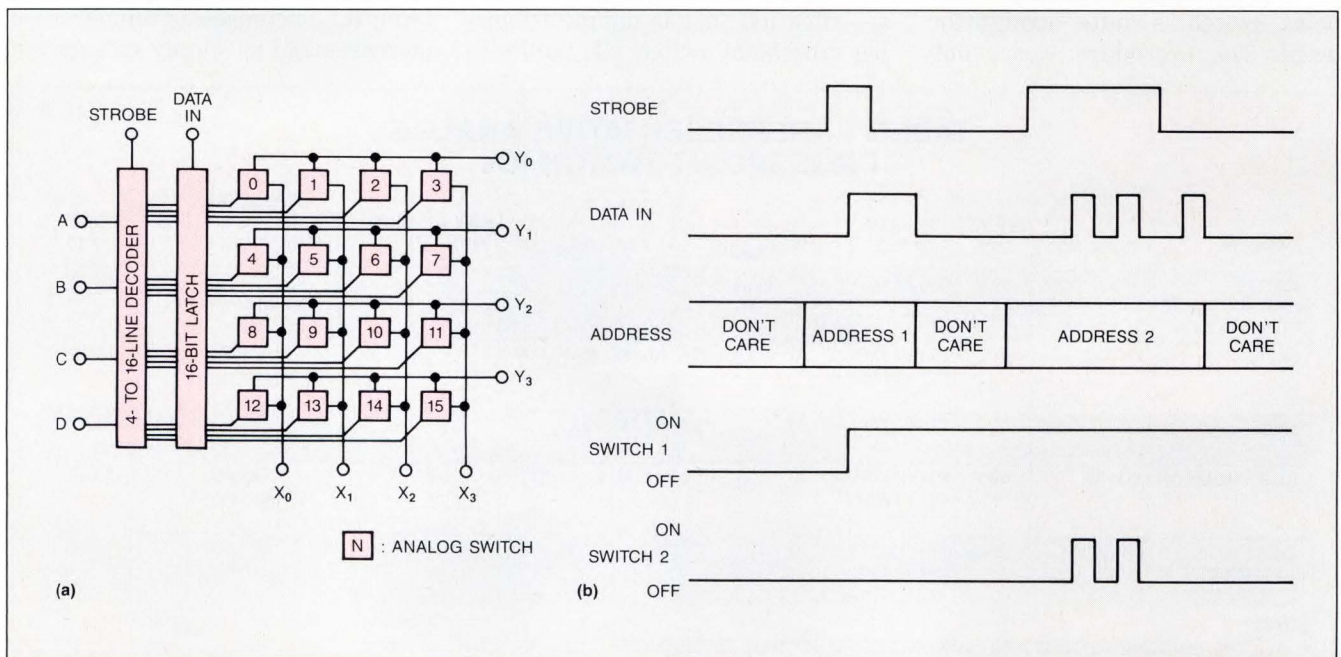


Fig 2—Analog crosspoint switches have the same basic architecture and programming requirements. The NEC μ PD22100C is representative.

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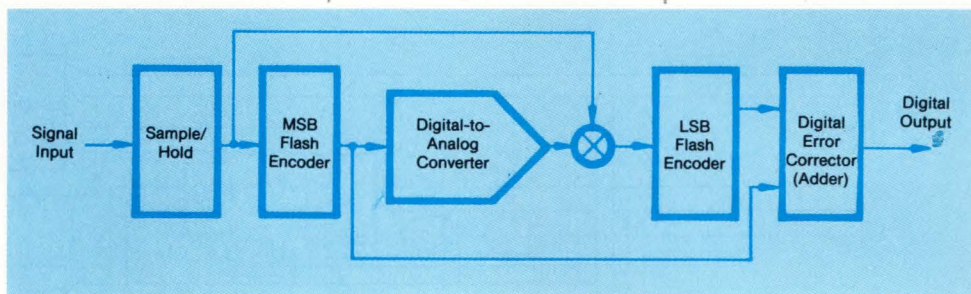
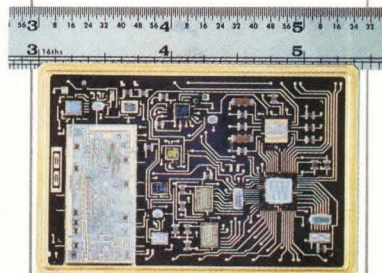
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Small Hybrid Package

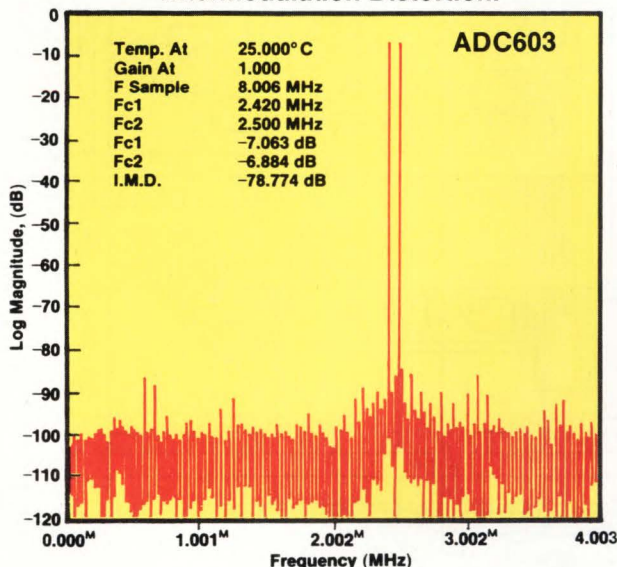
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TECHNOLOGY UPDATE

Crosspoint-switch ICs

ture (Fig 3). It can independently connect each of its 32 CMOS-compatible inputs to one or more of its 32 outputs in a nonblocking fashion. The input-signal frequency can be as high as 50 MHz; the maximum signal skew from input to output is 2 nsec.

The SC11320 chip consists of thirty-two 32:1 multiplexers, one for each output. Each of the outputs also has an associated 6-bit register. The logic levels that you store in the first five bits of the register determine which input channel is connected to that particular output. You can put the output channel's driver into either the high-impedance or the driving state by loading

a 0 or a 1 into the sixth bit of the register.

In addition to these programming features, the IC has a built-in diagnostic function that allows you to monitor the state of the 32 registers. You reconfigure a switch's output by placing its address on the address bus (A bus) and then manipulating the control lines. The time required from when you apply control to when an output bus changes is 85 nsec. The chip comes in a 120-pin pin-grid array and costs \$81.57 (100).

Switch speed is a crucial consideration in applications involving switching systems for fiber-optic communications. Gigabit Logic's

GaAs 8×8 10G050 and 16×16 10G051 digital crosspoint switches are capable of passing 1-GHz and 1.3-GHz signals, respectively. The architecture of these switches includes dual address registers. The 10G050 and 10G051 achieve switch reconfiguration times of 1 and 1.8 nsec by transferring the serially loaded contents of one register into the second in a parallel fashion.

If you're not sure which of the two switches is appropriate for your application, the manufacturer offers an easy rule of thumb. If the number of inputs and outputs falls between 9 and 16, Gibabit Logic recommends the 10G051. In all other cases, it recommends that you use

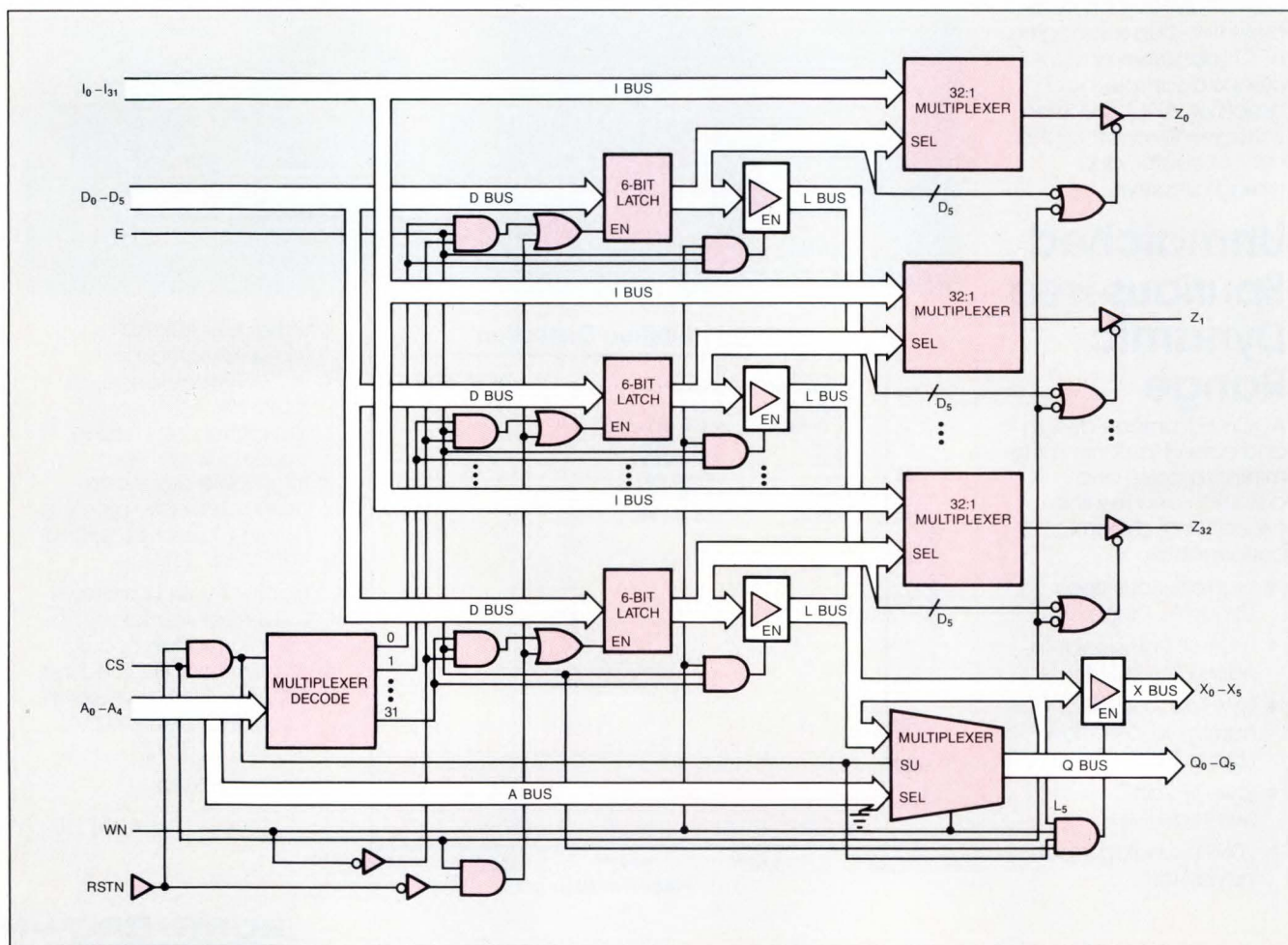


Fig 3—Unlike analog crosspoint switches, digital crosspoint switches don't have a common architecture, though this block diagram of the Sierra Semiconductor SC11320 32×32 digital switch contains many blocks common to the other digital types: multiplexers and registers.

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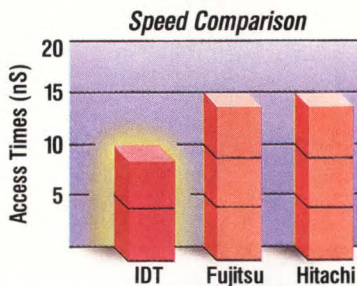
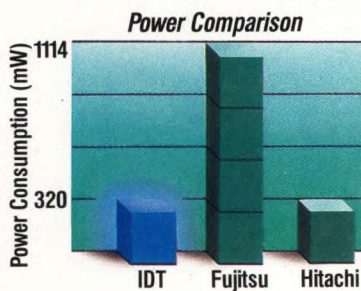
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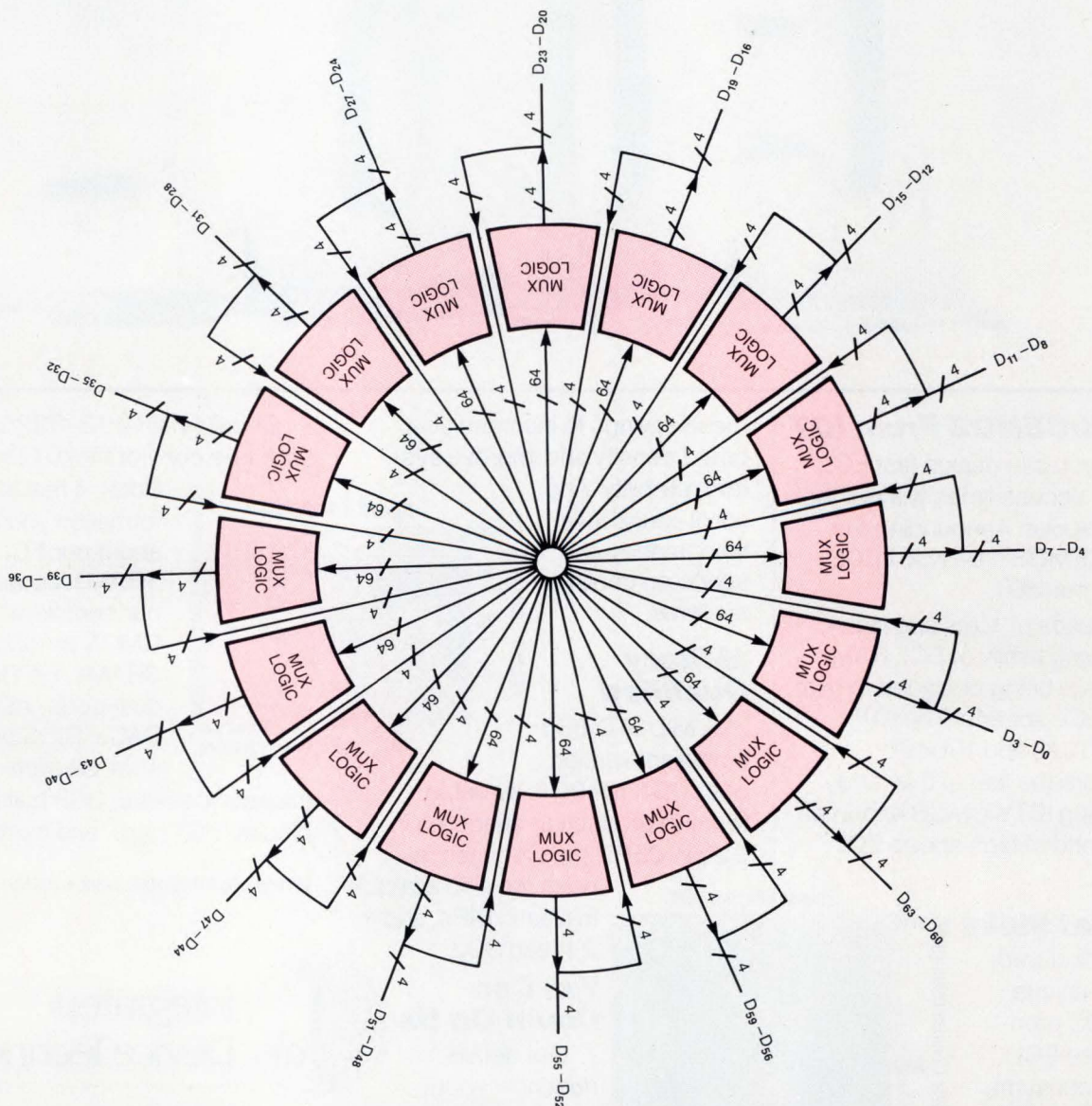
the 10G050, which has an architecture that provides for array expansion with its Expand Data Output lines and Expand Data Input lines. Both switches are compatible with ECL and Picologic signal levels, and both can drive 25Ω loads. The switches are available in either 68-pin PLCCs or unpackaged die form. The 10G050 and 10G051 sell for

\$251.80 and \$266.10 (100), respectively.

Parallel-processing applications require connections between processors, memory, and I/O ports; crossbar switches offer an alternative approach to the other types of bus management such as time-shared buses and multiport memories. The TI SN74AS8840 bipolar

digital crossbar switch, for example, is completely flexible (Fig 4). You can connect any input to any combination of 15 outputs, or the input itself can become an output when you operate it from its own data register.

The switch has 16 separate, 4-bit bidirectional ports and is nonblocking. Data transfers take a maximum





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TECHNOLOGY UPDATE

Crosspoint-switch ICs

of 25 nsec. Each multiplexer group can handle four bits of real-time data or four bits of registered data; you have a choice of passing either type of data to the common data bus. The SN74AS8840 has both hardwired controls and optional programmable control lines that you can use to specify data paths through the switch.

The 8840 does have a disadvantage. It needs two supply voltages: 5V for the logic and 2V for the switch array. If your application can't tolerate this requirement, you may want to consider the TI SN74ACT8841 CMOS switch. It has the same basic architecture as the bipolar 8840, but requires only one 5V supply. The 8840 and 8841 are not pin-for-pin compatible; the 8841 has six additional control inputs. Both are packaged in 156-pin pin-grid arrays; they cost \$70.20 and \$48 (1000), respectively.

Many digital crosspoint switches are designed to be compatible with specific communication networks such as ISDN. Mitel, for example, has developed the ST-Bus (serial telecom bus), a synchronous TDM

(time division multiplexing) serial busing scheme. It operates with 2048k-bps data streams configured as thirty-two 64k-bps channels. This rate and channel structure makes the ST-Bus scheme compatible with all narrowband ISDN transmission bit rates.

Switches work with ISDN

Mitel offers a variety of ST-Bus-based products, among which are the MT8980/81 nonblocking digital crosspoint switches. The MT8980/81 switches can switch PCM-encoded voice or data under microprocessor control. The MT8980 can switch eight serial inputs to eight serial outputs. Each serial input accepts 32 channels of digital data, and each of the 32 channels contains an 8-bit PCM-encoded word—encoded voice, for example. Because the device deals with 8 inputs \times 32 channels' worth of information, the manufacturer refers to the MT8980 as a 256 \times 256-channel switch; it actually contains 65,536 crosspoints.

The MT8981 is a 128 \times 128-channel switch with four serial inputs and four serial outputs, and it con-

sists of 16,384 internal crosspoints. You can put individual channels into a high-impedance state to create larger switching matrices.

Both switches require an 8-kHz frame pulse and a 4.096-MHz clock. If you're not familiar with TDM schemes, think of them in this way: At every frame pulse of 125 μ sec (8-kHz sync rate), information from thirty-two 8-bit channels is clocked into the crosspoint switch. The per-channel bit rate is 8 bps \times 8 kHz, or 64k bps. Because there are 32 channels of 64k-bps information, the actual bit transfer rate is 32 \times 64, or 2048k bps. Note that the switch's required clock rate is twice the bit rate, or 4.096 MHz.

Because of the complexity of the TDM input and output signals, the MT8980 and MT8981 do more than just switch data; they also provide for ST-Bus device control and interprocessor communication. The switches' architecture includes a microprocessor interface. The μ P can read the contents of all of the input channels and can write information to and read information from all of the output channels. You use a con-

For more information . . .

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

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UPDATE

Crosspoint-switch ICs

nection memory block to specify which input path should be connected to what output. The switches are available in either 40-pin plastic DIPs or 44-pin PLCCs. The DIP versions of the MT8980D and MT8990D cost \$11 and \$5.85 (1000), respectively.

SGS Thomson's M088 has operating parameters almost identical to those of the MT8980D. The 256 × 256-channel switch also works with PCM-encoded serial data streams and operates under microprocessor control. The contents that you load into an internal control memory determine the connections between inputs and outputs. Available in a 40-pin ceramic DIP, the M088 costs \$30 (1000).

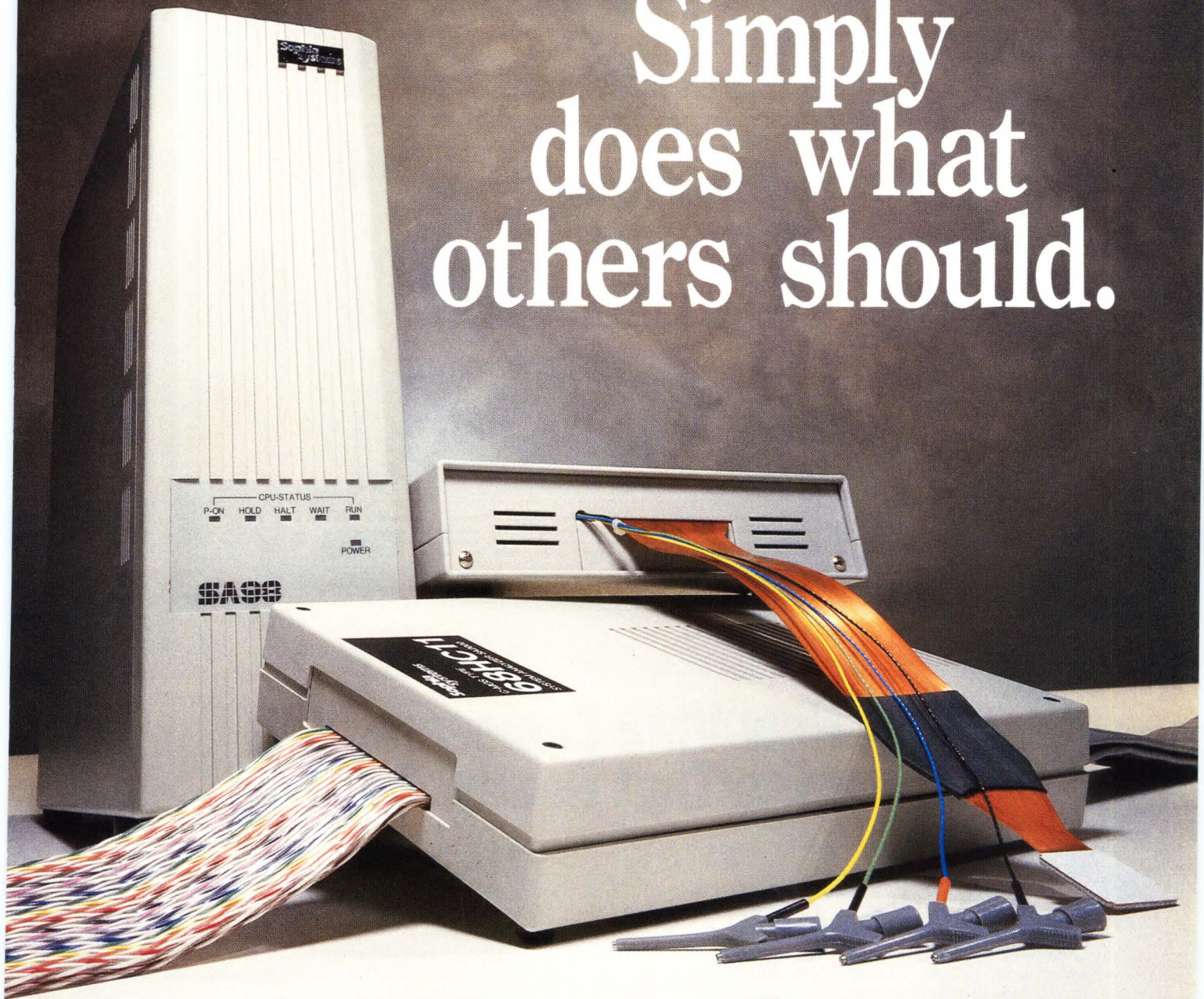
If your system requires really high integration, you should consider the NEC μ PD43501R Time Division Switch (TDSW) chip. The switch operates at 16.384 MHz and can switch 16-bit TDM data to any sequence on 1024 channels. As is true of some of the digital switches discussed above, it can be used in switching networks such as PBXs and the ISDN. The switch is available for \$200 (1000) in a 132-pin pin-grid array.

As you can see, crosspoint switches range from simple to complex. The great number and variety of crosspoint-switch types available certainly supply you with many options for implementing a switching system—analog and digital. **EDN**

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MaxChassis.

The image displays a central MaxChassis unit with its front panel open, revealing 16 vertical slots. The slots are populated with various modules, including a blue circuit board at the bottom. The chassis is surrounded by a large number of additional modules, some of which are labeled with 'MaxChassis' and 'MaxModule'.

1. *Journal of the American Medical Association*, 1997; 277: 1039-1043.

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88

Debugging tool offers combination of modeling, simulation, emulation, and analysis

The Mesa I in-circuit verifier offers a combination of modeling, emulation, simulation, and analysis features to ease the verification and debugging of designs using the Xilinx Logic Cell Array. This debugging tool consists of four parts: a logic pod, a probe and cable assembly, an IBM PC/AT controller board, and Microsoft Windows-based software.

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Because the Mesa I gives you complete control over interconnection between the target PGA and the shadow, you can run your test utilizing signals from your circuit or under software control. You can also direct outputs from the shadow to replace those from the target; this action allows you to test the effects of circuit changes in your system.

You can even use the Mesa I without a target circuit. This feature allows you to verify your design by running test vectors



More than just an in-circuit emulator, the Mesa I combines modeling, emulation, simulation, and analysis functions to use with programmable gate arrays.

through the shadow device. You can also single-step the shadow and monitor its internal states. The pod provides test-probe pins for external signals of the shadow and eases the attachment of other test instruments.

The pod and probe come in 68- and 84-pin versions. The controller board supports as many as four pods, providing power and interface signals to each.

To use the Mesa I, you need an IBM PC/AT or compatible. The computer must have at least 640k bytes of RAM, 1.5M bytes of hard-disk space, and an IBM EGA-compatible display. You can use a mouse, but it's not necessary.

The Mesa I software is compatible with Xilinx design software, allowing you to extract symbolic in-

formation from the design files and permitting you to refer to logic blocks by their symbolic names during debugging. The software's Windows-based user interface simplifies its use. The software also handles configuration of the pod. Because the pod itself is a Logic Cell Array-based design, revisions to Mesa I are incorporated as software updates.

Mesa I costs \$9390; delivery is eight weeks ARO.

—Richard A Quinnell

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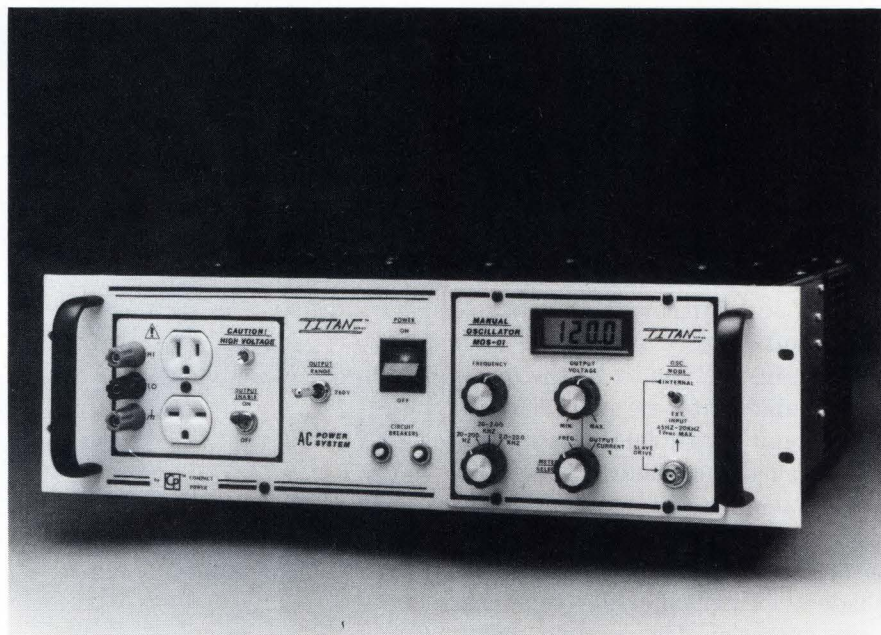
Wideband ac power sources deliver 70 to 82% efficiency across the full output range

The Titan Series of ac power sources consists of the MAC-01, MAC-02, and MAC-03 mainframes, as well as the MOS-01 manual oscillator module and the EIM-01 external input module. By employing patented switch-mode, thick-film, power-hybrid circuitry, the sources realize a 70 to 82% power transfer efficiency across the full output range. They can deliver a stable voltage and current output into any reactive load that have a leading or lagging power factor of 0 to 1.

The MAC-01, MAC-02, and MAC-03 sources operate without excessive heating and shutdown problems. They employ soft-start circuitry to remove all supply-line and power-supply-output current and voltage surges. In the event of an internal fault, a self-diagnostic fault-isolation system shuts down the sources to prevent any catastrophic failures. Furthermore, the thermal-protection circuitry shuts down the sources if the ventilation is blocked; the circuitry automatically resets the units when they cool. All outputs are protected against overload and short-circuit conditions.

The mainframes have an output capability of 1000, 500, and 165 VA, respectively. They have both a 0 to 130 and a 0 to 260V rms output range, which you select via the front-panel switch. The output currents for the two output ranges are 8.0 and 4.0, 4.0 and 2.0, and 1.4 and 0.7A for the MAC-01, MAC-02, and MAC-03, respectively.

Although the mainframes' full-output range is 45 Hz to 15 kHz, their usable frequency range extends to 20 kHz. The units' harmonic distortion is <1% from 45 Hz to 3 kHz and <3% from 3 to 20



To attain efficiencies in the 70 to 82% range, the Titan Series ac power sources employ a patented switch-mode, thick-film hybrid circuit. In addition, the sources feature toroidal magnetics in all critical performance areas to increase their bandwidth and decrease their size and weight.

kHz. The output noise is 60 dB below the full-rated output, and the gain stability is $\pm 0.25\%$ over 72 hours when the line and load regulation and the temperature are constant.

The MOS-01 module plugs into the mainframes and serves as a general-purpose sine-wave oscillator and a digital-readout monitoring system. You can use a single MOS-01 with as many as four MAC-01 mainframes to develop a 4-kVA power source. The module operates over a 20-Hz to 20-kHz frequency range in three switch-selectable, 1-decade scales—20 to 200 Hz, 0.2 to 2 kHz, and 2 to 20 kHz. You can set the front-panel LCD to read the frequency, voltage, or current parameters. Over a full 0 to 50°C operating range, the amplitude and frequency stability figures equal $\pm 0.25\%$ and $\pm 0.5\%$, respectively.

The EIM-01 external input module safely isolates and inputs an external drive signal into the power mainframes. The module accepts inputs from a laboratory oscillator, a programmable oscillator, or an MOS-01 oscillator when operating in slave mode. The EIM-01, which features a 0 to 70°C operating range, has a gain stability of $\pm 0.2\%$ at temperatures from 25 to 50°C.

The MAC-01, MAC-02, and MAC-03 come in gold, irridite-plated, steel main chassis and cost \$1950, \$1250, and \$889. The MOS-1 and EIM-01 modules are priced at \$349 and \$59, respectively. All items in the series include a 1-year warranty.—**Tom Ormond**

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Data-acquisition board for PC bus processes data in real time with DSP IC

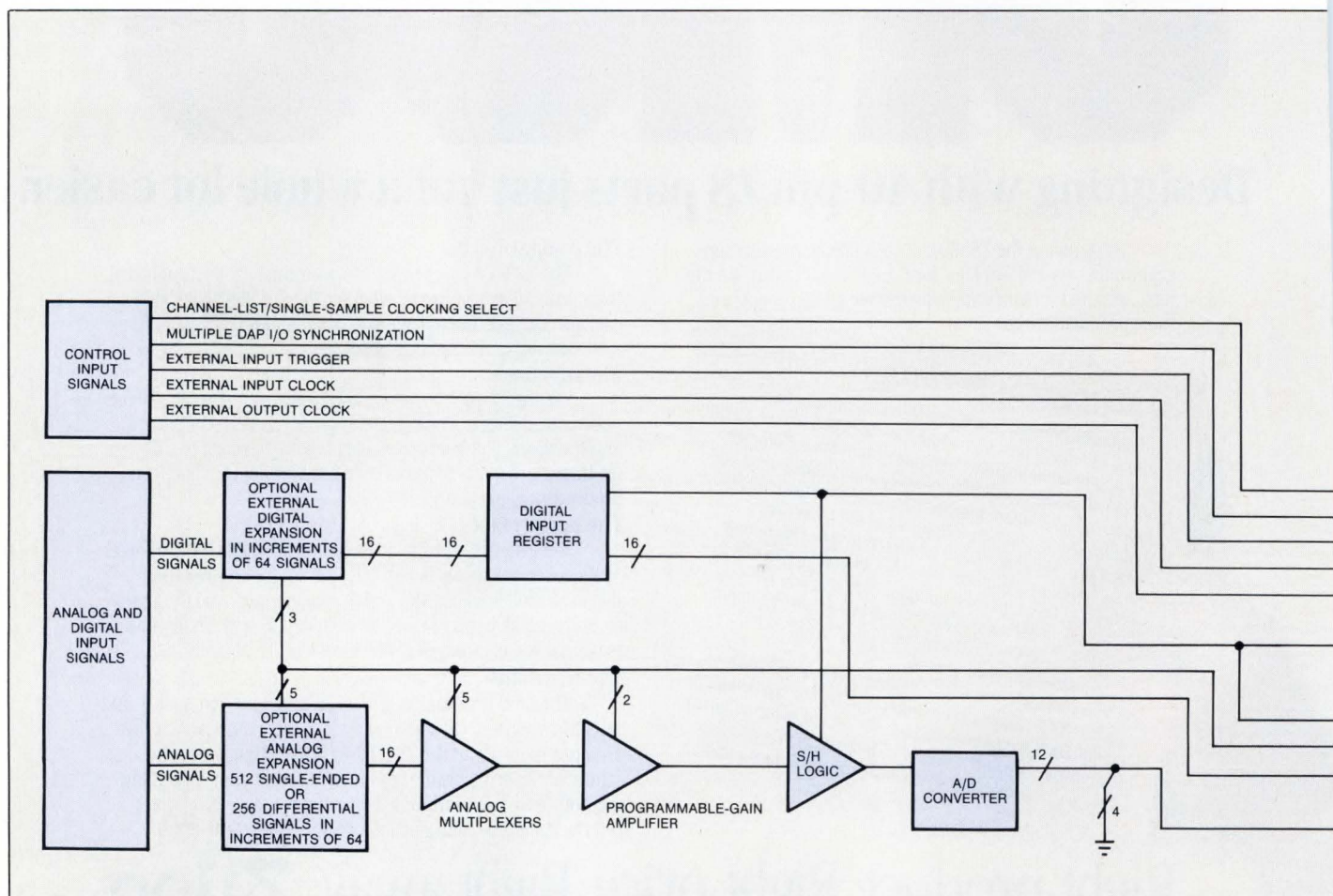
The DAP 2400 add-in data-acquisition board doesn't need to rely on the host PC to process acquired data because it has an Intel 80186 μ P on board as well as a Motorola DSP56001 DSP μ P. The IBM PC's μ P and the slow response time of the MS-DOS operating system can often be a bottleneck for a data-acquisition board that acquires data at rates in excess of 150,000 samples/sec. Although the board acquires data at a high rate, the PC can't process the data in anything close to real time.

The company's proprietary DAPL operating system runs on the 80186 and schedules the accessing of concurrent tasks to the DSP μ P. The DAPL also provides predefined commands for DSP applications, allowing you to command the board to perform DSP tasks such as FFTs and finite-impulse-response filtering without writing any code.

Because the DAP 2400 can generate signals at the same time it's acquiring them, it can acquire both analog and digital signals at rates

as high as 235,000 samples/sec, and concurrently update analog or digital outputs at rates as high as 250,000 values/sec. Analog I/O signals have a 12-bit resolution, and digital I/O signals have a 16-bit resolution.

You can software-select the board's clock source from two separate onboard crystal-controlled clocks or an external clock source. In the channel-list clocking mode, every positive edge of an external clock initiates the conversion of a software-configured series of chan-



Combining an Intel μ P and a Motorola DSP μ P, the DAP 2400 data-acquisition board offloads signal-processing chores from the host IBM PC. The board runs independently of the host under its own operating system, DAPL.

PRODUCT UPDATE

nels. When used with the manufacturer's simultaneous sampling board (basically a 16-channel S/H board), the DAP 2400 can acquire multiple analog signals on a single external clock edge.

Connecting as many as seven DAP 2400s, you can obtain an aggregate sampling rate of 1.64M samples/sec. You can configure the system so that the sampling and output control clocks from a master DAP 2400 serve as external control clocks to the other boards, or alternatively, you can have separate

clock sources for each board.

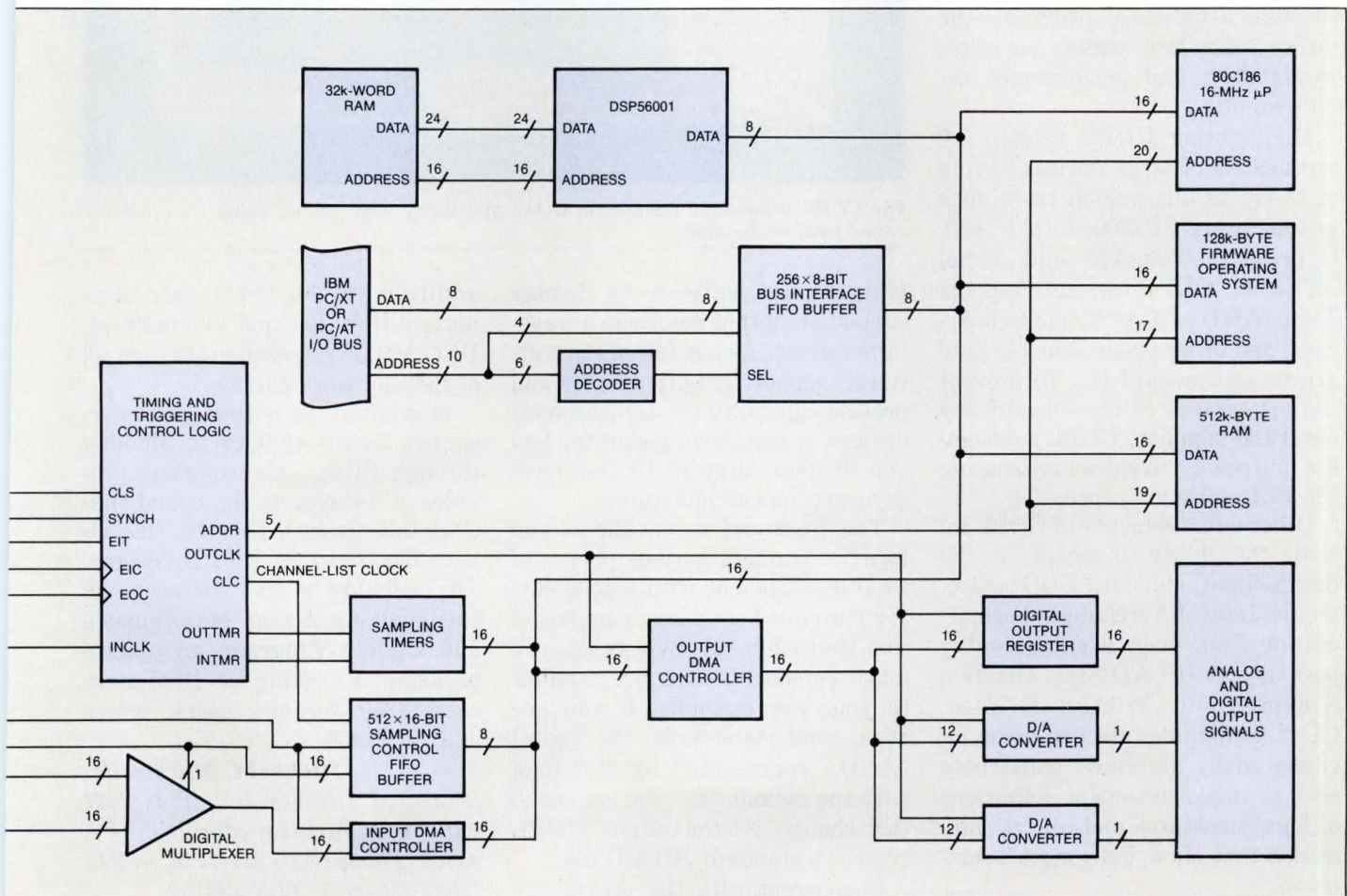
All versions of the board have a 20-MHz DSP56001. The DAP 2400/4, with a 10-MHz 80C186 μ P and a 2k 24-bit static RAM, has an output update rate of 156,000 values/sec and a sampling speed of 156,000 samples/sec. It's capable of a 512-point FFT and sells for \$2400. Priced at \$2800, the DAP 2400/5 features a 16-MHz 80C186 and 8k 24-bit words, is capable of a 2048-point FFT, and has an output update rate of 250,000 values/sec and a sampling speed of 235,000 sam-

ples/sec. The DAP 2400/6 has the same hardware as the 2400/5 version, but has 32k 24-bit words of static RAM, allowing it to perform an 8192-point FFT; it costs \$3200.

—Margery Conner

Microstar Laboratories, 2863 152nd Ave NE, Redmond, WA 98052. Phone (206) 881-4286. TWX 510-601-3473. FAX 206-881-5494.

Circle No 731



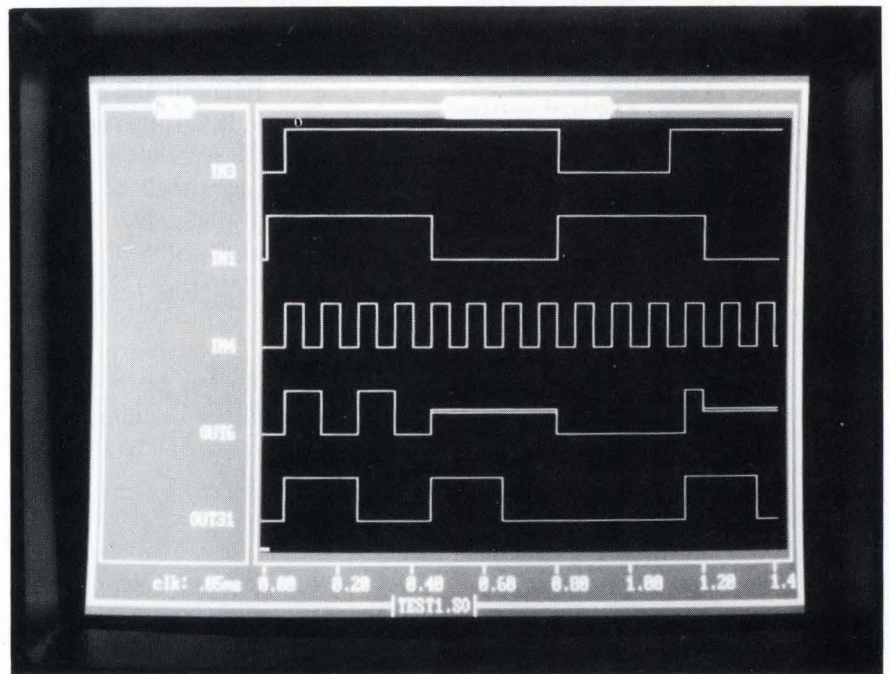
PLD design-tool enhancement simplifies circuit partitioning

One of the bugaboos of PLD design is the question: What is the most cost-effective solution to a particular circuit-design problem? The CUPL version 3.0 enhancement addresses this dilemma by letting you compile the entire design without concern for the architecture of any one PLD. You then perform simulation as a design-verification step. After you're satisfied that the design is correct, CUPL 3.0 creates a symbol table that indicates the PLD resources you need. You can then choose, either manually or through a database program, the device which best meets your price, availability, and performance requirements.

Highlighting CUPL version 3.0 are models of large devices having as many as one million fuses such as the Altera EP1800, Intel 5C180, Cypress CYC330-332, and Atmel ATV2500. CUPL can also support Xilinx/AMD's LCAs (Logic Cell Arrays) and other programmable gate arrays and megaPLDs. To prevent the appearance of bias toward any one PLD supplier, CUPL's designers purposely avoided automating the PLD selection process.

Other enhancements to CUPL include the ability to accept, as the design input, standard EDIF (Electronic Data Interchange Format) output from such graphics entry packages as OrCAD-SDT, Omation Schema, and Wintek HiWire. CUPL's upgraded preprocessor includes many high-level constructs such as single-statement definitions of logic structures and repeat commands that allow indexing of equations.

To aid in design verification, the vendor has added a graphics capa-



The CUPL version 3.0 enhancement lets you verify your design, using the graphical output from the simulator.

bility to the software to display simulation-output results in a waveform format. As a result of the software's support of buried nodes and preload capability for asynchronous devices, a waveform generator lets you simulate large PLDs that have asynchronous architectures.

The front-end menu allows you to move through various phases of PLD development with simple cursor movement or menu commands. The User Definable Syntax lets you make commands that are familiar to you. For example, if you are more comfortable with the logical "AND," represented by "*", than with the default "&," you can make that change. At the output, CUPL creates a standard JEDEC file.

Concurrent with the version 3.0 introduction, CUPL can now run on Apollo and Macintosh hardware in

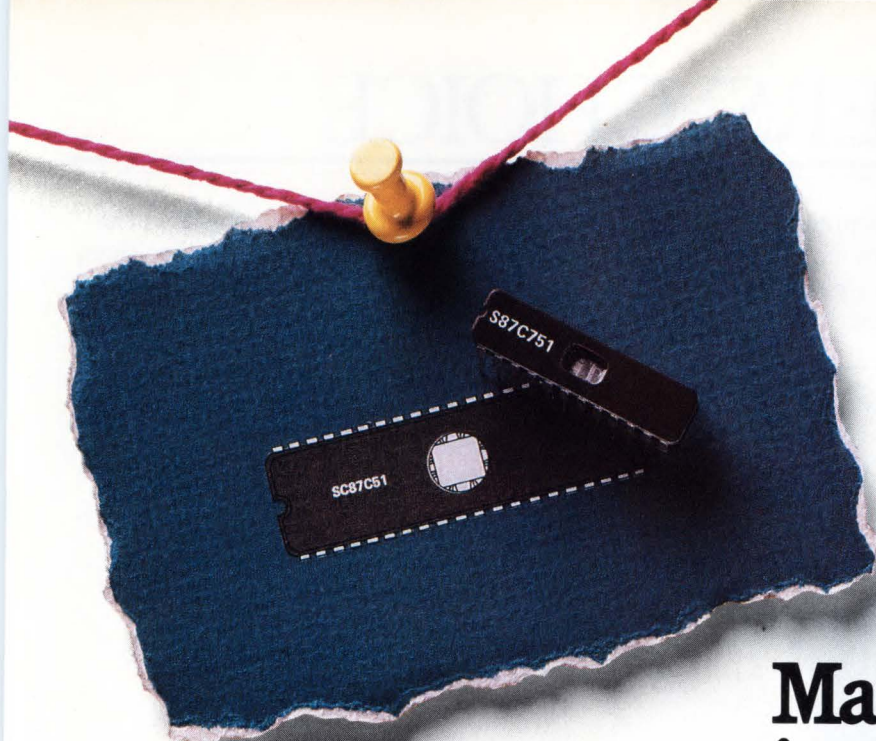
addition to the previously supported IBM PC and compatibles, DEC VMS/VAX computers, and all of the Sun workstations.

In addition to normal customer-service hours of 9 to 5, Monday through Friday, the company provides a 7-day-a-week, round-the-clock bulletin-board system that allows file transfers of PLD designs. The software is free for users on the vendor's 2-year Maintenance and Update Program; an update package for existing MS-DOS users costs \$250; for new users, prices start at \$1250.

—Michael C Markowitz

Logical Devices Inc, 1201 NW 65th Pl, Fort Lauderdale, FL 33309. Phone (800) 331-7766; in FL, (305) 974-0975. TLX 383142.

Circle No 733



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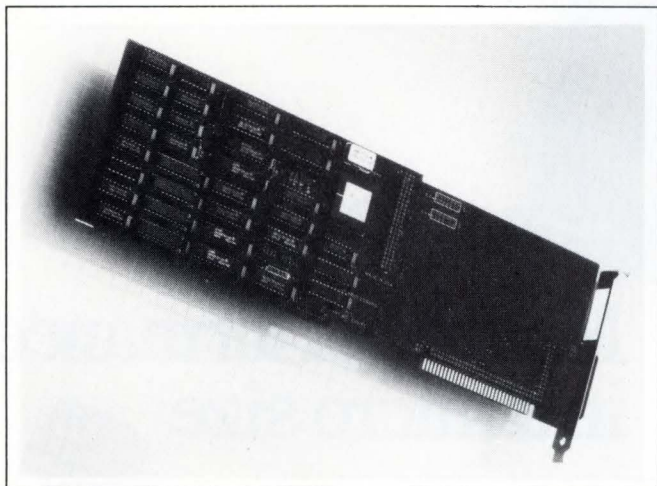


PHILIPS

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READERS' CHOICE

Of all the new products covered in EDN's **September 15, 1988**, issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, use EDN's Express Request service, or refer to the indicated pages in our **September 15, 1988**, issue.



◀ DSP DEVELOPER

The Chimera system is a DSP developer for TI's TMS320C25. The system's mother board provides a 16k-word memory for programming and data storage (pg 287).

Atlanta Signal Processors Inc.

Circle No 605

HALL-EFFECT IC

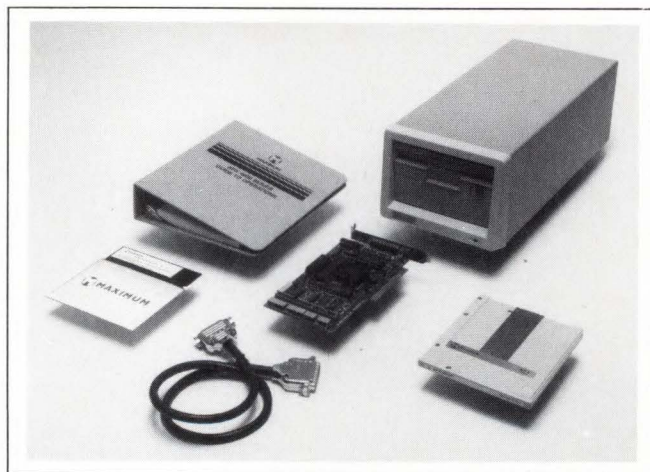
The TLE4910K Hall-effect IC produces an output voltage that is proportional to the flux density of its surrounding magnetic field (pg 271).

Siemens AG.

Circle No 603

Siemens Components Inc.

Circle No 604



▲ WORM DISK DRIVE

The full-height, 5¼-in., APX-4000 optical WORM (write-once, read-many) disk drive stores 244M bytes on each side of a 2-sided disk, providing a total storage capacity of 488 bytes (pg 125).

Maximum Storage Inc.

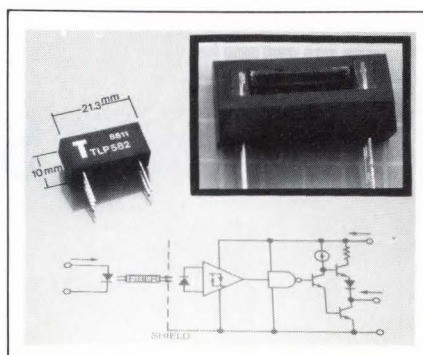
Circle No 601

LANGUAGE TRANSLATOR

QPARSER+ can automatically construct the syntax trees that are needed in order to translate from one programming language to another and provides a technique for the resolution of grammatical conflicts (pg 300).

QCAD Systems Inc.

Circle No 606

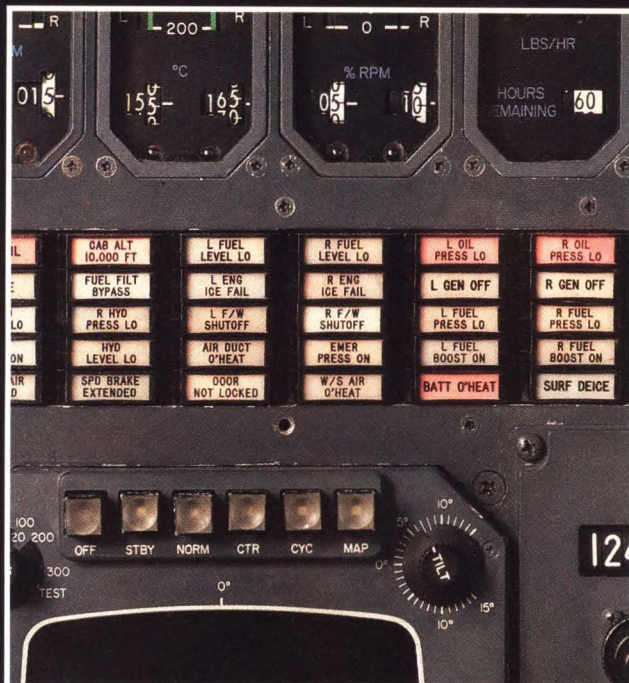


◀ PHOTOCOUPLER

The TLP582 photocoupler's design features a 0.5-in.-long optical fiber between the emitter and the detector, which, in essence, increases the separation distance between the two (pg 255).

Toshiba America Inc.

Circle No 602



Before



After

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LEADTIME INDEX

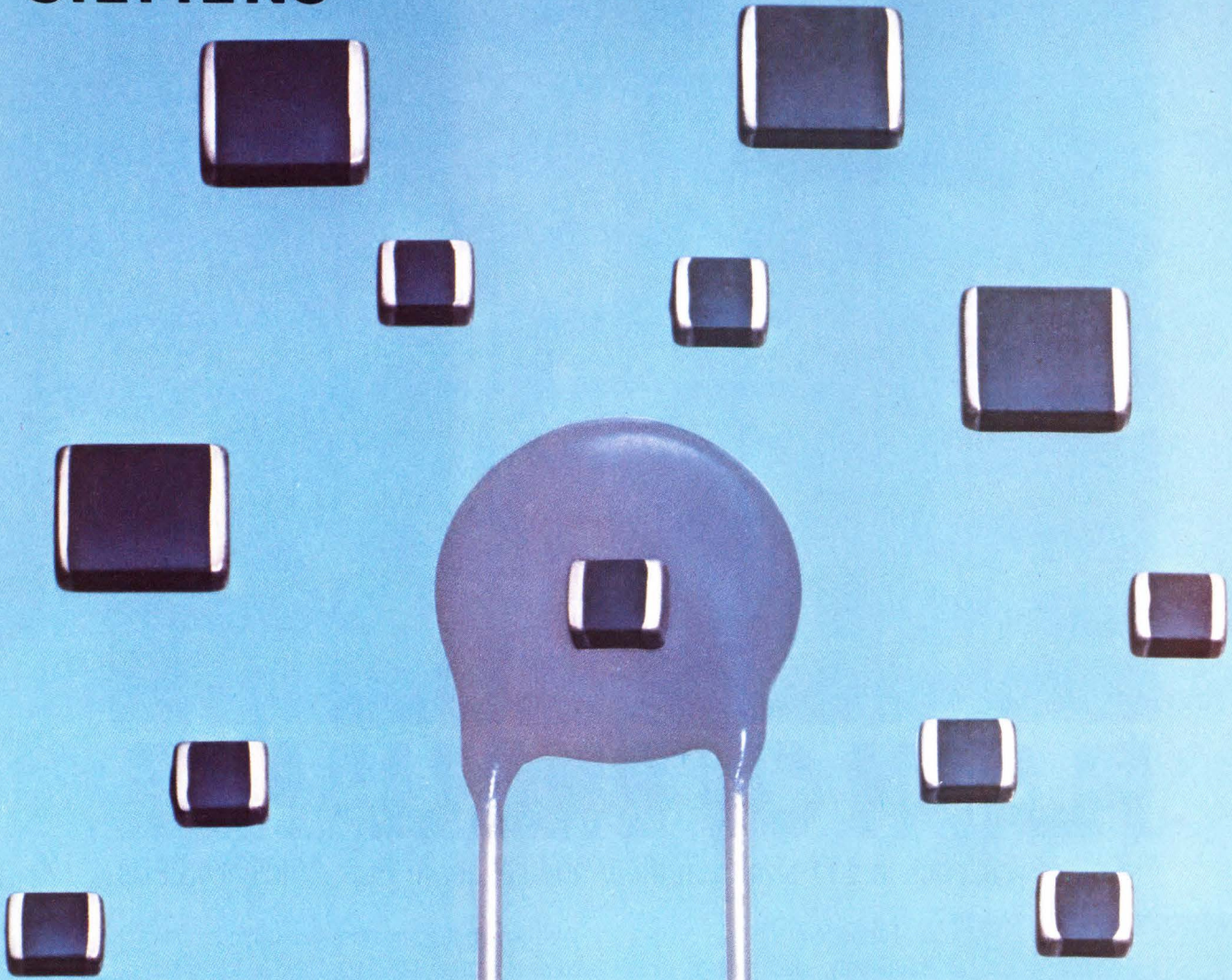
Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Last month's average (weeks)	Average (weeks)
TRANSFORMERS								
Toroidal	0	11	67	11	11	0	10.1	7.7
Pot-Core	7	8	57	21	7	0	9.8	8.9
Laminate (power)	0	25	67	8	0	0	7.3	5.8
CONNECTORS								
Military panel	0	25	37	13	25	0	12.0	7.5
Flat/Cable	36	35	29	0	0	0	3.3	4.4
Multi-pin circular	10	20	50	20	0	0	7.6	6.1
PC (2-piece)	15	38	38	0	9	0	6.4	4.6
RF/Coaxial	14	36	43	0	7	0	6.3	4.1
Socket	21	42	32	0	5	0	5.0	4.1
Terminal blocks	15	38	38	9	0	0	5.5	3.7
Edge card	9	36	55	0	0	0	5.4	5.8
D-Subminiature	18	55	27	0	0	0	3.8	4.7
Rack & panel	0	30	60	0	10	0	8.2	5.1
Power	27	18	45	0	10	0	6.6	7.1
PRINTED CIRCUIT BOARDS								
Single sided	0	70	24	6	0	0	4.9	4.7
Double sided	0	59	41	0	0	0	5.0	5.4
Multi-layer	0	28	55	17	0	0	7.8	8.0
Prototype	0	63	37	0	0	0	4.8	3.9
RESISTORS								
Carbon film	43	19	24	14	0	0	4.6	4.9
Carbon composition	48	23	24	5	0	0	3.3	3.6
Metal film	35	30	30	5	0	0	4.0	4.0
Metal oxide	14	50	15	21	0	0	5.9	4.2
Wirewound	12	41	35	12	0	0	5.8	4.4
Potentiometers	18	55	18	9	0	0	4.4	4.7
Networks	25	45	20	10	0	0	4.4	4.4
FUSES								
	61	22	11	6	0	0	2.4	2.6
SWITCHES								
Pushbutton	22	22	50	6	0	0	5.5	4.9
Rotary	13	31	44	6	6	0	6.9	5.7
Rocker	27	27	39	7	0	0	5.0	5.5
Thumbwheel	0	40	40	20	0	0	7.4	6.1
Snap action	0	36	45	19	0	0	7.6	6.5
Momentary	14	36	36	14	0	0	6.1	5.2
Dual-in-line	23	16	38	23	0	0	7.0	4.9
WIRE AND CABLE								
Coaxial	35	29	29	7	0	0	4.2	3.7
Flat ribbon	42	32	26	0	0	0	3.0	3.0
Multiconductor	30	30	40	0	0	0	4.0	3.7
Hookup	48	38	14	0	0	0	2.2	2.4
Wirewrap	45	25	25	0	0	5	4.3	3.4
Power cords	29	29	37	5	0	0	4.6	4.1
POWER SUPPLIES								
Switcher	14	28	29	29	0	0	7.6	8.1
Linear	23	23	23	23	0	8	8.5	8.1
CIRCUIT BREAKERS								
	11	33	33	23	0	0	7.1	5.4
HEAT SINKS								
	16	47	32	5	0	0	4.7	4.2
BATTERIES								
Lithium coin cells	21	36	36	7	0	0	5.0	5.5
9V alkaline	70	10	10	10	0	0	2.6	2.8
Real-time clock back-up	0	29	57	14	0	0	7.6	3.6
RELAYS								
General purpose	18	24	34	24	0	0	7.1	3.9
PC board	6	25	31	31	7	0	9.8	4.8

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Last month's average (weeks)	Average (weeks)
DISCRETE SEMICONDUCTORS								
Dry reed	0	14	29	57	0	0	11.5	6.8
Mercury	0	20	20	60	0	0	11.4	7.6
Solid state	0	19	18	45	18	0	13.5	4.2
DISCRETE SEMICONDUCTORS								
Diode	36	24	8	24	4	4	7.3	4.6
Zener	39	27	0	28	0	6	7.0	5.2
Thyristor	8	16	38	38	0	0	9.4	6.5
Small signal transistor	28	17	17	32	6	0	8.3	5.0
MOSFET	25	17	17	41	0	0	8.2	6.9
Power, bipolar	40	20	20	20	0	0	5.3	4.5
INTEGRATED CIRCUITS, DIGITAL								
Advanced CMOS	25	19	37	13	0	6	7.4	6.1
CMOS	18	45	9	23	0	5	7.1	4.3
TTL	27	36	14	23	0	0	5.7	3.7
LS	33	39	6	22	0	0	5.0	3.3
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	22	33	23	22	0	0	6.2	4.9
OP amplifier	36	36	7	21	0	0	4.8	5.2
Voltage regulator	25	19	19	31	6	0	8.4	4.1
MEMORY CIRCUITS								
DRAM 16K	0	29	14	43	14	0	12.2	7.7
DRAM 64K	0	37	25	25	13	0	10.2	7.8
DRAM 256K	0	38	31	16	15	0	9.9	11.5
DRAM 1M-bit	0	19	36	18	27	0	13.1	11.5
SRAM 4K x 8	0	0	40	0	60	0	18.5	11.9
SRAM 8K x 8	0	12	33	22	33	0	14.8	15.2
SRAM 2K x 8	0	0	29	29	42	0	17.5	10.4
ROM/PROM	0	25	37	38	0	0	9.5	7.3
EPROM 64K	18	27	18	27	0	10	9.5	7.5
EPROM 256K	25	17	25	25	0	8	8.8	8.0
EPROM 1M-bit	0	0	50	25	25	0	14.2	9.7
EEPROM 16K	0	17	33	50	0	0	10.8	9.9
EEPROM 64K	0	0	43	43	0	14	14.4	7.9
DISPLAYS								
Panel meters	0	23	44	33	0	0	9.3	7.2
Fluorescent	0	0	49	38	13	0	13.1	8.4
CRT 12-inch monochrome	0	0	50	50	0	0	11.7	7.7
LED	7	33	33	20	0	7	8.8	4.6
Liquid crystal	0	10	60	30	0	0	9.7	8.5
MICROPROCESSOR ICs								
8-bit	14	36	21	29	0	0	7.2	8.6
16-bit	6	35	24	29	6	0	8.9	8.9
32-bit	10	30	30	30	0	0	7.9	9.2
FUNCTION PACKAGES								
Amplifier	18	18	27	18	10	9	10.8	7.0
Converter, analog to digital	8	17	33	25	0	17	12.2	9.4
Converter, digital to analog	10	10	50	20	0	10	10.4	8.9
LINE FILTERS								
	8	33	25	25	9	0	9.1	8.1
CAPACITORS								
Ceramic monolithic	22	26	35	13	0	4	6.8	4.9
Ceramic disc	37	31	11	16	0	5	5.8	5.5
Film	27	33	7	33	0	0	6.6	5.5
Aluminum electrolytic	33	29	14	24	0	0	5.7	5.3
Tantalum	29	38	14	19	0	0	5.2	5.3
INDUCTORS								
	13	13	42	13	0	19	11.6	6.8

Source: Electronics Purchasing Magazine's survey of buyers.

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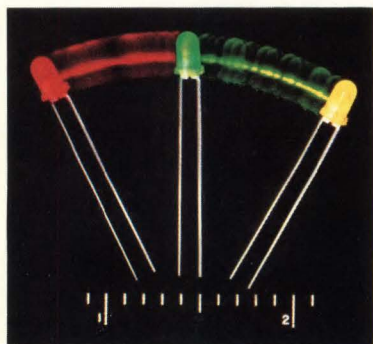
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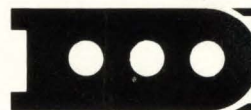
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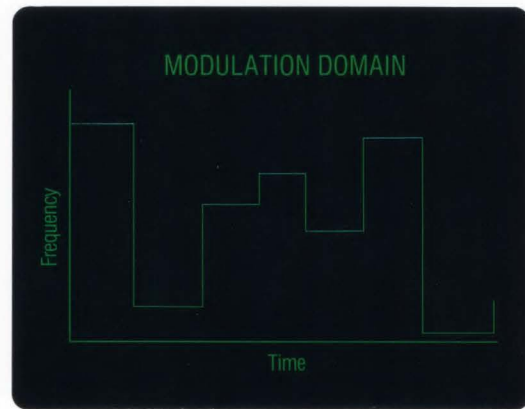
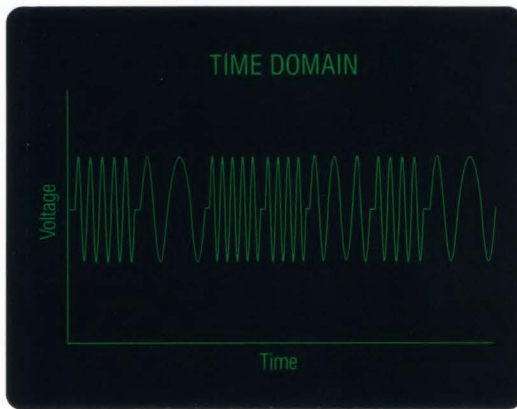
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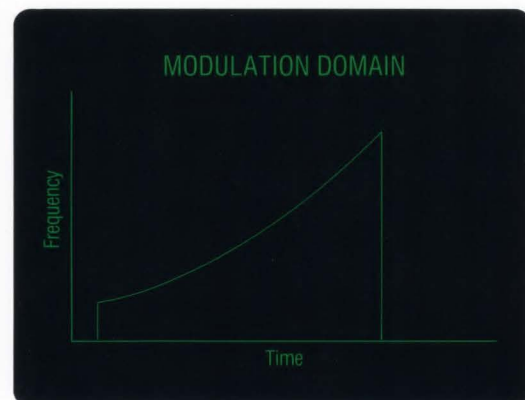
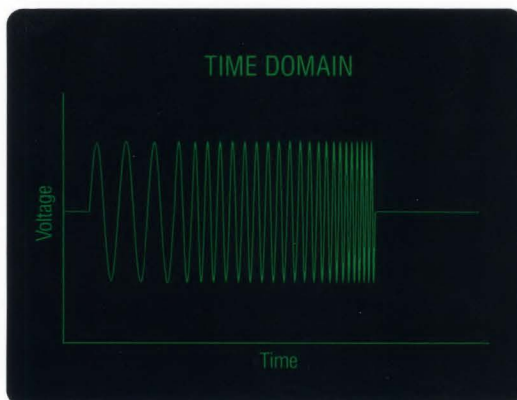
hop, hop, hop, hop
chirp, chirp, chirp
jitter, jitter, jitter

...like you've never seen them before.



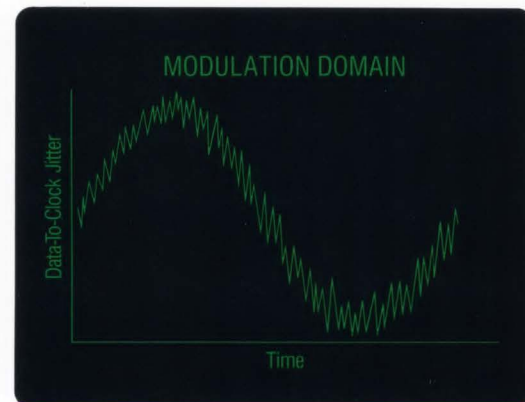
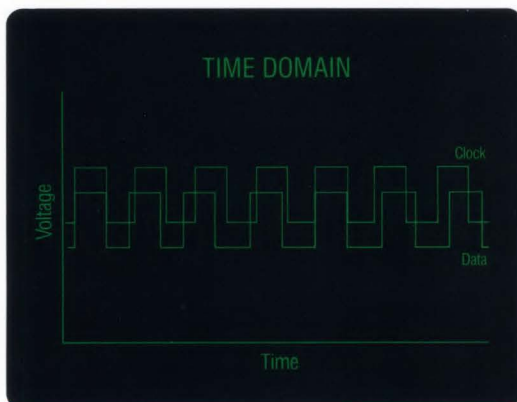
hop

...a time-domain view of a frequency-agile signal (left) reveals little useful information. The new modulation-domain view on the right clearly shows the hopping sequence, settling times, and channel frequencies.



chirp

...no quantitative data is available from the time-domain view of a radar chirp on the left. However, the frequency vs time display of this single-shot event clearly shows chirp linearity and frequency.



jitter

...a time-domain view of jitter shows only that the jittered data's edge is constantly changing with respect to the clock. In the modulation domain, the jitter magnitude and periodic content are clear.

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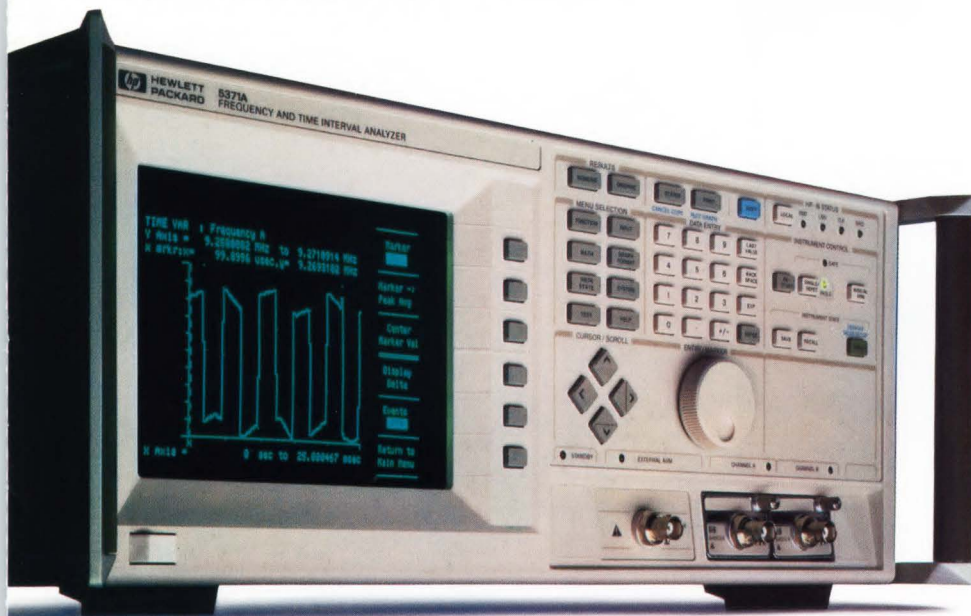
Of course you can combine the HP 5371A with other test instruments and computers via the HP-IB for enhanced capability. It will also drive HP printers and plotters directly for hard-copy records. And a variety of accessories and options are available to match your specific application.

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Like its predecessors — scopes and spectrum analyzers — the frequency and time interval analyzer is sure to give designers greater insight into system problems, and provide dramatic savings in product development and manufacturing. That's the best reason yet to explore the modulation domain. So mail the attached reply card today. Or, better yet, call 1-800-752-0900, Ext. 215U. Now, it's up to you.



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What if...

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Totally new measurement concepts are rare. The oscilloscope was one. It brought the time domain to voltage measurements. Spectrum analysis, which added the frequency domain, was another. Now, there's a breakthrough that puts you in the modulation domain. Dynamic frequency and time interval analysis.

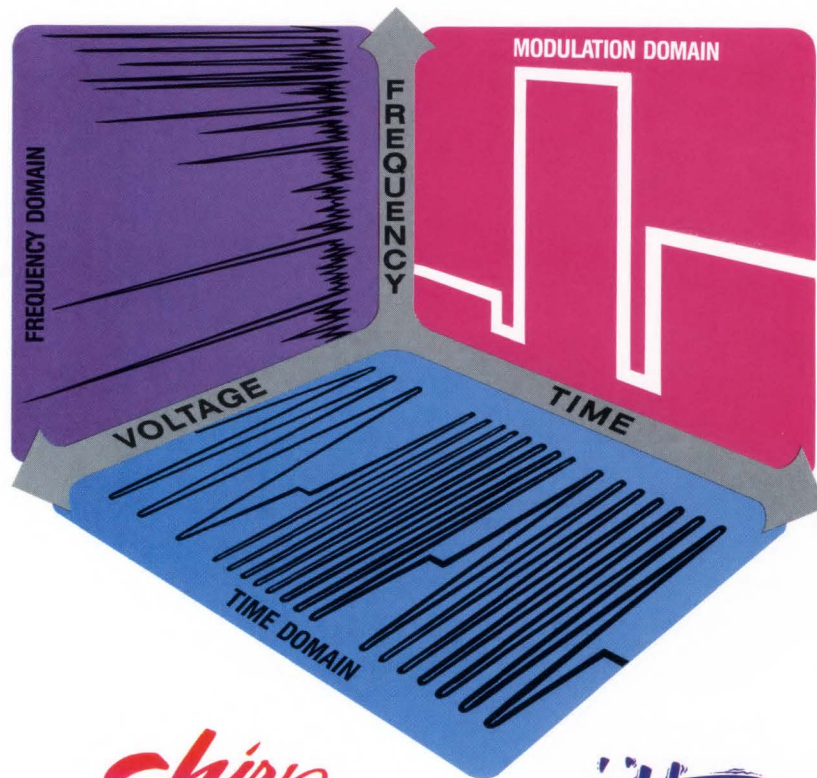
The new HP 5371A Frequency and Time Interval Analyzer gives you entirely new ways to view dynamic signals. Views that simplify and speed analysis of transient signals, modulation, and frequency stability. As well as time transients, jitter, and timing relationships between signals. If you're designing equipment for communications, radar, mass storage, data processing, and ATE, the HP 5371A gives you new insights for faster troubleshooting and characterization.

hop

...agile radio measurements that were impossible until now.

Say goodbye to static back-to-back and "golden unit" testing that's been costing you time and money without delivering the quantitative measurements you need.

Complete characterization of hopping radio transmitters is easy for the HP 5371A. Its dynamic single-shot capability captures hopping sequence, carrier frequencies, and modulation. Then it displays signals in a frequency vs time plot for quantitative measurements of overshoot and settling time (valuable for VCO signals too). You can also examine FM details. And, histogram displays give a clear picture of channel usage.



chirp

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Histogram displays and statistics of frequency or time interval show you quickly whether jitter effects are Gaussian or systematic. These results reveal valuable information leading to the prediction of bit error rate. And modulation domain displays give you a useful view of jitter periodicity. An FFT of this data gives you a jitter spectrum. With the HP 5371A, you can troubleshoot faster and get better characterization of timing jitter than ever before.

See the back page for more information.

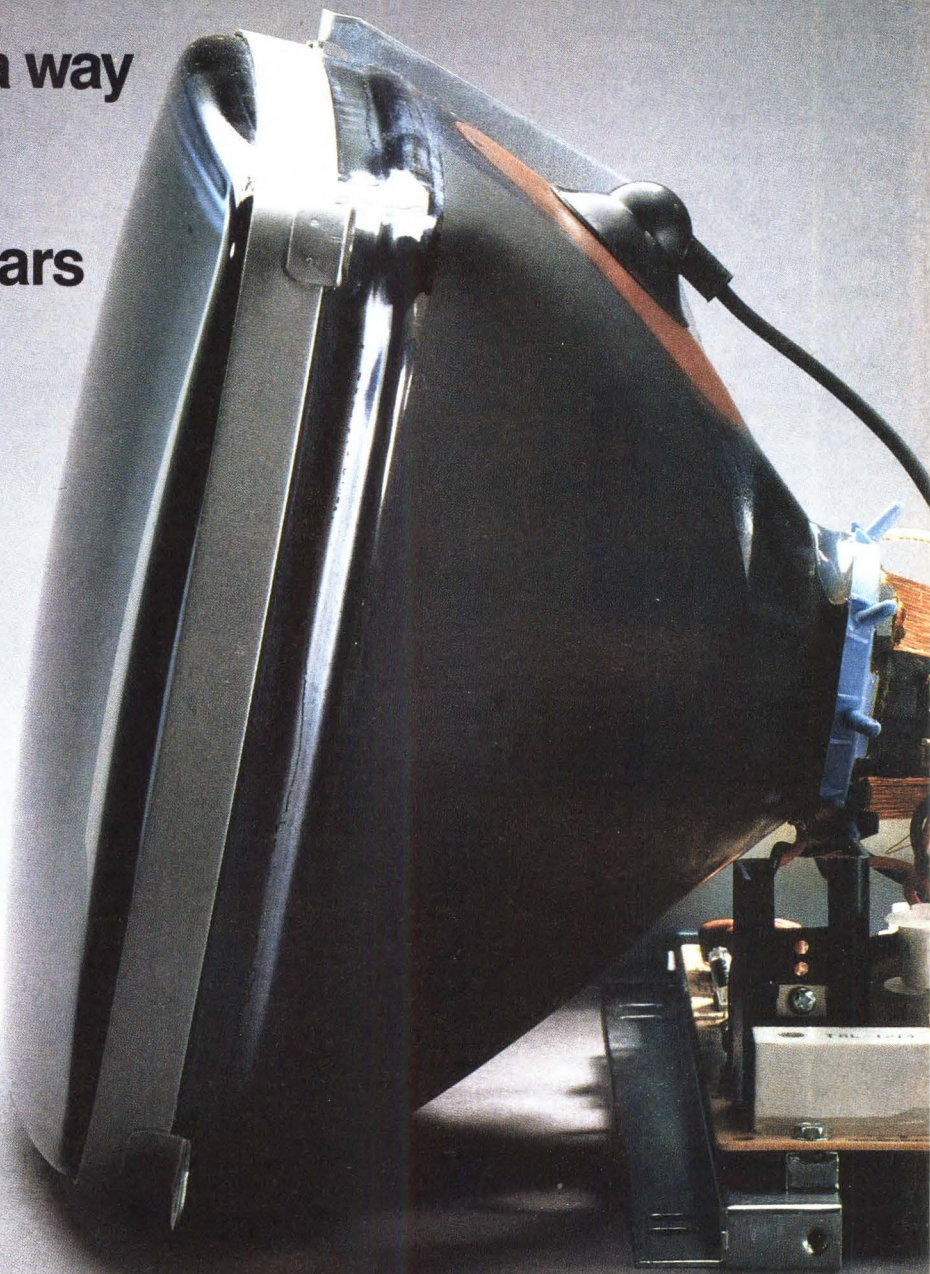
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Finally, you can go all out for system performance without being forced to use low-density SRAMs. This new device has an access time of only 15 nanoseconds. Yet it has the storage capacity of four 64-kbit ECL chips in one-fourth the space.

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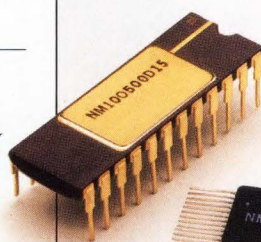
In worst-case testing, power dissipation stays below a single watt. In typical applications, it's only 600 to 700 milliwatts.

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What makes it all possible is National's proprietary BiCMOS III one-micron process, which combines the speed of pure bipolar with the high density, low power, and manufacturability of CMOS.

It gives you the best ratio of

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ECL SRAMs
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And we designed reliability into the process from the beginning. In fact, one-third of the development team had reliability as their sole responsibility.

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Because of its stable memory cell, the 256-kbit SRAM tolerates skewed address signals without disturbed bits.

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DOT-MATRIX



DISPLAY MODULES

Although most of the trade-press coverage of digital displays has concentrated on design activity involving high-resolution flat-panel devices, many applications don't need 25-line \times 80-character capability. For these applications, dot-matrix display modules suffice.

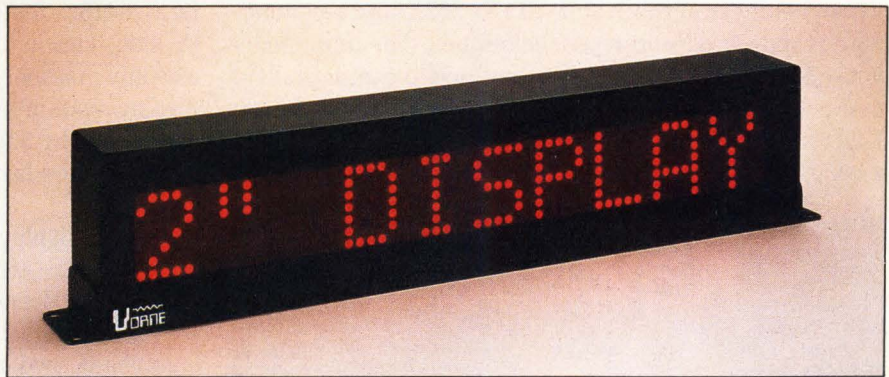
Tom Ormond, Senior Editor

The need to display short scrolling messages is a requirement for a plethora of applications—factory networks, assembly operations, benchtop instrumentation, telecommunications equipment, medical apparatus, automobile dashboards, appliances, and home-entertainment systems. Dot-matrix-display manufacturers supplying products to satisfy the needs of these message-display applications are using many different technologies and more and more onboard electronic intelligence to meet the performance needs of their customers. The four prevalent technologies are LED, LCD, vacuum fluorescent, and plasma.

Probably the primary reason for the staying power of LED display technology, which first made its debut over 20 years ago, is its high-luminance-level output. Aside from this attribute, LED displays also offer a good viewing angle: in excess of a 150° cone. And they are relatively easy to drive. Unfortunately, LED-based displays do consume a lot of power—typically 50 to 100 mW per LED—so they're not usually the optimum solution for portable applications.

The Model LT1441M from Sharp Electronics is side-by-side and end-to-end stackable, which makes it well suited for both indoor and outdoor display applications. The display is configured as a 16 \times 16 LED matrix. Although you can develop two 5 \times 7 or 7 \times 5 characters

within the matrix field if your application demands it, the LT1441M is essentially a 1-character or graphics-type display unit. Typical luminescence intensities span the 120- to 130-mcd range, making the LT1441M extremely visible and easy to read. The dot-matrix display's dichromatic LEDs produce red and green-orange-yellow light. Built-in shift registers, latch cir-



Capable of displaying ten 2-in. characters, the Vorne GY2200 module is ideal for applications where long-distance readability is a prime consideration. The unit can retransmit received data as is or convert the data to a different communications standard.

cuits, and low-power CMOS drive circuits control and generate the red and green/orange-yellow colors.

The display module is completely prepackaged—measuring 6.25 \times 6.25 \times 2.25 in.—and comes ready to plug in, program, and play. To operate, it requires only a 5V supply and a serial control input; the operating range spans -10 to +75°C. The LT1441M costs \$545.20.

Hewlett-Packard's 8-character, 5 \times 7-dot matrix LED HDSP-211X/212X Series is outstanding for its diverse programming options and many capabilities. First of all, you have a choice of colors: yellow, high-efficiency red, or high-efficiency green. Because the displays are wave solderable and end stackable, you

Let your fingers do the talking. A dot-matrix display that incorporates vacuum-fluorescent and infrared-touchscreen technology simplifies the user/display interface. (Photo courtesy IEE Inc; photography by Chuck Piscitello)

LED display modules have a wide viewing angle, are easy to drive, and have high output luminance, but they consume a great deal of power.

can develop displays that satisfy a variety of multidigit applications.

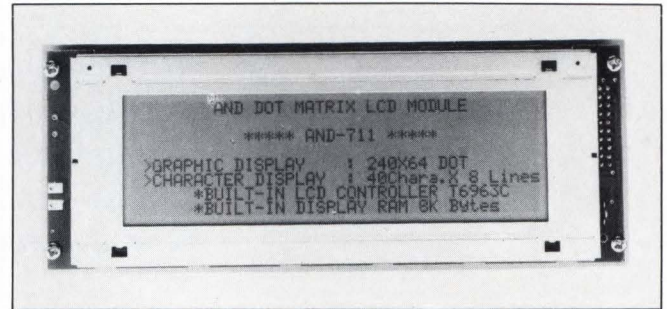
Each smart display features an onboard CMOS IC, built-in RAM, a character-set decoder, and LED drivers. The onboard CMOS IC can decode 128 ASCII characters (Models -2111/-2112/-2113) or 128 Katakana characters (-2121/-2122/-2123) and permanently store them in ROM. You can also use the onboard RAM to store 16 user-definable and -programmable symbols or characters. Seven brightness levels provide some flexibility in adjusting display intensity and power consumption.

An 8-bit control-word register provides access to the following user-programmable functions: self-test, clear, individual flashing characters, full-display blinking, and multilevel dimming and blanking. The lowest three bits control the brightness function. Bits 3 and 4 control the flash function and the blink function, respectively. Bits 5 and 6 handle the self-test functions, and bit 7 takes care of the clear function.

All members of the HDSP-211X/-212X line accommodate standard μ P-interface techniques. The units guarantee full TTL compatibility, read/write compatibility, and a high degree of ESD immunity. Like the Sharp LED display module, these displays also operate from a single 5V supply. They have a free-air operating



Particularly well suited for outdoor applications, the LT144M display module from Sharp uses a 16 \times 16 grid of dichromatic LEDs. Onboard electronics allows you to use multiple modules to create displays containing a combination of graphics and characters.



In addition to an integral character-generator ROM, the AND711AST LCD module from AND features an onboard controller, drivers, and 8k bytes of display RAM.

range of -20 to $+70^{\circ}\text{C}$. Hewlett-Packard charges \$39.60 (250) for Series HDSP-212X display modules.

Segment-type devices are on the way out

Siemens designed its Domino family of 4-digit dot-matrix LED displays to replace segment-type devices. The newest members of the family, the DLR/DLO/DLG 3416s, feature a 50° cone (X axis) and 75° cone (Y axis) viewing angle, and are end stackable. You can use any number of DLR/DLO/DLG 3416s to build a display system because each digit is independently addressable. In addition, each digit continues to display the character last stored until it's replaced by another character.

All the displays feature a CMOS IC, which contains memory, an ASCII ROM decoder, multiplexing circuitry, and drivers. Data entry is asynchronous. System interconnection is very straightforward. The least significant two address bits (A_0 and A_1) connect to similar inputs of all displays in the system; using four chip-enable signals, you can readily interconnect as many as four displays without using a decoder. Data lines and the write line connect to all DLR/DLO/DLG 3416s directly and in parallel; each display then behaves as a write-only memory. The cursor function causes all the dots making up a digit position to illuminate at a 50% brightness level. The cursor is not a character, so once it moves the previous digit reappears at the full brightness level.

To ensure that the modules will function in high-stress-assembly and -application environments, the displays go through a 100% burn-in process. Each display has a blanking capability, which allows you to dim the display and affords flexibility. A clear function simultaneously clears the cursor RAM and the ASCII-character RAM. The character set consists of 128 ASCII characters; language options are English, Ger-

man, Italian, Swedish, Danish, and Norwegian. The DLR/DLO/DLG 3416s run off of 5V supplies and withstand temperatures of -40 to $+85^{\circ}\text{C}$. The green DLG 3416 costs \$23.60 (1000).

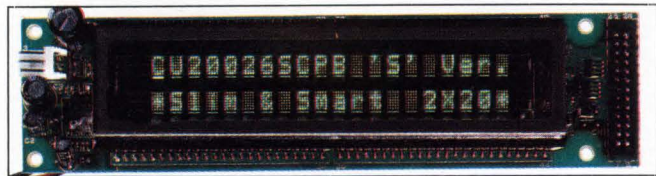
A display that's easy to see

Vorne's GY2200, a serial-input alphanumeric LED display, is designed to extend user-port capabilities. Measuring $20 \times 4.375 \times 2.4$ in., the stand-alone unit comprises a highly visible display with large 2-in.-high, 5×7 -dot-matrix characters. You can assign as many as 98 discrete addresses to individual displays or groups of displays for factory-network applications. Internal rotary DIP switches provide for address selection. The display can retransmit serial data and even internally convert data to a different communication standard to ease multidrop installation or peripheral interfacing. A plug-in communication board establishes the status of both the received and the transmitted data. In contrast to the majority of LED displays, the GY220 requires a 120V ac source.

You can use the 10-character field to display static information or have it scroll through as many as 60 characters. In the latter mode, the display is capable of providing complete messages to prompt or alert operators. By utilizing a continuous field of LED dots, the display provides a smooth flow of scrolled messages.

The display communicates to the host system via a 2-wire bus and accommodates TTL, current-loop, RS-232C, RS-422, and RS-485 formats at data rates of 300, 1200, 2400, 4800, and 9600 baud. Internal DIP switches provide a means of selecting baud rate, data bits, stop bits, parity, and line terminators in the field. A 9-pin female DB9 connector serves as the data interface. GY2200 modules cost \$625 apiece.

Chrono-log's K Series of dot-matrix LED modules are intended to display time and offer programmable control of equipment throughout a facility. Each display has an internal μP . Bright-red, 1.5-in.-high



To simplify system-integration problems, CU Series vacuum-fluorescent display modules from Noritake include onboard intelligence: complete control logic, high-voltage drivers, ASCII-character generators, refresh RAM, and power-conversion circuitry.



If your application involves message-and graphics-type displays, you'll want to evaluate the APD-192G088-1 plasma panel from Dale. The self-contained unit includes a 192-column \times 88-row display window, drive electronics, and a μP -based controller.

characters are readable at 50-ft distances, which makes the displays fitting for factory applications.

Via 3-wire, low-voltage RS-422 cabling, the master unit transmits the time of day in hours, minutes, and seconds to slave displays, each of which can be 4000 ft apart. The master clock (\$770) has a remote display-driver output that transmits the time five times a second. Each slave display (\$750) has a retransmitting output capable of driving as many as five other displays linked in parallel or in a daisy chain. Output connectors are hermaphroditic: If you want to bypass or remove a display from the system, you just have to plug the input and output cables together to preserve continuity with the rest of the system.

Each master and slave unit in the K Series provides eight separate contact-closure outputs to control external equipment. Front-panel switches enable you to program the contact-closure sequences. You can program each contact separately; you can specify that it close once every 1, 5, 10, 15, or 30 minutes; every 1, 2, 4, 8, or 12 hours; or at three preset times during the day. You also have the option of programming the duration of the periodic closure times in seconds or minutes; you can determine the duration of each of the three preset closure times with a preset opening time. Internal battery backup retains the programmed data. In case of a power failure, the battery will keep time in the master display for approximately six hours.

The K Series displays feature an internal DIP switch, which selects either a 12- or 24-hour format. If the master clock is set for the 24-hour format, the slaves have the option of using either 24- or 12-hour formats. If the master is set for the 12-hour format, all the slaves must use the 12-hour format also. For the 8-hour preset rate, a system must use the 24-hour format to program contact closures.

Although the master clock transmits the same time throughout the system, with an internal DIP switch you can program each display to offset the time in hourly increments. This allows you to have several remote displays under one roof, each set according to a different time zone.

Today's message-type display modules offer a good deal of flexibility when it comes to data rates and data formats.

Whereas LED-based displays offer advantages such as easy visibility and a wide viewing angle, they are power hungry. LCDs, on the other hand, are best characterized as low-power devices. A 160-character unit, for example, typically consumes 60 mW, and as such is a good choice for portable applications. LCD modules also have good character-capacity capabilities. On the negative side, limited viewing angles are typical (40 and 80° cones for the vertical and horizontal planes,

respectively), as are shorter-than-average lifetimes—in the 50,000-hour range. LCDs also tend to washout in direct sunlight and are hard to read in low-light environments without the aid of backlighting.

Hitachi's LCD LMXXX Series consumes a mere 10 mW. The family consists of 23 modules, ranging from the 1-line × 8-character Model LM054 to the 4-line × 20-character LM044L. Depending on the model, the effective viewing area varies from 61 × 15.8 mm to

Manufacturers of dot-matrix display modules

For more information on the dot-matrix display modules such as those described in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Amperex Electronic Corp
Providence Pike
Slatersville, RI 02876
(401) 762-3800
Circle No 650

Computerwise
302 N Winchester
Olathe, KS 66062
(913) 829-0600
Circle No 657

Eaton Corp
MSC Products
1640 Monrovia St
Costa Mesa, CA 92627
(714) 642-2427
Circle No 664

Hamlin
Lake & Grove Sts
Lake Mills, WI 53551
(414) 648-2361
Circle No 671

AND
770 Airport Blvd
Burlingame, CA 94010
(415) 347-9916
FAX 415-340-1670
Circle No 651

Crystaloid
Box 628
Hudson, OH 44236
(216) 655-2429
Circle No 658

EEV Inc
4 Westchester Plaza
Elmsford, NY 10523
(914) 592-6050
Circle No 665

Hewlett-Packard Co
3000 Hanover St
Palo Alto, CA 94304
Phone local office
Circle No 672

Astrosystems
6 Nevada Dr
Lake Success, NY 11042
(516) 328-1600
Circle No 652

Dale Electronics Inc
Box 609
Columbus, NE 68601
(402) 564-3131
TWX 910-626-8314
Circle No 659

Electro-Numerics Inc
1811 Reynolds St
Irvine, CA 92714
(714) 250-1501
Circle No 666

Hitachi America Ltd
300 N Martingale Rd, Suite 600
Schaumburg, IL 60173
(312) 517-1144
FAX 312-517-1155
Circle No 673

Babcock Display Products Inc
1051 S East St
Anaheim, CA 92805
(714) 491-5121
Circle No 653

Densitron Corp
2540 W 237th St
Torrance, CA 90505
(213) 530-3530
Circle No 660

Fujitsu America Inc
918 Sherwood Dr
Lake Bluff, IL 60044
(312) 295-2610
Circle No 667

IEE Inc
7740 Lemona Ave
Van Nuys, CA 91405
(818) 787-0311
FAX 818-902-3723
Circle No 674

Cherry Electrical Products
3600 Sunset Ave
Waukegan, IL 60087
(312) 360-3500
FAX 312-360-3566
Circle No 654

Digital Electronics Corp
31047 Genstar Rd
Hayward, CA 94544
(415) 471-4700
Circle No 661

Fujitsu Components of America
3320 Scott Blvd
Santa Clara, CA 95054
(408) 727-1700
Circle No 668

International Instrumentation Inc
2282 Townsgate Rd
Westlake Village, CA 91361
(805) 495-7673
Circle No 675

Chrono-log Corp
2 W Park Rd
Havertown, PA 19083
(215) 853-1130
TLX 831579
Circle No 655

Dixson Inc
Box 1449
Grand Junction, CO 81502
(303) 242-8863
Circle No 662

Futaba Corp
711 E State Parkway
Schaumburg, IL 60173
(312) 884-1444
FAX 312-884-1635
Circle No 669

International Instruments
Box 185
North Branford, CT 06471
(203) 481-3450
Circle No 676

Citizen Business Machines
2299 Overland Ave
Los Angeles, CA 90064
(213) 558-0961
Circle No 656

Dotronix
160 First St
New Brighton, MN 55112
(612) 633-1742
Circle No 663

General Instrument
3400 Hillview Ave
Palo Alto, CA 94304
(415) 493-0400
Circle No 670

Interswitch
770 Airport Blvd
Burlingame, CA 94010
(415) 347-8217
Circle No 677

141.19×16.7 mm; you have a choice of character heights ranging from 4.15 to 9.4 mm. All modules operate from single 5V supplies.

The series can display alphanumeric and kana symbols as well as graphics. A built-in LSI circuit (the HD44780) displays 160 types of 5×7-dot-matrix character fonts and 32 types of 5×10 fonts. The HD44780 CMOS controller/driver drives the LMXXX modules' LCD under control of a 4- or 8-bit μ C or μ P. The chip

includes all the functions necessary to drive the display. By using an external driver in combination with the HD44780, you can increase a module's capacity to 80 characters.

Reset function is automatic

The HD44780 also features circuitry that provides an automatic reset function when you power up. Instruction functions include the following: display clear,

Ledtronics Inc
4009 Pacific Coast Hwy
Torrance, CA 90505
(213) 676-7996
Circle No 678

Seiko Instruments USA Inc
2990 W Lomita Blvd
Torrance, CA 90505
(213) 530-8777
Circle No 685

Taliq Corp
1277 Reamwood Ave
Sunnyvale, CA 94089
(408) 745-0750
Circle No 692

Thor Electronics
321 Pennsylvania Ave
Linden, NJ 07036
(201) 486-3300
Circle No 696

Modutec Inc
Box 778
Norwalk, CT 06856
(203) 853-3636
Circle No 679

Sencon Inc
6385 W 74th St
Bedford Park, IL 60638
(312) 496-3100
Circle No 686

TEC Inc
6101 S Rural Rd, Suite 102
Tempe, AZ 85283
(602) 345-8188
Circle No 693

TL Industries Inc
Atron Div
2541 Tracy Rd
Northwood, OH 43619
(419) 666-8144
Circle No 697

NEC Electronics Inc
401 Ellis St
Mountain View, CA 94039
(415) 960-6000
Circle No 680

Sharp Electronics Corp
Sharp Plaza
Mahwah, NJ 07430
(201) 529-8757
Circle No 687

Teledyne Microelectronics
12964 Panama St
Los Angeles, CA 90066
(213) 822-8229
Circle No 694

UCE Inc
35 Rockland Rd
Norwalk, CT 06854
(203) 838-7500
FAX 203-838-2566
Circle No 698

Noritake Co
23820 Hawthorne Blvd, Suite 100
Torrance, CA 90505
(213) 373-6704
FAX 213-772-3918
Circle No 681

Shelly Associates Inc
14281 Chambers Rd
Tustin, CA 92680
(714) 669-9850
Circle No 688

Texas Optoelectronics Inc
714 Shepherd Dr
Garland, TX 75042
(214) 487-0085
Circle No 695

Vorne Industries Inc
5831 Northwest Hwy
Chicago, IL 60631
(312) 775-9440
FAX 312-775-3854
Circle No 699

Panasonic Industrial Co
1 Panasonic Way
Secaucus, NJ 07094
(201) 348-7000
Circle No 682

Siemens Components Inc
19000 Homestead Rd
Cupertino, CA 95014
(408) 257-7910
TWX 910-338-0022
Circle No 689

Refac Electronics Corp
Box 809
Winsted, CT 06098
(203) 379-2731
Circle No 683

Sigmatron Nova Inc
6 Industrial Way West
Eatontown, NJ 07724
(201) 542-2909
FAX 201-542-4137
Circle No 690

Rohm Corp
8 Whatney Ave
Irvine, CA 9271
(714) 855-2131
Circle No 684

Staver Co Inc
41-51 Saxon Ave
Bay Shore, NY 11706
(516) 666-8000
Circle No 691

LCD modules are a good choice for applications where low power consumption is a crucial parameter.

cursor home, display on/off, cursor on/off, character-display blinking, cursor shift, and display shift. In quantities of 100, prices range from \$12.90 for a 1-line \times 8-character LM054 to \$38 for a 4-line \times 20-character LM044L.

The AND711AST typifies the performance features available in AND's line of super-twist LCD dot-matrix modules. The intelligent, 240 \times 64-dot-matrix device contains an LSI-type controller, drivers, and 8k bytes of display RAM. All the electronics and the crystal display reside on one pc board. The AND711AST interfaces to a host computer (or other control source) via an 8-bit parallel bus for read/write operations. It is capable of operating in a user-selectable 6 \times 8- or 8 \times 8-matrix mode for character-display applications, graphics-display applications, or a combination of characters/graphics. When configured for the 6 \times 8-matrix mode, the display has a 40-character \times 8-line capability.

Viewing angle for the AND711AST ranges from a 10 to 40° cone; the contrast ratio is 4:1. The display can operate from either a 5 or -8.5V supply, and it draws 9 and 2 mA, respectively, with all dots on. It operates over the 0 to 50°C range, and sells for \$106 (100). The display is also available with integral fiber-optic-type backlighting.

Although LCD dot-matrix modules satisfy low-power applications, if a wide viewing angle and an extended operating range are of primary concern, you'll have to switch technologies. In these cases, vacuum-fluorescent (VF) displays are practicable. VF displays feature a good 3:1 character-height ratio and a character capacity in the 200 to 300 range. Lifetimes in excess of 80,000 hours and viewing-angle cones of 140° are not uncommon.



Combining a 6-line \times 40-character VF display with an infrared touchscreen, IEE's 4283-01 display module features 969 switch (touch) locations and is immune to false triggering by ambient light.

In days gone by, high-supply-voltage requirements were a negative aspect of VF technology. Today, display manufacturers include onboard power-conversion circuitry that allows you to operate VF units from single low-voltage supplies.

Model 4283-01, for example, is a recent addition to IEE's PEP (peripheral entry panel) family of interactive touch-entry display modules. The manufacturer has capitalized on the brightness and long life of VF technology and integrated a 6-line \times 40-character display with an infrared touchscreen. The combination of display characteristics and interactive capability make the 4283-01 well suited to menu-driven applications such as industrial controllers, automated bank tellers, point-of-sale terminals, and medical equipment.

According to IEE, the 4283-01's infrared touchscreen outperforms other touchscreen technologies such as resistive membrane and capacitive and is even superior to comparable infrared systems. Unlike other touchscreens, the 4283-01 uses no overlays, which might impair the appearance of the display. Whereas other infrared systems suffer from resolution problems and are susceptible to ambient light, the 4283-01 has 969 active-switch (touchscreen) locations and is immune from false triggering by ambient light—even in direct sunlight. Because many of the switch locations extend beyond the active display area, the 4283-01's design assigns fixed-function switch locations to the area surrounding the display tube. You can identify these touch-sensitive switch locations with silkscreened legends on the display's filter. The vendor will customize these legends to suit specific applications. Customized filters with user-defined graphics are optional.

A 5 \times 7 dot matrix forms each of the display's 240 5-mm-high characters. The characters are a bright blue-green color that's easy on the eyes in both short- and long-term viewing applications. Three software-controlled brightness levels range to 185 fL max. The unit can store and retrieve user-programmable canned messages. An 8k-byte CMOS RAM accommodates as many as 127 messages, and an onboard battery-backup circuit retains messages even after you remove power. An onboard μ P controls all display and touch-input operations, the comprehensive self-diagnostic test program, and the serial data interface (either RS-232C or RS-422C) with the host computer.

The 4283-01 requires one 5V supply. To ease installation problems in an existing system, the module comes in a single integrated package. The exposed bezel is injection-molded polycarbonate with a peripheral O-

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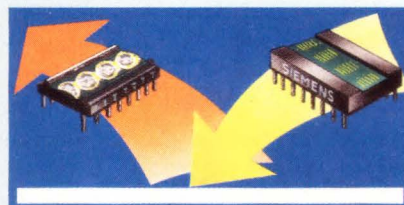
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CG/2600-043 WLM 835

Because today's dot-matrix display modules require only 5V supplies, you can easily integrate them into TTL systems.

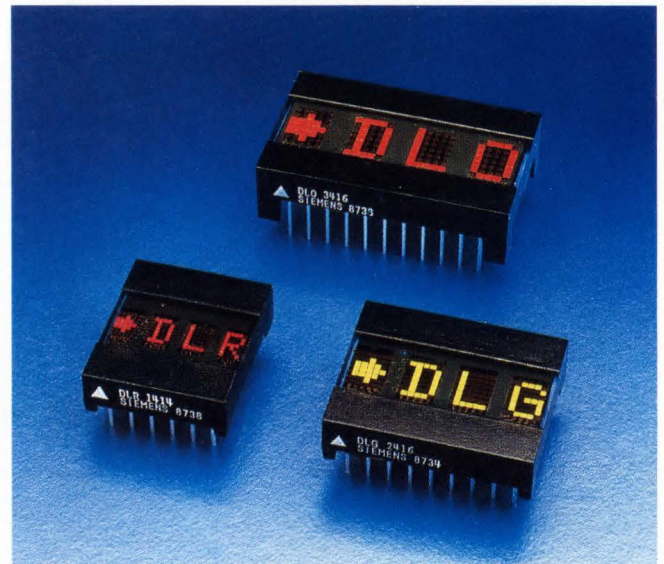
ring seal that provides a drip- and splash-proof interface with the system's front panel. Prices start at \$800 (100).

Targeting the international market

Futaba's GJ (English font) and GA (Japanese font) Series of vacuum-fluorescent display modules offers 1- or 2-line by 20- or 40-character capacities. The modules include an oscillator, a CPU, driver circuitry, and a dc/dc converter. The internal electronic circuitry allows you to directly connect the display modules to the host system's bus. You can input data in either parallel or serial modes at data rates of 1200, 2400, 4800, or 9600 baud. The internal dc/dc converter supplies all of the necessary power from a 5V supply input. Extensive use of surface-mounted components improves display reliability and reduces overall module size—the 2-line×40-character unit measures only 43×240×30 mm.

The 5×7 dot matrix produces a 5-mm-high blue-green character; all units except the 1-line×20-character model include a cursor. You can display as many as 222 alphanumeric or symbolic characters; the viewing-angle cone is 70°. A dimming function allows you to control display brightness at four levels over a 20 to 100% range. The modules' standard operating range spans 0 to 50°C, but operation over the -40 to +85°C range is available as an option. The 1-line×20-character Model M20SD03GJ, a typical member of the family, sells for \$71 (100).

Noritake is another manufacturer involved in producing VF displays and offers more than a dozen display-module lines. The 14-member CU Series, for ex-



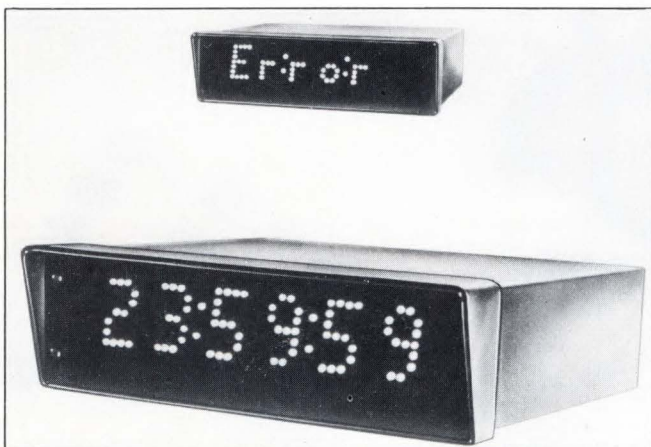
Designed to replace segmented-type displays, the DLR/DLO/DLG 3416 LED display modules from Siemens incorporate a CMOS IC that contains memory, an ASCII ROM decoder, multiplexing circuitry, and drivers.

ample, includes models with character-display capacities ranging from 1 line by 16 characters to 8 lines by 40 characters. All units have a 5×7-dot-matrix font; characters are available in heights of 5, 9, 9.2, 11.3, and 15.1 mm. The displays have a 140° viewing cone. Using appropriate filters, you can change the standard blue-green characters to blue, green, yellow, or orange. Luminance measures 200 fL typ, 100 fL min.

The CU Series features all the requisite logic control, high-voltage drivers, full ASCII-character generators, refresh RAM, and power-conversion circuitry. All models can display standard ASCII characters as well as international characters; 10 models also provide a cursor. Each member of the series includes TTL-compatible input/output lines and interfaces readily to the host system's data bus. Font selection is user programmable. Reset, blank-display, self-test, and busy-output control lines are standard.

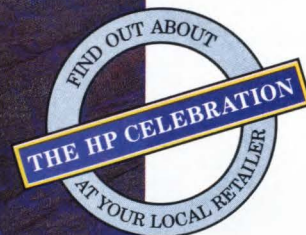
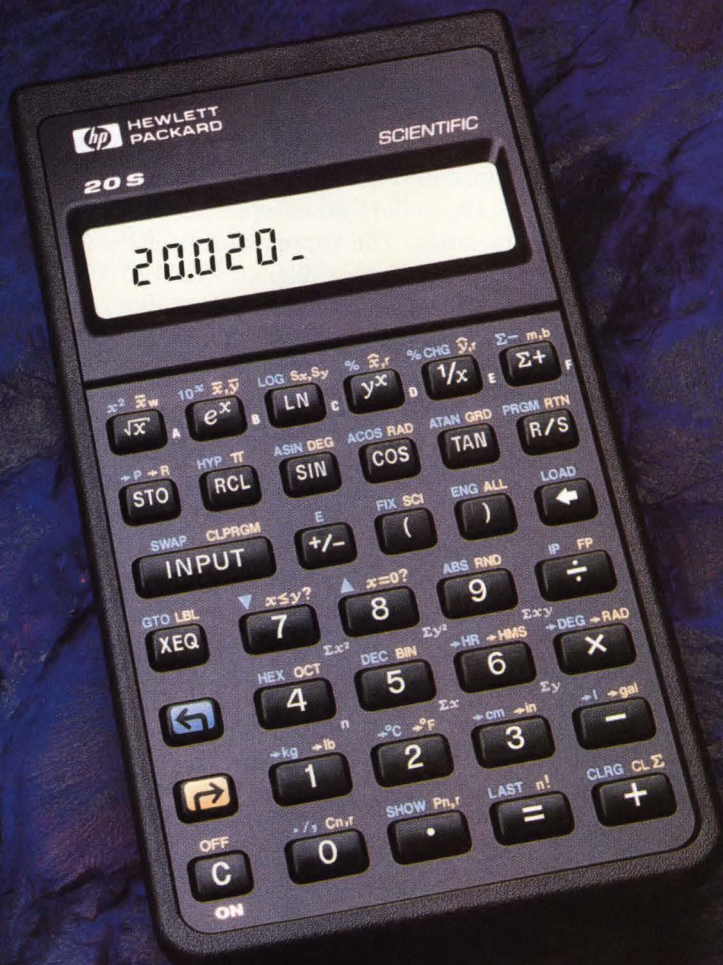
The modules require single 5V supplies for operation, drawing 0.2 to 3.2A. They operate over the -10 to +60°C range and can handle relative humidities of 20 to 85%. The modules' design takes advantage of surface-mount technology to improve reliability. A 1-line×20-character and a 2-line×20-character model cost \$59 and \$99 (100), respectively.

Although VF displays offer good message-display capabilities, they aren't your only choice for such applications. Plasma displays also have good character-



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CIRCLE NO 8

count characteristics—in the 200 to 300 range. Plasma-display technology seems to be gaining in popularity. Plasma-panel displays are bright red-orange, easy on a viewer's eyes, and reliable. Historically, they've suffered on two counts—high cost and driving difficulties. Today's plasma displays, however, no longer suffer from these problems; improved driving circuitry requires fewer components, thereby reducing both power consumption and cost.

Dale offers an extensive line of plasma-panel display modules. The representative APD-192G088-1 is a full-field dot-matrix display with 192 columns and 88 rows. It consists of a dc plasma graphics-display panel, drive circuitry, and a controller. Chip-on-glass construction eliminates hundreds of connections, which increases reliability and reduces cost.

The onboard controller maintains all the refresh memory, character generation, and control logic; therefore, the APD-192G088-1 can serve as a direct-readout device for communication terminals, computer readouts, μ P-based instruments, or any other system that requires a self-contained readout.

You can program the display to operate in either a parallel or a serial mode. The parallel interface consists of a basic 8-bit configuration with handshaking lines and some dedicated control lines. The serial interface is RS-232C compatible and accommodates two bit formats; eight selectable data rates span 75 to 9600 baud. All module input lines are LSTTL compatible. The module uses a dc/dc converter to generate all the necessary internal voltages from a 12V supply input.

You can use 1- or 2-byte commands to generate simplified code or to accomplish complex display tasking such as scrolling or lines/characters insertion. The character generator is a 4k \times 8-bit EPROM that includes 256 characters consisting of 128 ASCII characters (including control codes) and 128 block-graphics characters. The -192G088-1 offers the option of factory or user programmability for developing alternate character sets.

The APD-192G088-1's viewing area measures 7.66 \times 3.5 in. Respective brightness, color, and viewing-angle-cone specs are 80 fL, neon-orange, and 60°. It withstands temperatures of 0 to 55°C. The display costs approximately \$699 (100).

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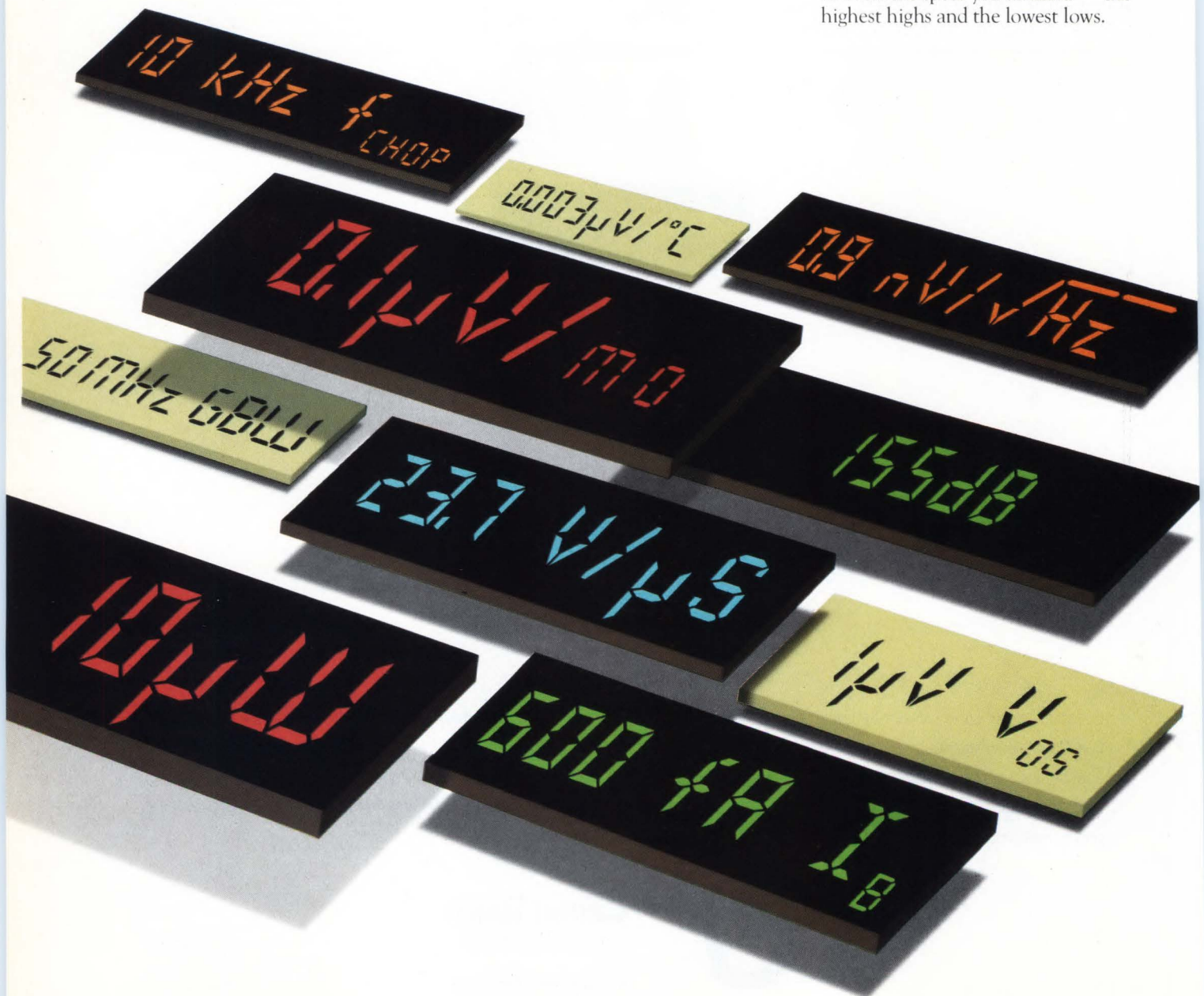
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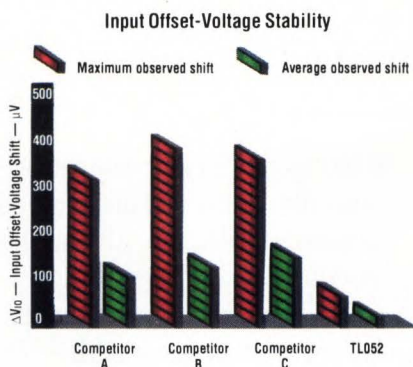
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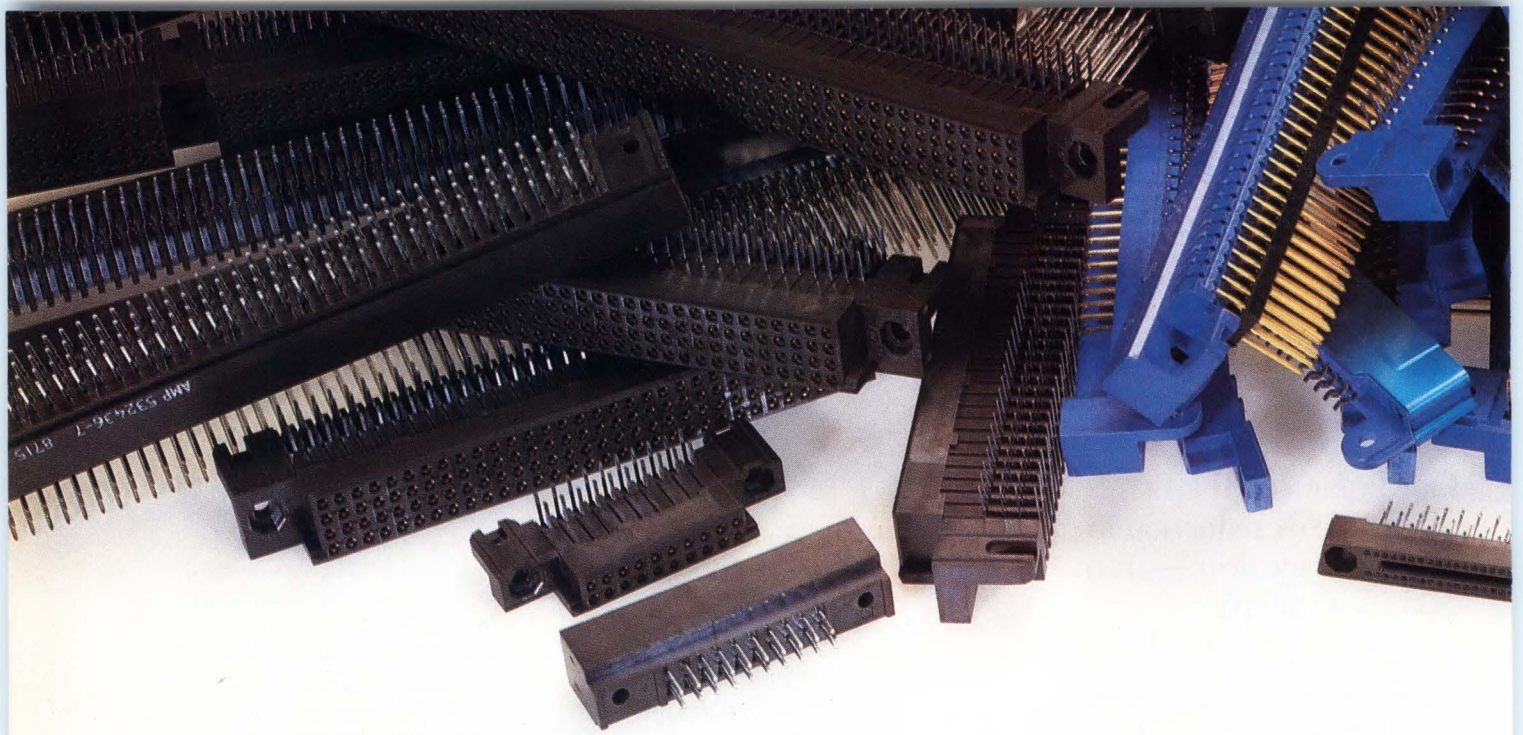
This broad choice of functions is matched by an equally broad packaging choice — metal cans, ceramic and plastic DIPs, and plastic SOs.

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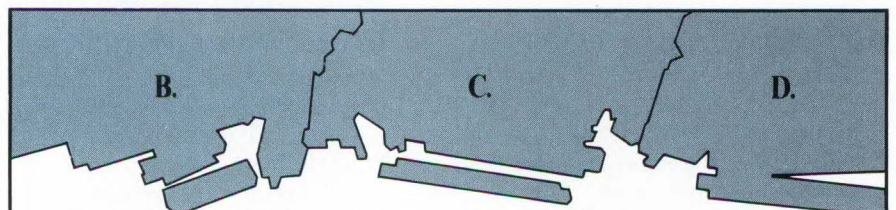
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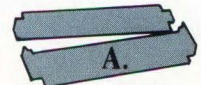
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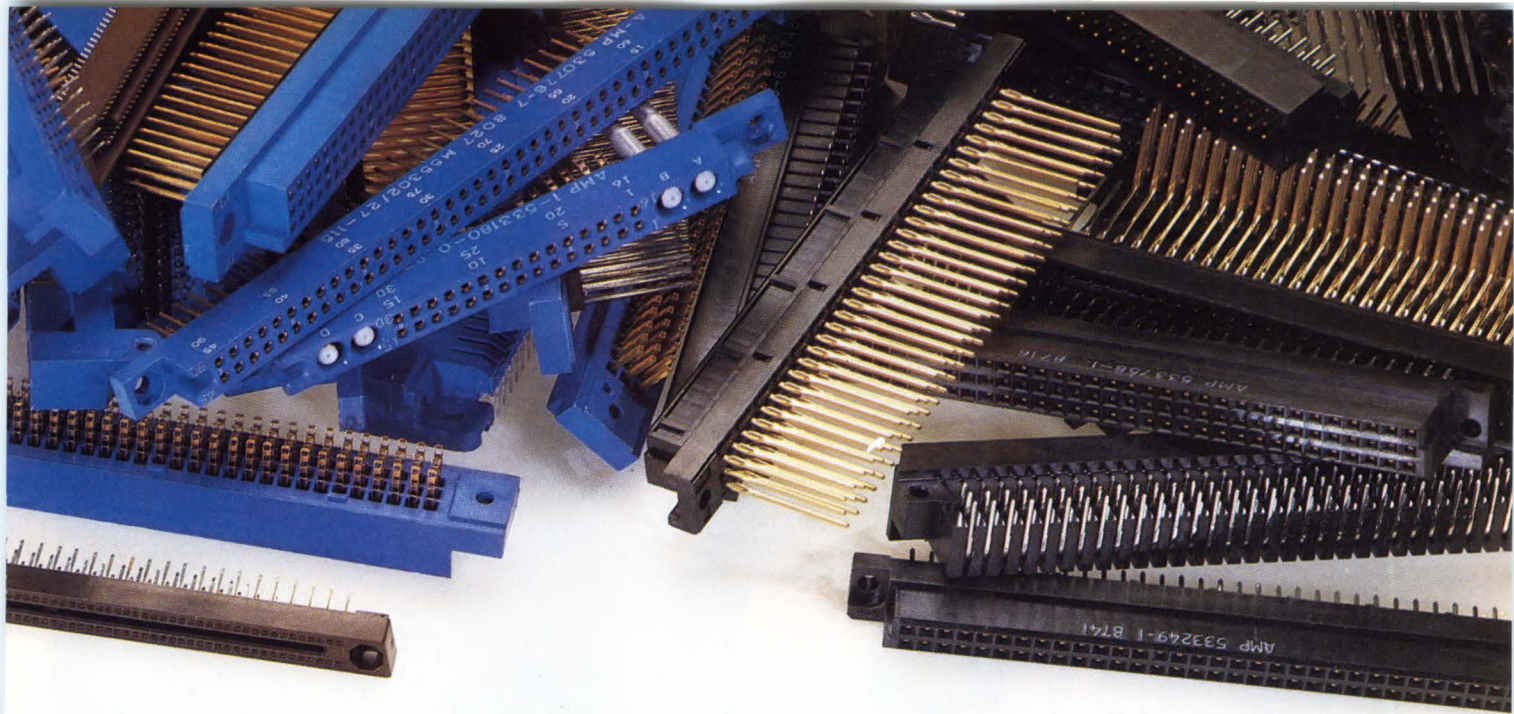
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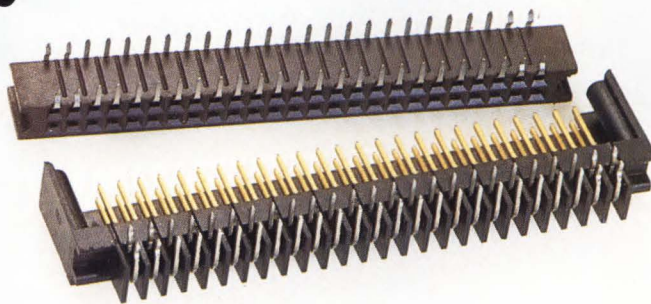


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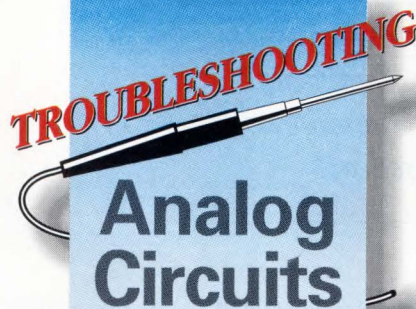
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PART 4

A knowledge of capacitor subtleties helps solve capacitor-based troubles

Earlier installments of this series have described a good analog troubleshooter's mindset, armamentarium of test equipment, and requisite knowledge of resistors, inductors, and transformers. Now, ace troubleshooter Pease reveals some of the secrets of an often-underestimated class of components—capacitors. And much of what you need to know to troubleshoot capacitor-related problems is not in any book—it's not even in data sheets.

Robert A Pease, *National Semiconductor Corp*

Capacitors are rather remarkable. We consider capacitors, like resistors, to be "passive." But if you charge up a good as capacitor to 10V and take a 2-week vacation, when you come back the voltage may not have decreased by as much as 20 or even 10%. The capacitor may have stored and retained enough energy to run a micropower circuit for hours or to light an LED for a shorter interval. Calling components with such exceptional properties "passive" is more than a little unfair.

Ordinary, aluminum, electrolytic capacitors are most often used for power-supply filtering and bypassing. In the old vacuum-tube days, electrolytic capacitors were often used at levels of 150, 300, 500V, or more.

There are several basic problems with these old circuits. First, if the voltage across a capacitor is much higher than 350V, the part's reliability is not nearly as good as that of devices operated below 350V. Also, if a piece of old equipment has not been powered up for years, it is advisable to apply the ac power gradually by cranking up the line voltage slowly with a variable transformer so that the electrolytic film has a chance to "form" up. If you hit it with full voltage instantly, an old capacitor may fail. Of course, if you are hit by high voltage, you may fail, too.

At this point, I should remind you that when working on high-voltage circuits, probe with one hand only and keep the other hand in your pocket. Avoid grounding your body at any other place and stand or sit on an insulating slab of dry material. These precautions can prevent a shock from causing you serious harm. When I start work on a high-voltage circuit, I solder a neon lamp in series with a 100-k Ω resistor across the high-voltage power supply as a glowing reminder that this circuit is powered by a voltage much higher than 15V.

After you operate a high-voltage power supply at full voltage, if you turn off the power and decide that for safety's sake you should short out the filters with a few hundred ohms, be careful. A few minutes later, the voltage on the capacitors may come back up to 60 or 80V and give you a shocking experience. The partial

The partial recovery of voltage on a discharged capacitor is caused by "soakage," which causes the dielectric to "remember" the voltage it was recently biased at.

recovery of voltage on a discharged capacitor is caused by "soakage," or dielectric absorption, which causes the dielectric of the capacitor to "remember" the voltage it was recently at. In high-voltage equipment, it is wise to install a 2W resistor of a few hundred kilohms across each large high-voltage filter capacitor to bleed off the charge and decrease the chance of shocks (Ref 1).

The last problem with old vacuum-tube equipment is that the heat tends to dry up the capacitors' electrolyte, thus causing their capacitance to decrease. This decrease is evidenced by excessive ripple, or "hum," on various signals and, of course, on the power-supply output of unregulated supplies. Although I have presented these maladies as problems afflicting old equipment, you should consider them even in new designs.

In modern power-supply designs, it is critical that you choose a filter capacitor whose effective series impedance is low at all rated temperatures. Otherwise the rms filter current multiplied by the resistive component of the series impedance can cause excessive self heating. And if the heat can't flow out of the capacitor, the temperature will rise and cause poor reliability. Excessive heating is one of the most common causes of failure in electrolytic capacitors.

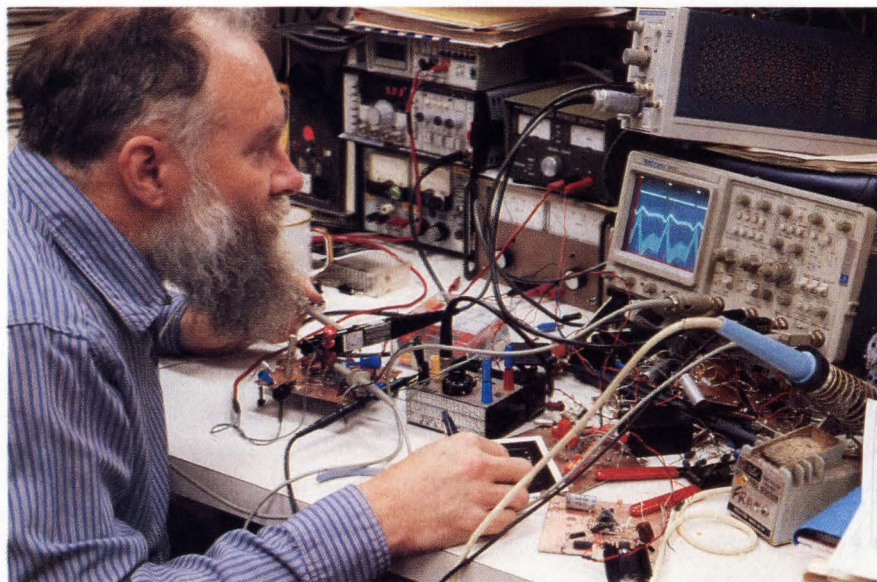
For instance, at 120 Hz, which is the frequency of the ripple current flowing in the filter capacitors that follow a full-wave rectifier operated from a 60-Hz ac source, some manufacturers rate their capacitors at 2A rms for each 1000 μ F. Because the rms current in the capacitor is nearly 2A rms when the dc output is

1A, this rating is consistent with the rule of thumb for an ordinary full-wave bridge rectifier: Provide at least 1000 μ F of filter capacitance for each 1A of dc output. At 20 or 40 kHz, which is the ripple-current frequency in many switch-mode power-supply filters, the capacitor will have a higher series resistance. Thus, the capacitor won't be suitable for handling even 1A rms. If you insist on using a 120-Hz-rated capacitor as a filter in a switch-mode supply, you will probably have to contact the capacitor vendor for data or advice.

Of course, if you install an electrolytic capacitor with reversed polarity and apply working voltage, the reliability will be poor and the failure mode will probably be dramatic. So, please be careful working with big power supplies and big filter capacitors that store large amounts of energy. Wear protective goggles or glasses with safety lenses for protection because a capacitor in a high-energy supply might decide to blow up while you are peering at it. In fact, a friend of mine pointed out that a 6V electrolytic capacitor of even a few microfarads can blow out as explosively as a shotgun blast if you apply 6V dc of the wrong polarity or 6V ac to it. So, again, be very careful with your polar electrolytic capacitors.

Nonpolar capacitors can be a bear

You can buy nonpolar electrolytic capacitors made of either aluminum or tantalum. They are bigger and more expensive than ordinary, polar capacitors, so they are fairly uncommon. But, have you seen the little 3-leaded electrolytic types recently brought to market?



That's funny, it worked just fine the last time I tried it.

The lead in the center is the positive terminal and the other two leads are negative. This configuration not only gives you lower inductance but also allows you to insert the device into a board two ways—and *both* are correct.

Tantalum capacitors have many characteristics similar to those of aluminum electrolytic capacitors; and, for the extra price you pay, you can get less leakage and somewhat lower series resistance. Designers often try out a timing circuit using a tantalum capacitor and a high-value resistor. But when they try to buy a tantalum capacitor with leakage guaranteed low enough to make the circuit work every time, they get quite angry when nobody is interested in selling such a device. Of course, if you were a manufacturer of tantalum capacitors and someone asked you to measure the leakage, you would refuse the business, too, because testing is so difficult. Even though this leakage is usually quite low, nobody wants to have to measure it in production.

Wound-film and stacked-film capacitors cover wide ranges, from small signal-coupling capacitors to large high-power filters. The different dielectrics are their most interesting ingredients. Often a designer installs a polyester capacitor (technically, polyethylene terephthalate, often called Mylar—a trademark of DuPont Corp) and wonders why something in the circuit is drifting 2 or 3% as the circuit warms up. What's drifting is probably the polyester capacitor; its TC of 500 to 800 ppm/°C is 10 times as high as that of a metal-film resistor.

If you give up on polyester and go to polystyrene, polypropylene, or Teflon, the TC gets better—about -120 ppm/°C. Polystyrene and polypropylene have low leakage and good dielectric absorption—almost as good as Teflon's, which is the best (Ref 1). But Teflon is quite expensive and much larger in package size than the other types. Be careful with polystyrene; its maximum temperature is +85°C, so you can damage it during ordinary wave soldering. Polycarbonate has a TC of 150 ppm/°C but has inferior soakage.

Foiled again!

Now let's discuss the difference between a polyester foil capacitor and a metallized polyester capacitor. The foil capacitor is made of alternating layers of film and foil, where both the delicate film and the metal foil are just a couple of tenths of a mil thick. This construction makes a good capacitor at a nominal price and in a nominal size. The metallized-film capacitor is made with only a very thin film of polyester—the metal is

deposited on the polyester. This construction leads to an even smaller size for a given capacitance and voltage rating, but the deposited metal is so thin that its current-carrying capacity is much less than that of the metal in the foil capacitor. If a pinhole short develops in the metallized-polyester capacitor's plastic film, the metal layer in the vicinity of the pinhole will briefly carry such a high current density that it will vaporize like a fuse and "clear" the short.

For many years, metallized polyester capacitors were popular in vacuum-tube television sets. These metallized capacitors would recover from pinhole flaws not just once but several times. However, at low voltages, the energy stored in the capacitors would often prove insufficient to clear a fault. Thus, the capacitors' reliability at low voltages was often markedly worse than it was at their rated voltage. You could safely use a cheap, compact, metallized-polyester capacitor in a 100V TV circuit but not in a 2V circuit. Fortunately, there are now classes of metallized-polycarbonate, metallized-polyester, and metallized-polypropylene capacitors that are reliable and highly suitable for use at both low and high voltages.

When the old metallized-polyester capacitors began to fail in a TV set, the "clearing" of the shorts would make the signals very noisy. Likewise, when used as audio coupling capacitors, "dry" tantalum capacitors would sometimes make a lot of noise as they "cleared" their leaky spots. These parts have therefore become unpopular for audio coupling. Similarly, you can use an electrolytic capacitor with a small reverse voltage—perhaps 0.5V—with no harm or problems. But a friend told me of a time an electrolytic capacitor used as an audio coupling capacitor with 2V of reverse bias produced all sorts of low-frequency noise and jitter. So, excess noise is often a clue that something is going wrong.

Extended foil offers extensive advantages

Another aspect of the film capacitor is whether or not it uses "extended-foil" construction. The leads of many inexpensive wound-foil capacitors are merely connected to the ends of the long strip of metal foil. However, in an extended-foil capacitor, the foils extend out on each end to form a direct low-resistance, low-inductance path to the leads. This construction is well suited for capacitors that must provide low ESR (equivalent series resistance) in applications such as high-frequency filters. But if you substitute a capacitor without extended foil, the filter's performance will be

It is critical to choose a filter capacitor whose effective series impedance is low at all rated temperatures.

drastically degraded.

So there are several methods of construction and several dielectrics that are important for most capacitor applications. If an aggressive purchasing agent wants to do some substituting to improve cost or availability, the components engineer or design engineer may have to do a lot of work to make sure that the substitution won't cause problems. If a substitution is made, the replacement part is a good place to start looking for trouble. For example, a capacitor with higher-than-planned-for ESR can cause a feedback loop to oscillate—for example, when a capacitor without extended-foil construction is substituted for one with such construction. Substitution of capacitors with higher ESR than the designer intended can also cause filters to fail to properly attenuate ripple. Another consequence of excessive ESR is the overheating and failing of capacitors—capacitors may be passive components, but they are not trivial.

Not only does extended-foil construction lower a capacitor's ESR, it also lowers the component's inductance. As a friend pointed out, "Pease, you understand things really well if they are at dc or just a little bit faster than dc." I replied, "Well, that's true, but what's your point?" His point was that in RF circuits, and many other kinds of fast circuits, you should use capacitors and other components dressed closely together, so that the inductance is small and well controlled. He was absolutely right—the layout of a high-speed, fast-settling or a high-frequency circuit greatly affects its performance. Capacitors for such circuits must be compact and not have long leads. Ceramic and silvered-mica capacitors are often used for that reason.

Every year, billions of ceramic capacitors find their way into electronic products of all kinds. There are basically three classes of these parts: the "high-K" and "stable-K" types and the C0G or NP0 types.

The high-K types, such as those with a "Z5U" characteristic, give you a lot of capacitance in a small space—for example, 10^6 pF in a 0.3-in. square that is 0.15-in. thick. That's the good news. The bad news is that the capacitance of parts with this Z5U characteristic drops 20% below the room-temperature value at 0 and 55°C; it drops 60% below the room-temperature value at -25 and +90°C. Also, the dielectric has a poor dissipation factor, mediocre leakage, and a mediocre voltage coefficient of capacitance. Still, none of these drawbacks prevents capacitors of this type from being used as bypass capacitors across the supply terminals of virtually every digital IC in the whole world. That's a lot of capacitors!

These ceramic capacitors have a feature that is both an advantage and a drawback—a typical ESR of 0.1Ω or lower. So, when a digital IC tries to draw a 50-mA surge of current for a couple of nanoseconds, the low ESR is a good feature: It helps to prevent spikes on the power-supply bus. However, when you have 10 ICs in a row and 10 ceramic bypass capacitors, you've got a long L-C resonator (**Fig 1**) with the power-supply bus acting as a low-loss inductor between each pair of bypass capacitors. When repetitive pulses excite this resonator, ringing of rather large amplitude can build up and cause an excessively noisy power-supply bus.

The standard solution is to add 2 μF of tantalum electrolytic bypass capacitors or 20 μF of aluminum electrolytic capacitors for every three to five ICs. The

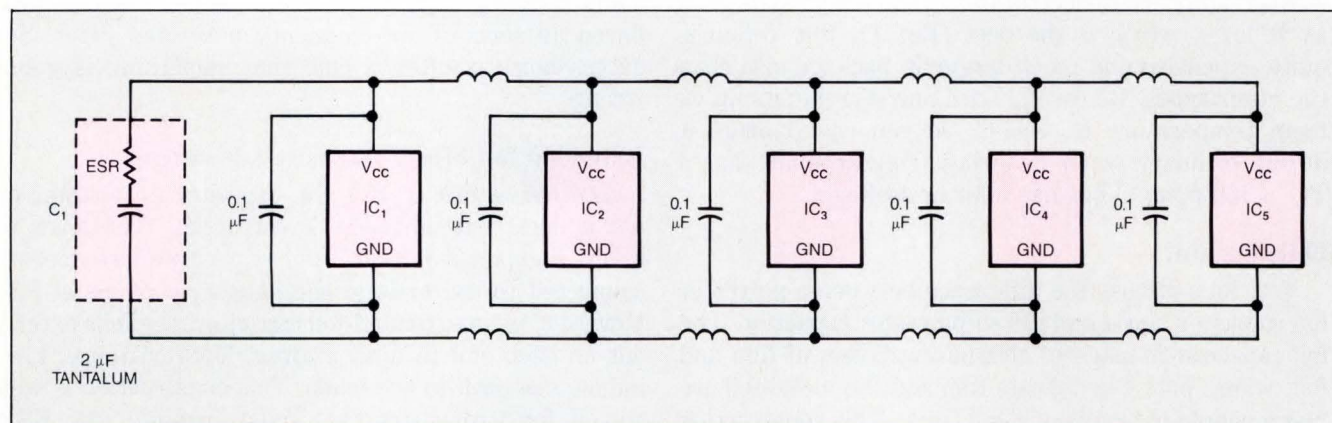


Fig 1—Low ESR in a decoupling capacitor is a 2-edged sword. Though a capacitor with low ESR stabilizes the supply bus when the ICs draw short-duration current spikes, the low dissipation encourages ringing by allowing the decoupling capacitance to resonate with the bus inductance. One cure is to place an electrolytic capacitor, such as C₁, across the bus. C₁'s ESR of approximately 1Ω damps the ringing.

ESR of the electrolytic capacitors, typically 1Ω , is essential to damp out the ringing. I have read a few ads in which some capacitor manufacturers claim that their ceramic bypass capacitors are so good that ringing is no longer a problem, but I find the claims hard to believe. I invite your comments.

ESR, friend or foe?

Specifically, some capacitor manufacturers claim that the series resistance, R_S , is so low that you won't have a problem with ringing. But low R_S would seem to exacerbate the ringing problem. Conversely, I've heard that one capacitor manufacturer is proposing to market ceramic capacitors whose series R_S has a lower limit—a few ohms—to help damp out any ringing. I'm going to have to look into that. But if you have bypass capacitors with a very low R_S , you can lower the Q of the resonator you have inadvertently constructed around them by adding a resistor of 2.7 to 4.7Ω in series with each capacitor. Adding resistance in series with bypass capacitors might seem a bit silly, but it's a very useful trick.

High-K ceramic capacitors also can exhibit piezoelectric effects: When you put a good amount of ac voltage across them, they can hum audibly; if you rattle or vibrate them, they can kick out charge or voltage. (Other types can do the same thing, but high-K types are worse.) Be careful when using these capacitors in a high-vibration environment.

The capacitance of stable-K capacitors, such as X7R, typically decreases by 15% from the room-temperature value over the -55 to $+125^\circ\text{C}$ range. These capacitors are general-purpose devices and are usually available in the 100- to 10,000-pF range; in the larger packages, you can get as much as 300,000 pF. However, you can buy a 10,000-pF capacitor in either a high-K or a stable-K type; and you can't be sure of the kind you're getting unless you check the catalog and the part number.

The last type of ceramic capacitor was originally called "NP0" for Negative-Positive-Zero and is now usually called "C0G." The C0G capacitor is really a high-grade capacitor with a guaranteed TC of less than ± 30 ppm/ $^\circ\text{C}$. Their dissipation factor, dielectric absorption, and long-term stability are not quite as good as those of Teflon capacitors but are comparable to those of other good precision-film capacitors. So, if you want to make a S/H circuit usable over the military temperature range, you'll find that C0G capacitors are more compact and less expensive than Teflon parts. Many, but not all, ceramic capacitors smaller than 100

pF are made with the C0G characteristic. You can get a 22,000-pF C0G capacitor in a 0.3-in.-square package.

Recently, a customer called me about a drift problem: His V/F converter had a poor TC, even though he said that he had put in a C0G 0.01- μF capacitor as the main timer. Troubleshooting by phone—it's always a wonderful challenge. I asked him, "This C0G-ceramic 0.01- μF capacitor . . . is it . . . as big as your little fingernail?" He said, "Oh no. It's a lot smaller than that." I replied, "Well, that's too small; it can't be a C0G." Problem solved.

One observed failure mode for ceramic capacitors can arise when the capacitor's leads are attached to the dielectric with ordinary, low-temperature solder. When the capacitor goes through a wave-solder machine, the lead may become disconnected from the capacitor. If this problem occurs, you'll have to switch to capacitors from a manufacturer that uses high-temperature solder.

Don't forget silvered mica

Silvered-mica capacitors have many features similar to C0G capacitors. They have low ESR and a TC of 0 to 100 ppm/ $^\circ\text{C}$. They can also work at temperatures above 200°C if assembled with high-temperature solder. Unfortunately, they have poor soakage characteristics.

A major problem with silvered-mica capacitors is their marking. The silvered-mica capacitors in old radios had completely inscrutable markings—six color dots. Some of the new ones have such odd codes that even if the marking on the capacitor hasn't rubbed off, you can never be sure whether "10C00" means 10, 100, or 1000 pF. You really need to use some kind of capacitance meter. Similarly, in the old days, some ceramic capacitors were marked in an inscrutable way. I remember two little capacitors both marked "15K." One was a 15-pF capacitor with a 'K' characteristic, and the other was a 15,000-pF capacitor—yet they were both the same size and had the same marking.

I must also mention that, in the past, you could buy a pretty good capacitor that had never been tested for its capacitance. About 99% of the time, they were excellent, reliable capacitors. But once in a while, some of the capacitors came through with a completely different value. One time I saw a whole box of "capacitors" in which the two leads were still made of one loop of wire that had not been snipped apart. Obviously, the manufacturer wasn't interested in testing and measuring these capacitors before sending them out the door.

A 6V electrolytic capacitor of even a few microfarads can blow out as explosively as a shotgun blast if you apply 6V dc of the wrong polarity to it.

So, if you are buying capacitors to a 1% AQL (Acceptance Quality Level) and not 0.1% or 0.01%, you should be aware that some low-priced parts have not even been sample tested.

Variable capacitors have finite rotational lives

Variable capacitors are usually made of low-K material with characteristics similar to those of COG capacitors. Their performance is excellent. The dielectric doesn't cause much trouble, but the metal sliding contacts or electrodes on some types are very thin; after only a small number of rotations—hundreds or even dozens—the metal may wear out and fail to connect to the capacitance.

In general, capacitors are very reliable components; and, if you don't fry them with heat or zap them mercilessly, the small-signal ones will last forever and the electrolytic ones will last for many years. (Old oil-filled capacitors aren't quite that reliable and have probably been replaced already—at least they should have been replaced.) The only way you can have an unreliable capacitor is to use a type that is unsuitable for the task. And that's the engineer's fault, not the capacitor's

fault. Still, some troubleshooting may be required; and if you recognize the clues that distinguish different types of capacitors, you've taken a step in the right direction.

What procedures are best for troubleshooting capacitors? I use two basic procedures, the first of which is the add-it-on approach. Most circuits are not hopelessly critical about capacitor values, as long as the capacitors' values are large enough. So, if there is a 0.01- μ F capacitor that I suspect of not doing its job, I just slap another 0.01- μ F capacitor across it. If the ripple or the capacitor's effect changes by a factor of two, the original capacitor was probably doing its job and something else must be causing the problem. But if I observe little or no change or a change of a factor of three, five, or ten, I suspect that capacitor's value was not what it was supposed to be. I pull the capacitor out and measure it. Of course, the capacitor substitution boxes I mentioned in the section on test equipment can be valuable here; they let me fool around with different values. But in critical circuits, the lead length of the wires going to the substitution box can cause crosstalk, oscillation, or noise pickup; so I may have

But is this really troubleshooting?

When I passed the first draft of this article around to a few friends, one guy asked, "Why are you telling us all these things about weird capacitors? What does that have to do with troubleshooting?" I gave him the same answer I give you here: If you had a mediocre coupling capacitor and you didn't realize that it could keep on "leaking" for many seconds or minutes longer than a good coupling capacitor would, you wouldn't look for problems traceable to that capacitor. I cannot foresee every problem you will have in a circuit, but I can point out that similar-looking components can have startlingly different characteristics.

You can't learn about these characteristics from looking in books, or even in data sheets. So, if you get in trouble, I'm trying to suggest clues to look for to help you get out. Conversely, if you study these precautions and think about what can happen, you may be able to avoid getting into trouble in the first place. That's even better than being able to get out.

In fact, maybe some of the warnings I have presented here will explain why you once had a problem whose cause you could never figure out. Every once in a while, I learn something that stops me in my tracks: "That explains why the oscillator I made two years ago never worked

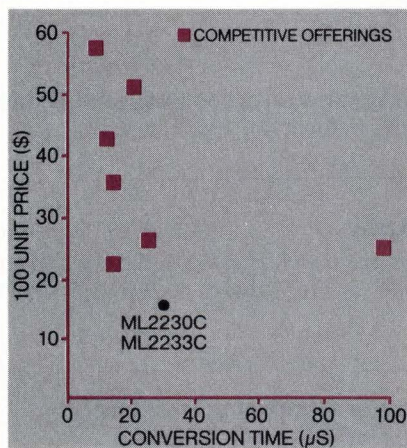
right." If you stand on my shoulders, you may be able to get to places that neither of us could get to alone.

I certainly didn't figure out every one of these ideas by myself. I am passing along many ideas that I gleaned from other people's experience. Furthermore, I doubt if they invented all those ideas themselves. Surely, they benefited from other people's ideas that they picked up along the way. I am just trying to pass along insights that are not book learning but that I learned in the College of Hard Knocks. It may or may not be troubleshooting, but it's close enough for me.

New price performance level attained with algorithmic 12-bit + sign A/D converters.

Micro Linear now has two 12-bit + sign A/D algorithmic converters that incorporate auto-zeroing circuitry and self-calibration; the ML2230, and the ML2233. This approach has no trimming and less circuitry, resulting in a lower price and an A/D converter that maintains accuracy over time.

Priced at \$15.95 in 100 unit quantities, both the standard 24-pin DIP ML2230, and the 28-pin DIP ML2233, include an internal sample-and-hold and an easy to use microprocessor interface.

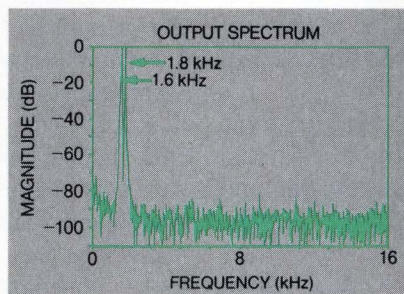


12-bit A/D price/performance comparison including sample-and-hold cost.

Accuracy and Speed

Total conversion time is 31 microseconds, including the on-chip sample-and-hold acqui-

sition time. Both devices can digitize a $-2.5V$ to $+2.5V$ sine wave at 12 kHz with a 73 db signal-to-noise ratio. Harmonic distortion is just 0.01%.

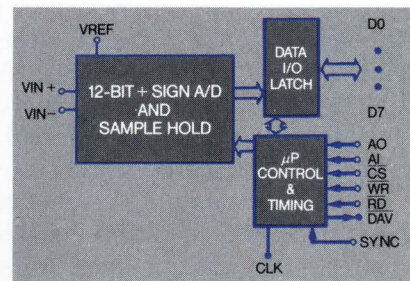


*The FFT plot of the ML2233.
A two tone, $-2.5V$ to $+2.5V$, low distortion sine wave input.*

All errors of the sample-and-hold are accounted for in the accuracy specification. Integral nonlinearity is $\pm\frac{1}{2}$ LSB or ± 1 LSB, there are no missing codes, and full scale and zero errors are less than ± 1 LSB. This is over the temperature range, and with $\pm 5\%$ tolerance on $+5V$ and $-5V$ power supplies.

Versatility and Ease of Use

These 12-bit + sign A/D converters are designed for ease of use. The analog inputs can withstand 7V beyond the supplies. The high impedance analog input is differential for noise immunity and power supply rejection.



ML2230 block diagram

These devices support several interface techniques: interrupt, DMA or polling. The ML2230 is designed to interface to an 8-bit microprocessor bus by outputting the data result in two 8-bit bytes. To interface to a 16-bit bus, the ML2233 provides a 13-bit data result. Both are designed to interface without additional components and are fully TTL and CMOS compatible. Bus timing parameters are compatible with the fastest microprocessors currently available.

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Be careful with polystyrene; its maximum temperature is +85°C, so you can damage it during ordinary wave soldering.

to just "touch in" a single capacitor to a circuit.

Suppose, for example, that I have a polyester coupling capacitor that seems to be adding a big, slow "long tail" to my circuit's response. I don't expect the performance with the polyester capacitor to be perfect, but a tail like this one is ridiculous! So, I lift up one end of the polyester capacitor and install a polypropylene unit of the same value. I expect the new capacitor's characteristics to be a lot better than those of the old capacitor. If the tail gets a lot smaller, either my plan to use polyester was not a good one or this particular polyester capacitor is much worse than usual. It's time to check. But usually, I'd expect to find that the polypropylene capacitor doesn't make the circuit perform much better than the polyester capacitor did, and I'd conclude that something else must be causing the problem.

For either of these techniques to work, it is helpful to have a large stock of assorted capacitors. In our lab, we have several cartons of used—but not too badly beaten up—components left over from old experiments: One is a box of small mica and ceramic capacitors, one holds various electrolytic capacitors, and one is a tray of assorted wound-film capacitors. These boxes are extremely valuable because if I need an odd type, I can usually fish in one of those cartons and find something close. Or I can find some capacitors that give the right value if I parallel two or three of them. I can use these capacitors per the add-it-on or the substitution method to find out what my unhappy circuit is trying to tell me. In addition, I keep a couple of Teflon capacitors in my file cabinet for when I need a super-good capacitor.

A technique that nobody talks about but is as old as the hills is a favorite trick of mine. Sometimes it drives my technicians wild, but then they learn the trick and find it awfully useful. Let's say I want to compare a Mylar capacitor with a ceramic capacitor in a small, precision circuit. The technician starts to remove the Mylar capacitor and install the ceramic one. Wrong! Instead, remove one lead of the first capacitor and lift it up slightly. Then tack solder one end of the second capacitor to the circuit. At this point, neither capacitor is actually in the circuit—both capacitors are just waving in the breezes.

After the solder thoroughly cools down, I can use the springiness of the leads to let me "touch in" one of the capacitors or the other or both, as needed. It only takes a second to go from one mode to the other. (Of course, I'm assuming there's not enough voltage

to "bite" my finger.) If I actually desolder and resolder the capacitors and allow enough time for these temperature-sensitive components to cool off, I'll probably forget what the difference between them looks like. So, this technique can save a lot of time and greatly facilitates A-B comparisons—it lets me use my eyeball to evaluate the nuances of small performance changes.

Of course, if I have two or three of these spring-loaded options at one time and they begin to get wobbly, it may be time to tack solder down the ones that I am not actively pursuing. In general, though, this technique is extremely valuable, and I've never seen it in any book. Use it with my compliments. It works with diodes, resistors, and transistors, too. Just make sure that solder flux doesn't prevent the spring-loaded component lead from contacting the conductor. And make sure that your finger doesn't add a lot of capacitance, impedance, or noise into the circuit. If you do have this problem, push on the component with the edge of a fingernail instead of a finger. A fingernail adds less than $\frac{1}{2}$ pF. **EDN**

Reference

1. Pease, R A, "Understand capacitor soakage to optimize analog systems," *EDN*, October 13, 1982, pg 125.

Author's biography

For more information about Bob Pease, see the **box**, "Who is Bob Pease, anyway?" in the January 5, 1989, edition of *EDN*.

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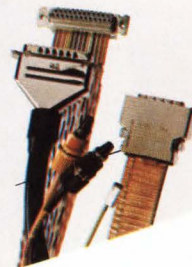
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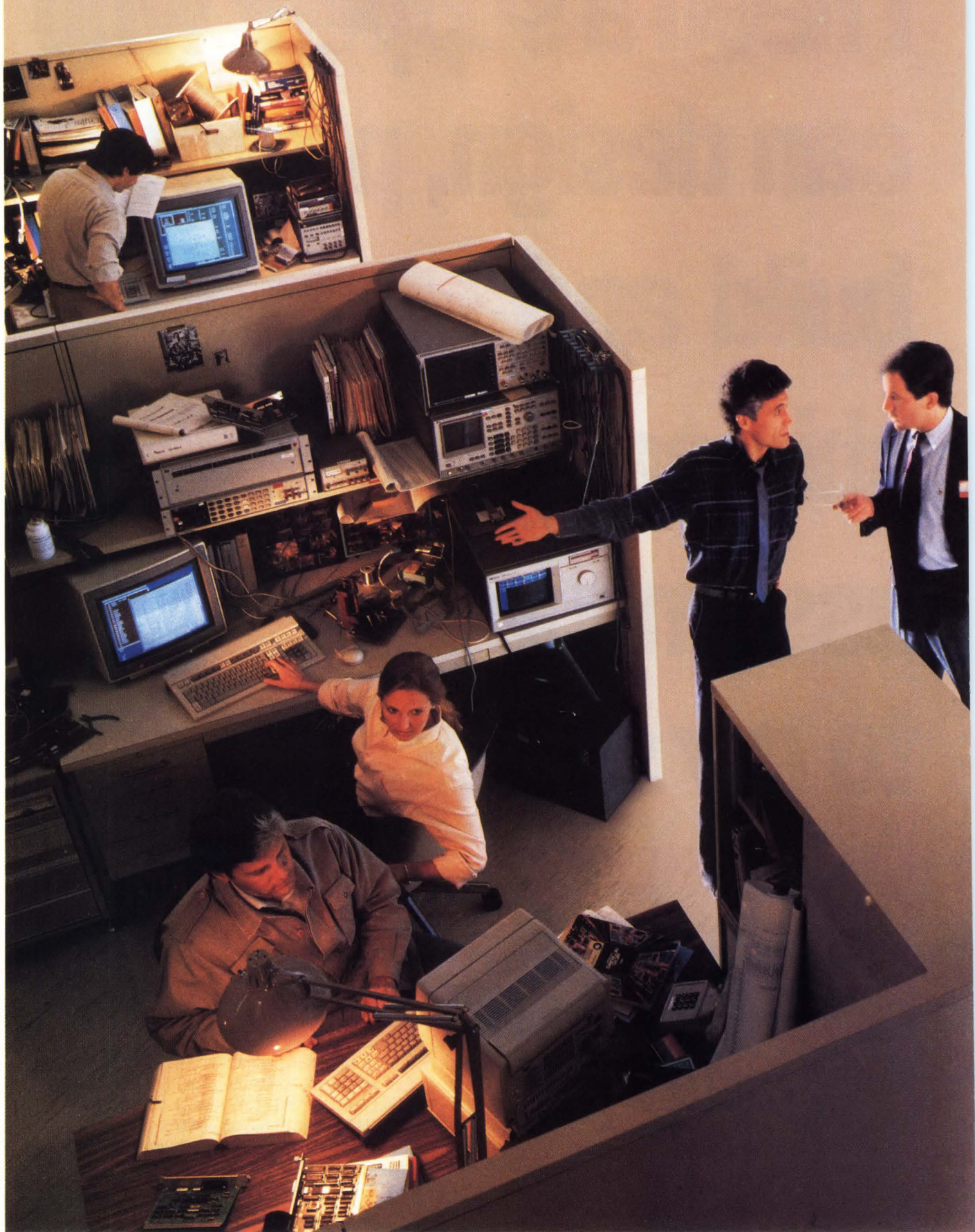
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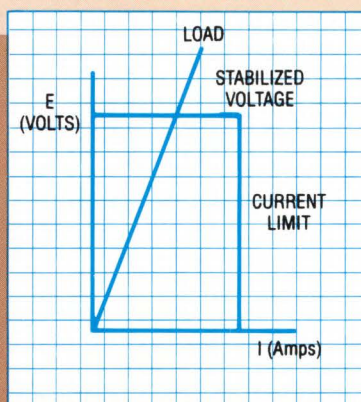
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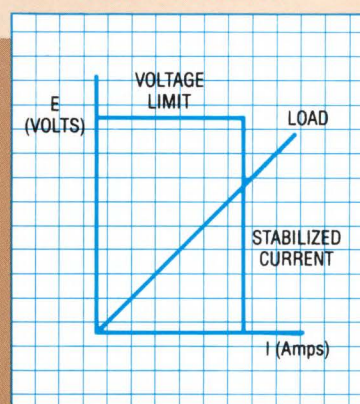
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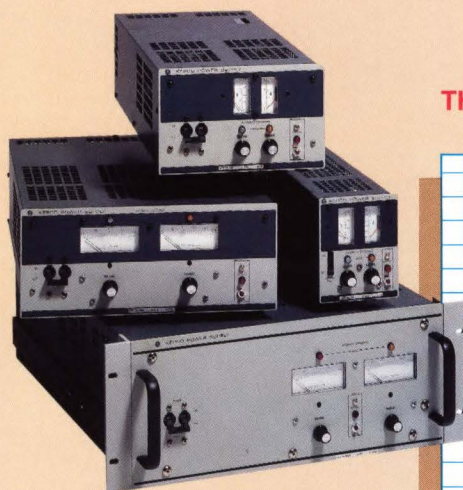


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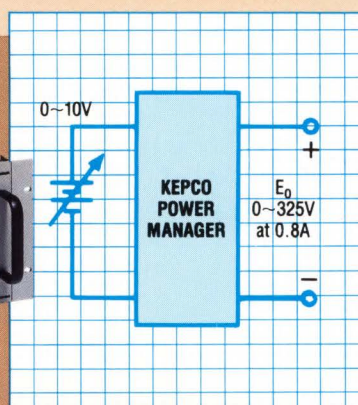
AND CURRENT.



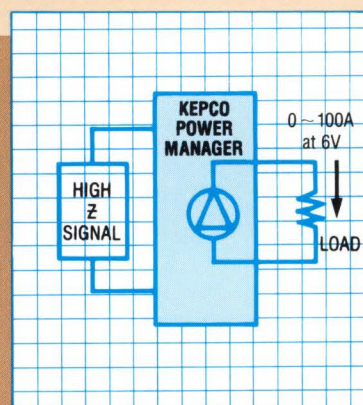
0.005% current stabilizer



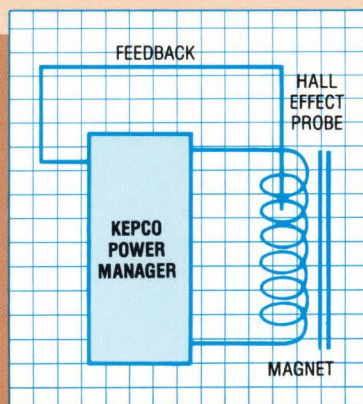
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A voltage stabilizer controlled
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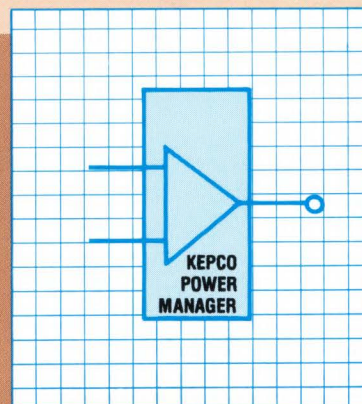
THEY'RE PROGRAMMABLE IN CURRENT MODE.

A current stabilizer controlled
by a high impedance source

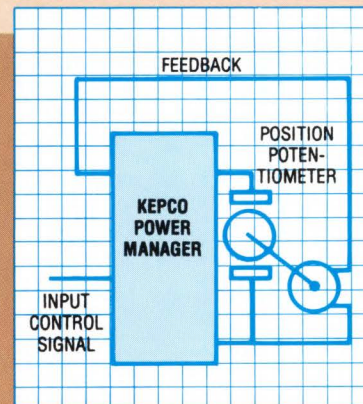
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MODEL	D-C OUTPUT RANGE		OUTPUT IMPEDANCE VOLTAGE MODE			OUTPUT IMPEDANCE CURRENT MODE		
	VOLTS	AMPS	SERIES RESISTANCE	SERIES INDUCTANCE SLOW	FAST	SHUNT (2) RESISTANCE	SHUNT CAPACITANCE SLOW	FAST
ATE 6-5M	0-6	0-5	24 $\mu\Omega$	0.5 μH	5 μH	12 k Ω	1,000 μF	1 μF
ATE 15-3M	0-15	0-3	100 $\mu\Omega$	0.5 μH	5 μH	30 k Ω	450 μF	0.4 μF
ATE 25-2M	0-25	0-2	250 $\mu\Omega$	1 μH	10 μH	50 k Ω	250 μF	0.25 μF
ATE 36-1.5M	0-36	0-1.5	480 $\mu\Omega$	1 μH	10 μH	72 k Ω	200 μF	0.2 μF
ATE 55-1M	0-55	0-1	1.1 m Ω	2 μH	20 μH	110 k Ω	150 μF	0.15 μF
ATE 75-0.7M	0-75	0-0.7	2.15 m Ω	2 μH	20 μH	150 k Ω	110 μF	0.1 μF
ATE 100-0.5M	0-100	0-0.5	4 m Ω	4 μH	40 μH	200 k Ω	50 μF	0.05 μF
ATE 150-0.3M	0-150	0-0.3	10 m Ω	4 μH	40 μH	300 k Ω	55 μF	0.02 μF

Size: 57 $\frac{32}{32}$ " H x 45 $\frac{32}{32}$ " W x 17 $\frac{1}{8}$ " D (132.6mm H x 105.6mm W x 435.0mm D)⁽¹⁾ Net Weight: 14 lbs. (6.4 kg.)

MODEL	D-C OUTPUT RANGE		OUTPUT IMPEDANCE VOLTAGE MODE			OUTPUT IMPEDANCE CURRENT MODE		
	VOLTS	AMPS	SERIES RESISTANCE	SERIES INDUCTANCE SLOW	FAST	SHUNT (2) RESISTANCE	SHUNT CAPACITANCE SLOW	FAST
ATE 6-10M	0-6	0-10	12 $\mu\Omega$	0.5 μH	5 μH	12 k Ω	1,800 μF	2 μF
ATE 15-6M	0-15	0-6	50 $\mu\Omega$	0.5 μH	5 μH	30 k Ω	1000 μF	0.8 μF
ATE 25-4M	0-25	0-4	125 $\mu\Omega$	1 μH	10 μH	50 k Ω	500 μF	0.5 μF
ATE 36-3M	0-36	0-3	240 $\mu\Omega$	1 μH	10 μH	72 k Ω	350 μF	0.4 μF
ATE 55-2M	0-55	0-2	0.55 m Ω	2 μH	20 μH	110 k Ω	200 μF	0.3 μF
ATE 75-1.5M	0-75	0-1.5	1 m Ω	2 μH	20 μH	150 k Ω	110 μF	0.2 μF
ATE 100-1M	0-100	0-1	2 m Ω	4 μH	40 μH	200 k Ω	80 μF	0.1 μF
ATE 150-0.7M	0-150	0-0.7	4 m Ω	4 μH	40 μH	300 k Ω	55 μF	0.04 μF

Size: 57 $\frac{32}{32}$ " H x 45 $\frac{32}{32}$ " W x 17 $\frac{1}{8}$ " D (132.6mm H x 105.6mm W x 435.0mm D)⁽¹⁾ Net Weight: 17 lbs. (7.7 kg.)

ACCESSORY FOR RACK MOUNTING: RA 37

MODEL	D-C OUTPUT RANGE		OUTPUT IMPEDANCE VOLTAGE MODE			OUTPUT IMPEDANCE CURRENT MODE		
	VOLTS	AMPS	SERIES RESISTANCE	SERIES INDUCTANCE SLOW	FAST	SHUNT (2) RESISTANCE	SHUNT CAPACITANCE SLOW	FAST
ATE 6-25M	0-6	0-25	4.8 $\mu\Omega$	0.5 μH	5 μH	12 k Ω	11,000 μF	5 μF
ATE 15-15M	0-15	0-15	20 $\mu\Omega$	0.5 μH	5 μH	30 k Ω	5,800 μF	2 μF
ATE 25-10M	0-25	0-10	50 $\mu\Omega$	1 μH	10 μH	50 k Ω	2,900 μF	1.25 μF
ATE 36-8M	0-36	0-8	90 $\mu\Omega$	1 μH	10 μH	72 k Ω	2,400 μF	1 μF
ATE 55-5M	0-55	0-5	0.22 m Ω	2 μH	20 μH	110 k Ω	1,400 μF	0.75 μF
ATE 75-3M	0-75	0-3	0.5 m Ω	2 μH	20 μH	150 k Ω	850 μF	0.5 μF
ATE 100-2.5M	0-100	0-2.5	0.8 m Ω	4 μH	40 μH	200 k Ω	375 μF	0.25 μF
ATE 150-1.5M	0-150	0-1.5	2 m Ω	4 μH	40 μH	300 k Ω	275 μF	0.1 μF
ATE 325-0.8M	0-325	0-0.8	8.1 m Ω	100 μH	1 mH	650 k Ω	180 μF	0.01 μF

Size: 57 $\frac{32}{32}$ " H x 81 $\frac{1}{32}$ " W x 17 $\frac{1}{8}$ " D (132.6mm H x 211.9mm W x 435.4mm D)⁽¹⁾ Net Weight: 35 lbs. (15.9 kg.)

ACCESSORY FOR RACK MOUNTING: RA 37

MODEL	D-C OUTPUT RANGE		OUTPUT IMPEDANCE VOLTAGE MODE			OUTPUT IMPEDANCE CURRENT MODE		
	VOLTS	AMPS	SERIES RESISTANCE	SERIES INDUCTANCE SLOW	FAST	SHUNT (2) RESISTANCE	SHUNT CAPACITANCE SLOW	FAST
ATE 6-50M	0-6	0-50	2.4 $\mu\Omega$	0.5 μH	5 μH	12 k Ω	12,000 μF	10 μF
ATE 15-25M	0-15	0-25	12 $\mu\Omega$	0.5 μH	5 μH	30 k Ω	8,000 μF	4 μF
ATE 25-20M	0-25	0-20	25 $\mu\Omega$	1 μH	10 μH	50 k Ω	5,800 μF	2.5 μF
ATE 36-15M	0-36	0-15	48 $\mu\Omega$	1 μH	10 μH	72 k Ω	4,900 μF	2 μF
ATE 55-10M	0-55	0-10	0.11 m Ω	2 μH	20 μH	110 k Ω	2,900 μF	1.5 μF
ATE 75-8M	0-75	0-8	0.19 m Ω	2 μH	20 μH	150 k Ω	1,200 μF	1 μF
ATE 100-5M	0-100	0-5	0.4 m Ω	4 μH	40 μH	200 k Ω	600 μF	0.5 μF
ATE 150-3.5M	0-150	0-3.5	0.86 m Ω	4 μH	40 μH	300 k Ω	440 μF	0.2 μF

Size: 57 $\frac{32}{32}$ " H x 121 $\frac{17}{32}$ " W x 17 $\frac{1}{8}$ " D (132.6mm H x 318.3mm W x 435.4mm D)⁽¹⁾ Net Weight: 43 lbs. (19.5 kg.)

The full rack model is supplied with brackets for direct mounting in a standard 19-inch rack.

MODEL	D-C OUTPUT RANGE		OUTPUT IMPEDANCE VOLTAGE MODE			OUTPUT IMPEDANCE CURRENT MODE		
	VOLTS	AMPS	SERIES RESISTANCE	SERIES INDUCTANCE SLOW	FAST	SHUNT (2) RESISTANCE	SHUNT CAPACITANCE SLOW	FAST
ATE 6-100M	0-6	0-100	1.2 $\mu\Omega$	0.5 μH	5 μH	12 k Ω	22,000 μF	15 μF
ATE 15-50M	0-15	0-50	6 $\mu\Omega$	0.5 μH	5 μH	30 k Ω	12,000 μF	6 μF
ATE 25-40M	0-25	0-40	12.5 $\mu\Omega$	1 μH	10 μH	50 k Ω	11,000 μF	4 μF
ATE 36-30M	0-36	0-30	24 $\mu\Omega$	1 μH	10 μH	72 k Ω	9,500 μF	3 μF
ATE 55-20M	0-55	0-20	55 $\mu\Omega$	2 μH	20 μH	110 k Ω	5,200 μF	2.25 μF
ATE 75-15M	0-75	0-15	0.1 m Ω	2 μH	20 μH	150 k Ω	3,400 μF	1.5 μF
ATE 100-10M	0-100	0-10	0.2 m Ω	4 μH	40 μH	200 k Ω	1,200 μF	0.75 μF
ATE 150-7M	0-150	0-7	0.42 m Ω	4 μH	40 μH	300 k Ω	1,050 μF	0.3 μF

Size: 63 $\frac{1}{32}$ " H x 16 $\frac{1}{2}$ " W x 20 $\frac{1}{8}$ " D (177.0mm H x 419.1mm W x 508.4mm D)⁽¹⁾ Net Weight: 87 lbs. (39.5 kg.)

⁽¹⁾Add 2 $\frac{1}{2}$ " (63.5mm) for connector protrusion. ⁽²⁾Based on 0.5 mA load effect in FAST mode.

⁽³⁾For determining dynamic impedance in voltage mode. ⁽⁴⁾For determining dynamic impedance in current mode.

...To get any of these functions, buy a KEPCO ATE Power Manager™

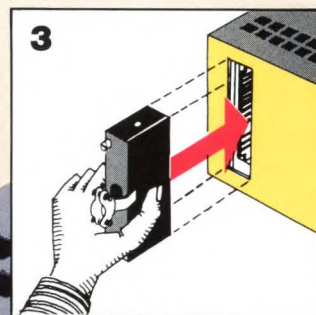
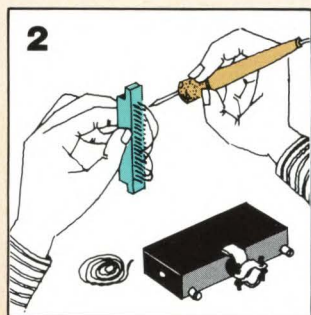
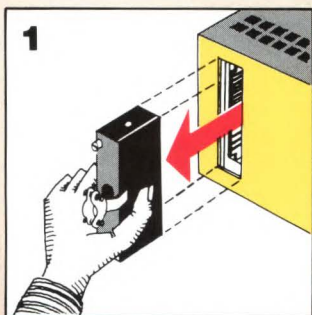
Your Kepco ATE Power Manager, like most *conventional* power supplies, is delivered with large output and feedback capacitors connected. This equips it to give you a rock steady voltage in the face of varying load currents.

The ATE, however, is no conventional power supply. The thing that makes it *unconventional* is the 50-terminal user port at the rear.

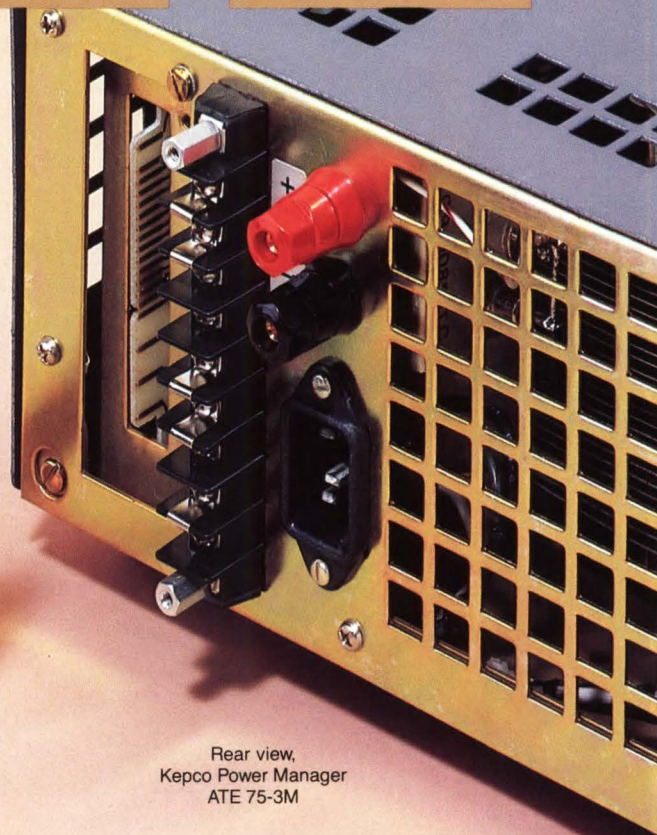
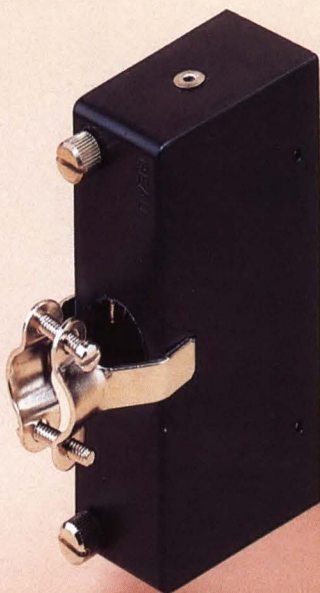
By simply (1) pulling out the mating connector, (2) rewiring it, and (3) putting it back, you can in a matter of minutes obtain access to a host of control functions. You can, for example, cut out the output and feedback capacitors and configure your ATE* to give you a steady current against a varying voltage. Better yet, buy a blank connector (they're only \$18 apiece) and wire it up in the current stabilizer configuration. Then, you can make the transformation in moments.

What the Kepco user port does is give you the ability to connect any element in the ATE's control assembly with nearly any other. So the way you wire it determines the nature of the ATE. One configuration lets you control the voltage channel with a 0-10V analog d-c signal (or a digital signal via a Kepco SN or TLD digital interface); another lets you control the current channel with a 0-1V signal. Other configurations let you control voltage or current with a 2-terminal resistance, or a high impedance source; others turn your ATE into a self-powered, oversized op amp or a servo amplifier. And still others let you use the uncommitted amplifiers we've included in the ATE's control assembly, to sum, scale, invert, or integrate control signals. The possibilities are limited only by your imagination.

*On Size E models, you must also remove a link from the rear barrier strip.



50-terminal connector, supplied as PC-13, prewired for local control, slow mode, of 1/4-rack models, and as PC-14 for 1/2-, 3/4-, and full-rack models. Available unwired as PC-12.



Rear view,
Kepco Power Manager
ATE 75-3M

STATIC STABILIZATION TABLE

INFLUENCE QUANTITY	OUTPUT EFFECTS VOLTAGE MODE		OUTPUT EFFECTS CURRENT MODE		OFFSETS ⁽⁴⁾	
	Typ.	Max.	Typ.	Max.	ΔE_{IO}	ΔI_{IO}
SOURCE VOLTAGE (min.-max.):	< 0.0005% E_0 max.	0.001% E_0 max.	< 0.002% I_0 max.	0.005% I_0 max.	< 1 μ V	< 1 nA
LOAD (no load-full load):	< 0.001% E_0 max.	0.002% E_0 max.	< 0.5 mA ⁽¹⁾	1 mA ⁽¹⁾	—	—
TIME (8-hour drift):	< 0.005% E_0 max.	0.01% E_0 max.	< 0.01% I_0 max.	0.02% I_0 max.	< 20 μ V	< 1 nA
TEMPERATURE, per °C:	< 0.005% E_0 max.	0.01% E_0 max.	< 0.01% I_0 max.	0.02% I_0 max.	< 20 μ V	< 2 nA
RIPPLE and NOISE ⁽²⁾ rms:	< 0.1 mV	0.3 mV	< 0.01% I_0 max.	0.03% I_0 max.	—	—
(Slow Mode) p-p: ⁽³⁾	< 1 mV	3 mV	< 0.1% I_0 max.	0.3% I_0 max.	—	—
RIPPLE and NOISE ⁽²⁾ rms:	< 1 mV	3 mV	< 0.01% I_0 max.	0.03% I_0 max.	—	—
(Fast Mode) p-p: ⁽³⁾	< 10 mV	30 mV	< 0.1% I_0 max.	0.3% I_0 max.	—	—

(1) For models with output current rating of 50A and higher, the load effect is 2 mA typical and 5 mA maximum. In slow mode, the leakage current through the output capacitor adds approximately 0-6 mA to the current mode load effect.

(2) One terminal must be grounded for this measurement, or connected so that common mode current does not flow through the load or, in current mode, through the current-sensing resistor.

(3) Peak-to-peak ripple is measured over a 20 Hz to 10 MHz bandwidth.

(4) Uncommitted amplifier offsets.

GENERAL

Crowbar trigger time:

Slow mode — 50 μ sec.
Fast mode — 500 μ sec delay, to avoid false triggering.

OVP action:

- 1) Short output with SCR.
- 2) Trip a-c circuit breaker.
- 3) Generate optically isolated flag signal.

Series operation:

To the 500V limit of the isolation voltage; master/slave operation is possible.

Parallel operation:

Master/slave operation, and redundant connections, are possible.

Isolation:

Output may be floated up to 500V off ground. Common mode current — 5 μ A rms, 50 μ A peak to peak, at 115V a-c.

Temperature:

Storage — -40°C to 85°C.
Operating — 0°C to +55°C (derate to 90% of rated current at +65°C.)

Cooling:

Built-in fan (2 in full-rack models) exhausts air to rear.

D-C output terminal (Rear):

1/4-rack models — barrier strip.
1/2- and 3/4-rack models — binding posts.
Full-rack models — compression studs.

Meters:

1/4- and 1/2-rack models:
Two 1 1/2", 3%
3/4- and full-rack models:
Two 2 1/2", 2%

Source voltage:

User selectable, 95-113, 105-125, 190-226, or 210-250V a-c, 50-65 Hz, single phase; do not use on 400Hz.

Source current:

See Table 1.

Output current:

Continuously adjustable or programmable, 0-100%.

Control voltage:

Local — 10-turn rheostat on front panel.
Remote — 0 to 10V signal.

Control current:

Local — 10-turn rheostat on front panel.
Remote — 0 to 1V signal.

Remote error sensing:

Provision made for 4-terminal connection to load; static drop of 0.5V/lead may be compensated, and an extra volt is provided for this purpose.

Program speed (programming time constant, τ):

Slow mode — $\tau = R_1 \times C_{out}$ (see model tables).
Fast mode — see Table 2.

Current recovery for a step load voltage:

Exponential with programming time constant, τ .

Mode Indicators

Voltage — green LED, front panel.
Current — amber LED, front panel.
OVP — red LED, front panel.

Mode flags

TTL logic signals delivered to rear connector as optically isolated outputs.

OVP control:

Local — trimmer adjustable.
Remote — 0-10V signal, or may be set to track output voltage.

Remote trigger:

Optically isolated "trigger-in" port allows overvoltage tripping by remotely generated pulse, so that OVPs of several power supplies can be interconnected or sequenced or simultaneous shutdown. Lower limit for OVP is 3V, adjustable to 110% E_0 . Minimum threshold adjustment: 0.5V or 2% E_0 , whichever is greater.

Table 1 Source Current

(Measured, worst case, at 125V a-c source voltage)
Size A-1.4A max.
Size B-2.4A max.
Size C-6.0A max.
Size D-11.0A max.
Size E-20.0A max.

Table 2 Dynamic Specifications

Output Voltage Ratings	Bandwidth (-3dB) KHz	Programming Time Constant (μ sec)
	Min.	Max.
6V	16.0	10.0
15V	10.6	15.0
25V	8.0	20.0
36V	6.4	25.0
55V	4.0	40.0
75V	3.5	45.0
100V	2.5	65.0
150V	1.7	95.0
325V	0.94	170.0

Voltage recovery: For step load change between 10% and 100% I_0 maximum <50 μ sec typ., <100 μ sec max. to recover within 10mV



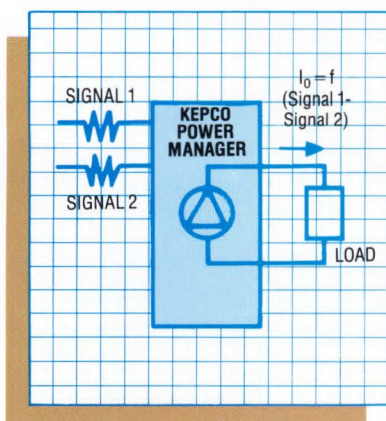
TEAR ON DOTTED LINE TO REMOVE AND SAVE.

Kepeco ATE Power Managers are unipolar linear programmable power supplies that give you full external control over both voltage and current, with automatic crossover. They have panel-mounted meters for monitoring both channels, and front panel LEDs (and optically isolated flags accessible through the user port) to tell you which channel is in charge. Local control is by panel-mounted 10-turn rheostats.



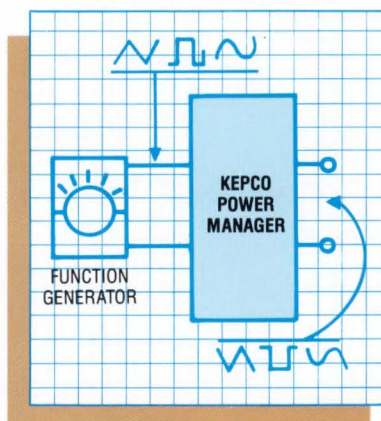
ATE POWER SUPPLIES
50 Watts to 1000 Watts

**ATE CAN SUM
INPUT CONTROL SIGNALS**



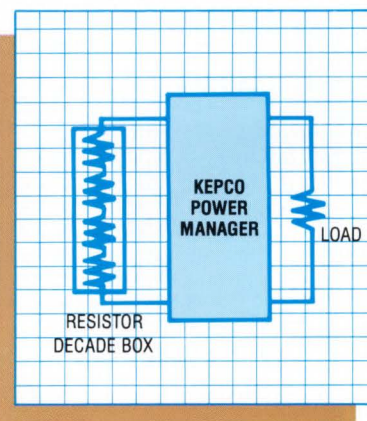
A current stabilizer controlled
by the difference between
two signals

**...BE DRIVEN BY
AN ANALOG FUNCTION**



A voltage stabilizer controlled
by a signal generator

**OR INTERFACE TO
THE DIGITAL WORLD
(See back cover).**



A voltage stabilizer controlled
by a passive resistance
decade box

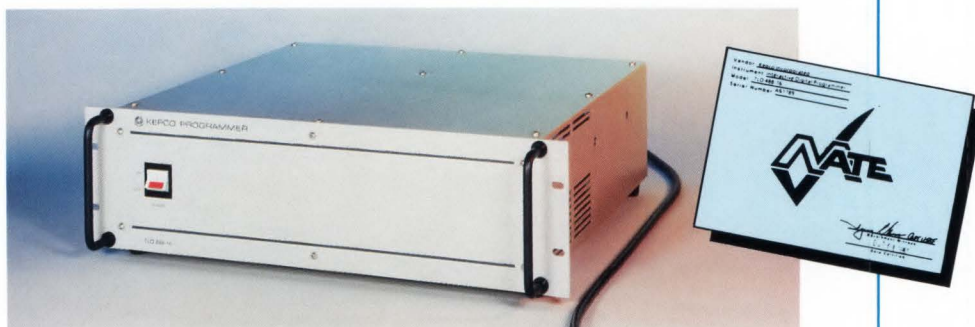
"Power Manager," "ATE Power Manager,"
"BOP Power Manager" and "Kepeco Power Manager"
are Trade Marks of Kepeco, Inc.



Data subject to change without notice.
© 1989 KEPCO, INC. Litho in U.S.A.

Kepeco's Series ATE power supplies are "MATE-verified" for use in Modular Automatic Test Equipment that is addressed in the (CIIL) Control Interface Intermediate Language.

Kepeco's TLD 488-16 interactive digital interface is an IEEE-488-driven talker-listener that has been verified as a TMA (Test Module Adapter) for Kepeco's ATE and BOP⁽¹⁾ power supplies.



On October 1, 1987 Kepeco's TLD officially achieved "MATE-verified" status. The certificate shown was issued by the MATE program office, Kelly AFB, Texas.

The TLD 488-16 responds to commands in CIIL (Control Interface Intermediate Language) over the IEEE-488 bus from your computer or digital controller, and passes them along to the Power Managers under its control. It can control up to 16 Kepeco ATE and/or BOP Power Managers at once, and if one of them cannot obey a command, it sends back a flag which the TLD 488-16 translates into CIIL and passes along to the controller as an "error message." Among the error messages it can send are "crowbarred," "overload," "voltage comparison error," and "current comparison error."

You can give your commands to the TLD 488-16 directly in Volts and Amps, because it knows the voltage and current ranges of every Power Manager under its control and can calculate what percentage of full scale a given voltage or current setting is.

(1) BOP are Kepeco Bipolar Power Supplies. Please see brochure 146-1636.

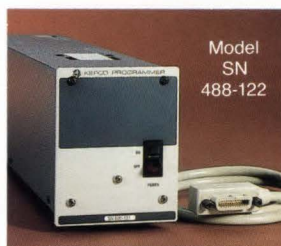
Kepeco Series ATE power supplies may be listener-addressed using a selection of 1-, 4- and 8-channel digital interfaces.

SN 488 works with the IEEE-488 bus, and SN 500 works with buses using bit-parallel data transfer, but they're otherwise identical. They're both available with one channel or with two isolated channels, and if you buy a single channel model, you can buy a field-installable second channel any time you need it.

SNR 488-4 and SNR 488-8 are card cages into which you can plug four to eight dual channel programming cards.

Output of all SN cards is 0 to $\pm 1V$ or 0 to $\pm 10V$ selectable, and all offer models that accept data in 12-bit hex or 3 digit BCD.

TYPE SN STAND ALONE INTERFACE



MODEL	SINGLE AND DUAL CHANNEL PROGRAMMERS, 1/4-RACK SIZE							
	SN488-				SN500-			
	121	122	031	032	121	122	031	032
NUMBER OF CHANNELS	1	2	1	2	1	2	1	2
INPUT DATA CODING FORMAT	Hex		Decimal		Hex		Decimal	
RESOLUTION	12 Bit		3 Digit		12 Bit		3 Digit	

TYPE SNR 488-4
(Addresses up to 4 ATE power supplies)

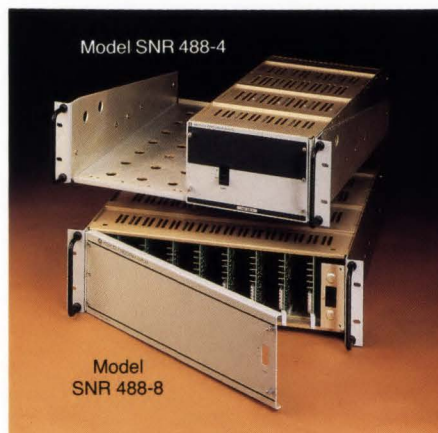
TYPE SNR 488-8
(Addresses up to 8 ATE power supplies)

SNR Housings

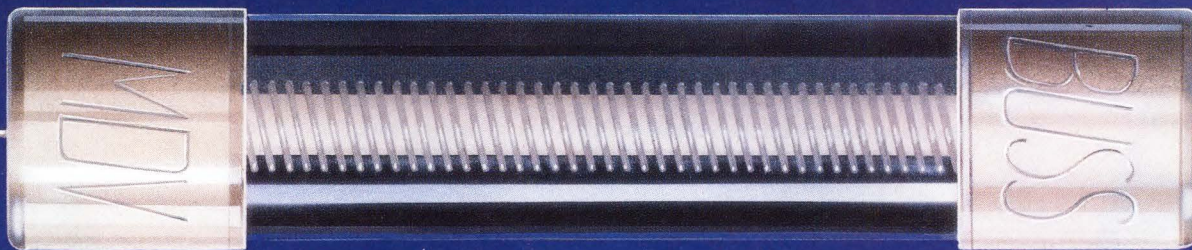
MODEL	HOLDS
SNR 488-4	4 Cards
SNR 488-8	8 Cards

Interface cards

MODEL	DATA FORMAT	RESOLUTION
SN 488-B	Hex	12-bit binary
SN 488-D	Decimal	3-digit BCD

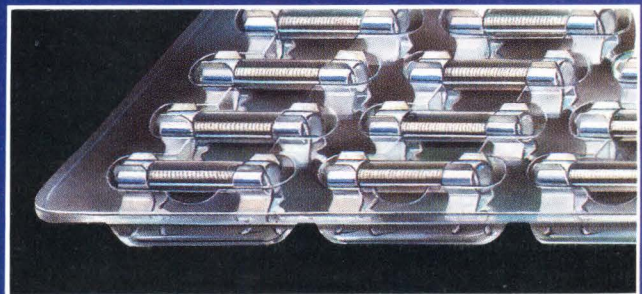


NON BREAKTHROUGH BY BUSSMANN



NEW GLASS TUBE FUSE KEEPS WASHING FLUID OUT.

Washing of printed circuit boards carrying glass tube fuses has long posed an open-ended problem: every "nth" fuse will fill with washing fluid. Compromising performance and creating field problems. ■ An expensive solution has been to substitute dummies for the fuses before washing and replace them with fuses afterwards. Now Bussmann offers glass tube fuses which are sealed against moisture—avoiding field problems and eliminating extra manufacturing steps. It's the same glass fuse you're using, the same footprint but with one important difference. ■ For test samples contact Bussmann Division, Cooper Industries, P.O. Box 14460, St. Louis, MO 63178, (314) 394-2877.

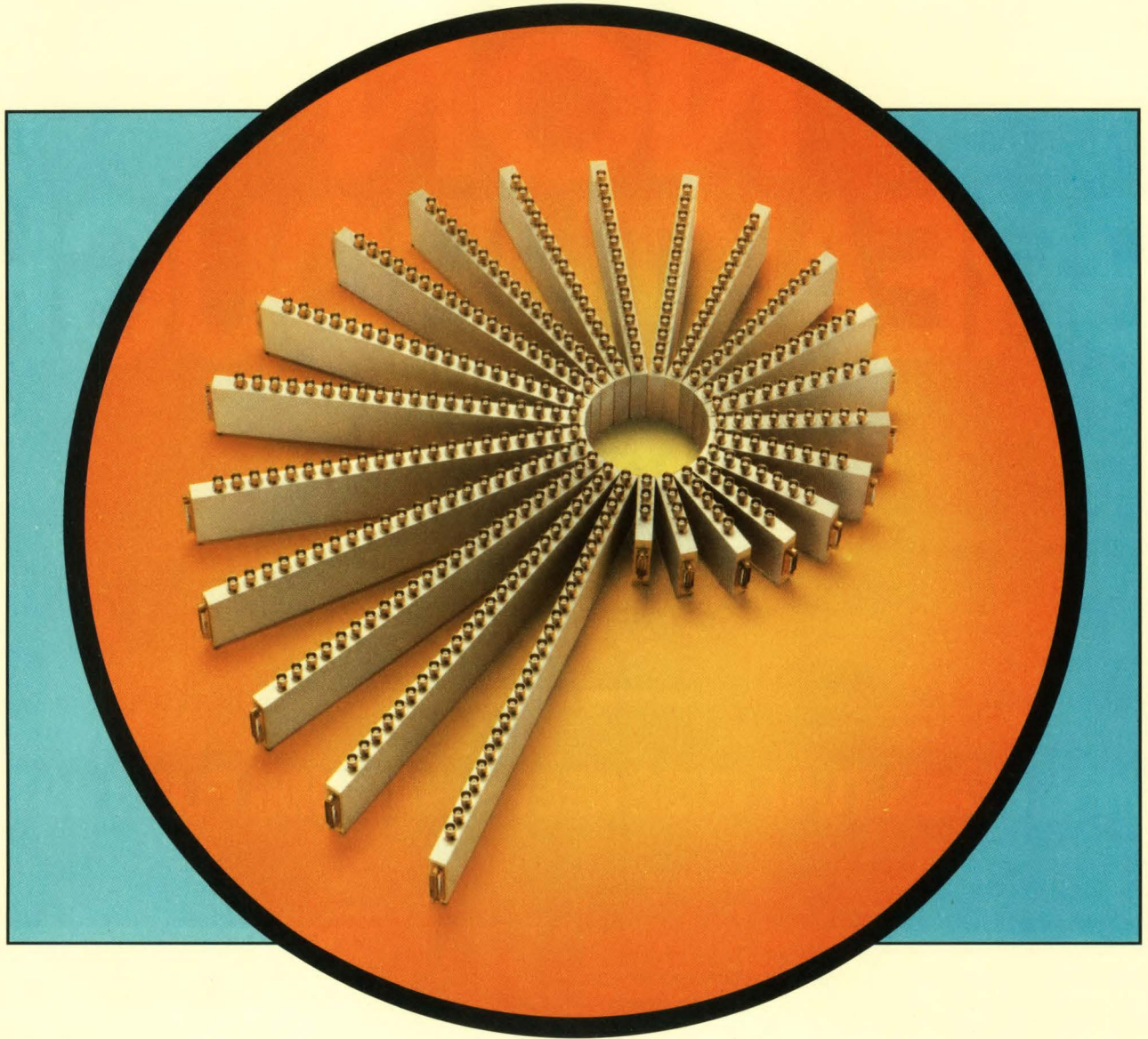


New BUSSMANN sealed glass tube fuses are available pre-inserted into PCB clips and assembled into trays to maintain registration during shipment. Now you can order, inventory and install one part number instead of three. And insure reliable fuse performance in your product while reducing manufacturing cost.



BUSSMANN

NEED BROAD-BAND COAXIAL RELAYS? FROM 2 TO 24 THROW, MATRIX HAS THE ANSWER



Our versatile 7000 series of coaxial relays have band-widths from DC up to 800 MHz. They're available from 2 to 24 throw. And by using our 9000 series cross-straps, switching matrices of any size can be configured.

Why have Matrix broad-band relays become the industry standard? Because we construct them of precision machined anodized aluminum alloy, all signal shield paths are silver plated, and basic switch elements are hermetically sealed in nitrogen filled gas envelopes with rhodium plated contacts to insure non-stick operation.

The end result is extremely low crosstalk, EMI and VSWR. Another plus, all switchpoints are individually field replaceable.

The units are plug compatible with Matrix 6100A and 1600 Series Logic Modules for compatibility with RS-232, RS-422 and IEEE-488 Interface busses as well as 16 bit parallel.

Non-blocking Matrix configuration may be easily assembled

using our self-terminating relays and 5100A series power dividers. Built-in Video/RF amplifiers allow zero insertion loss designs.

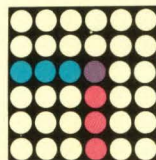
So if you're looking for broad-band relays, it pays to deal with Matrix. After all, we've been designing state-of-the-art reed relay and semiconductor switching systems for over 18 years.

Our customers include government agencies, defense contractors, the TV industry, ATE and telecommunications companies—and more.

Phone: 818-992-6776

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MATRIX
SYSTEMS CORPORATION

5177 NORTH DOUGLAS FIR ROAD
CALABASAS, CALIFORNIA 91302

CIRCLE NO 134

A simple analysis helps to clarify a DSO's performance specs

The relationship between a digitizing oscilloscope's sample rate and the analog bandwidth of the waveforms it displays is not always obvious. In today's world, you need to understand these concepts.

Robert A Witte, Hewlett-Packard

As digital signal-processing techniques become more common, engineers are familiarizing themselves with the concept of sampling. But this familiarity does not mean that the characteristics of the various digitizing oscilloscopes are well understood. Fundamental differences distinguish the various scopes, and these differences are obscured if you look only at the scopes' digitizing rates.

Modern digitizing oscilloscopes use one or more of three types of sampling: real-time sampling, sequential sampling, and random-repetitive sampling (Fig 1).

The most straightforward type of sampling is real-time sampling—the type commonly described in digital signal-processing textbooks. This type is the most intuitive form of sampling and is what most engineers think of when discussing sampled signals. Real-time sampling digitizes the signal at a sample rate greater than the Nyquist rate to produce a sampled waveform.

Briefly, the Nyquist criterion states that you can

characterize a band-limited baseband signal if you sample it at greater than twice its highest frequency component. For most practical applications, however, you need higher sample rates if you are to make any sense of the displayed digitized data points. The real-time digitizing scope captures an entire waveform upon a single trigger event; therefore, it is capable of capturing even a transient, or single-shot, event. Unfortunately, this method requires a relatively expensive, fast, A/D converter to meet the Nyquist criterion.

Fig 2 shows the block diagram of a scope which uses only real-time sampling. In this case, the input amplifier feeds directly into the input of a flash A/D converter, though it can also feed into a scan converter or a charge-coupled device. The A/D converter must be fast enough to sample significantly above the Nyquist rate. The scope stores the output of the A/D converter in memory (which also must be very fast in the case of flash converters) and displays the waveform on its screen.

Real-time digitizing oscilloscopes use a digital reconstruction filter after their A/D converters to produce an accurate waveform. If the filter's cutoff is too steep, the pulse response of the scope will be poor because of overshoot distortion. If the filter's response rolls off more slowly, the scope will require a higher sample rate than the scope that has a sharp cutoff. These design tradeoffs are complex and beyond the scope of this article. The important point is that for a given reconstruction scheme, the ratio of sample rate to

For a given reconstruction scheme, the ratio of sample rate to bandwidth is constant.

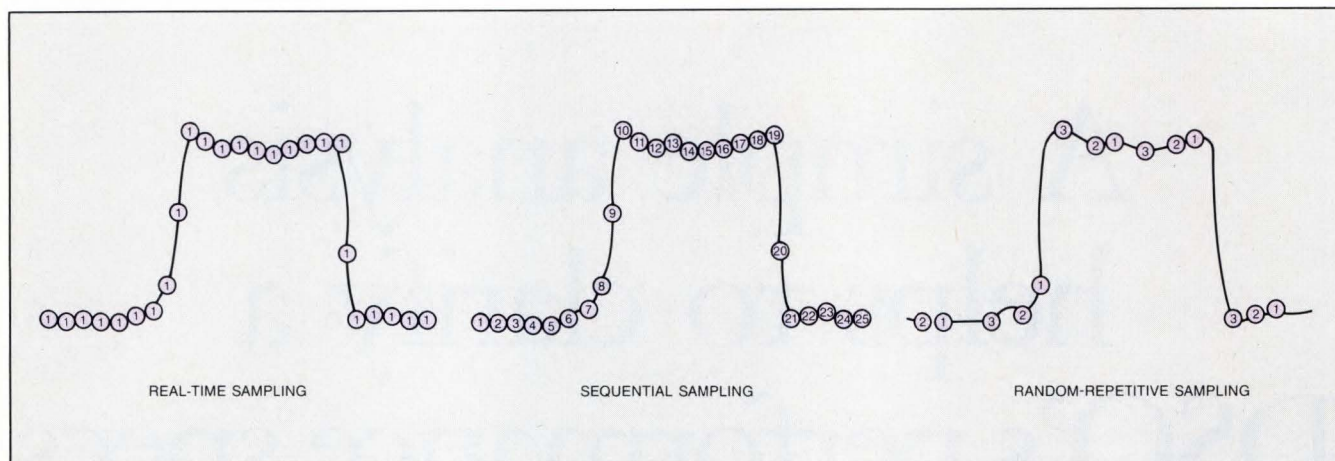


Fig 1—The numbers on each sample point indicate which trigger the sample was acquired on. Sequential sampling and random-repetitive sampling require many triggers to acquire a complete waveform.

bandwidth is constant. Hewlett-Packard real-time scopes generally use a sample rate that is 4 times the bandwidth.

Sequential-sampling oscilloscopes offer an advantage compared with real-time sampling scopes: A much slower—and hence less expensive—A/D converter is sufficient. Sequential sampling digitizes a signal by taking samples, with a sample-and-hold or track-and-hold circuit, from many different cycles of the signal. When a trigger event occurs, the instrument acquires a new sample at a certain time interval after the trigger. The instrument increases this time delay by a fixed amount after each sample, thereby sampling a different point of the signal, until it has digitized the entire signal. You can use sequential sampling as long as the following two conditions are met:

- The waveform is repetitive
- A stable trigger is available.

Random-repetitive sampling is similar to sequential sampling except that the time difference between the trigger point and the sample point is random. The technique requires the same two preconditions as sequential sampling: a repetitive signal and a stable trigger. As the instrument takes a sample, it measures the sample's time relationship to the trigger point. This measurement allows the scope to place the sample point at the proper location on the display. A stable trigger is important because it provides the time reference for collecting the waveform samples.

Scope makers sometimes quote an "effective sample rate" for sequential or random-repetitive sampling oscilloscopes. An *effective* sample rate is more impressive than a scope's actual sample rate because it is much faster than the sample rate of the scope's A/D con-

verter. The effective sample rate is the reciprocal of the minimum time between the repetitively acquired sample points. The only limit to the effective sample rate is how accurately the scope can place the samples, in time, relative to the trigger. Of course, the scope's input analog bandwidth determines the actual upper limit of the scope's response.

Random-repetitive sampling has an advantage over sequential sampling: A portion of the sample points occurs before the trigger; these samples allow you to view waveform information preceding the trigger. A disadvantage of this technique is the reduced display update rate for small timebase (time/div) settings.

Fig 3 shows the display results of a random-repetitive sampling scope. Using a sample rate of only 10M samples/sec, the scope accurately measures a 30-nsec repetitive pulse. The width of the pulse is smaller than the A/D converter's conversion period (100 nsec), but the random-repetitive timebase circuitry provides a timing resolution of 100 psec.

Fig 4's block diagram is that of a random-repetitive

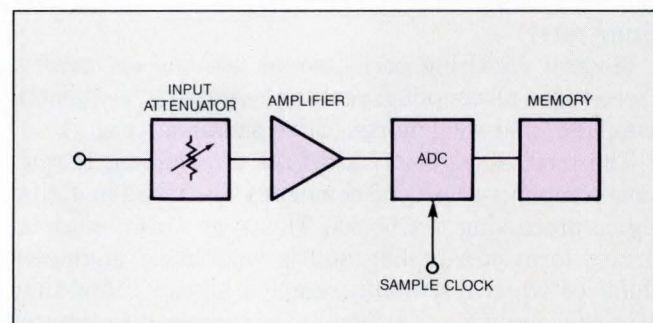


Fig 2—A real-time digitizing scope uses an A/D converter that can sample at a rate higher than the Nyquist rate.

scope. Note that the diagram shows a sampler (either a track-and-hold or sample-and-hold circuit) in front of the A/D converter. One of these circuits is necessary because the A/D converter usually operates at a rate that is much slower than the Nyquist rate, and therefore the signal can vary significantly during the analog-to-digital conversion. Thus, the sampler must acquire the sample with minimal time jitter and hold the sample's voltage level long enough for the A/D converter to perform the conversion. Such a system has high bandwidth in front of its sampler, but a much lower bandwidth after it. Thus, it too can use a slower, more economical—or more realizable—A/D converter and memory.

Random-repetitive and sequential sampling scopes generally do not use a reconstruction filter as real-time scopes do and, hence, their A/D converters' sample

rate has no fixed relationship to the scope's bandwidth. (In a real-time scope, $f_s = n(BW)$, where f_s is the sample rate and n is typically between 2.5 and 4, depending on the reconstruction filter.) In fact, a random-

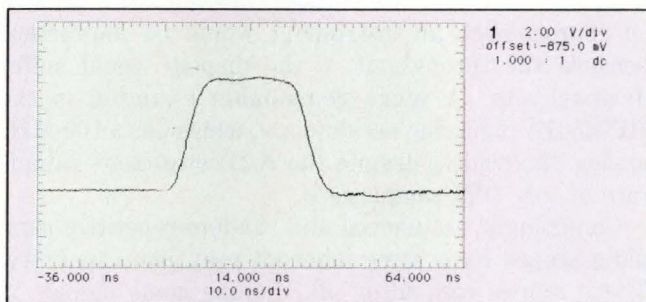


Fig 3—This random-repetitive sampling scope display clearly shows this repetitive 30-nsec pulse, even though the sample rate of the scope's A/D converter is only 10M samples/sec.

Exercise your newfound scope-selection powers

You never know for sure if you've understood the underlying concepts of an article until you try to apply that knowledge. The following miniquiz is intended for those interested in trying out their newfound knowledge.

You have the following scopes available:

- a 100-MHz repetitive scope with a 10M-sample/sec sample rate
- a 1-GHz repetitive scope with a 10M-sample/sec sample rate
- a 100-MHz real-time scope with a 400M-sample/sec sample rate.

1. You must measure the amplitude and frequency of a nominal 5-MHz sine wave. Which of the three scopes can perform this measurement?

This is clearly a repetitive application; the sine wave is presumably continuous. Because 5 MHz is well within the bandwidth of all of the scopes, you could use any one of them to make this

measurement.

2. A 100-nsec-wide transient pulse occurs every time you reset a μP at power-on. Which scope can accurately characterize this pulse?

This measurement is a single-shot one and requires a scope with a single-shot bandwidth fast enough to capture the pulse. The 100-MHz single-shot scope, with its 400M-sample/sec sample rate, acquires a sample every 2.5 nsec. This bandwidth and sample rate should be more than adequate to capture a 100-nsec pulse.

3. An emitter-coupled logic signal has a period of 12 nsec and a positive pulse width of 5 nsec. Which digitizing scope can accurately acquire this signal?

The signal is periodic and therefore the measurement is repetitive. The 12-nsec period implies a fundamental frequency of 83 MHz. A 100-MHz repetitive bandwidth would barely measure the fundamental frequency and none of the harmonic energy (the

pulse will have significant frequency content above 100 MHz). However, the 1-GHz repetitive scope has adequate bandwidth to include the twelfth harmonic of the signal in its measurement.

4. You must capture the turn-on transient of a power supply. If the output of the power supply is band limited to 25 kHz, which scope can you use to acquire this signal?

Clearly this is a single-shot measurement, which requires real-time sampling capability. However, digitizing scopes using random-repetitive sampling also provide some real-time capability. This is a trick question: Both repetitive scopes have a sample rate of 10M samples/sec, which provides a 1-MHz single-shot bandwidth. Because the power-supply output is band limited to only 25 kHz, any of the three scopes can perform this measurement.

Sequential and random-repetitive sampling scopes have some inherent real-time capability.

repetitive or sequential sampling scope could have an extremely slow A/D converter—say 1 sample/sec—along with a 1-GHz bandwidth as long as the scope's sampler could hold the voltage constant for a second. Of course, such an instrument would be impractical because the throughput to the display would suffer dramatically. A more reasonable example is the HP54501A digitizing oscilloscope, which has a 100-MHz analog bandwidth, despite the A/D converter's sample rate of only 10M samples/sec.

Confusingly, sequential and random-repetitive sampling scopes have some inherent real-time capability. These scopes can, after all, digitize some signals in real time as long as the signals' frequencies are lower than the scopes' digitizing rates. The effective real-time bandwidth of a sequential or random-repetitive sampling scopes depends, again, on how many data points you need to define a waveform. Because sequential and random-repetitive scopes generally have no reconstruction schemes to aid you in visualizing a captured waveform, HP specifies the real-time (single-shot) bandwidth of its random-repetitive scopes as $f_s/10$ —which gives 10 samples per cycle of a sine wave. So, by HP standards, a sequential or random-repetitive scope sampling at 10M samples/sec has a single-shot bandwidth of 1 MHz.

To relate the information in this article to the practical problem of choosing the right type of scope for your job, you must determine whether the measurement is single-shot or repetitive. This determination sounds easy, but scope users often confuse the two. For example, capturing a fast glitch on a digital signal may look like a single-shot measurement because of the short time period of the glitch. A single, nonrepetitive glitch does indeed imply a single-shot measurement, but if the glitch occurs periodically—say once every 10 μ sec—the measurement is actually a repeti-

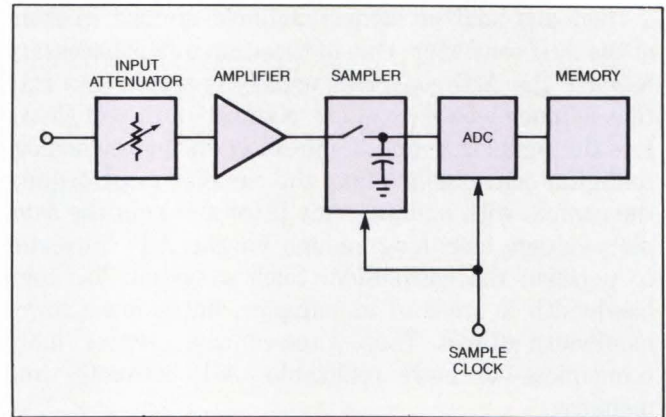


Fig 4—A random-repetitive digitizing scope uses a sampler to acquire and hold the voltage while the A/D converter digitizes it.

tive one. Analog scope users will recall that a nonstorage analog oscilloscope can only display repeating signals. True single-shot events are but a brief flash across the screen. If a nonstorage analog scope can make the measurement, the measurement is repetitive.

If the measurement is truly single-shot—occurring only once or repeating so slowly that a repetitive measurement would take too long—you need a scope that has sufficient real-time bandwidth, which really means a sufficient sample rate. If the measurement is repetitive, however, you don't need to worry about the A/D converter's sample rate or the single-shot bandwidth of the scope. In this case, the repetitive bandwidth and timing resolution of the scope are important.

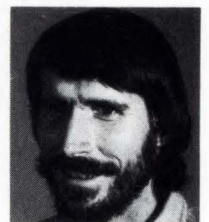
EDN

Right name for right attribute

Unfortunately, some scope makers still murkily specify both bandwidth and sample rate in hertz, leaving an engineer to wonder if a 100-MHz scope has a 100-MHz bandwidth or a 100-MHz sample rate. Most manufacturers, primarily at the urging of the editors of EDN magazine, now specify bandwidth in megahertz and state the sample rate in megasamples/sec.

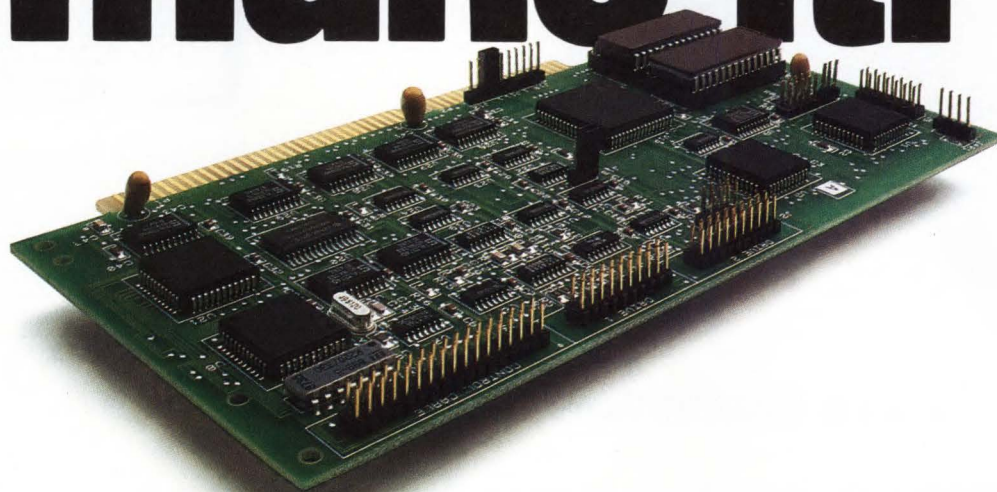
Author's biography

Robert A Witte is an R&D project manager at Hewlett-Packard's Colorado Springs Div, where he develops digitizing oscilloscopes. He has been with HP for 10 years. Robert obtained a BSEE at Purdue University and an MSEE at Colorado State University. He is a member of the IEEE and in his spare time enjoys hiking, skiing, and camping.



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DESIGN IDEAS

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Equations yield hysteresis values

Art Vaughn

Ajax Magnethermic Corp, Warren, OH

Most often, data sheets for IC comparators list equations that yield hysteresis-voltage levels in terms of the comparator's external-component values. For Fig 1's comparator circuit, the analysis equations are:

$$V_{RH} = \frac{(R_1 R_3 + R_2 R_3) \times V_D + R_3 R_4 V_C}{R_1 R_3 + R_2 R_3 + R_1 R_4 + R_2 R_4 + R_3 R_4}$$

$$V_{RL} = \frac{R_3 R_4 V_{CE} + R_2 R_3 V_D}{R_3 R_4 + R_2 R_4 + R_2 R_3}$$

$$V_{OH} = V_{RH} + (V_C - V_{RH}) \times \frac{R_2}{R_1 + R_2}$$

Recasting the equations to yield component values in terms of hysteresis-voltage levels, however, proves much more useful to designers:

$$R_2 = \frac{R_1 (V_{RH} - V_{OH})}{V_{OH} - V_C}$$

$$R_3 = \frac{V_{RH} \left(\frac{V_{R1} - V_D}{V_{RH} - V_D} \right) - V_{RL}}{\frac{V_{RL} - V_{CE}}{R_2} + \left(\frac{V_{RL} - V_D}{V_{RH} - V_D} \right) \times \left(\frac{V_C - V_{RH}}{R_1 + R_2} \right)}$$

$$R_4 = \frac{V_{RH} - V_D}{\left(\frac{V_C - V_{RH}}{R_1 + R_2} \right) - \frac{V_{RH}}{R_3}}$$

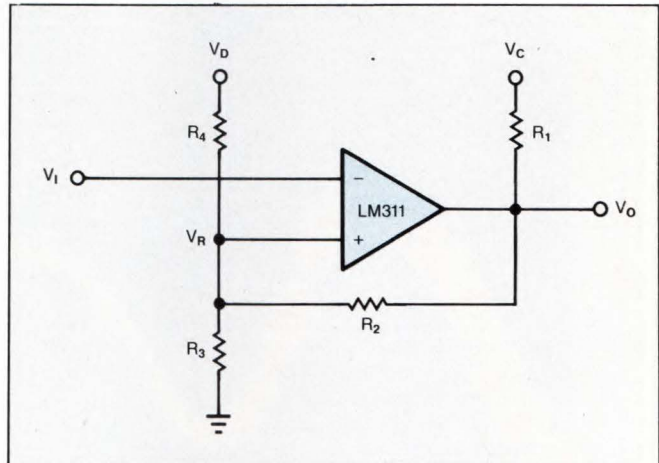


Fig 1—Solving the usual data-sheet hysteresis-level equations for the hysteresis-network component values lets you design such a network easily.

where V_{CE} is the comparator's low output-saturation level.

To design a hysteresis network, choose your desired high and low hysteresis levels, V_{RH} and V_{RL} . If either level is below ground, V_D must be a negative supply; otherwise, V_C and V_D can be any available positive supply. You then choose a suitable value for R_1 and your desired high output level from the comparator, V_{OH} . You can easily calculate the remaining resistor values.

EDN

To Vote For This Design, Circle No 748

Current mirror enhances DAC

Alfred P Neves

Precision Monolithics Inc, Santa Clara, CA

By adding a Wilson current mirror to the output of a complementary D/A converter, you can extend the converter's application range to include designs that require that it both sink and source current. The circuit

in Fig 1 generates ± 2 mA and maintains linearity well within 1 LSB (± 2 mA/256 = 15.6- μ A resolution).

The circuit uses a DAC-08 that's configured for a 2-mA full-scale output. The circuit functions by inverting the I_{OUT} output via the Wilson current mirror and summing this inverted output with the converter's complemented output, I_{OUT} .

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6810	to 8M pts	5 MS/sec	2.5 MHz	12 bits	4/2/1
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DESIGN IDEAS

The full-scale output for the DAC-08, I_{FS} , is a linear function of I_{REF} :

$$I_{FS} = \frac{255}{256} \times I_{REF}$$

$$I_{OUT} + \overline{I_{OUT}} = I_{FS} = I_{REF} \left(\frac{255}{256} \right).$$

The current-mirror output is $I_{OUT} - \overline{I_{OUT}} = 1$, so if $I_{REF} = 2 \text{ mA}$, $I_{FS} = 1.922 \text{ mA}$.

$$I = 2I_{OUT} - 1.922 \text{ mA}$$

$$= 2 \left(\frac{\text{INPUT CODE}}{256} \right) 2 \text{ mA} - 1.922 \text{ mA},$$

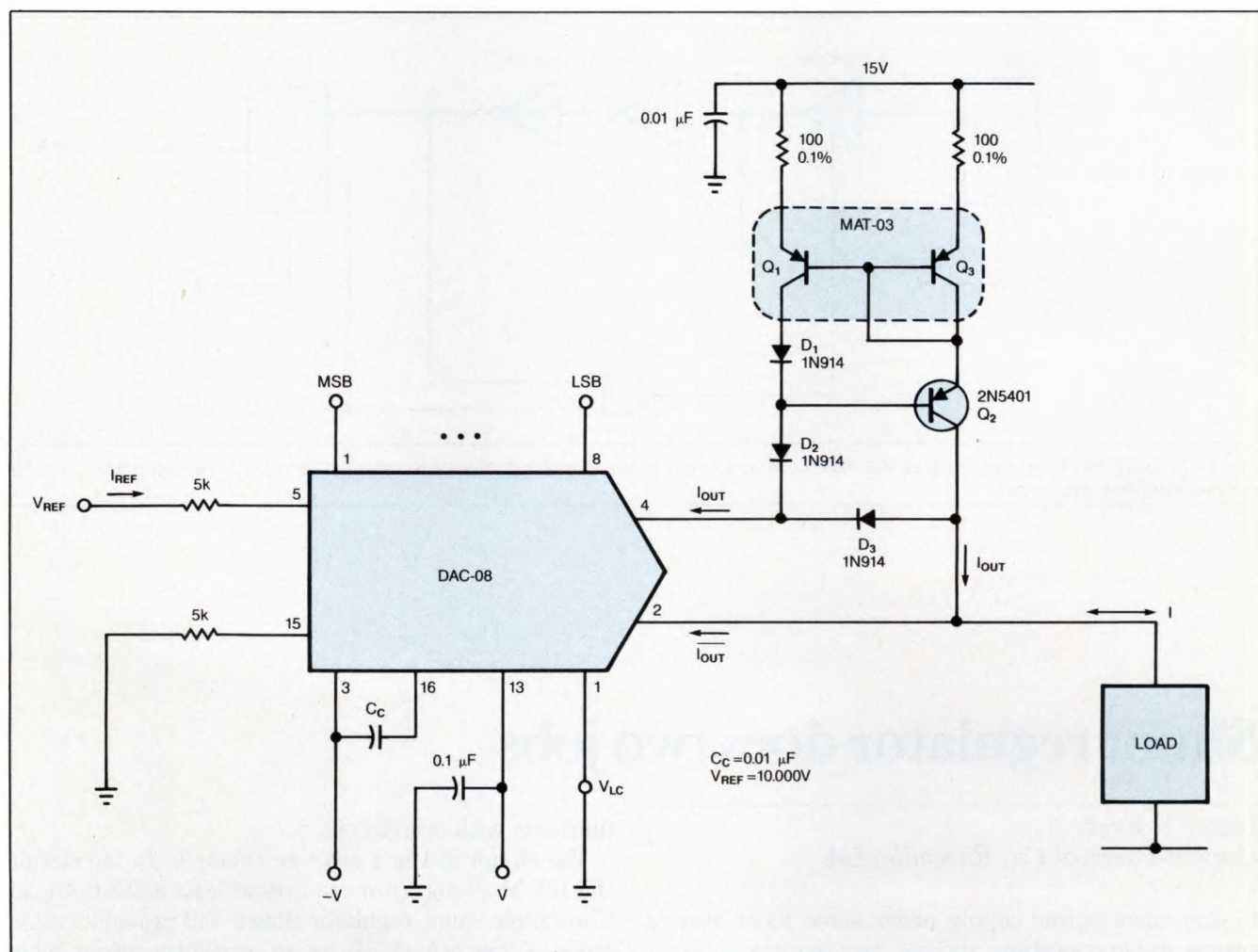
	INPUT CODE	OUTPUT I (mA)
FULL RANGE	11111111	+1.992
HALF SCALE	10000000	+0.008
ZERO SCALE	00000000	-1.992

The Wilson current mirror requires tightly matched

transistors if it is to mirror current accurately over a 4-mA range. The MAT-03 matched transistor pair offers low offset voltage between the two transistors ($100 \mu\text{V}$ max). Offset voltage exponentially degrades the current mirror's accuracy. D_1 matches the collector-emitter voltage across both Q_1 and Q_3 . Q_3 's collector-emitter voltage remains constant, independently of the voltage across the current-source output. This independence prevents an increase in offset voltage, because the collector-base voltages between Q_1 and Q_3 are different.

Q_2 buffers Q_3 , providing feedback that raises the circuit's output impedance. Q_2 also improves the circuit's accuracy by reducing Q_3 's base-width modulation, which occurs when the collector-emitter voltage varies. Diodes D_2 and D_3 form a Baker clamp, which prevents Q_2 from turning off, thereby improving the switching performance of the current mirror. **EDN**

To Vote For This Design, Circle No 749



Buffer prevents metastability

Brian Rockermann
Millidyne, Raleigh, NC

The circuit in **Fig 1** adds a maximum of 1.5 clock cycles of delay to an input signal in return for preventing metastability problems. For any clock rate as high as 4.5 MHz and any input pulse of at least 20-nsec duration, this circuit will guarantee stable data from IC₂.

When the input goes active, IC₁'s Q₀ output latches the input state asynchronously with respect to the clock. Because the first buffer is enabled only when the clock is high, the level at node D₁ can change only outside the setup-and-hold window of flip-flop IC₁.

The circuit requires the Schmitt triggers between nodes D₀ and D₁ in case the first buffer receives a rising edge at its input from IC₁ and a falling edge at its

EN input at nearly the same time. In that case, the output of the first buffer may not reach full value before assuming a high-impedance state. Only if the first buffer does reach full value will the Schmitt triggers pass the input along to be latched by flip-flop IC₂.

When the data-processing system has recorded the input's transition, it can activate a reset line to clear both flip-flops and return the buffer to its receptive state. You should select the value of R so that the time constant at the input of the second Schmitt trigger exceeds the maximum loop delay of all the gates between the two flip-flops (if the trigger is CMOS, you should select 100 kΩ).

EDN

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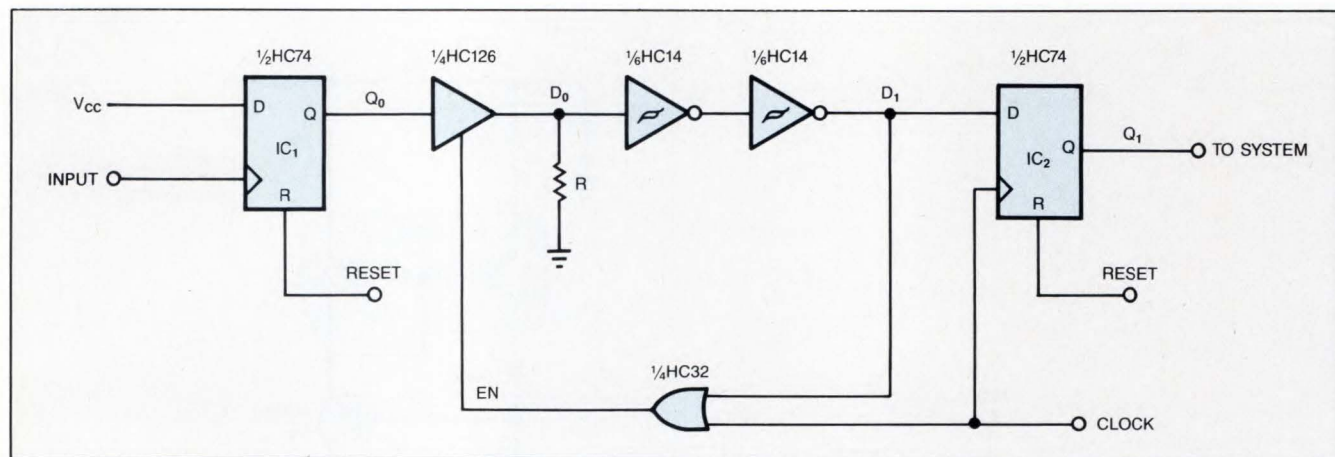


Fig 1—For any clock rate as high as 4.5 MHz and any input pulse of at least 20-nsec duration, this circuit will guarantee a stable, metastability-free data input.

Shunt regulator does two jobs

James K Koch
Hewlett-Packard Co, Roseville, CA

If your main power supply needs some fixed load to ensure stable operation, and you also require an auxiliary voltage, consider adding a shunt regulator to your main output. By doing so, you can accomplish both

functions with one circuit.

The circuit in **Fig 1** gives an example. In the circuit, the 12V buck regulator requires at least a 250-mA load. The simple shunt regulator shown will provide a maximum of 250 mA at 5V as an auxiliary output while sinking a constant 250 mA from the main supply.

Alternative solutions, such as adding another wind-



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CIRCLE NO 135



F127 REV. ORIG.

DESIGN IDEAS

ing to the buck regulator's inductor or appending a linear regulator to the main output, would entail shunting the main output with power-wasting ballast resistors.

A further advantage of the shunt regulator is its

inherent short-circuit current-limiting ability.

EDN

To Vote For This Design, Circle No 747

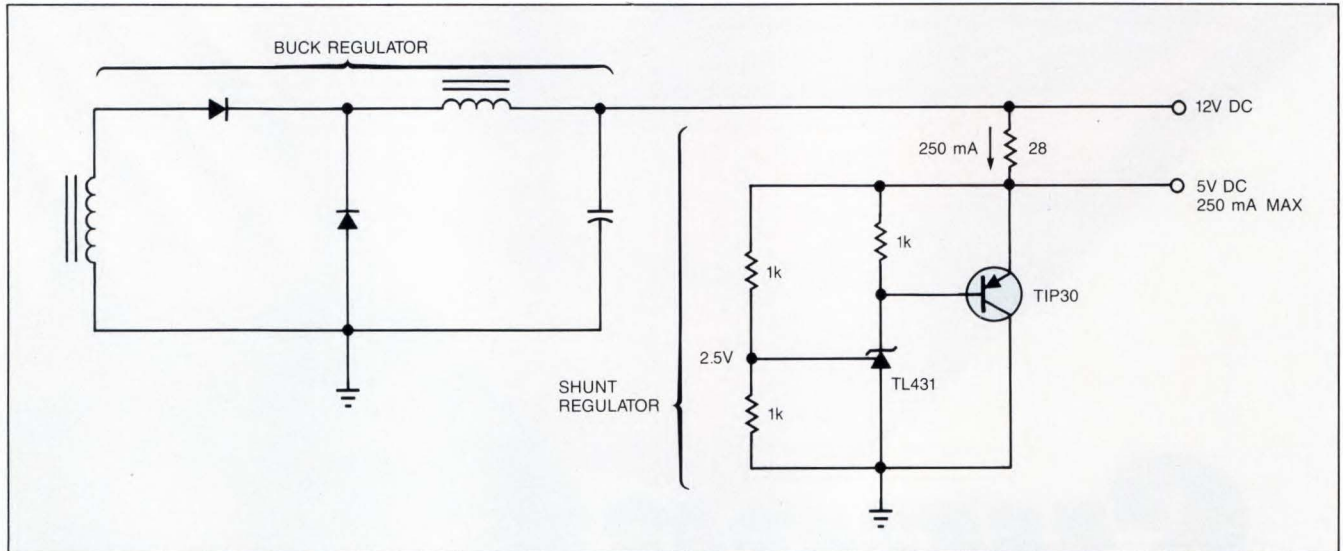


Fig 1—A shunt regulator can replace power-wasting ballast resistors in a switching power supply's main output while providing an auxiliary supply voltage.

Variable-capacitance diode sparks VCO

Peter Baasch

Brüel and Kjaer, Naerum, Denmark

You can transform a 74S124 multivibrator into a wide-band VCO (voltage-controlled oscillator) if you replace its conventional fixed capacitor with a variable-capacitance diode (Fig 1). The only disadvantage of this scheme is the 30V biasing voltage that the diode requires.

Capacitors C_1 and C_2 couple the Philips BB909A variable-capacitance diode to the 74S124. R_1 and R_2 are large enough to isolate ground and control voltages from the timing capacitors. R_3 and R_4 form a voltage divider for the 74S124's control input.

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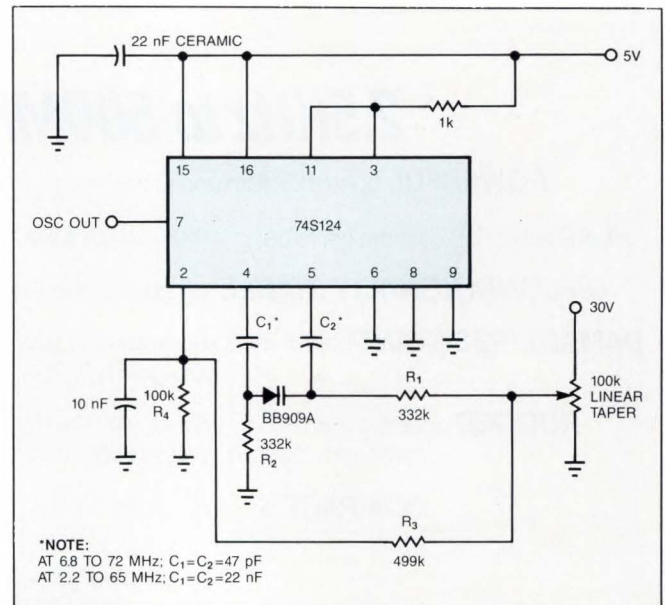
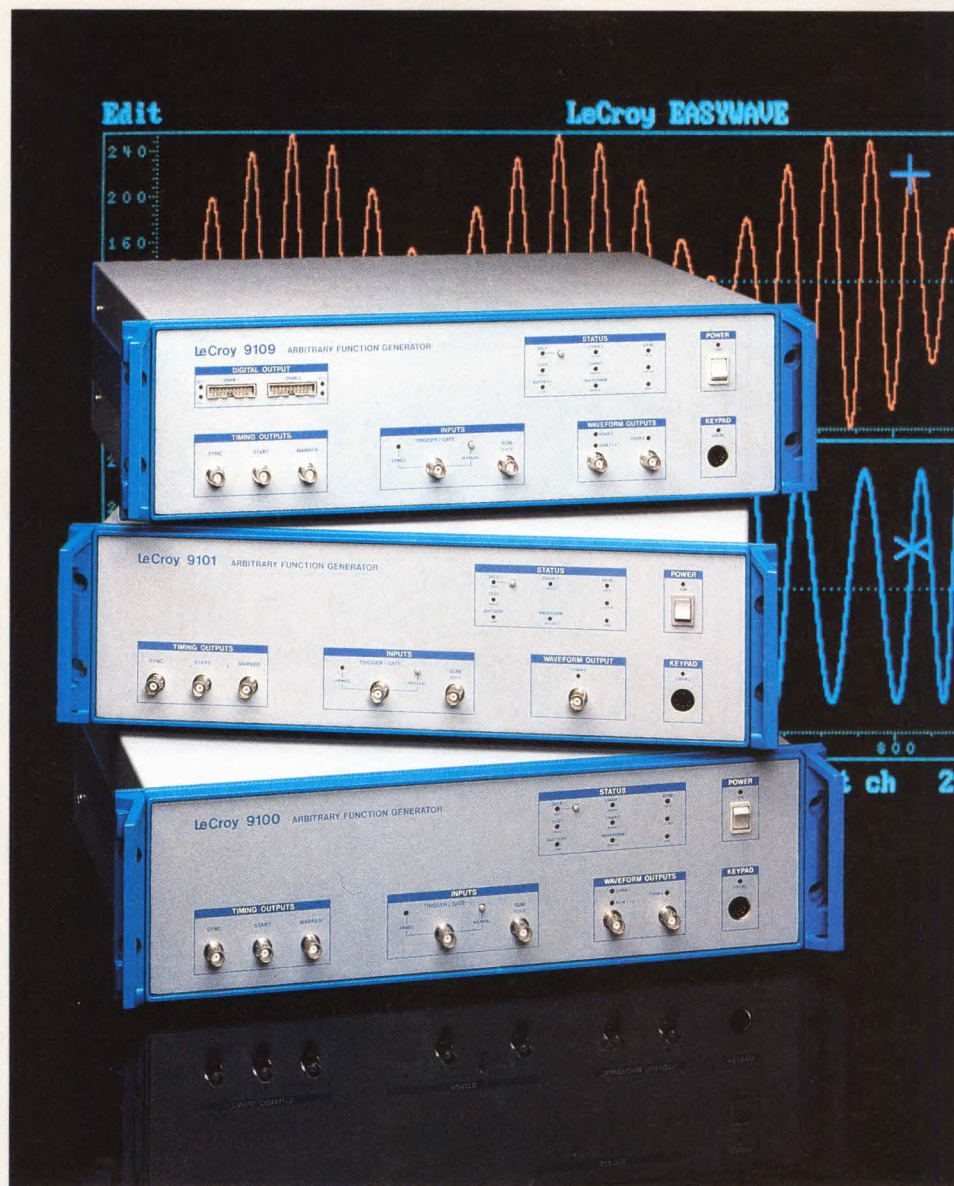


Fig 1—Adding a variable-capacitance diode to the timing circuit of a 74S124 transforms it into a wideband VCO.

To Vote For This Design, Circle No 746

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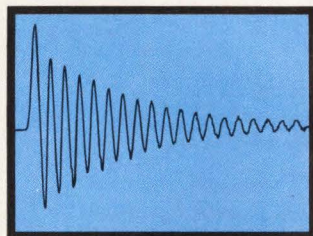
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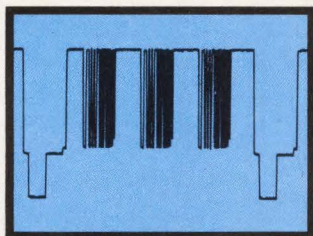
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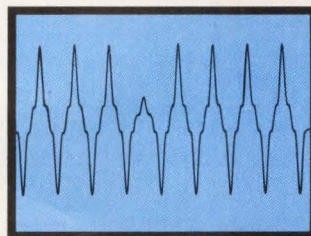
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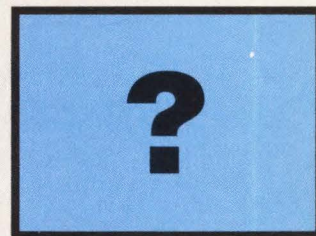
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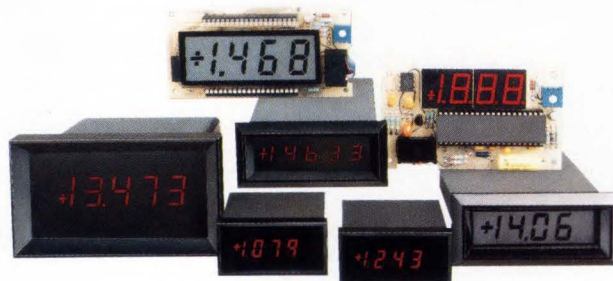
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FEATURES	4-20 mA In, BCD Out, Ruggedized, Units Display



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CIRCLE NO 9

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EDN



February, 1989

Brian Huffman

The supply current is programmed with an external resistor. The R_{SET} resistor allows trade-offs between speed and power consumption. The propagation delay, with the I_{SET} pin at V^- and a single 5V supply, is typically 100ns with a total supply current of 4.5mA. The quiescent current can be brought down to 100 μ A (15 microamps per comparator) with an R_{SET} of 1M and a propagation delay of only 1.2 μ s. In addition, the I_{SET} pin completely shuts off power and latches the translator output voltages. The DISABLE input sets the six outputs to a high impedance state allowing the LTC1045 to be interfaced to a data bus.

Figure 1. TTL/CMOS Logic Levels to $\pm 5V$ Analog Switch Driver

Figure 3 shows a simple way to build a battery powered RS232 receiver. The input voltage may be driven $\pm 30V$ without adverse effects because the 100k resistor prevents device damage. With a 1M R_{SET} the hex RS232 line receiver draws only 100 μA of quiescent current and has a propagation delay of 1.2 μs . Only a single supply is needed for operation.

Board space can be saved by using the LTC1045 level translator as a hex comparator — even though both comparator inputs are not available. Figure 4 shows the LTC1045 used as a

power supply monitor. The outputs of three power supplies are tied to the positive inputs through an appropriate resistive voltage divider. The divider ratio is set so that the voltage into the comparator equals the reference on the inverting input when the power supply voltage is at a critical level.

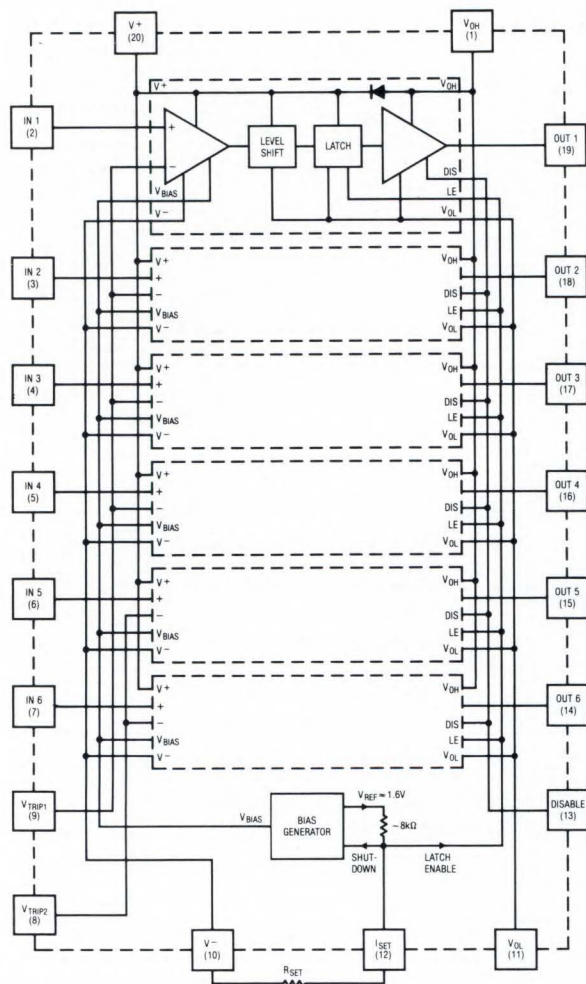


Figure 2. LTC1045 Block Diagram

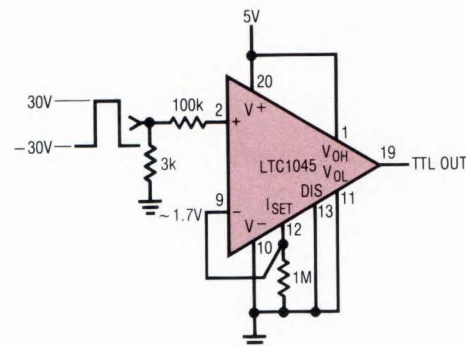


Figure 3. RS232 Receiver

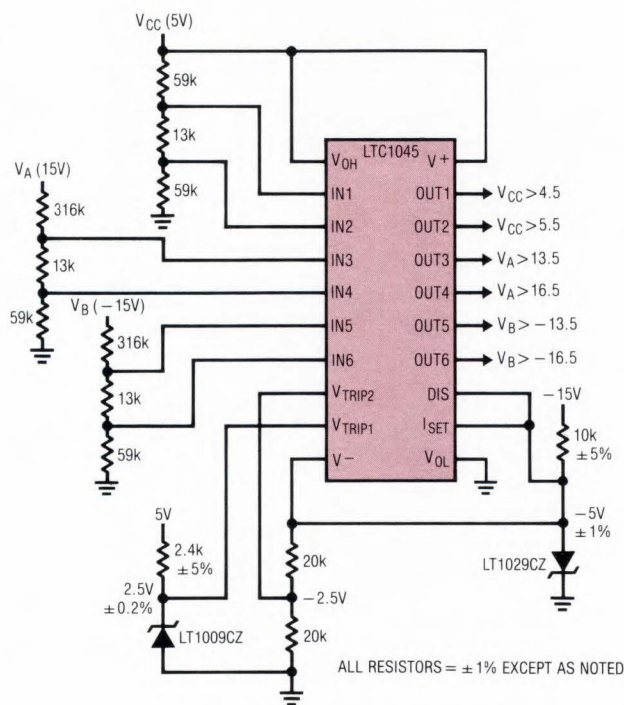


Figure 4. Power Supply Monitor

For literature on the LTC1045, call 800-637-5545.
For applications help, call (408) 432-1900, Ext. 361.

NEW PRODUCTS

COMPONENTS & POWER SUPPLIES

DC/DC CONVERTER

- Provides a 15W output
- Has 80% min efficiency

The Model 12S5.3000XC accepts any input from 9 to 27V dc and provides an output of 5V at 3A. The converter offers a 0.2% line and load regulation, 30-mV p-p output noise, 80% min efficiency at 20% full load, 0.3% per 1000-hours long-term stability, 500V dc input-to-output isolation, and a -25 to 80°C operating range. The converter's design provides a minimum of eight hours of short-circuit protection. When the case temperature exceeds specified limits, an internal thermal-limit switch shuts down the unit; the converter automatically restarts when the temperature returns to normal. Filter circuits provide conducted noise protection, and the 6-side,

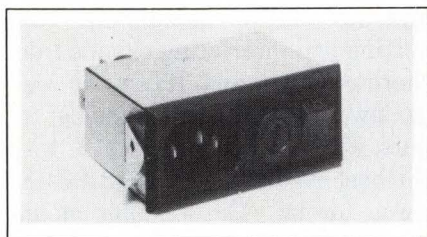


shielded case provides RFI protection. \$120.

Calex Mfg Co Inc, 3355 Vincent

Rd, Pleasant Hill, CA 94523. Phone (415) 932-3911. FAX 415-932-6017.

Circle No 400



CONNECTOR/FILTER

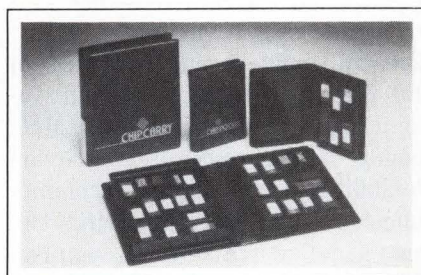
- Features a 6A rating
- Combines three front-panel components

The Model FCA6-PS2 EMI filter combines three front-panel components in a single package—an IEC power-entry receptacle, a fuse, and an on/off power switch. A snap-in mounting scheme provides a positive bond to the host panel and requires no screws or brackets. The device has a 6A/115/230V ac power rating. Leakage-current figures (line-to-ground) are 0.25 mA max at 115V and 0.5 mA at 230V. The filter's test voltages for line-to-ground and line-to-line are 2250 and 1450V dc, respectively. The unit meets international safety stan-

dards, including UL, CSA, VDE, and TUV. \$9 (1000). Delivery, stock to eight weeks ARO.

Stanford Applied Engineering, 3520 De La Cruz Blvd, Santa Clara, CA 95054. Phone (408) 988-0700. FAX 408-727-6430.

Circle No 401



IC STORAGE ALBUMS

- Have crushproof and dust-tight packages
- Hold as many as 30 ICs

The ChipCarry and ChipPocket storage albums have crushproof and dust-tight packages, which feature a snap-fastened closure mechanism. The 5×6-in. ChipCarry stores fam-

ily sets of ICs. It will hold more than 30 24-pin DIP devices in any orientation. The ChipPocket, measuring 3×5 in., fits in your shirt pocket. It can hold as many as six 24-pin DIPs. Both albums come with a supply of self-adhesive IC labels. ChipCarry, \$12.95; ChipPocket, \$6.95.

iTOI Enterprises Co, Box 59, Newton Highlands, MA 02161. Phone (617) 332-1010.

Circle No 402

POWER CONVERTER

- Designed to power APDs
- Offers stability of 0.02% per °C min

The Model APDS-HE1 is designed to bias low-voltage avalanche photo diodes (APDs). The unit has a 50% min efficiency and draws <1 mA from a 5V dc source when driving a 20 μ A/110V load. Stability is better than 0.02% per °C over a 0 to 50°C operating range. Ripple and noise measure <1 mV p-p. Stan-

dard features include remote on/off control, voltage and resistance programmability, and permanent short-circuit protection. The converter is available in a variety of package styles. Conformally coated version, \$49 (10,000). Delivery, eight to thirteen weeks ARO.

Wautec Inc, Box 3495, Santa Barbara, CA 93130. Phone (805) 688-3295.

Circle No 403

SWITCHES

- Control 10A loads
- Feature a sealed design

Series B5 snap-action switches control loads as high as 10A. Constructed in accordance with MIL-S-8805, the switches are available in both military and commercial grades. A variety of switch contact configurations are available: spst NO, spst NC, double-break, spst double-break form Z, 2-circuit, and spdt form C single break. The electrical life for a full-resistive load is projected at 100,000 cycles. The bright-acid, tin-plated terminals are sealed to prevent solder-flux entry. You have a choice of terminals, including solder, taper tabs that mate with AMP 78 receptacles; 0.110-in., quick-connect tabs that mate with AMP 110 receptacles; and pc-type pins. From \$3.45 (1000). Delivery, stock to six weeks ARO.

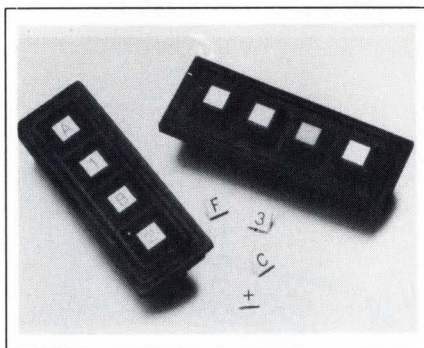
Otto Controls, 2 E Main St, Carpenterville, IL 60110. Phone (312) 428-7171. FAX 312-428-1956.

Circle No 404

KEYPADS

- Have a 5×10^6 operation life
- Feature gold-plated contacts

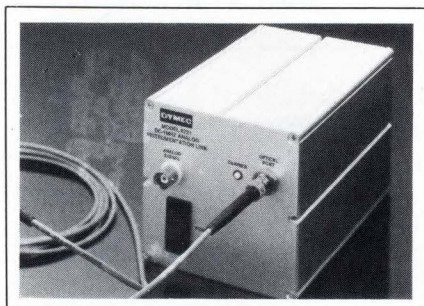
The 1x4-position keypads in the KNM20 and KNM30 Series keyboards can function in harsh environments; they can, for example, operate under 3 ft of water. Both the flush- or raised-key styles meet the high-reliability standards of the European IP67 document. The pads feature a springless, magnetic re-



turn mechanism; dual, gold-plated contacts; tactile feedback; and a 5×10^6 operation life per button. A variety of keytops and accessories for either front- or rear-mounting are available. The keypads are also available in 3x4- and 4x4-position versions. Including keytops and mounting hardware, \$29 (100).

Interswitch, 770 Airport Blvd, Burlingame, CA 94010. Phone (415) 347-8217. TWX 910-374-2353.

Circle No 405



OPTICAL LINKS

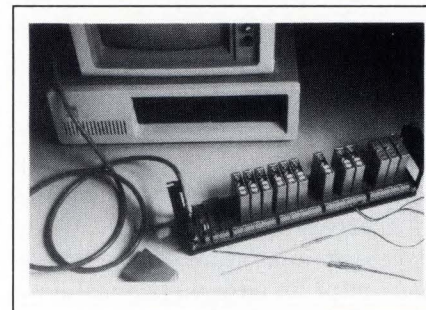
- Feature a 1-MHz bandwidth
- Operate in two modes

The transmitters and receivers in the 6720 Series provide point-to-point transmission of dc to 1-MHz analog signals. The units provide flexibility in both signal accommodation and mounting. Using the rear panel switch settings, you can independently set the full-scale input and output ranges to ± 1 , ± 5 , and ± 10 V. Offset and gain adjustment controls are also mounted on the rear panel. Transmitters are available with both single-ended and differential input configurations. The units are housed in $3\frac{1}{2} \times 3\frac{1}{2} \times 6$ -in., $\frac{1}{4}$ DIN aluminum cases. The links come with front-

panel BNC and ST-type connectors for signal and optical cables, respectively. An LED indicator signals when the devices are functioning properly. Receivers, \$525; transmitters, \$542.

Dymec Inc, 8 Lowell Ave, Winchester, MA 01890. Phone (617) 729-7870. TWX 710-348-6596.

Circle No 406



SIGNAL CONDITIONERS

- Employ a dedicated microcontroller
- Have a 19k-baud data rate

Each 6B Series module includes both a dedicated microcontroller and nonvolatile memory for converting and interfacing signals from thermocouples and RTDs, as well as low- and high-level analog inputs. The board communicates with the host system via an RS-232C/485 serial format. The modules mount on 1-, 4-, or 16-channel backplanes, which provide the RS-232/485 interface capability. You can connect as many as 256 modules to a single serial-communications I/O port. The maximum rate for 15-bit conversions is 9 samples/sec, and the communications rate is as high as 19.2k-baud. Three input modules are available: the 6B11 for thermocouple, voltage, and current inputs; the 6B12 for voltage and current inputs; and the 6B13 for platinum, nickel, and copper RTDs. The modules operate from 5V supplies. \$140 (100); 16-channel backplane, \$290. Delivery, four to six weeks ARO.

Analog Devices Inc, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 329-4700.

Circle No 407

When size and speed matter, Look to Seagate's 3.5" ST157 Family

When 5.25" drives won't fit, or if you just think "small is beautiful," Seagate's ST157 family provides less than 30 msec access time for today's generation of high-performance personal computers.

Select from the 21 MB ST125, the 32 MB ST138 or the 48 MB ST157, all available with either SCSI or ST412 interface options.

With over one million produced, Seagate now builds over 8,000 ST157 family drives per day. And

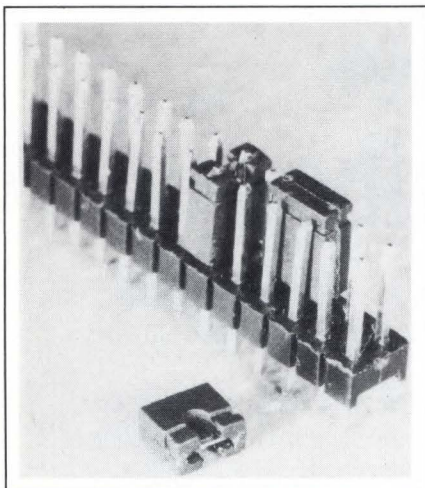
each one is built with the quality and reliability you've come to expect from the first name in disc drives.

For easier installation, you can configure the right 3.5" solution by choosing from Seagate's line of controllers and adapters for the ST157 family.

For more information on the small drives that are big on speed, contact your authorized Seagate Distributor, or call Seagate at 800-468-DISC.

 **Seagate**
The first name in disc drives





SHUNT JUMPERS

- Employ a gold-plated contact
- Available in three versions

The Series CSS-101 header shunts provide dual-point position shorting of .025-in. square pins on 0.1-in. mounting centers. They are available in three styles: closed-top (CSS-101-01), open-top (CSS-101-02), and subminiature (CSS-101-03).

All three units feature side-to-side and end-to-end stacking capabilities on the 0.1-in. grid pattern. They employ a gold-plated, phosphor bronze contact, which mates on two sides of each header post. The housings are 30% glass-filled thermoplastic, which has a UL 94V-0 rating. \$0.03 to \$0.05, depending on quantity.

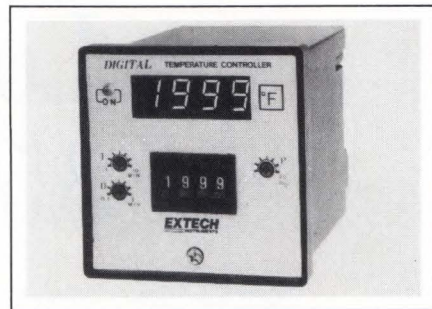
Components Corp., 6 Kinsey Pl, Denville, NJ 07834. Phone (201) 627-0290. FAX 201-361-5801.

Circle No 408

CONTROLLERS

- Housed in 1/4 DIN packages
- Offer a choice of control options

Series 480 temperature controllers are housed in 1/4 DIN packages to facilitate mounting in existing control panels. The controllers include a choice of on/off, proportional, or 3-mode control action. They also offer simple front-panel tuning and a



choice of two outputs—either 7A spdt relay or 12V dc pulse. An optional 4- to 20-mA output is available on the Model 484 if you need a continuous output. Analog and digital models feature an LED output-status indicator and a pushbutton set-point switch or analog adjustment dial, which gives you the control status. The controllers accept inputs from thermocouple or RTD sensors. From \$99 to \$269.

Extech Instruments Corp., 150 Bear Hill Rd, Waltham, MA 02154. Phone (617) 890-7440.

Circle No 409

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Candela Laser Corporation, Wayland, MA Telephone (800) 255-1287 Dept. 205 or in MA (508) 358-7637

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HV Plus is available in both high-rel and industrial versions, in two axial leaded body sizes, with 2.0 amp and 4.0 amp ratings. Prices are reasonable and performance is unmatched.

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1N6623	800V	50nS	8pf	200μA	1.5A
1N6625	1000V	50nS	8pf	200μA	1.5A
1N6628	600V	30nS	30pf	500μA	4.0A
1N6629	800V	50nS	30pf	500μA	3.0A
1N6631	1000V	50nS	30pf	500μA	3.0A

HV Plus data sheets are available now. Call or write today for your copy. Your competition will.

Highest voltage + fastest recovery = *HV Plus*™



SEMICONDUCTOR
PRODUCTS

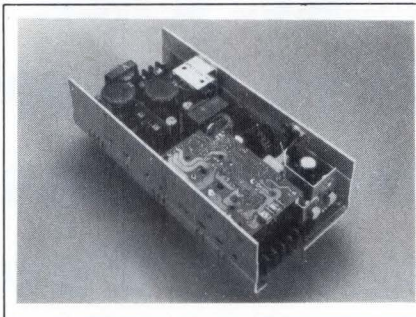
UNITRODE

580 Pleasant Street
Watertown, MA 02172
(617) 926-0404

POWER SUPPLIES

- Accept any input from 85 to 264V ac
- Deliver a 350W output

The NFS350 Series open-frame switchers accept any input voltage from 85 to 264V ac without the need for jumper wires or a switch. The NFS350-7625 model has outputs of 5.1, ± 12 , and a floating output that

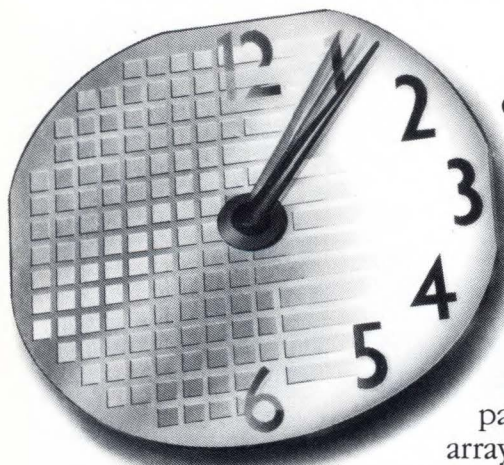


you can adjust from 4½ to 16½V and reference as either positive or negative. A second model, the NFS350-7626, offers outputs of 5.1, ± 12 , and a floating output that you can adjust from 15 to 30V and reference as either positive or negative. Total output power at an ambient temperature of 50°C is 350W with forced-air cooling of 30 cfm. The supplies' typical efficiency is 70%. The NFS350 Series supplies are UL-, CSA-, and VDE-approved, and their built-in line filter reduces conducted noise below FCC limit B and VDE limit A. \$319 (100).

Computer Products/Boschert, 3797 Spinnaker Ct, Fremont, CA 94538. Phone (415) 657-6700.

Circle No 410

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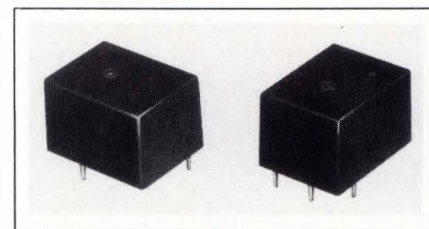
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CIRCLE NO 11



PC-BOARD RELAYS

- Switch loads ranging to 10A
- Have 100,000-operation min life

T73 Series pc-board relays are housed in sealed plastic cases and are available with various contact materials. All models have a 100,000-operation lifetime. Bifurcated gold-overlay silver palladium contacts are rated for 1A at 30V dc/120V ac and are available in spst-NO and spdt arrangements. Single-button gold-overlay silver nickel contacts are rated for 5A at the same voltages. Single-button silver tin contacts are rated for 10A at 24V dc/120V ac and are available only in spst arrangements. Coil-voltage ratings range from 3 to 48V dc. Nominal coil power dissipation equals 450 mW for most models. From \$1.44 (5000). Delivery, stock to 10 weeks ARO.

Potter & Brumfield Inc, 200 S Richland Creek Dr, Princeton, IN 47671. Phone (812) 386-1000.

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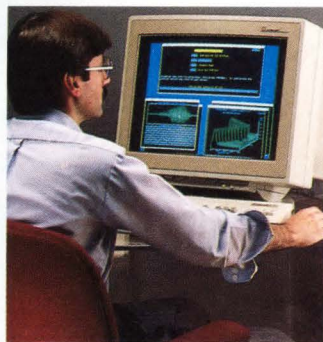
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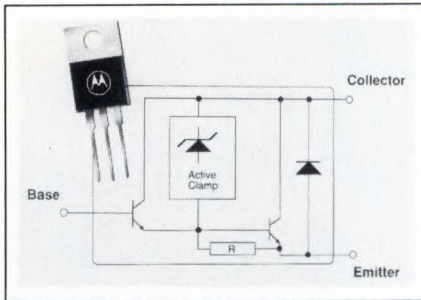


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EDN021689



POWER DARLINGTON

- Uses an active clamp
- Compatible with logic-level drives

The MJE5420Z 8A power Darlington transistor incorporates an active 25V clamp, which provides protection from voltage transients. The unit can be driven by CMOS or LSTTL level signals. The device is composed of a planar zener diode, an epi-collector npn Darlington output device, a driver transistor, and a resistive divider network. The planar zener diode is the control element for the clamp and includes a

temperature compensation circuit, providing a 6-mV/°C thermal coefficient over the full -40 to +150°C operating range. The output Darlington has a 1.5V max $V_{CE(sat)}$ at 25°C and at a forced gain of 800. Its leakage current is only 10 μ A. \$0.95 (1000). Delivery, stock to six weeks ARO.

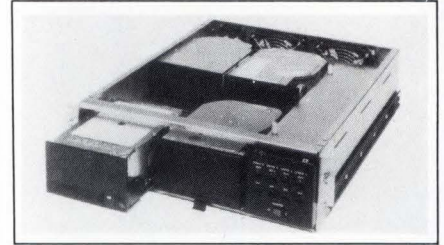
Motorola Inc., 5005 E McDowell Rd, Phoenix, AZ 85008. Phone (602) 244-4912.

Circle No 412

ENCLOSURE

- Supports four disk drives
- Includes five power supplies

The SA-H188 rack-mount expansion chassis can support four 5 $\frac{1}{4}$ -in. removable Winchester disk drives. The drives mount on a bracket that's compatible with DEC's drive-mounting shoe and that slides easily in and out of the chassis. The unit includes a front console that fea-



tures Write-protect and Ready switches and LEDs for each drive. It also includes a controller I/O panel that eases the cabling task to an ESDI or SCSI disk controller. The chassis contains five 52W power modules. Each module powers one of the four drives. The fifth module powers the fans and other chassis functions. You can replace any power module without affecting the operation of the other drives in the chassis. \$1270.

Sigma Information Systems, 3401 E LaPalma Ave, Anaheim, CA 92806. Phone (714) 630-6553. FAX 714-630-5417. TLX 298607.

Circle No 413

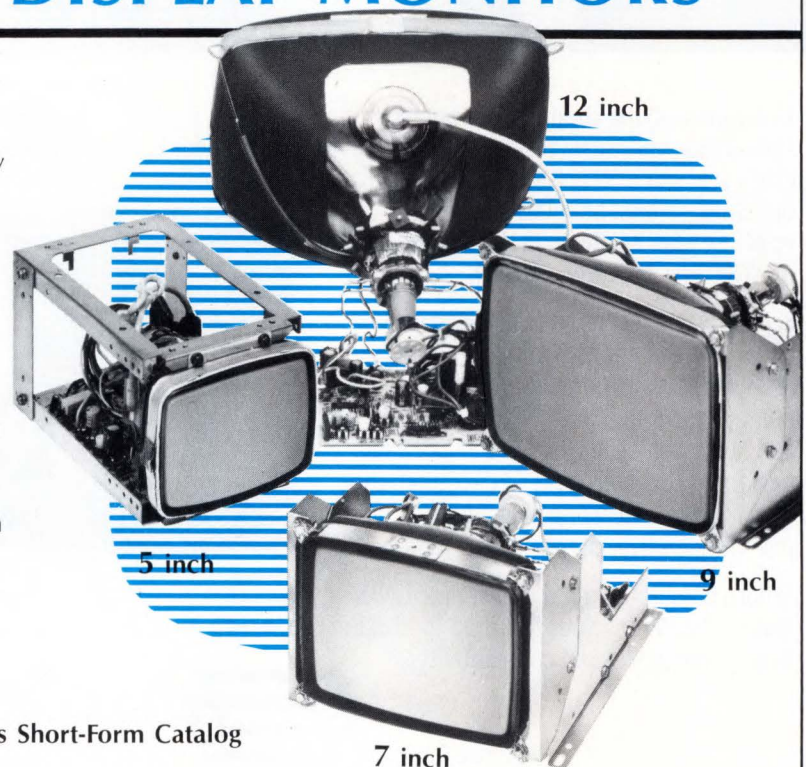
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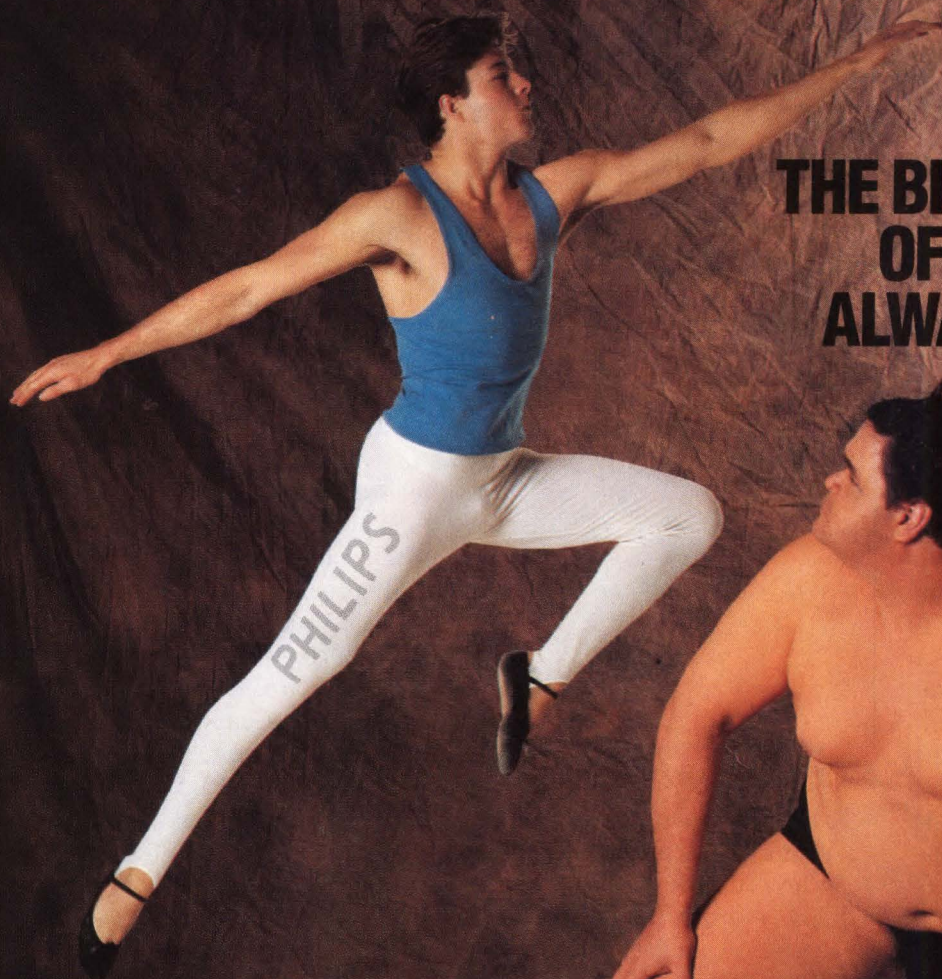
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George Washington Highway, Smithfield, RI 02917 (401) 232-0500
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DC/DC CONVERTER

- Provides isolated 5 and 40V outputs
- Powers ISDN interfaces from the ISDN U-bus line voltage

Suitable for use in ISDN equipment, the 48 ITS 1-05-40-T dc/dc converter allows you to generate the 40V required for the ISDN S-bus, and the 5V supply required by interface logic, from the voltage on the ISDN U-bus. The converter's isolated 5V and 40V outputs can deliver an output power of 1W, and you can adjust the 40V output to provide higher or lower voltages if required. The units achieve a typical efficiency of 80% over their entire input voltage range and require no derating over their operating temperature range of -25 to +71°C. They are packaged in pc-board 40-pin DIP cases. SFr 85 (100).

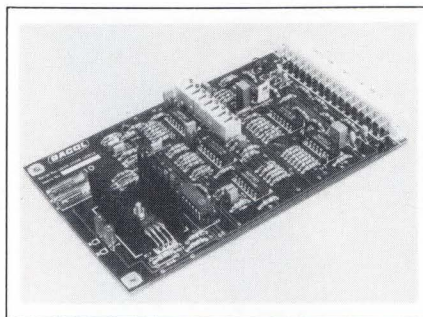
Melcher AG, Ackerstrasse 56, 8610 Uster, Switzerland. Phone (01)

944-8111. TLX 828554. FAX 01-940-9858.

Circle No 414

Melcher Inc, 10 Cochituate St, Natick, MA 01760. Phone (508) 653-9979. FAX 508-655-7984.

Circle No 415



MOTION CONTROLLER

- Suits electromechanical and hydraulic servo-controlled systems
- Incorporates ramp-rate and set-point controls

The AMC10 single-board motion controller contains all the electron-

ics required to operate most single-channel, closed-loop, servo-controlled systems that incorporate analog transducers for feedback elements. The board provides a proportional-integral-differential (PID) controller that is suitable for use with hydraulic or electromechanical systems in which the controller has to cope with nonlinear stick/slip characteristics, variable stiffness, and residual load forces. To control the system's rate of change and final setpoint, you can use either a direct input from a feedback transducer or an onboard ramp generator. You use the enable line to ramp the output towards or away from the setpoint. You can also adjust each of the PID values, as well as the frequency and amplitude of a dither signal. Using a single resistor, you can program a current limit for the board's constant current output. The board has onboard excitation supplies for feedback transduc-

Performance

by

paracom

PC/AT

MAC II

PS/2

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- High performance, inexpensive Parallel Processing
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Why our button makes the better rechargeable.



Today, Varta leads the world in making cells for the smaller NiCd batteries. The reason lies in understanding the two ways cells are made. One is Varta's original development: the mass-plate NiCd button cell. Its electrodes are thick, solid masses with small surface areas. Result: a very low self-discharge which provides up to four times longer stand-by life and reduced charging current.

In the other cells, the long, thin, sintered electrodes, which are wrapped around in a cylindrical shape, have a large surface area. Result: cylindrical cells with an inherently fast self-discharge. Most of these NiCd batteries have a useful stand-by life of less than 3 months and, in use, require more frequent charging with "heavier" charging current.

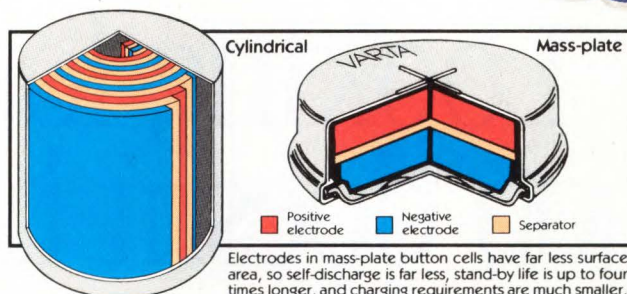
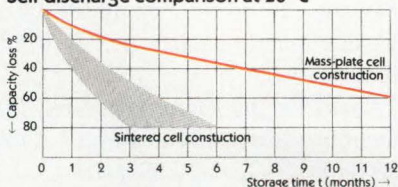
Better operational characteristics. Mass-plate construction results in NiCd batteries with no "memory" effect, so they can be trickle-charged long-term without reduction in effective capacity. They have a longer, 1000-cycle life, according to IEC 509. And they can be stored in any state of charge

for over five years without significant performance loss.

Safer, tougher.

Mass-plate design protects against over-charge and/or over-discharge. Mass-plate

Self discharge comparison at 20°C



cells perform better under vibration, as shown by MIL STD 810C. Key cell sizes are UL-recognized. They can be wave-soldered for up to 10 seconds in a fully charged state.

More sizes and types for any application. Mass-plate cells range from 4 mAh (world's smallest) to 1000 mAh. Taking up to 40% less space, batteries are available flat or stacked with all types of connections. Safetronic and Mempac batteries are pin-equipped for easy plug-in.

New "high-temperature" types. The Varta DKT Series can be charged, discharged and stored in temperatures up to 65°C, allowing operation about 15°C higher than before.

Most cost-effective. Despite all their advantages, Varta mass-plate button cells and batteries are competitively priced.

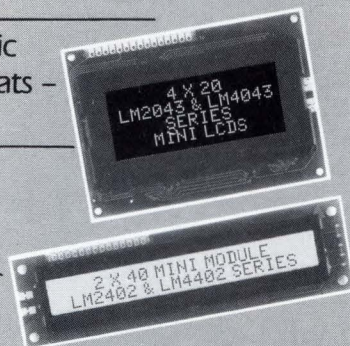
For applications above 1000 mAh, Varta also offers a complete line of NiCd cells and batteries. For information, please call 1-800-431-2504, Ext. 260, or write below.



VARTA Batteries, Inc., 300 Executive Blvd., Elmsford, NY 10523, USA, Tel. 1-800-431-2504, Ext. 260
 VARTA Batterie AG, Am Leineufer 51, D-3000 Hannover 21, West Germany, Tel. (49) 0511/79031
 VARTA Batteries Pte Ltd., 1646 Bedok North P.O. Box 55, Singapore 9146, Tel. (65) 241-2633
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Mini LCDs Maximize Space.

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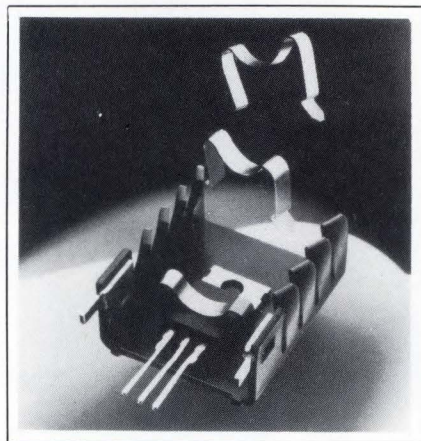
**TURN TO
PAGE 228**

COMPONENTS & POWER SUPPLIES

ers, and separate gain and null adjustments for the feedback signal. The AMC10 is housed on a 100x160-mm, Eurocard pc board. £295.

Sacol Powerline Ltd, Commercial Rd, Totton, Southampton SO4 3ZQ, UK. Phone (0703) 860101. FAX 0703-872757.

Circle No 416



HEAT SINK

- Designed for TO-220 packages
- Cuts assembly costs

The Model 5342 clip-on heat sink is designed for use with TO-220 semiconductor packages. It cuts assembly costs because the transistor can be mounted firmly into position, using the spring clip instead of the traditional nut and bolt. The spring clip eliminates the problem of gaps that occur when threaded fasteners holding the heat sink to the transistor are torqued too tightly. The spring clip applies even pressure to provide a uniform package to the heat-sink interface. The heat sink is designed for vertical mounting and features two solderable tabs. The 1.18-in. high device has a 16° C/W thermal resistance under natural convection with a 3W load. \$0.426 (1000).

Aavid Engineering Inc, Box 400, Laconia, NH 03247. Phone (603) 528-3400. FAX 603-528-1478.

Circle No 417

THE CHOICE IS YOURS



Avantek Offers Both GaAs & Silicon Wideband MMIC Amplifiers

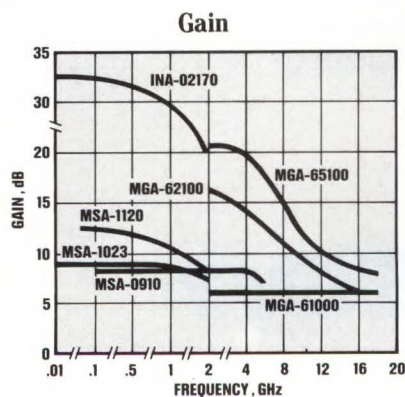
Now, both GaAs and silicon MMIC amplifiers covering the frequency range from DC to 18.0 GHz, are available from one reliable source... Avantek. Avantek's GaAs and silicon MMICs offer outstanding broadband amplifier performance, providing increased circuit density, and reduced system complexity. They are ideal solutions to your system performance and cost goals.

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Avantek's MMIC amplifiers are available with a wide spectrum of performance options to satisfy nearly every design need. These easy to use MMIC amplifiers provide premium performance and reliability. They are available with a range of chip to hermetic package options for use in the most demanding industrial and military applications.

Typical MMIC Performance

Model	Test Frequency (GHz)	Gain (dB)	Noise Figure (dB)	P _{1dB} (dBm)
INA-02170	0.5	31.0	1.9	11.0
MSA-1120	0.5	12.0	3.5	18.0
MSA-1023	1.0	9.0	—	27.0
MSA-0910	2.0	8.0	6.0	11.0
MGA-62100	4.0	14.0	2.5	12.0
MGA-65100	14.0	10.0	—	24.0
MGA-61000	18.0	6.0	6.5	14.0



GaAs and Silicon MMICs... Distributor Direct

Each year Avantek produces more than ten million high performance, high frequency MMICs. So you can be assured the MMICs you need, in packaged and chip form, will be available to support your volume production needs. And, these MMICs are in stock at your local Avantek distributor for immediate delivery. For additional information, or the name and address of your local distributor, contact the regional sales office nearest you.

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Eastern: (301) 381-2600

Central: (312) 358-8963

Western: (805) 373-3870

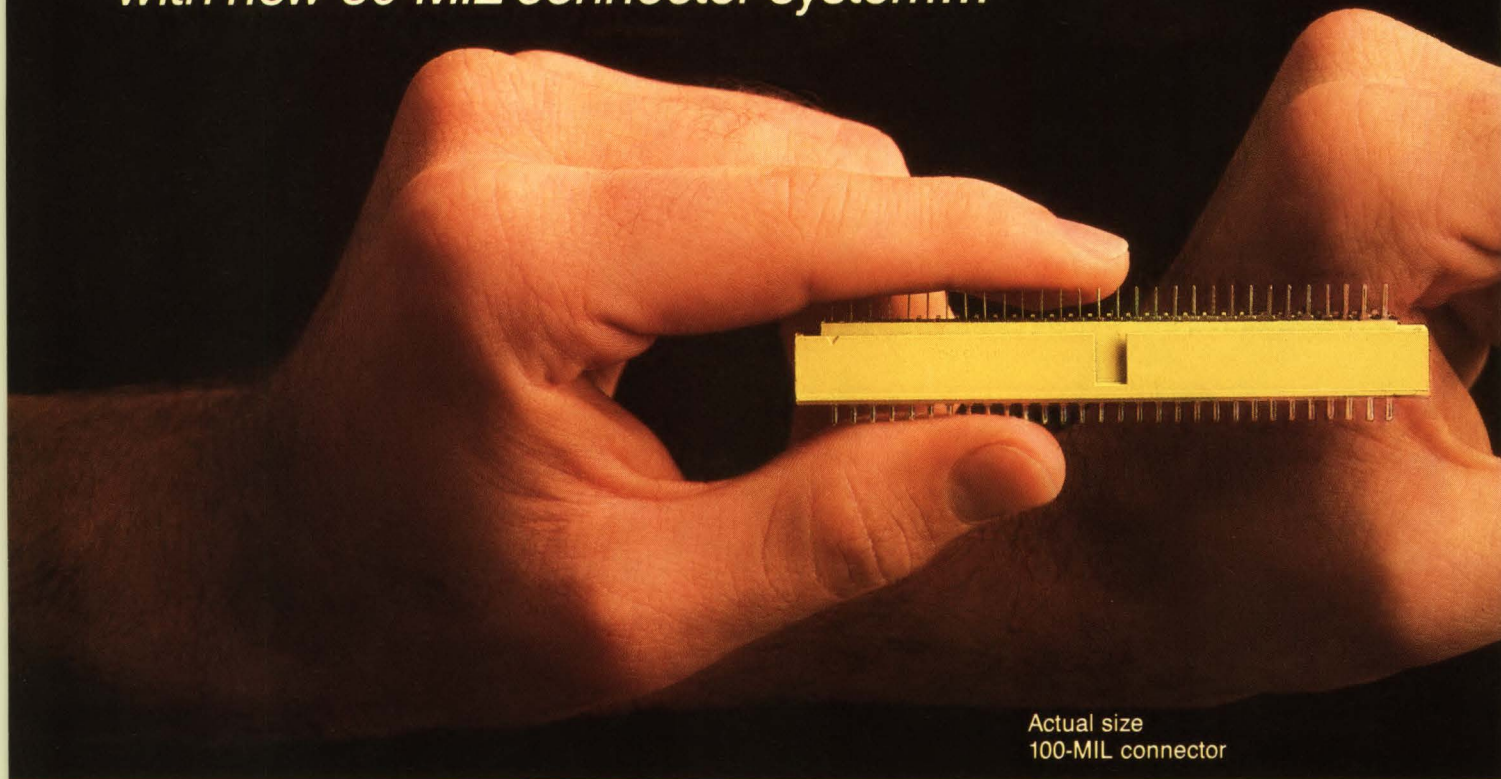
European

(44) 276-685753

MMIC Technology Leadership



*Space needs shrink
with new 50-MIL connector system...*

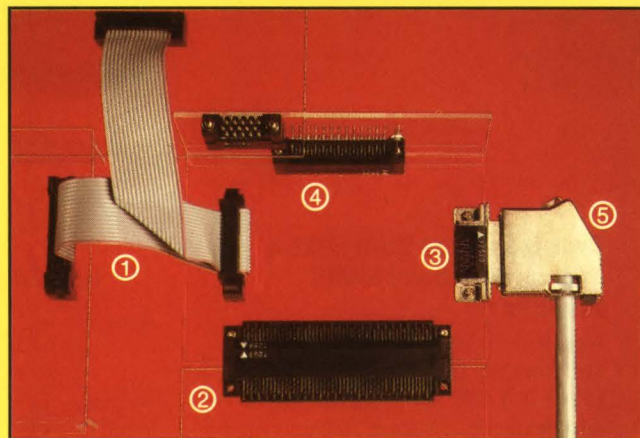


Actual size
100-MIL connector

The new Robinson Nugent PAK-50™ interconnect system replaces existing 100-MIL spacing with 50-MIL spacing, doubling your PC board connector density. You can now reduce the cost of your systems with smaller PC boards without decreasing I/O— or add more I/O without increasing board size.

RN PAK-50™ incorporates a dynamic contact interface, the male and the female contacts simultaneously deflect. This dynamic movement facilitates a high density/high pin count interconnect system with low insertion/withdrawal forces, low contact resistance, high normal forces, and high wear resistance.

Investigate this cost saving, high reliability interconnect system today. The RN PAK-50™ system includes 2-piece PCB connectors, IDC flat cable connectors, and laminated or discrete wire I/O connectors—all in micro-miniaturized 50-MIL configurations.



This is the complete RN-PAK-50™ Interconnect System:

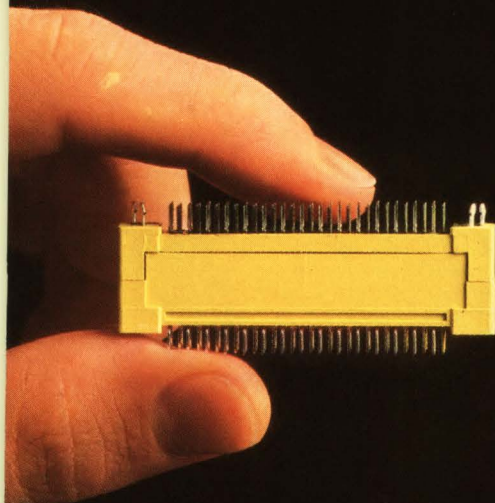
1. 2-pc. IDC cable connectors—50-MIL cable assures compatibility between .050" and 100" center technology.
2. 2-pc. horizontally mated connectors.
3. Right angle board mount I/O connector.
4. 2-pc. vertically mated connectors.
5. Discrete or laminated wire I/O connector with EMI shielded back shell.

CIRCLE NO 103

**Robinson
Nugent**

800 East Eighth Street, New Albany, Indiana 47150 • Phone: (812) 945-0211 FAX: (812) 945-0804
In Europe: Rue St. Georges 6, CH 2800 Delemont, Switzerland • Phone: (066) 22 9822 FAX: 011-41-622-9813

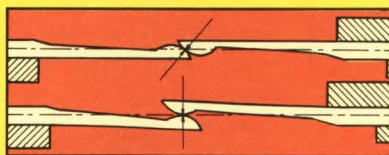
The RN "Partners in Quality" Team delivers new PAK-50™ connector system that shrinks needed board space by 50%!



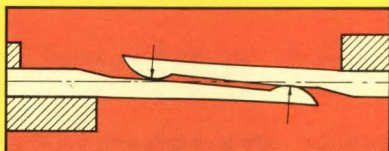
Actual size
PAK-50™ connector

THE RN PAK-50™ redundant ribbon contact is the key to the high reliability of the PAK-50™ interconnect system, providing a low 20 gram insertion force with high 100 gram minimum normal forces. As the RN PAK-50™ connectors are mated, the two straight beam contacts mate in the axial direction of the contacts. Both contact surfaces move together when mated so contact surfaces work together, not against each other. Because contacts are shrouded, they are protected from misalignment and pin damage is minimized.

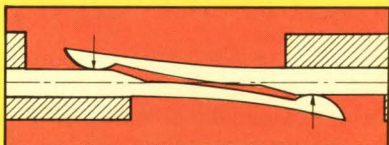
Write today for specifications and test data on the new RN-PAK-50™ micro-miniaturized connector system.



First stage mating—Smoothly curved tips of each contact meet and slide over each other's surface.



Second stage mating—Each curved contact tip wipes against the smooth tapered beam of the other contact.



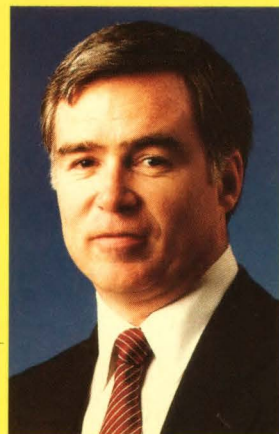
Third stage mating—Finally the mating point of each tip reaches the trunk of the other contact.

CIRCLE NO 104

"The RN 'P/Q TEAM' concept brings all of our design, engineering and production skills to bear on *your* unique socket/connector problems. We work closely with your people to create solutions that are delivered on-time and defect-free. *You have my personal guarantee on it.*"

R. A. Lindenmuth

R. A. Lindenmuth
President/CEO



Write or call today for the comprehensive new brochure: "*The RN P/Q Team in Action*". You'll learn how smart companies are putting the brains, resources and experience of RN engineers to work to solve tough interconnection problems with speed and efficiency.

CIRCLE NO 105



The RN "P/Q TEAM"...your Partners in Quality



World's biggest selection of little power supplies and Acopian ships them in only 3 days!

Single output power supplies with outputs from 1 to 75 Vdc, to 2.5 amps. Dual supplies with tracking ± 12 or ± 15 volt outputs, to 500 mA/output. Other duals with any combination of 30 output ratings from 1 to 28 volts (or two outputs of the same rating). Even triple output supplies providing ± 12 or ± 15 volt tracking outputs and your choice for the third output. All have short circuit protection and are UL Recognized.

DC-DC converters operate on inputs of 5 to 48 volts, and provide single outputs of 5 to 28 volts, to 1.25 amps. Dual output models have tracking ± 10 ,

± 12 , ± 15 and ± 18 volt outputs, to 300 mA/output. All have 100 megohms input/output isolation, and are electrostatically shielded on all sides.

All are available in board-mountable form. Most supplies are alternately available with screw terminals and provision for chassis mounting.

For detailed specs, drawings and prices, ASK FOR OUR 52-PAGE CATALOG. You'll remember our 3-day shipment promise when you receive your order with this reminder...



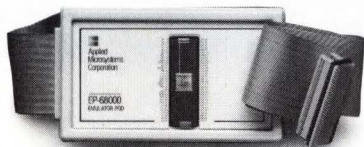
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68020 EMULATION NOW AT 25MHz.



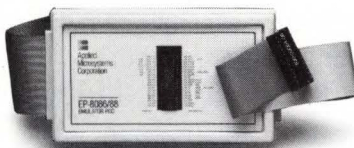
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80C186/C188-16MHz

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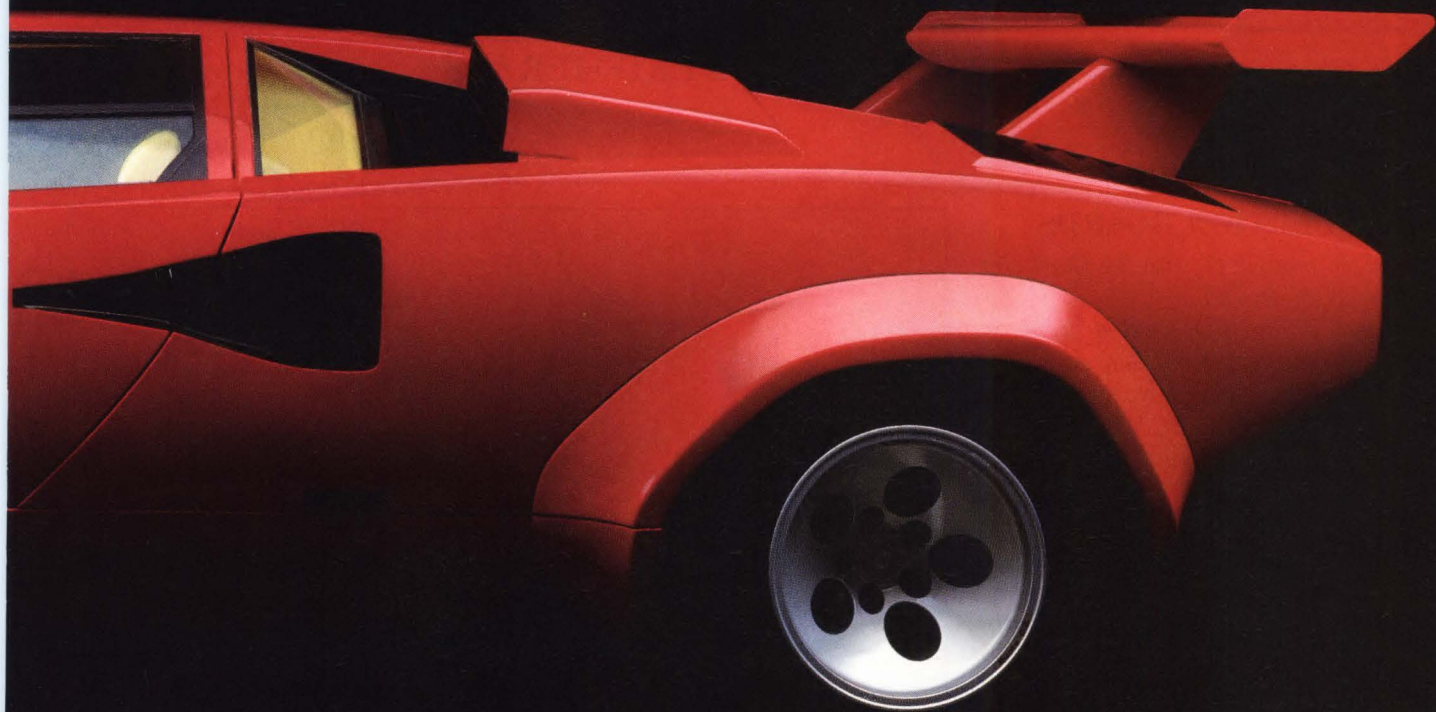
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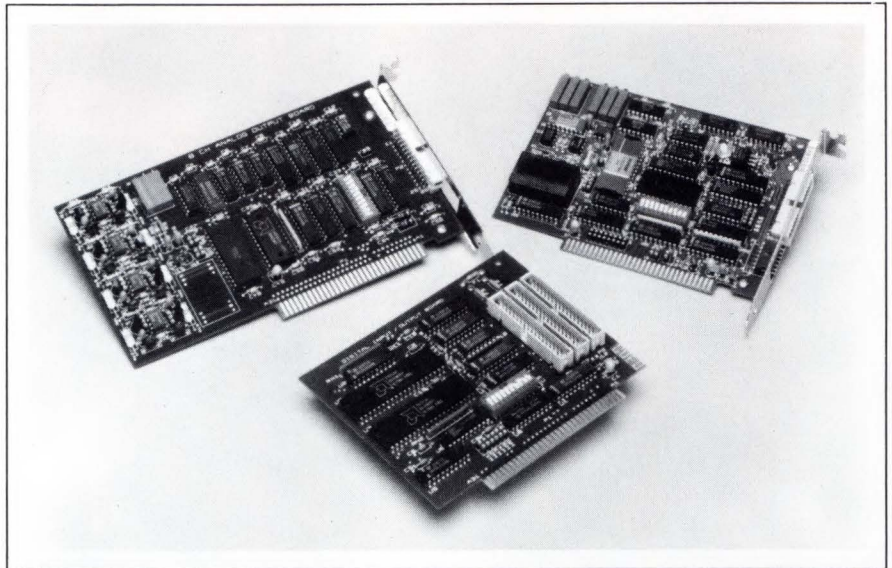
NEW PRODUCTS

COMPUTERS & PERIPHERALS

ACQUISITION BOARDS

- Two models fit into the short slot of IBM PC/XT
- Has digital I/O, analog input, and analog output boards

Three Superboards work with the IBM PC, PC/XT, PC/AT, and compatibles, as well as 386-type machines and the IBM PS/2, model 30. Two of the models, the IQ-187W-1 and IQ-189W-1, are small enough to fit in the short slot of the PC/XT. The IQ-187W digital I/O board provides 40 8-bit TTL-compatible channels. You can synchronize two of the board's five ports to external events. Data transfer rates as fast as 360k bytes/sec are possible. The IQ-189W analog input board has 16 single-ended or 8 differential inputs. Its features include a 12-bit A/D converter; software gain control settings of 1, 10, and 100; a sample rate as high as 32 kHz; and an internal timebase generator. The

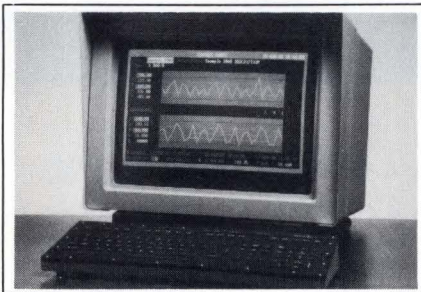


IQ-193W-1 analog output board provides eight voltage or current outputs. A proprietary dynamic refreshing technique updates all eight channels within 256 μ sec. The boards come with Basic software drivers and a diagnostic utility. IQ-

187W-1, \$165; IQ-189W-1 and IQ-193W-1, \$495.

Intelligent I/O, 1141 W Grant Rd, MS-131, Tucson, AZ 85705. Phone (602) 629-9872. TWX 910-997-0735. FAX 602-623-8965.

Circle No 418



INDUSTRIAL PC

- NEMA 2 enclosure with a 20-in. VGA-compatible display
- Contains an 80286 μ P and a 20M-byte hard-disk drive

The IPT 2000 industrial IBM PC/AT-compatible computer is housed in a NEMA 2 enclosure and contains an 80286 μ P and a 20M-byte hard-disk drive. It also has a 20-in. IBM VGA-compatible display, which provides 640 \times 480-pixel resolution. Other features include two serial ports, one parallel port, a 3½-in. floppy-disk drive, and the com-

pany's autoranging power supply, which allows the unit to operate with international power sources without switches or jumpers. Optional features include infrared, resistive, and capacitive touch screens; a 40M-byte hard disk; and a membrane keyboard. Trade-in allowances are available. \$7995.

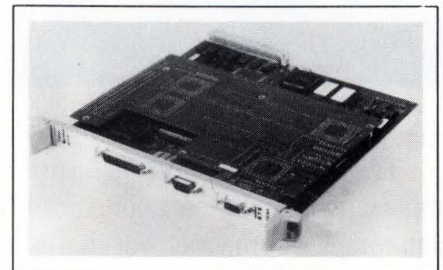
Intecolor, 2150 Boggs Rd, Duluth, GA 30136. Phone (404) 623-9145. FAX 404-623-9163.

Circle No 419

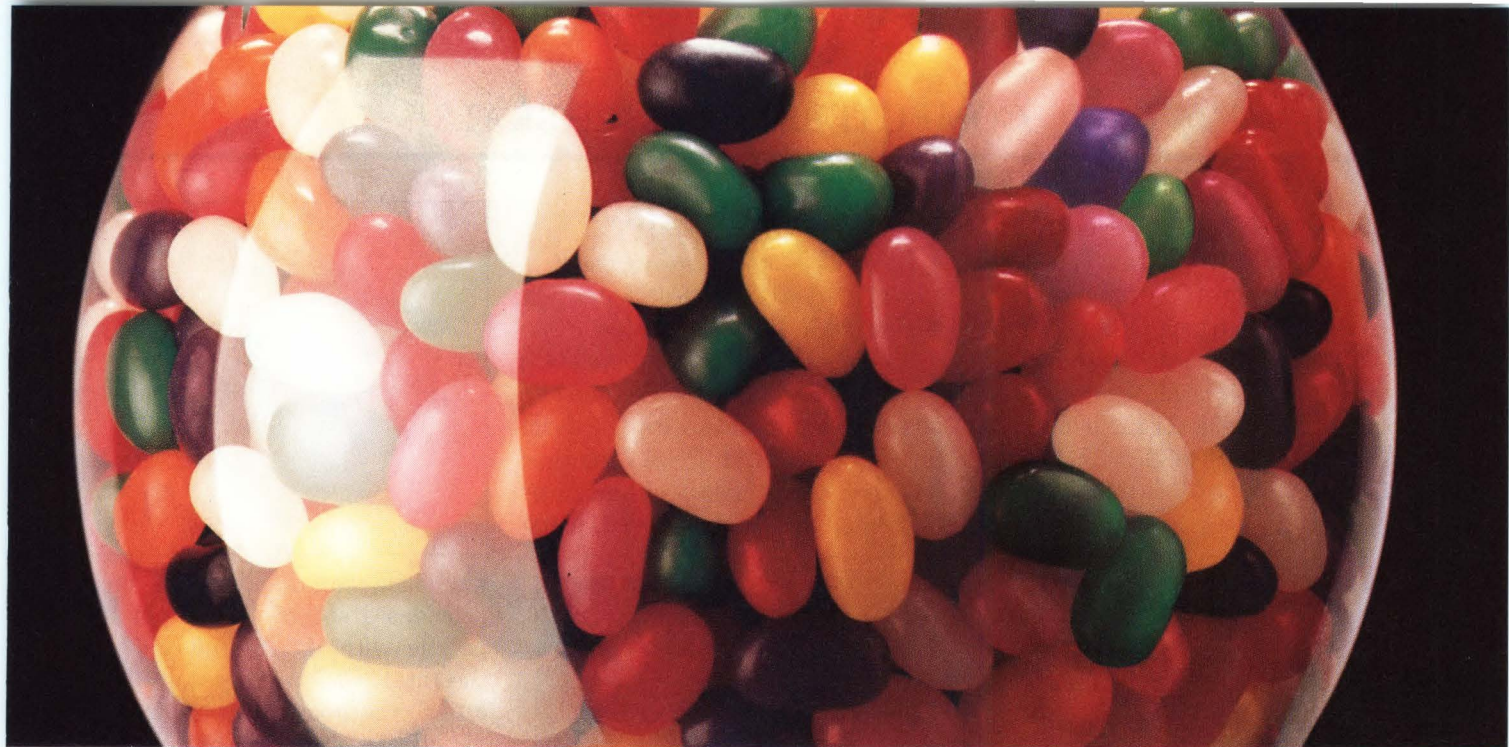
GRAPHICS PROCESSOR

- Generates 125,000 vectors/sec on Multibus II systems
- Provides 1280 \times 1024-pixel resolution

The MMG-1281 graphics processor board for Multibus II systems provides 1280 \times 1024-pixel resolution, generates 125,000 vectors/sec, and performs BitBlt operations at



12.5M pixels/sec. The drawing speed is accomplished with a TMS34010 graphics processor and three custom gate arrays. In addition, the board contains an NEC V50 μ P, which acts as a local host controlling the data flow between the message-passing coprocessor and board. The NEC V50 also provides built-in test features that allow you to configure under software control. The board has two serial ports which let you connect it to a graphics input device and a keyboard. The 1M-byte RAM stores firmware, display lists, fonts, pat-



If this is how you see LEDs, the ad is over.

The popular myth goes something like this: "An LED, is an LED, is an LED." Or: "If you've seen one, you've seen them all." And of course: "LEDs? They're commodity products." Notions we at Dialight, steadfastly reject. And once you're familiar with our products, you'll know why.

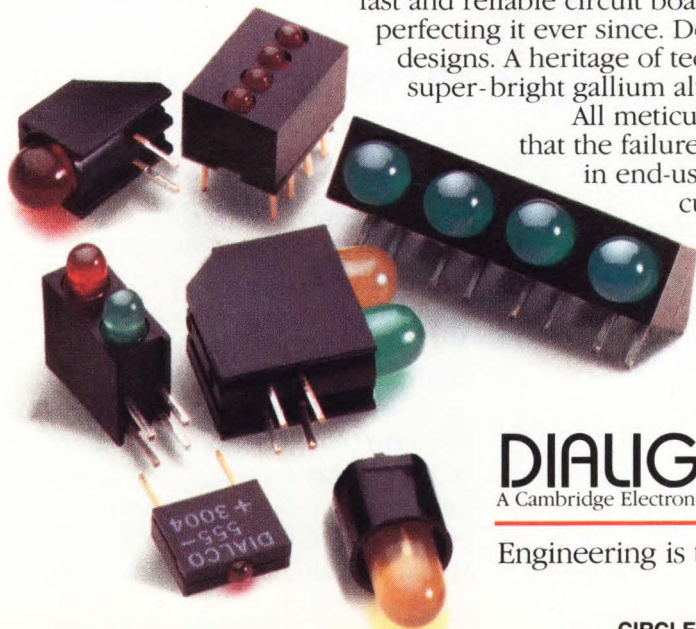
Take our Circuit Board Indicators. Single or multiple discretes aligned in a sturdy plastic housing, complete with their own current limiting resistor. The entire assembly polarity-keyed to guarantee correct insertion.

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Dialight pioneered the concept more than fifteen years ago to satisfy the OEM need for fast and reliable circuit board installation of LEDs. And we've been perfecting it ever since. Developing hundreds of standard and custom designs. A heritage of technological advance you can see in our new super-bright gallium aluminum arsenide units.

All meticulously engineered with the understanding that the failure of a "jelly bean product" can cost thousands in end-user downtime, and who-knows-what in customer loyalty.

The same understanding might bring you to call 201-223-9400, or write Dialight Corporation, 1913 Atlantic Ave., Manasquan, NJ 08736, and ask for our catalog or a product sample. At the very least, it's brought you to the real end of our ad.



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terns, and images. The board can produce 256 colors from a palette of 16.7M colors. Version with a $1k \times 1k \times 8$ -bit frame buffer, \$6495.

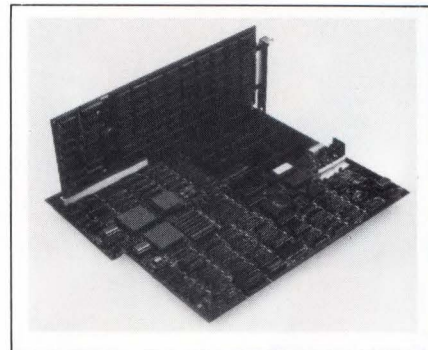
Matrox Electronic Systems Ltd., 1055 St Regis Blvd, Dorval, Quebec, Canada H9P 2T4. Phone (514) 685-2630. FAX 514-685-2853. TLX 05822798.

Circle No 420

386 MOTHER BOARD

- Runs at 25 MHz and supports 3167 and 80387 coprocessors
- Five IBM PC/AT- and two PC/XT-compatible expansion slots

The 2525 Weitek 80386 mother board is compatible with the form factor of an IBM PC/AT mother board. You can select either 25 or 8 MHz as the running speed, using



keyboard commands. The board provides a socket that is pin compatible with the Weitek 3167 and the Intel 80387 coprocessors. In addition, the board has 32k bytes of direct-map or 2-way set-associative cache memory. It provides five 16-bit IBM PC/AT- and two 8-bit PC/XT-compatible expansion slots. A 32-bit expansion bus connects to a memory card that contains as much as 16M bytes of memory. Compatible operating systems include OS/2, Unix, Xenix, PC-DOS, MS-DOS, Novell, Windows 386, Concurrent DOS, and PC-MOS. The board gives you a choice of using either the Phoenix 386 or Award 386 BIOS and achieves a Norton SI 4.0 performance rating of 30.5. Mother board and memory card with 4M bytes of memory, \$5765.

Micronics Computers Inc., 935 Benecia Ave, Sunnyvale, CA 94086. Phone (800) 234-4386; in CA, (408) 732-0940. FAX 408-732-6048.

Circle No 421

Vactrols- Analog Opto-Isolators

EG&G VACTEC

VACTROLS™ resistance decreases with increasing input current source (LED, neon, incandescent). Provides unique control where higher speed phototransistor isolators are not suitable.

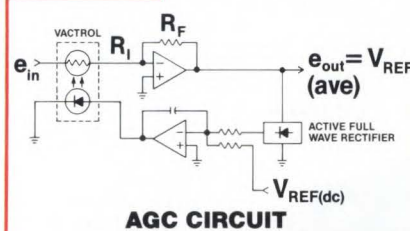
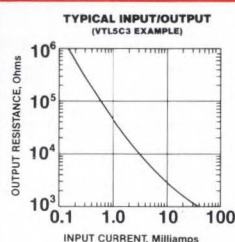
For example:

- power limiters for audio amplifiers
- AGC circuits for DC-5MHz carriers
- remote gain control for amplifiers
- noiseless potentiometers or switching
- signal modulators

An example of the AGC application and a characteristic for VTL5C3 are illustrated. EG&G Vactec manufactures many optoelectronic components. Included are Blue Sensitive and High Speed Photodiodes, Phototransistors, Photodarlington, I-R LEDs (GaAs and GaAlAs), I-R Reflective and Slotted Switches, Light Activated Switches, and a variety of Custom Sensor Assemblies.

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(314) 423-4900 or TWX 910-764-0811 or FAX 314-423-3956



TRANSPUTER BOARD

- Provides four Transputers in one IBM PC or PC/AT slot
- Allows software control of Transputer array topology

Incorporating four T800 or T414 Transputers and two C004 Transputer link switches, the MTM-PC Transputer board for IBM PC, PC/XT, PC/AT, or compatible computers allows you to software configure the Transputers into any array topology. To provide larger arrays, you can cascade several boards together or add additional Transputers that are

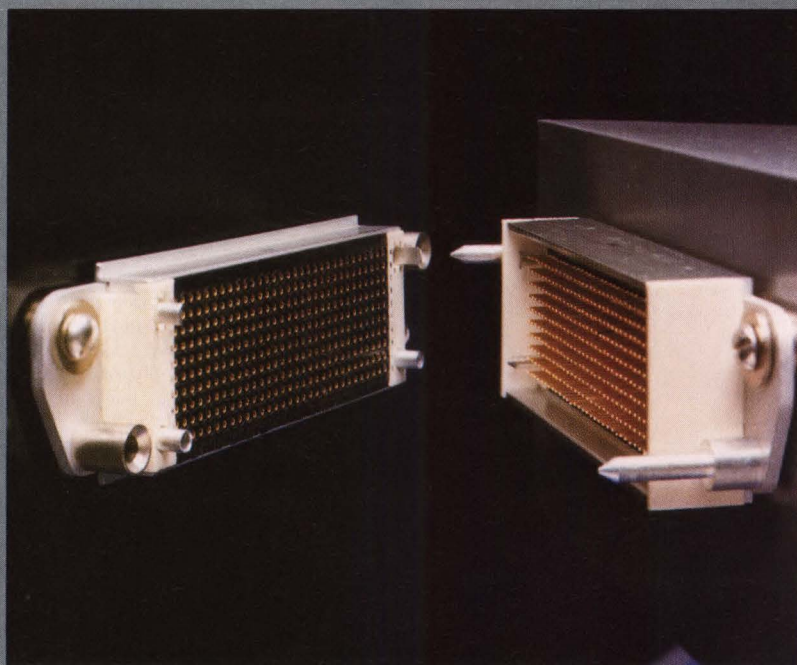
End the connector compromise...

1. 70 TO 350 LOW INSERTION FORCE CONTACTS

2. CONTACT WIPE ELIMINATES INTERMITTANCE

3. MIL-C-28748A RELIABILITY

...in electronic equipment



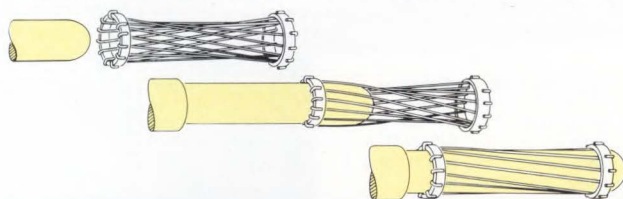
Only Hypertronics ends the compromise in multi-pin connectors for disc drive, burn-in and other rack & panel applications...by combining Low Insertion Force (LIF) connections with high cycle life reliability and a blind mating tolerance up to .049" radial misalignment.

Our N Series design provides 70 to 350 LIF contacts with solder cup, crimp, flow solder or wire wrap terminations. The contact is rated at 3 amps at less than 5 milliohms over a mechanical cycle life in excess of 100,000 operations.

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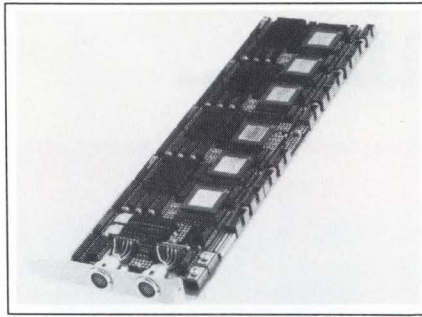
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CIRCLE NO 72

mounted on piggyback modules and maintain the software programmability of the array topology. The Transputer links operate at 20M bps, and two links are brought out to rear-panel connectors so you can connect the Transputer array to remote systems. You can link the MTM-PC to the company's Megaframe video, graphics, and



parallel I/O Transputer modules, which also fit inside an IBM PC. The company can also provide interfaces to VME Bus, Q Bus, Nubus, SMP, and ECB bus systems. Software support includes the Helios distributed operating system, and the company's Megatool development-system software, which includes compilers for Occam, C, Fortran, Pascal, and Parallel Prolog. DM 12,800.

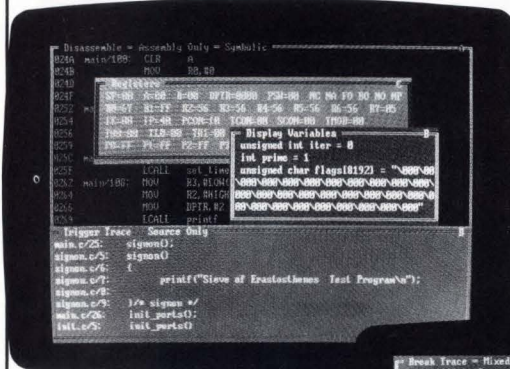
Parsytec GmbH, Juelicher Strasse 338, D-5100 Aachen, West Germany. Phone (0241) 166000. FAX 241-1660050.

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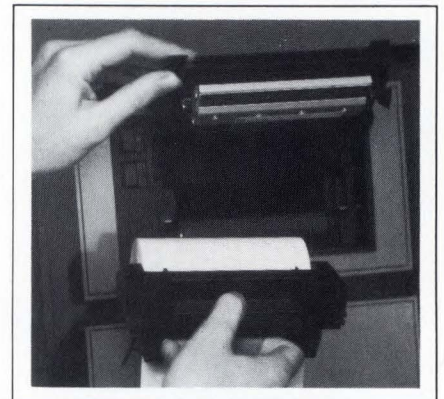
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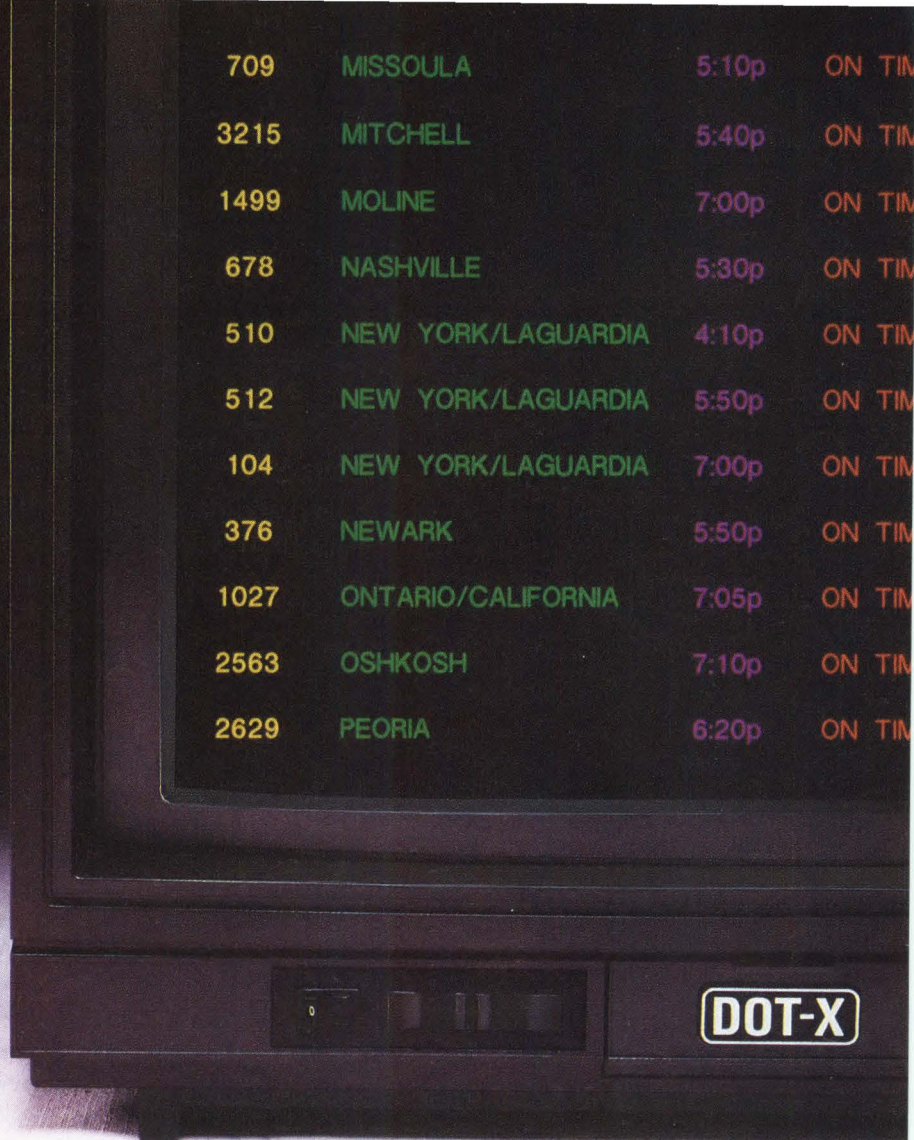
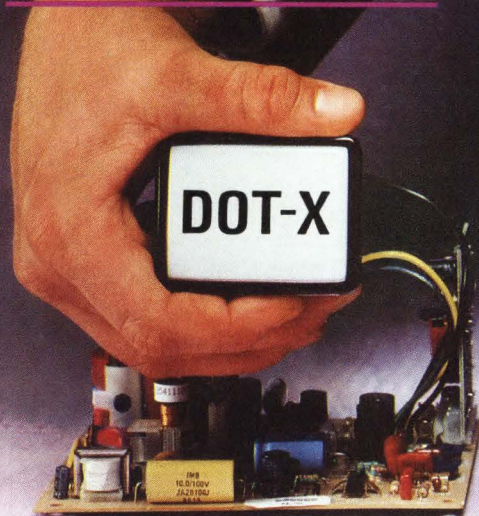


THERMAL PRINTER

- Print head moves for easy paper loading
- Prints 12 lines/sec with 150-dpi resolution

The Printrex 415 fixed-head thermal printer for instrumentation and point-of-sale systems features a proprietary print-head mounting technique for easy paper loading. The print head automatically moves out of the way when the door is opened to insert the paper carrier. The 40-column unit prints at 12 lines/sec with 150-dpi resolution. The unit is available in a panel-mount configuration or as a stand-alone printer in a case with an ac power supply. The printer has a single-board controller that provides brownout and watchdog protection along with fail-safe shutdown in case of component failures. The unit has a Centronics parallel interface

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CIRCLE NO 32

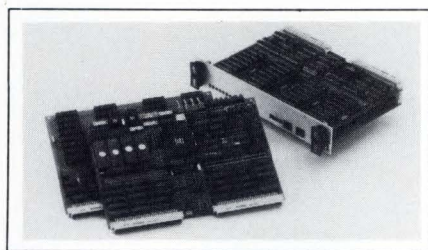
Locations at: Boulder, CO • Eau Claire, WI (VMI) • Minneapolis, MN • Elk River, MN • Hsinchu, Taiwan

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and is compatible with the character set and control codes for the IBM PC. In addition, the printer provides 128 graphics symbols along with the standard 96 ASCII characters and bit-mapped graphics. The unit can do double-width and double-pitch printing, as well as upside-down character printing. \$500 (OEM qty).

Printrex, 2108 Bering Dr, Suite C, San Jose, CA 95131. Phone (408) 436-0801. FAX 408-436-0803.

Circle No 423



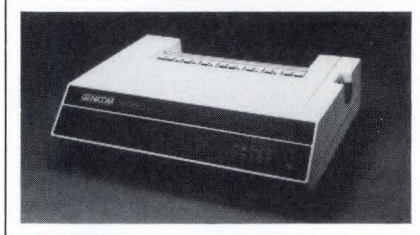
VME SPARC MODULE

- 2-board set uses a 20- or 25-MHz RISC processor
- Has 1M byte of SRAM and two RS-232C ports

The MZ7170 real-time module for VME-based systems uses a 20- or 25-MHz SPARC processor to deliver 12 or 15 sustained MIPS, respectively. The module contains 1M byte of static RAM, as much as 4M bytes of EPROM, two RS-232C ports, a real-time clock with battery backup, a 32-bit master/slave interface to the VME Bus, and full system-controller functions with four levels of arbitration. In addition, the unit contains an interrupt handler, an interrupt generator, and provisions for mailbox interrupts. The board supports Wind River System's VxWorks real-time operating system and the company's debug monitor package. You can develop software, using the SunOS Unix operating system on a Sun workstation or the company's hybrid development system. \$6995.

Mizar Inc, 1419 Dunn Dr, Carrollton, TX 75006. Phone (800) 635-0200 ext 920. FAX 214-522-5997.

Circle No 424



BARCODE PRINTER

- Prints at 400 cps with 10 cpi
- Contains all of the OCR-A and OCR-B barcode fonts

The Model 3410XBQ dedicated barcode printer contains all of the OCR-A and OCR-B barcode fonts as standard items. As a printer, it can print 400 cps at 10 cpi and 480 cps at 12 cpi in draft mode. It can also print 100 cps at 10 cpi and 120 cps at 12 cpi in letter-quality mode. A variable barcode density feature permits even faster barcode printing. The printer lets you rotate a form 90° for printing oversized characters. You can feed paper through the bottom of the unit for heavy forms and labels. A rear paper-feed path is also standard and can handle 6-part forms. The unit works at 55 and 57 dBA, using the bottom-feed feature. A Centronic/Genicom parallel port and an RS-232C port provide the computer interfaces. \$2280.

Genicom Corp, 1 Genicom Dr, Waynesboro, VA 22980. Phone (703) 949-1875.

Circle No 425

LAN INTERFACE

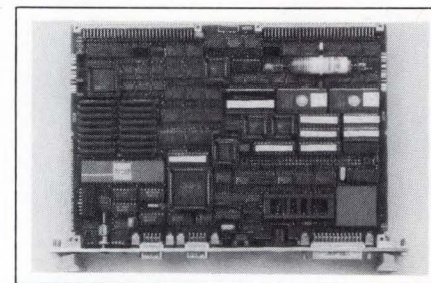
- Connects VME Bus systems to Ethernet LANs
- Supports TCP/IP and ARPA protocols

The SIEC-802.3 interface board connects VME Bus systems to Ethernet (IEEE 802.3) LANs. It has an onboard 10-MHz 68010 μ P, 64k bytes of high-speed static RAM, as much as 2M bytes of dynamic RAM, and 64k bytes of EPROM. The dynamic RAM is ported to the board's VME and VSB Bus interfaces, and to the 68010 μ P. Local processing allows the board to support the

Transmission Control Protocol/Internet Protocol and the address-resolution protocol. You can either download the required firmware from a host processor running the Unix operating system, or operate the board from EPROM resident firmware. In addition to device drivers for Unix V.2 and V.3, utility and service programs to support the ARPA protocol are also available. Approximately DM 6300.

Stollmann GmbH, Max-Brauer-Allee 81, 2000 Hamburg 50, West Germany. Phone (040) 3890030. FAX 040-3809224.

Circle No 426



COMPUTER

- Provides VME Bus systems with IBM PC/AT compatibility
- Runs the MS-DOS, OS/2, or Xenix operating systems

Offering full IBM PC/AT compatibility, the PX4010 VME Bus module allows VME Bus systems to run operating systems and application programs that are written for the IBM PC/AT. In addition to supporting MS-DOS, the module's 10-MHz 80286 μ P and 1.64M bytes of on-board RAM allow you to run the OS/2 and Xenix operating systems. The module includes a graphics adapter for IBM CGA, IBM EGA, or Hercules standards, onboard hard-disk and floppy-disk interfaces, a keyboard interface, a real-time clock, a parallel port, and two RS-232C/RS-422 I/O ports. VME Bus accesses are transparent to the processor, allowing memory and I/O on the VME Bus to appear as though they are within a normal IBM PC/AT environment. The board's IBM P-2 connector also car-

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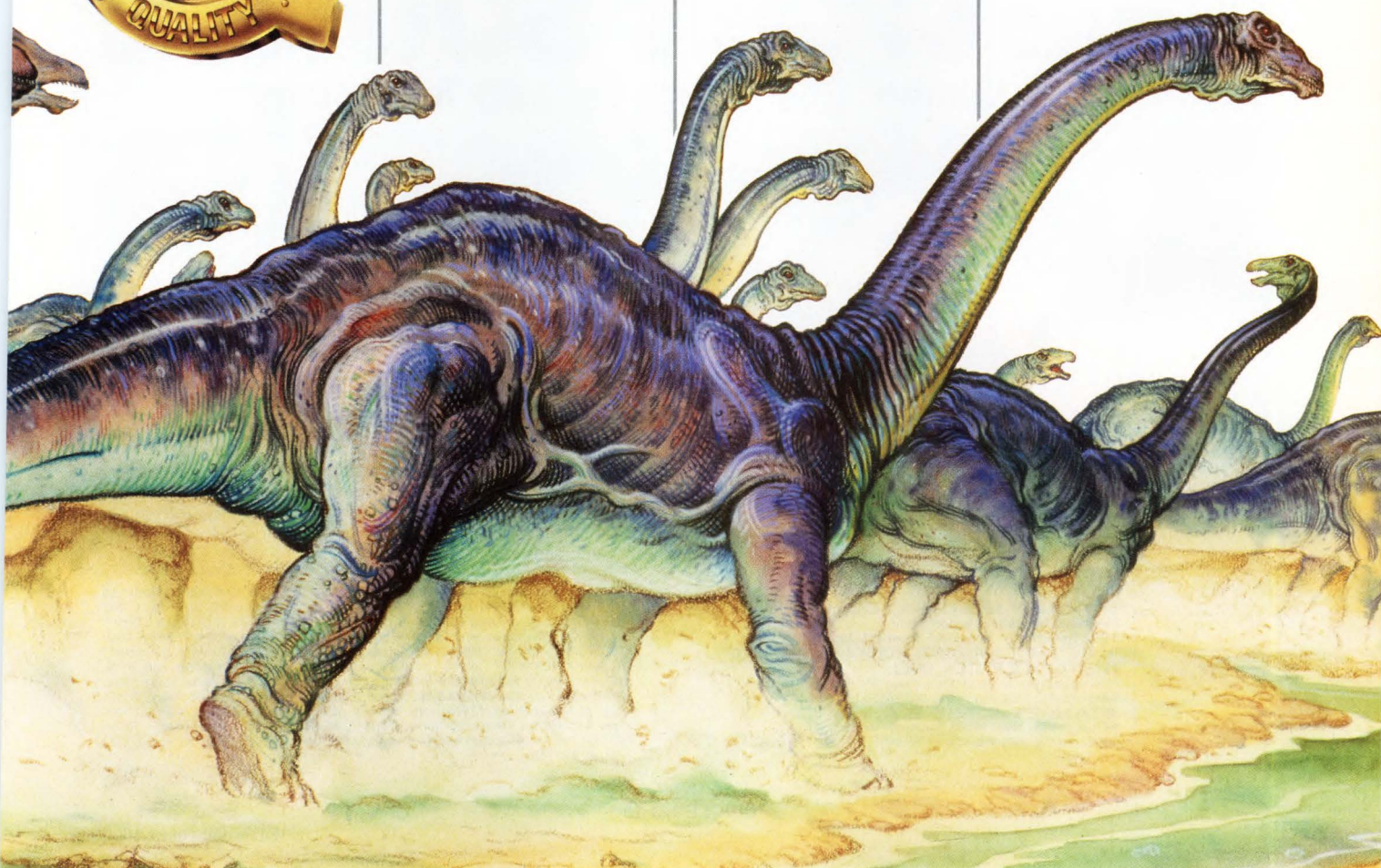
Hamilton/Avnet Electronics

10950 Washington Blvd.

Culver City, CA 90230

EDN021689

CIRCLE NO 121



ries an interface that's compatible with the IBM PC/XT system bus. By coupling this to a suitable backplane, you can expand the system with standard PC-compatible add-in cards. The PX4010 is a 2-board sandwich that occupies two VME Bus slots. gld 7500.

Philips, Industrial & Electro-acoustic Systems Div, 5600 MD Eindhoven, The Netherlands. Phone (040) 788620. TLX 35000.

Circle No 427

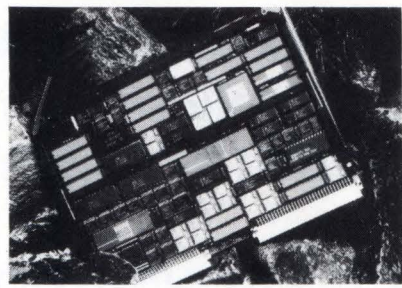
Philips Electronic Instruments Inc, 85 McKee Dr, Mahwah, NJ 07430. Phone (201) 529-3800. FAX 201-529-2252.

Circle No 428

SCSI BOARD

- Suitable for use in military VME Bus systems
- Has an onboard μP , DMA controller, and dual-port RAM

The PMV 68 SCSI-1 SCSI interface



board for VME Bus systems can operate in military or other harsh environments. The board is available in three versions. The first version is a full MIL-spec variant that features onboard conduction cooling, and components that are screened to MIL-STD-883C requirement. This version meets MIL-E-5400, MIL-E-4158, and MIL-E-16400 requirements. The second version's ceramic components can operate over a temperature range of -40 to $+85^{\circ}\text{C}$. The third version's commercial-temperature-range components provide a lower-cost develop-

ment vehicle. The boards have an onboard 68000 μP , a DMA controller, 16k bytes of EPROM resident firmware, and 16k bytes of dual-port static RAM. The board's SCSI bus interface supports the scatter/gather and disconnect/reselect SCSI bus modes, and you can configure it as either a SCSI target or an initiator device. The board can sustain SCSI bus data rates as high as 1.5M bytes/sec, and pass data to or from the VME Bus, using 32-bit DMA transfers. MIL-spec version, \$10,000.

Radstone Technology plc, Water Lane, Towcester, Northants NN12 7JN, UK. Phone (0327) 50312. TLX 31628. FAX 0327-52985.

Circle No 429

Radstone Technology Corp, 1 Blue Hill Plaza, Pearl River, NY 10965. Phone (914) 735-4661. FAX 914-735-9527.

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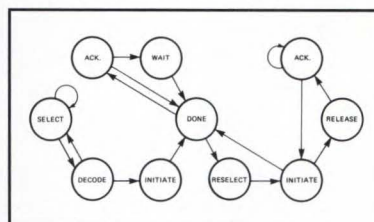
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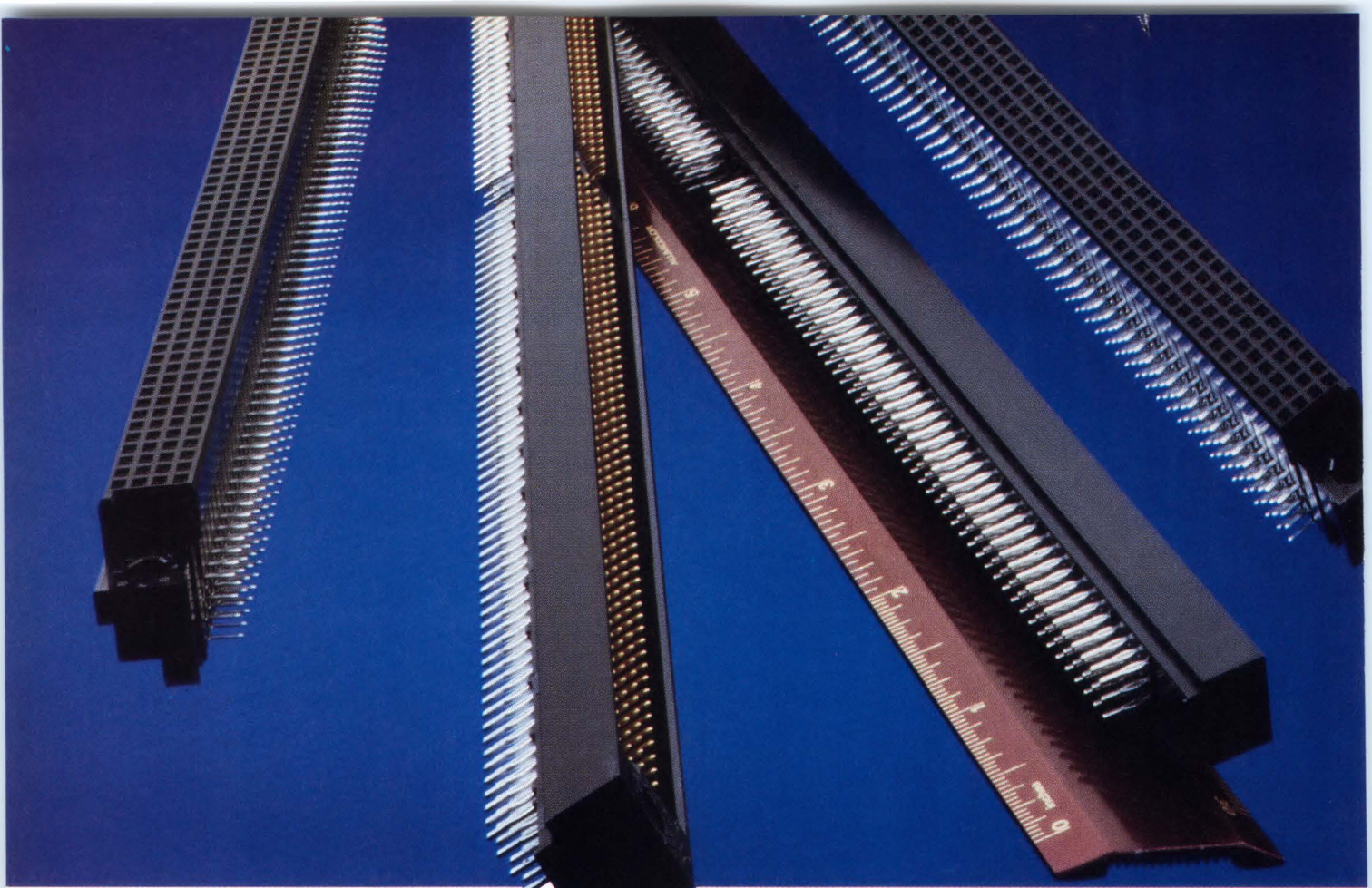
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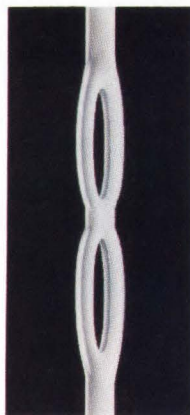
The XD/P™ two-piece high density connector system also provides for all types of packaging/system designs.

Standard designs include three and four rows of contacts on a .100" grid, in one-, two- or three-cell configurations with as many as 684 positions.

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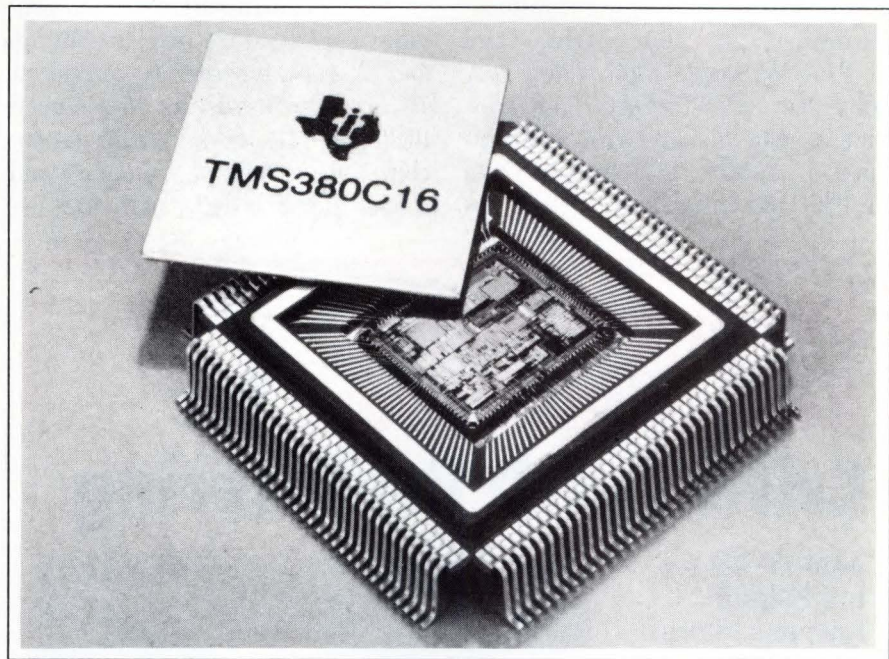
NEW PRODUCTS

INTEGRATED CIRCUITS

TOKEN-RING CHIPS

- Supports IEEE 802.5 protocols
- Include a communications processor

The second-generation TMS380C16 Token-Ring COMMprocessor integrates the communications processor, protocol handler, system interface, and memory-expansion functions on a single chip. The TMS380C16 supports the IEEE 802.5 Media Access Control protocols and the IEEE 802.2 Logical Link Control protocols. It contains a 16-bit CPU, a register cache, four DMA channels, a DMA interface, a parity checker and generator, memory-mapping registers, and automatic-address-decode and DRAM-refresh logic. The TMS380C16 provides as many as four MIPs of processing power. A second chip, the TMS38053 Ring Interface, provides the physical interface from the TMS380C16 to the To-



ken-Ring network and includes the digital and analog circuitry to connect separate transmit and receive channels. TMS380C16, \$96; TMS38053, \$24 (1000).

Texas Instruments Inc., Semiconductor Group SC-876, Box 809066, Dallas, TX 75380. Phone (800) 232-3200, ext 700.

Circle No 351

GRAPHICS IC

- Provides a palette of 16M colors
- Operates with either 6- or 8-bit D/A converter resolution

The IMSG178 high-performance color look-up table integrates the functions of a 16M-color palette, a triple D/A converter, and a μ P interface into a single IC. To provide greater color resolution and to create graphics with smooth shading, you can program the device to operate its D/A converters at 6- or 8-bit resolution. Programming of the required resolution takes place via a single device pin. Additional features include composite sync and read-back facilities. The IMSG178 is available in versions with maximum clock frequencies of 40, 50, or 65 MHz, and an 80-MHz version is scheduled for the second half of 1989. Packaged in a 32-pin plastic leaded-chip carrier, the device is pin-compatible with the company's

PLCC-packaged IMSG176 color look-up table. Samples of the 40-MHz IMSG178 are available for £24.24 (100).

Inmos Ltd., 1000 Aztec W, Almondsbury, Bristol BS12 4SQ, UK. Phone (0454) 616616. TLX 444723. FAX 0454-617910.

Circle No 352

Inmos Corp., Box 16000, Colorado Springs, CO 80935. Phone (719) 630-4000.

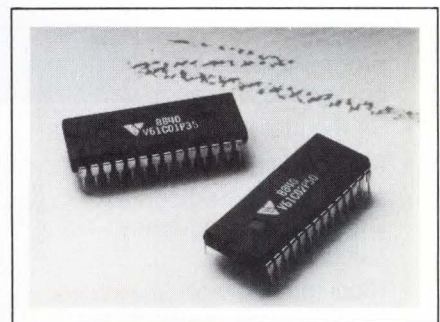
Circle No 353

FIFO MEMORIES

- Come in 12-, 16-, and 22-MHz versions

- Available in two organizations

The V61C01 and V61C02 dual-port FIFO (first in, first out) memories are suitable for use as data buffers between devices of different speeds. They are available in 12-, 16-, and 22-MHz versions. The



V61C01 is a 512 \times 9-bit configuration and is pin compatible with the MK4501 and IDT7201 devices. The V61C02 is a 1k \times 9-bit configuration and is pin compatible with the IDT7202. Both devices, which have half-full flags in single-device operation, accept data on a 9-bit bus and recover data in the same order on another 9-bit bus. 12-MHz V61C01, \$9; 12-MHz V61C02, \$13 (10,000).

Vitellic Corp., 3910 N First St, San Jose, CA 95134. Phone (408) 433-6000. FAX 408-433-0331.

Circle No 354

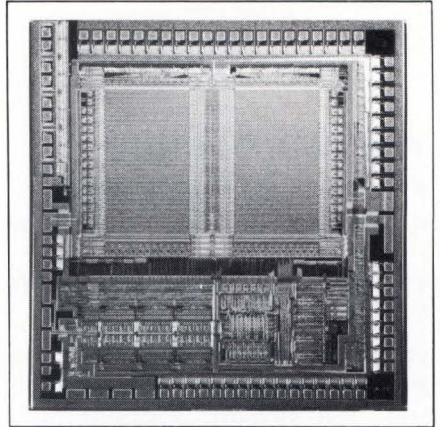
VIDEO DAC

- Can provide 1600×1200-pixel resolutions

- Available in five speed versions

Running at 165 MHz, the IDT75C458 triple 8-bit video D/A converter (PaletteDAC) can provide a color display with a resolution of 1600×1200 pixels. The IDT75C458 interfaces with a 25-

MHz μ P and offers no-wait-state operation. The device is available in 165-, 135-, 125-, 110-, and 80-MHz versions. The 135-MHz version provides a 1280×1024-pixel resolution and allows the screen to refresh at 70 Hz, which results in reduced flickering. The DAC includes an on-chip, 6-nsec, dual-port memory and a fixed pipeline delay of 8 clock cy-



cles, which eliminates external reset and synchronizing circuitry. The IDT75C458 also features accuracy to $\frac{1}{2}$ LSB. It consumes 1W of power. Packaging options include an 84-pin pin-grid-array package and an 84-pin plastic-leaded chip carrier. 165-MHz version, \$223.40; 125-MHz version, \$194.00 (100).

Integrated Device Technology Inc., Box 58015, Santa Clara, CA 95052. Phone (408) 727-6116. FAX 408-988-3029.

Circle No 355

Programmable Anti-Alias Filters for Critical A/D Prefiltering

848P8E Series are Elliptic lowpass filters providing extremely sharp roll-off for A/D prefiltering.

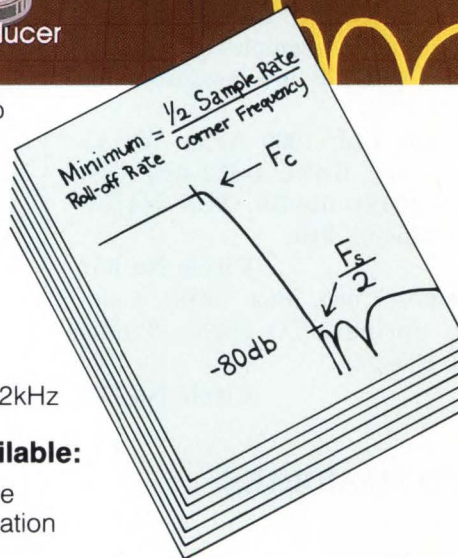
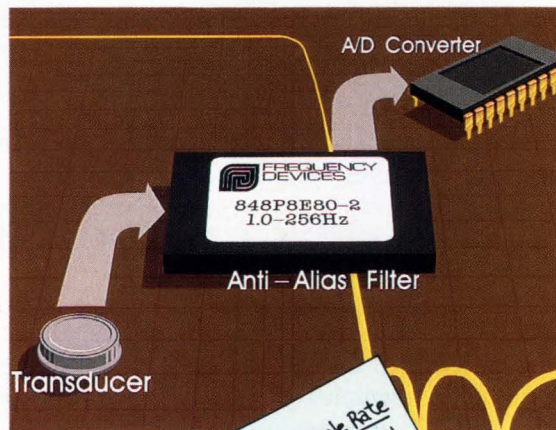
Features:

- 8 pole, 6 zero elliptic lowpass filters
- Digitally programmable corner frequency
- Shape factor of 1.77 at 80db
- 8 bit (256:1) tuning ratio
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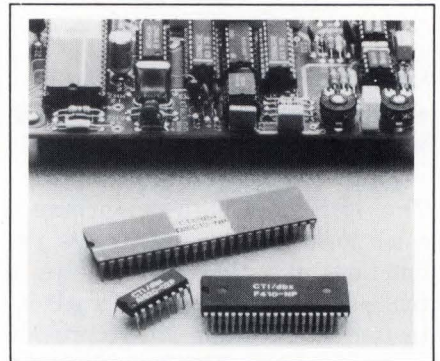
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Haverhill, MA 01830
(508) 374-0761



AUDIO ADC CHIP SET

- Offers 18-bit resolution
- Features low distortion

The F410/D20C10/A1520 A/D converter (ADC) chip set is designed for high-performance audio applications. It consists of the F410 front-end IC, the D20C10 20-bit decimator, and the A1520 precision resistor network. The ADC uses noise-shaped oversampling at 6 MHz and flash, 4-bit conversion. The D20C10 is a digital filter with a 6-bit input and a 20-bit output; it has a 128:1 ratio of input-to-output sample



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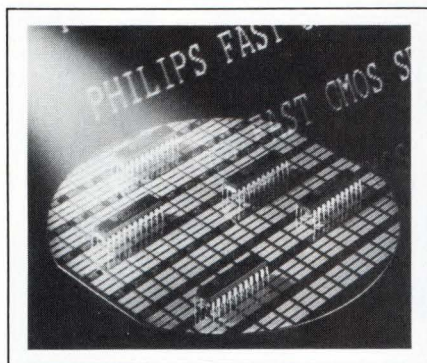
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INTEGRATED CIRCUITS

rates. The A1520 contains 15 matched, 20-k Ω resistors. It works in conjunction with the F410 and two 8-bit flip-flops to form the complete A/D converter. The basic chip set features 18-bit resolution, a signal-to-noise ratio of 105 dB, <0.005% THD at maximum output, and differential linearity of 0.000000076%. For 20-bit resolution, a second F410 and A1520 are required. \$130 (100).

CTI Research, 71 Chapel St, Newton, MA 02195. Phone (617) 964-3210.

Circle No 356



STATIC RAMS

- Pin compatible with industry-standard 64k-bit static RAMs
- Include low-power versions suitable for battery backup

Available with access times of 35, 45, or 55 nsec, the FCB61C61 and FCB61C62 CMOS static RAMs are pin compatible with other industry-standard 64k-bit static RAMs. The FCB61C61 is organized as a 64k \times 1-bit RAM, and the FCB61C62 is organized as a 16k \times 4-bit unit. The RAMs operate from a single 5V supply and have a typical active current consumption of 100 mA. In standby mode, they have a current consumption of 10 mA if you operate them at TTL logic levels and 1 mA if you operate them at CMOS levels. Both devices are available as L-suffix versions with a standby current consumption of 100 μ A and a data-retention voltage of 2V. All the RAMs have 3-state outputs with wired-OR capability. They are available in 22-pin DIPs or 24-pin

J-lead surface-mount packages. Around gld 50 (100).

Philips Components, Box 218, 5600 MD Eindhoven, The Netherlands. Phone (040) 757189. TLX 51573.

Circle No 357

Signetics Corp, 811 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 991-2000.

Circle No 358

BiCMOS STATIC RAMs

- Two organizations available
- Feature 20-nsec access speed

Fabricated in a high-density BiCMOS process, these 256k-bit static RAMs come in two versions and feature access speeds of 20 or 25 nsec. The HM6707 has a 256k \times 1-bit organization; the HM6708 is a 64k \times 4-bit version. According to the company, the BiCMOS ICs feature the low power of CMOS ICs with three times their

speed and ten times their internal and external drive capability. The HM6707 and HM6708 are available in 24-pin DIPs and surface-mount packages. \$111.14 to \$138.90 (100).

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

Circle No 359

QUAD BiFET OP AMP

- Settles to 0.01% in 1 μ sec
 - THD is 0.0003% at 3V rms output
- According to the manufacturer, the AD713 quad BiFET op amp features the best combination of ac and dc performance available. In addition to settling to 0.01% in 1 μ sec for a 10V step, the AD713 offers an input offset voltage of 0.5 mV, a bias current of 40 pA, and a total harmonic distortion (THD) of 0.0003% at 3V rms output. The IC's guaranteed matching characteristics include a maximum offset volt-

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154.52	19.090	15.778	197.35	16.230
188.58	129.34	174.58	19.875	1.9465
1.3876	101.09	16.790	1.9721	1.6759
1.7566	18.236	1.7805	198.67	189.20
187.43	17.647	152.78	189.36	17.654
18.347	16.154	1.5737	18.745	195.86
17.961	1.8497	15.876	191.60	17.949
16.975	186.67	175.87	15.134	145.87
1.8264	13.478	16.783	16.598	157.83
15.783	1.1654	136.56	11.387	1.6781
15.786	118.75	158.70	114.36	17.169
11.080	1.1342	178.67	10.287	1.6085
1.2136	1.8514	10.562	1.2905	191.70

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CIRCLE NO 22

SECS 386

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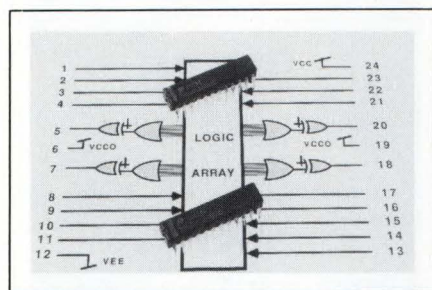
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age of 0.8 mV and an offset-voltage drift of $<25 \mu\text{V}/^\circ\text{C}$. Other key specs include a 3-MHz min unity-gain bandwidth, an $18\text{V}/\mu\text{sec}$ slew-rate, a $400\text{V}/\text{mV}$ open-loop gain, and an 84-dB min common-mode rejection. The AD713 is available in 14-pin plastic and ceramic packages in three temperature grades. \$3.50 to \$5.90 (100).

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

Circle No 360



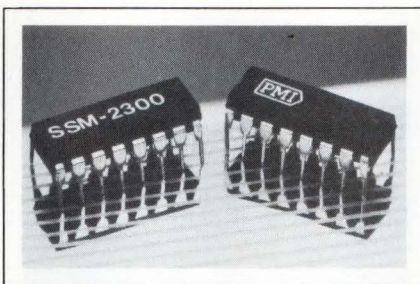
BIPOLAR PAL CHIPS

- *Contain transistor-based fuses*
- *Feature a 10-nsec propagation delay*

Featuring a maximum propagation delay of 10 nsec, the 4-chip PAL16D Series of PAL (programmable array logic) devices uses the company's AIM (avalanche induced migration) technique for blowing fuses. AIM uses a transistor-based vertical fuse rather than the common metal-film horizontal fuse, which can damage a chip or leave it vulnerable to future failures. The four devices in the series range from a pure combinatorial type, the PAL16L8D, to a pure registered type, the PAL16R8D. The other two chips, the PAL16R6D and the PAL16R4D, offer a mixture of combinatorial and registered outputs. Each 20-pin PAL circuit can replace from four to eight SSI/MSI discrete logic devices. The company provides complete hardware and software support. \$6.50 (100).

National Semiconductor Corp,
Box 58090. Santa Clara, CA 95052.
Phone (408) 721-5341. TLX 346353.

Circle No 361



SAMPLE-AND-HOLD IC

- Includes 1:8 demultiplexer
- Features 12-bit linearity

The SSM-2300 is an 8-channel, multiplexed sample-and-hold IC for data distribution in μ P-controlled systems. Packaged in a 16-pin DIP, the SSM-2300 contains a 4051-type 1:8 demultiplexer, eight on-chip hold capacitors, and output buffers. Offering 12-bit linearity, each channel can acquire an input signal to 0.01% in $<1 \mu\text{sec}$. The SSM-2300 can demultiplex the output of a 12-bit D/A converter into eight separate 12-bit linear voltage levels. The IC's output swing includes the

negative supply for single- or dual-supply operation from 5 to 18V. The chip's control inputs are TTL- and CMOS-compatible. \$3.33 (100).

Precision Monolithics Inc, Box 58020, Santa Clara, CA 95052. Phone (408) 727-9222. FAX 408-727-1550.

Circle No 362

DSP MICROCONTROLLER

- Offers 16-bit performance
- Features 25.6-MHz operating speed

Combining the high performance of a digital signal processor (DSP) with the on-chip peripheral functions of a microcontroller, the 320C14 features 16-bit performance and an operating speed of 25.6 MHz. The 320C14 is object-code compatible with the industry-standard TMS320C10 DSP and comes with 256k words (512k bytes) of on-chip RAM and 4k words (8k bytes)

Find the small change:

[illegible]

The 197 Microvolt DMM detects the small change—one part in 220,000—for small change: \$620. And you can automate with its IEEE-488 option. Find out how to get a big change in your measurement capabilities. Call the Keithley Product Information Center: (216) 248-0400.

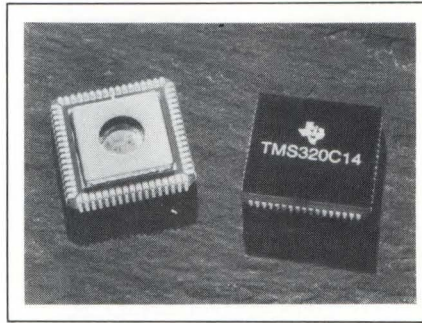


The Model 197 Microvolt DMM

KEITHLEY

CIRCLE NO 23

of on-chip ROM; it can also address 4k words of off-chip memory. The 320C14 architecture includes DSP and general-purpose instructions; it executes most instructions in a single cycle. The device uses a Harvard architecture and employs multiple internal buses to further increase the execution speed obtained by the chip's hardware-imple-



mented 16×16 multiplier. To provide greater precision, the 320C14 has a 32-bit ALU and 32-bit registers. \$10 (OEM qty).

Texas Instruments, Semiconductor Group SC-862, Box 809066, Dallas, TX 75380. Phone (800) 232-3200, ext 700.

Circle No 363

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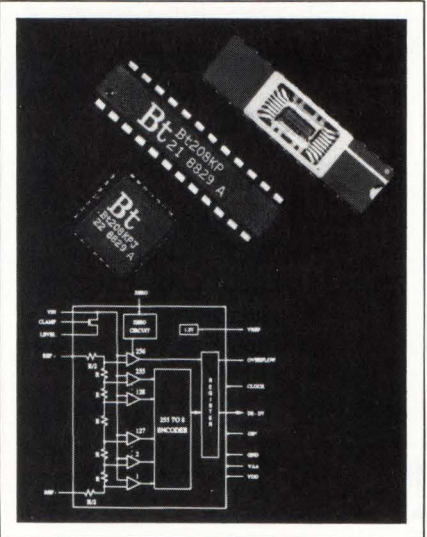
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CIRCLE NO 21



8-BIT FLASH ADC

- 20M-sample/sec rate
- Features external zero and clamp control

The Bt208 8-bit flash ADC offers many features for image-capture applications. Incorporating an analog input range of 0.714 to 1.2V, the Bt208 covers the NTSC, PAL, SECAM, and RS-343A video standards. The sampling rate of 20M samples/sec allows $4 \times$ oversampling of NTSC, PAL, and SECAM video signals. An output-enable control lets you pull data outputs to a high-impedance state asynchronously. The Bt208 has an input control for zeroing the comparators. The vendor provides differential nonlinearity at $\pm 1/4$ LSB and integral nonlinearity at $\pm 1/2$ LSB. The Bt208 is available in either a 24-pin 0.3-in. plastic DIP or a 28-pin PLCC. \$26 (100).

Brooktree Corp., 9950 Barnes Canyon Rd, San Diego, CA 92121. Phone (619) 452-7580.

Circle No 364

NEW PRODUCTS

TEST & MEASUREMENT INSTRUMENTS

WAVEFORM DIGITIZER

- Uses IBM PC/AT as host
- Digitizes to 14 bits at 1M samples/sec

The AT6400 is a waveform digitizer that has capabilities equal to those of competitive units that cost three or four times as much. It digitizes two to eight channels to 14 bits at a combined maximum rate of 1M samples/sec; you can slow the rate in 0.25- μ sec increments to $\frac{1}{16}$ M samples/sec and in steps of 1.6 to 3% to 2 samples/sec. The most sensitive full-scale range is ± 128 mV. The inputs are differential, and are isolated from the chassis. CMRR exceeds 80 dB at 60 Hz. System noise is <3 counts p-p, and full-power analog bandwidth is 500 kHz. The unit uses your IBM PC/AT or compatible computer as a host; its proprietary interface plugs directly into the 16-bit bus and transfers data to memory using DMA. The maximum rate for long bursts of data depends on the bus speed; on a 10-MHz PC/AT clone, in which I/O

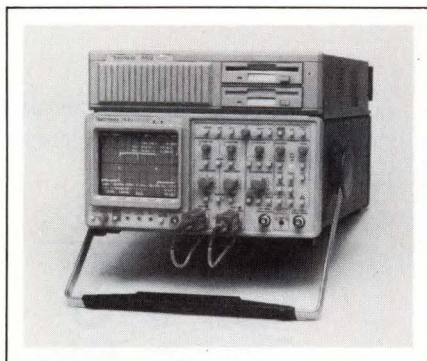


operations do not slow the clock (as they do on faster machines), you achieve speeds in excess of 300k points/sec. With a PC/AT equipped with 16M bytes of RAM, you can record 8M samples. A trio of third-party software packages, Dadisp, Assystant, and Snapshot Storage

Scope, are sold separately and incorporate drivers for the unit. From less than \$4000; software, \$500 to \$1000. Delivery, 90 days ARO.

Acrosystems Corp, 66 Cherry Hill Dr, Beverly, MA 01915. Phone (508) 927-8880. FAX 508-922-5114.

Circle No 370



DSO ENHANCER

- Attaches to vendor's 2400 series scopes
- Stores as many as 500 waveforms

If you connect a keyboard and a monitor to the ports provided on the 2402 TekMate, you have a complete MS-DOS PC based on the NEC V40 μ P. The small unit bolts to the vendor's 2400 series DSOs

and includes a pair of 720k-byte 3 $\frac{1}{2}$ -in. floppy-disk drives. The vendor believes, however, that the majority of users won't add the keyboard and monitor and will control the unit's operation via the menus it displays on the scope's CRT and the "soft" keys beneath the CRT. All of the supplied software uses this interface. Among the unit's capabilities are storage of 500 waveforms on floppy disk, time/date stamping of the disk files, and processing of stored waveforms using integration or FFTs. The unit also directly drives a parallel-interfaced printer or plotter, two RS-232C devices and an IEEE-488 bus. It operates in an unattended mode, in which it awaits the occurrence of a complex trigger sequence, or an out-of-limits signal condition to re-

cord a waveform. \$2990 including software.

Tektronix Inc, Box 1700, Beaverton, OR 97075. Phone (800) 426-2200.

Circle No 371

80386 EMULATOR

- Emulates in real time to 25 MHz
- Is also usable with 386SX, 387, and 387SX chips

The ICE-386/25 in-circuit emulator supports the 25-MHz version of the vendor's 80386 μ P; another version of the emulator supports the 386SX chip and a companion emulator supports the 376 embedded processor. The emulators and the associated software development tools also support the 387 and 387SX numeric coprocessors. The emulators pro-

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TEST & MEASUREMENT INSTRUMENTS

vide complete access to the processors' internal states and achieve 100% accuracy in execution history tracing. The development tools include an assembler, a debugger, C and PL/M compilers, relocation, linkage and library tools, and an Ada development environment. ICE-386/25, \$19,995; ICE-376, \$17,995; ICE-386SX, \$18,995; ICE-386 for 20-MHz processors, \$14,995. Probe conversion kits, \$4495 to \$7995. Software tools from \$600.

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

Circle No 372



LOGIC ANALYZER

- Provides between 48 and 192 state or timing channels
- Transitional timing at clock frequencies as high as 200 MHz

You can configure the PLA/2 modular logic analyzer to provide from 48 to 192 input channels, each with a trace memory depth of 4k bits. The input channels are divided into 16-channel groups, and each group is switchable between internal and external clock sources to provide timing analysis at clock speeds as high as 100 MHz, or state analysis at clock frequencies as high as 50 MHz. By sacrificing half of the input channels, you can perform timing analysis at a clock speed of 200 MHz. To maintain maximum timing resolution without limiting the period that you can trace data, the analyzer uses transitional timing techniques. You can qualify data capture with control signals, with single-address or address-range information, or with Boolean expres-

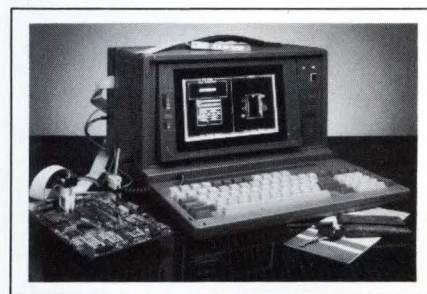
sions. In addition, a pre-store facility, which appends two previously qualified samples to the recorded data, helps determine program flow. From DM 20,000.

Kontron Elektronik GmbH, Oskar-von-Miller-Strasse 1, 8057 Eching/Munich, West Germany. Phone (08165) 770. TLX 526719. FAX 08165-77512.

Circle No 373

Kontron Electronics, 630 Clyde Ave., Mountain View, CA 94039. Phone (415) 965-7020. TWX 910-378-5207.

Circle No 374



PORTABLE PCB TESTER

- Performs functional tests on pc-board-mounted ICs
- Housed in a PC with EL display

The Brads 2040 is an automatic test system housed in a sewing-machine-size PC that incorporates an electroluminescent (EL), flat-panel display. The system performs functional tests on digital ICs mounted on pc boards. By back driving device pins, the unit can measure the passive impedance (V vs I) of custom devices and circuit hybrids, and test interconnections. Further, slots are available on the PC's bus for the addition of instrumentation modules such as a 100-MHz logic analyzer; a digital word generator; or a 2-channel, 10-MHz DSO. You can select a PC based on an 80286 clocked at 12 MHz or a RAM-cached 80386 clocked at 20 MHz. \$9995 to 13,995; optional PC-bus-based instruments, from \$1000.

Paxr Corp., 50 Airport Pky Suite 101, San Jose, CA 95110. Phone (408) 437-7701. FAX 408-437-4915.

Circle No 375

LOGIC ANALYZER

- Incorporates time and value analysis
- Provides 16 channels at 400 MHz or 160 channels at 50 MHz

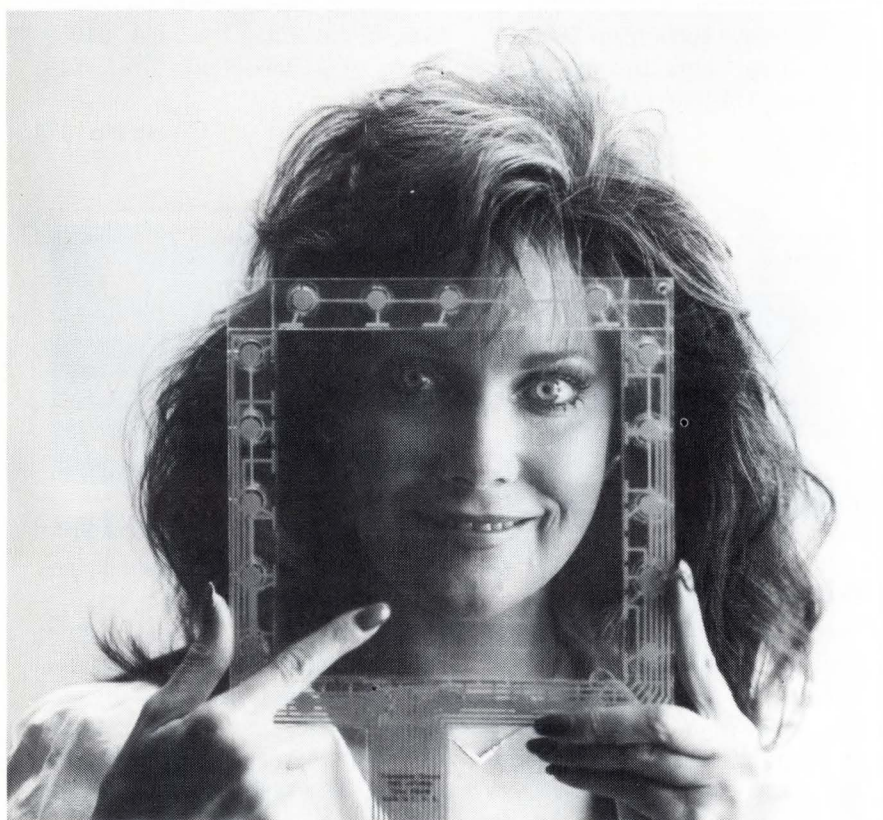
The ML4400 logic analyzer, which provides as many as 16 channels at a 400-MHz sampling rate or 160 channels at a 50-MHz sampling rate, performs time and value

analysis. Time analysis lets you define as many as four ranges and lets the unit display, in bar-graph form, the percentage of time that the input binary values are in any of the ranges. Value analysis lets you determine the relative frequency of a range of values. Both features allow you to use the analyzer for software-performance analysis and for

fine tuning code to optimize efficiency. You can upgrade existing ML4400s by plugging new ROMs into a socket located behind a pop-off cover. The upgrade is free, but you must return the analyzer's old ROMs. From \$5495.

Arium Corp., 1931 Wright Circle, Anaheim, CA 92806. Phone (800) 862-7486; in CA, (714) 978-9531.

Circle No 376



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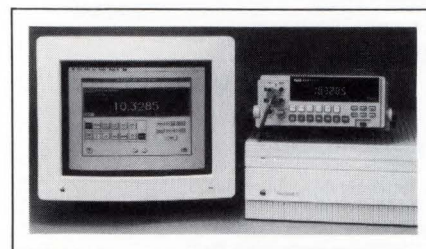
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CIRCLE NO 24



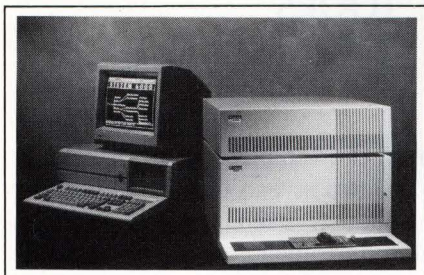
IEEE-488 SOFTWARE

- Runs on Apple Macintosh SE and Macintosh II
- Is based on Hypercard stacks and Hypertalk language

Hyper488 is a set of "stacks" used with Apple Computer's Hypercard software to interactively develop instrument-control applications for Macintosh SE and Macintosh II personal computers. Hyper488 is part of an IEEE-488 handler software package, called NI-488, that in conjunction with an IEEE-488 hardware interface, enables the two Macintosh models to control and read data from external programmable instruments. Once you have installed the interface hardware and NI-488 in the computer's operating system, you can use the Macintosh to design custom Hypercard stacks for instrument control. You can also design control programs in the Hypertalk language or in MS Basic, in Lightspeed C or in MPW C. The vendor furnishes NI-488 with its \$495 to \$1295 IEEE-488 hardware interfaces for the Macintosh line.

National Instruments Corp., 12109 Technology Blvd, Austin, TX 78727. Phone (800) 531-4742; in TX, (800) 433-3488. TLX 756737.

Circle No 377



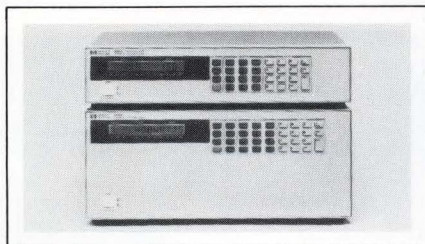
ASIC ANALYZER

- Hosted by 80386-based PC
- Lets any pin drive and detect

The SYS6000 ASIC analysis system is controlled by an 80386-based PC, which is included in the price. You can configure the analyzer in 16-pin increments with 64 to 352 pins. Each tester pin can drive a device pin, receive signals from a device pin, or both. Optionally, the system can perform dc parametric tests. The system can analyze data at a rate of 25M frames/sec; each frame can contain four signal edges and eight time locations. \$38,000 to \$129,000.

Gould Inc, Cadac Inc, Design & Test Systems, 19050 Pruneridge Ave, Cupertino, CA 95014. Phone (503) 645-2222.

Circle No 378



ELECTRONIC LOADS

- Absorb 300 and 1800W in constant V, I, and R modes
- Accept commands via IEEE-488 bus

The HP 6060A is a 300W electronic load. The HP 6050A is a modular 1800W unit that accommodates a maximum of six load modules with 150, 300, and 600W ratings. Except for its power rating, each of the 6050A modules offers performance similar to that of the self-contained HP 6060A. The 6060A can operate in constant-voltage, constant-cur-

rent, and constant-resistance modes. The input current is 0 to 60A, the input voltage is 3 to 60V (operation below 3V is possible at reduced current levels), and rise and fall times are as short as 12 μ sec. You can control the loads via the IEEE-488 bus. Pulse-waveform generation is built in; you can vary the amplitude, frequency, duty cy-

cle, and slew rate. The loads are protected from overvoltage, overcurrent, overtemperature, and reversed input polarity. HP 6060A, \$1995; HP 6050A, \$1800; modules from \$1250.

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone local sales office.

Circle No 379

At JAE, the future is now!





TX7 Series

The leader in high density connectors

As one of the top five worldwide connector manufacturers, JAE—in cooperation with major electronics O.E.M.s—has developed a complete family of 2-piece PCB connectors for small computer interface. The TX Series of low profile, high density connectors are real estate efficient, stackable, and **available now**.

JAE has been a leading manufacturer of electronic components for over 30 years and has a connector for virtually every application. As electronics equipment becomes smaller and lighter, JAE continues to research and develop connectors to meet the changing needs of the industry. The TX Series is just one example of how JAE is keeping pace with the industry. These high density connectors meet all EMI specifications and can be used in a wide range of state-of-the-art electronic systems applications.

Call or write today for information on the TX Series and the complete line of JAE connectors. JAE...where the future is now!



TX10 Series

JAE

JAE Electronics, Inc.

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 Santa Ana, CA 92705
 714/250-8770
 800/JAE-PART (523-7278)
 except CA and AK
 FAX 714/250-8957

CIRCLE NO 20

NEW PRODUCTS

CAE & SOFTWARE DEVELOPMENT TOOLS

SCHEMATIC EDITOR

- Can use as many as 16M bytes of memory for schematics
- Includes interfaces to other CAD systems

The enhanced CapFast CF1000 schematic-design package uses as many as 16M bytes of extended memory on IBM PC/ATs, PS/2s, and compatibles. The package lets you capture large single-page or multipage schematics and extract netlists. A packaging program automatically assigns reference designators and pin numbers to physical packages fetched from one of the libraries. CapFast contains drivers for several laser printers and the Houston Instruments DM/PL pen plotter. Additional features include a parts-list program, interfaces to other widely used PCB-CAD sys-

tems, a general-purpose symbol editor, and a symbol library containing more than 2000 parts. \$495.

Phase Three Logic Inc., 1600 NW 167th Place, Beaverton, OR 97006. Phone (503) 645-0313.

Circle No 385

TABLET TEMPLATES

- Work with intelligent graphics tablet
- Let you execute most AutoCAD commands with a single click

IS/Templates work with the vendor's IS/One intelligent graphics tablet and the AutoCAD software running on IBM PCs and compatibles. When you place a template on the surface of the graphics tablet, you can "click" on commands and predrawn symbols directly

from the template, instead of pulling down screen menus or drawing frequently used objects. You can obtain templates for various fields such as mechanical, electrical, and civil engineering; architectural design; and air conditioning. One template, \$69; two, \$99; five, \$249.

Kurta Corp., Box 60250, Phoenix, AZ 85082. Phone (602) 276-5533. FAX 602-276-7823.

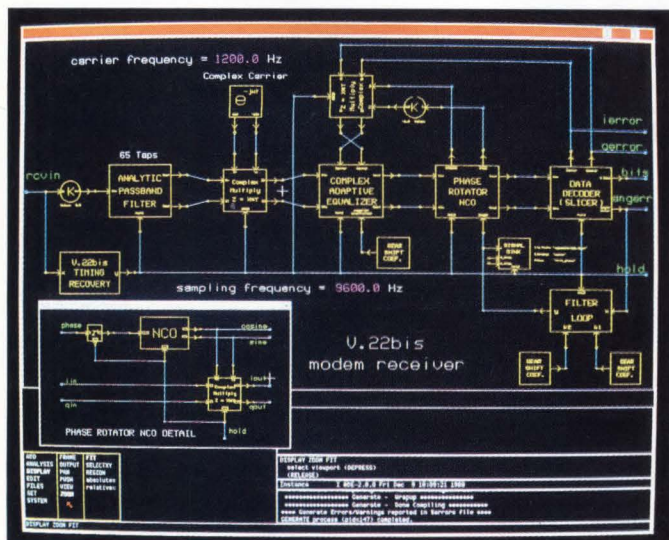
Circle No 386

C COMPILER

- Retargetable to any microprogrammable CPU
- Performs machine-independent optimization procedures

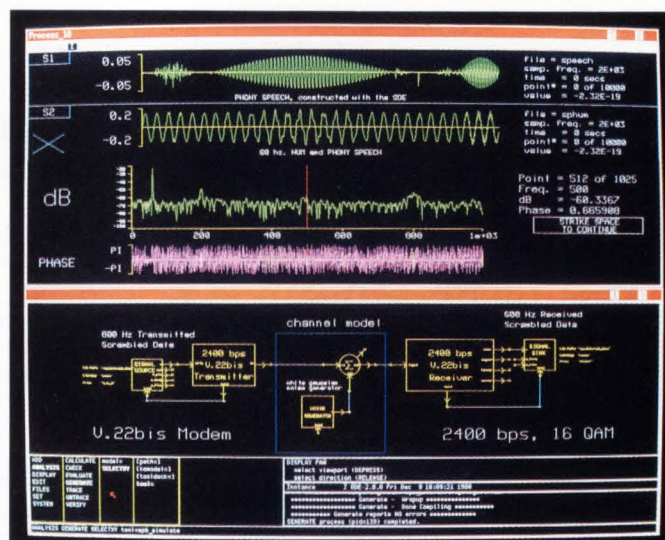
The MetaStep Microprogram C Compiler lets you define the architecture of the target system by

AT LAST, DESIGN DSP

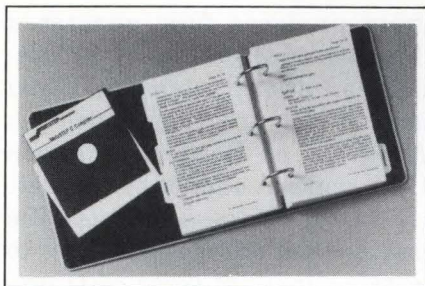


Use our Block Diagram Editor to graphically capture and edit your DSP or communications design algorithm on-screen with hierarchical function blocks.

AND THEN TEST IT



Automatically simulate your block diagram with the Simulation Program Builder, all with just a few clicks of a mouse.



means of machine-definition statements. You can then write your program in C. The compiler works with an augmented version of the vendor's MetaStep microprogram language and performs machine-independent optimizations such as recognition of duplicated expressions, strength reduction, live/dead-code analysis, elimination of common subexpressions, loop rolling and unrolling, and management of constants. The MetaStep microprogram language system then performs all machine-dependent optimizations and tailors the microcode to the custom architecture that

you define. The package runs on a variety of host computers, including MS-DOS machines, Sun/Unix workstations, and VAX/Unix minicomputers. Single-user MS-DOS machine, from \$4995.

Step Engineering, Box 3166, Sunnyvale, CA 94088. Phone (408) 733-7837. FAX 408-773-1073.

Circle No 387

HIGH-LEVEL DEBUGGER

- Works alone or with in-circuit emulators
- Can debug optimized code

XRAY86 is a high-level debugger for code that runs on the Intel 8086/186/286 μ Ps. The program can work alone or with ICEs from Hewlett-Packard (Palo Alto, CA), Microcase (Beaverton, OR), and other vendors. A programmable-window interface lets you scan source code, monitor variables and expressions, trace procedure calls, and set sim-

ple or complex conditional breakpoints. The debugger works with code generated by the vendor's C and Pascal compilers, as well as Intel's C, Pascal, and PL/M compilers. It will run on IBM PCs and compatibles, Sun, Hewlett-Packard and Apollo workstations, and VAX minicomputers. Prices range from \$3500 for a PC version to \$14,000 for a VAX version.

Microtec Research, 2350 Mission College Blvd, Santa Clara, CA 95054. Phone (408) 980-1300. FAX 408-982-8266.

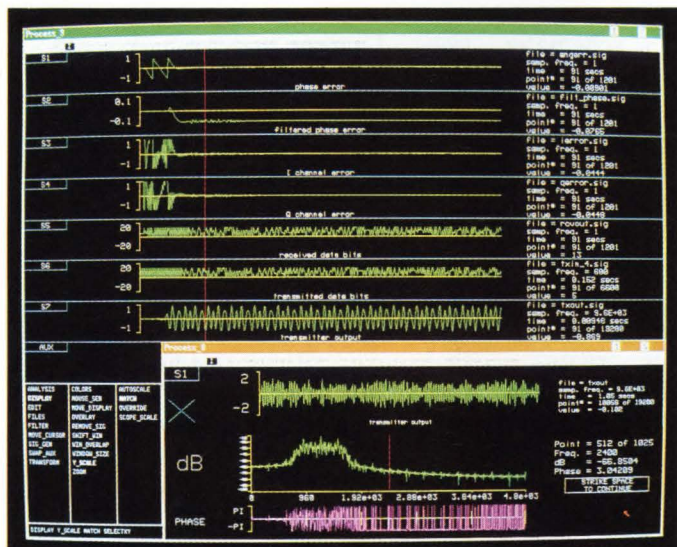
Circle No 388

PLD COMPILER

- Generates fuse plots for a range of PLD devices
- Runs under the OS-9/68k operating system

The PLDASM-EKF assembler/compiler for a range of programmable logic devices, including PALs,

WITH REAL WORLD DATA



Analyze and modify signals on-screen with the Signal Display Editor. GPIB support allows simulation and analysis with real world data.

WITH ONE TOOL, SPW™

From start to finish, the Signal Processing WorkSystem™ from Comdisco Systems is the only comprehensive, integrated software tool that lets you graphically and interactively design, simulate and test digital signal processing systems.

Design complete DSP and communications systems. SPW automates the design cycle and lets you try as many alternatives as you wish – using real world data to test and perfect your design.

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comdisco
SYSTEMS, INC.

101 California Street, San Francisco, CA 94111

GALs, and MegaPALs, runs under the OS-9 operating system for 68000 family processors. The device accepts Boolean equations for data input and has a macro capability that allows you to define more complex Boolean functions. As you step through generated source-code files, the PLDASM-EKF marks and comments on syntax errors and checks physical restrictions of the selected PLD device. If required, you can display the compiled fuse plot on a terminal, or plot it on a hardcopy device. The PLDASM-EKF generates a standard JEDEC format output file that's suitable for inputting into a variety of PLD programmers. Approximately \$500.

EKF-Elektronik-Messtechnik GmbH, Weidekampstrasse 1a, 4700 Hamm 1, West Germany. Phone (02381) 12630. TLX 828621. FAX 02381-15067.

Circle No 389

STATS ROUTINES

- Provide statistical routines for engineers
- Run on IBM PCs, PS/2s, and compatibles

Statistics I and II mathematical routines solve specific computational problems and are intended for use with the vendor's MathCAD Version 2.0 or higher. Statistics I, Tests and Estimation, consists of 16 standard routines, including parametric and nonparametric techniques. Statistics II, Modeling and Simulation, contains 16 routines for modeling data and executing Monte Carlo simulations. You can load any routine into MathCAD and calculate results immediately. The two routines, which are part of a series of applications packages, are targeted to technical professionals who occasionally perform statistical analyses. Statistics I, \$59; Statistics II, \$69; both, \$99.

MathSoft Inc., One Kendall Sq, Cambridge, MA 02139. Phone (617) 577-1017. FAX 617-577-8829.

Circle No 390



MICROWAVE CAD TOOL

- Integrates design entry, simulation, and layout
- Minimizes the number of design steps for a buildable layout

ACADEMY is a graphical design system for microwave and rf engineers, which covers all design phases from schematic entry, through mask layout and circuit simulation, to documentation. You can create a schematic in the standard way, or you can place your layout elements directly (without first having to create a schematic diagram) and then initiate simulation, in which case the program automatically creates a schematic from your component layout data. If you want to change elements or topology, sweep, tune, or optimize your circuit, or perform any other simulation function, you can do so either from the schematic representation or from the layout. The ACADEMY package, which integrates the vendor's Touchstone, Libra, and MiCAD tools, creates a single simulation database that contains all the information regarding the schematic, the layout, and the design parameters of the circuit. As a result, changes in the schematic cause the layout to be updated and, conversely, changes in the layout are immediately reflected in the layout diagram; in either case the netlist is automatically updated. The element-macro feature lets you create custom elements. The pro-

gram produces fully annotated drawings or schematics for production and design notebooks; if you use other programs such as AutoCAD or Hewlett-Packard's EGS, optional utilities can convert the layout to these formats. The package also provides interfaces to a wide variety of other CAD programs and mask-making tools. Price ranges from \$6000 to \$14,000, depending on the type of host computer and the number of options selected.

EEsof Inc., 5795 Lindero Canyon Rd, Westlake Village, CA 91362. Phone (818) 991-7530. FAX 818-991-7109.

Circle No 391

ANALOG PRESCREENER

- Helps you debug standard-cell-based IC designs
- Checks for analog-related errors

The Design Kit Prescreener works with the vendor's Design Kit for Mentor Graphics workstations. The prescreener checks your design's schematics and netlists for a standard-cell-based IC and flags more than 35 common analog-related errors, including incorrect connections of power and ground; loads that exceed the drive capability of the driving cell; incorrect uses and connections of resistors and capacitors; and incorrect uses of any of the 300 analog, digital, and EEPROM cells contained in the vendor's library. The Prescreener generates a report to warn you about all the pins in your design that have critical restrictions on source or load impedances. No charge with the purchase of the vendor's Mentor Graphics Design Kit, \$199.

Sierra Semiconductor, 2075 N Capitol Ave, San Jose, CA 95132. Phone (408) 263-9300. TLX 384467.

Circle No 392

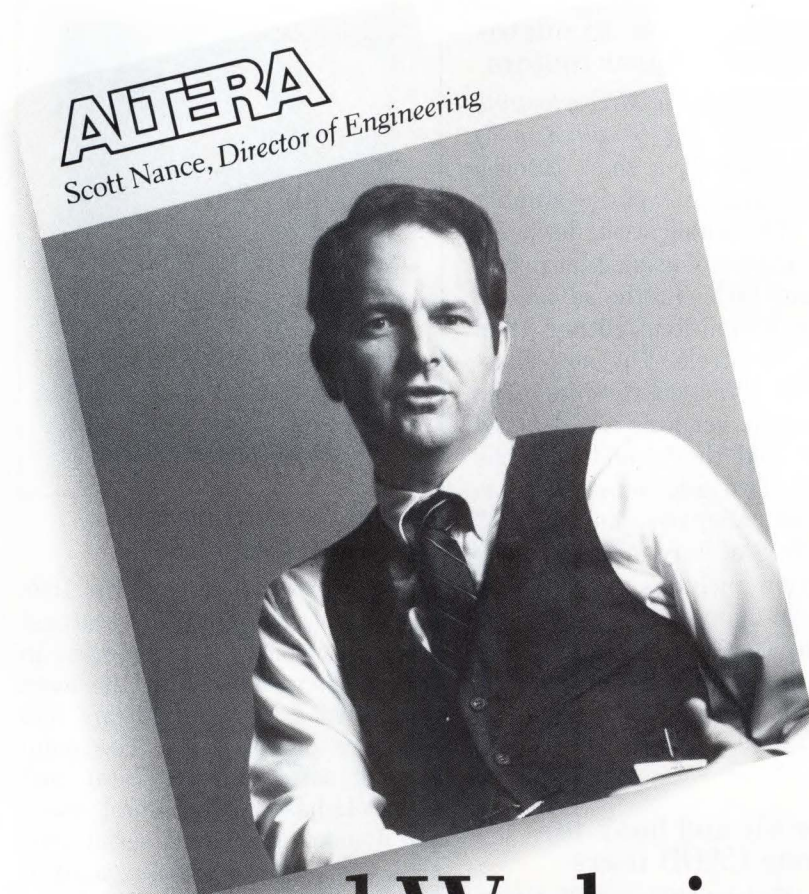
"We wanted to change the way electronics engineers thought about EPLDs—erasable, programmable logic devices. With the new MAX product line, we gave EPLDs speed and density beyond conventional limits.

To design the new MAX family architecture, we needed to make available to each engineer a personal CAE system that could handle circuits with 500,000 or more transistors. That's why we chose Workview.

With Workview, we captured and simulated the design up-front—making it easier for the engineer to find and fix errors early in the design cycle. This provided tremendous cost-savings both in people-time and money.

The MAX project has been very critical to Altera's success. With Workview, we got it right the first time."


VIEWlogic®
1-800-CAE-VIEW



"At Altera, we used Workview to design the new MAX family of EPLD products."

Viewlogic Systems Inc., 313 Boston Post Road West, Marlboro, MA 01752 508-480-0881

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CIRCLE NO 94

ANALOG DEVICES APPLICATION NOTE

ONE TECHNOLOGY WAY • P.O. BOX 9106 • NORWOOD, MASSACHUSETTS 02062-9106 • 617/329-4700

Microstepping Drive Circuits for Single-Supply Systems

by John Wynn, Analog Devices Inc. & Mark Hobb, Sprague Electric Co.

This application note contains a brief review of the basic principles of microstepping, a method of controlling a stepper motor by driving it with a series of small current steps. The note also contains a detailed description of the microstepping drive circuit, which is a single-supply system. The note includes a block diagram of the circuit and a photograph of the circuit board.

BASIC PRINCIPLES OF THE TWO-PHASE PM STEPPER MOTOR

A stepper motor is a synchronous motor. Unlike an induction motor, which requires a continuous supply of power to maintain its rotation, a stepper motor can be driven by a series of pulses. The pulses are applied to the motor's stator windings, which create a magnetic field that pulls the motor's rotor into alignment with it. The rotor is a permanent magnet, and the stator windings are arranged in pairs. By applying current to different pairs of windings, the motor can be moved in discrete steps.

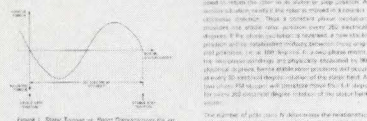


Figure 1: Stepper motor rotor position relative to stator current.

Note explains how to microstep 2-phase stepper motors

The application note, *Microstepping Drive Circuits for Single-Supply Systems*, features a short tutorial on microstepping 2-phase stepper motors. The publication discusses the advantages of using 8-bit rather than 6-bit DACs and the advantage of using closed-loop rather than open-loop controls. The note illustrates two "Practical Circuits": The first uses the vendor's AD7628 and AD7820, and the second uses the AD7669. Two additional sections are titled "Microstepping Basics" and "Effect of Torque Load." The publication includes several diagrams and figures.

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021.

Circle No 435

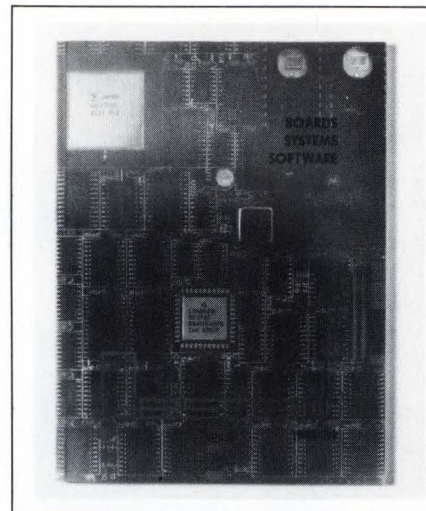
Starter kit and book for first-time CADD users

The CADD (computer-aided design and drafting) Starter Kit for DOS-based microcomputers and the book, *Converting to CADD: The Generic Software Guide for Businesses*, are easy-to-understand guides that help you learn CADD. The starter kit, which contains a step-by-step tutorial workbook, a symbol library, and a disk of sample drawings, teaches you how to create floor plans, elevations, product

drawings, flow charts, graphs, charts, and other graphical drawings. The book addresses such issues as the transition from manual to electronic drafting, customizing the CADD system to a particular design discipline, and the benefits of using CADD compared with the use of manual drafting. Starter kit, \$159.95; book, \$24.95.

Generic Software Inc, 11911 North Creek Parkway S, Bothell, WA 98011.

INQUIRE DIRECT



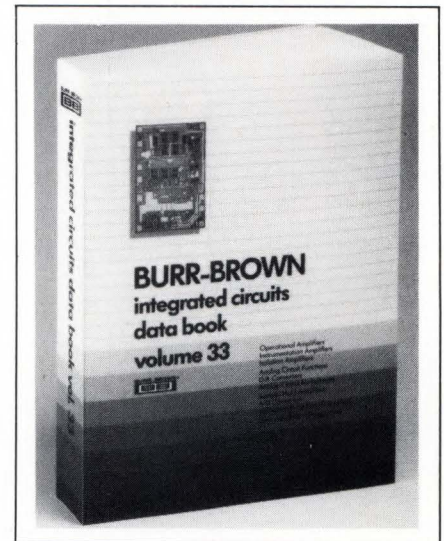
Extensive catalog of board-level devices

According to the vendor, the 1989 product catalog presents the largest selection of board-level products in the industry, as well as the most diversified array of hardware and software components. The main product categories are Intel- and Motorola-based processors; static and dynamic memories; serial, parallel, and analog interfaces; controllers for disks, graphics, data communications, networking, and motor control; and accessories such as card cages, cables, and backplanes. A new product category offers linear scan cameras and controllers. In the software section, you'll find a library of software drivers for most of the vendor's boards, software development utilities, real-time operating systems, and high-level languages. Another important

section deals with ready-to-use development systems and OEM computers.

Gespac Inc, 50 W Hoover Ave, Mesa, AZ 85210.

Circle No 437



Publication presents plethora of IC products

The vendor's 1250-pg Circuits Data Book lists more than 800 products, including precision operational and instrumentation amplifiers; isolation amplifiers and power supplies; high-resolution A/D and D/A converters for instrumentation, digital audio- and digital signal-processing applications; S/H amplifiers; and data-acquisition systems. Further, new features include a special selection guide for components in surface-mount packages and a cross-reference section, as well as a complete price list in the US edition.

Burr-Brown Corp, Box 11400, Tucson AZ 85734.

Circle No 438

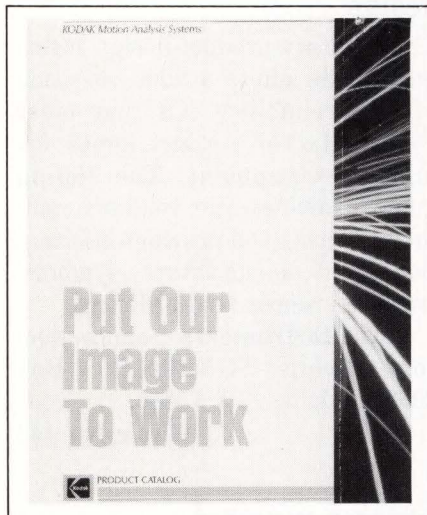
Computer numerical control for factory-floor environment

Excerpted from the vendor's 5-volume *Manufacturing Automation Series*, the 42-pg report, "Numerical Control Overview," reviews the use of CNC (computer numerical control) systems in factory-floor environments. Comparison columns

cover applications; control, operating, and programming features; diagnostics; and physical attributes of 47 numerical controllers from 18 vendors. The publication also outlines numerical control programming languages and systems, helps you select a CNC system, and analyzes how CAD/CAM systems effect a CNC system in a computer-integrated manufacturing environment. \$35.

Datapro Research, 1805 Underwood Blvd, Delran, NJ 08075.

INQUIRE DIRECT



Booklet details high-speed motion-analysis systems

In-depth descriptions and applications data for the EktaPro 1000 motion analyzer and the SP2000-C motion-analysis system are the focus of this 22-pg, 4-color catalog. With the help of product photographs, charts, and diagrams, the publication describes each unit's features and applications, which include automated manufacturing, transportation systems, aerospace hardware development, packaging, biomechanics, and fluid mechanics. A summary of accessories, sales and delivery terms, and training and service information complete the publication.

Eastman Kodak Co, Spin Physics Div, 11633 Sorrento Valley Rd, San Diego, CA 92121.

Circle No 440

Pamphlet sums up cable-connector assembly

The vendor's brochure VA-3 explains its cable-connector assembly program, which provides custom preassembled flexible cable interconnections, fiber-optic assemblies, and mass-termination systems. The publication stresses how the vendor's authorized centers allow

OEMs to cut costs in the areas of assembly tooling and production space, testing, waste, personnel, and inspection, and how the centers allow OEMs to ensure system stability.

Thomas & Betts Corp, 1001 Frontier Rd, Bridgewater, NJ 08807.

Circle No 441

CABLE and CONNECTORS

ON CENTER EVERY TIME

Get the best in cable and connectors from Amphenol Spectra-Strip. Our full line of mass termination IDC and interconnect products offers you single source convenience. Cable. Connectors. Or both. One phone call connects you to proven product quality. And added convenience.

Reliability Advanced quality control procedures insure consistent accuracy throughout our product line. Our extremely low material return rate is a standard many other manufacturers can only shoot for.

Delivery Our efficiency rating for on-time delivery is as close to perfect as you'll find. Standard products are shipped immediately from our extensive inventory. JIT is no problem. And if you need custom work, we'll do it on-time, to keep your production schedule on track.

Full Line If you're engineering a product that requires termination to a standard flat ribbon cable, coaxial, high flex life, twisted pair, Twist 'N' Flat®, flat conductor, Round 'N' Flat® or .025" center spacing; we've got you covered. If you're designing an interconnect system that requires DIN, D-subminiature, Micro Ribbon, high and low profile sockets and headers, card-edge, two-piece board mount, .025" and high density connectors: you're connected to the best.

Amphenol SPECTRA-STRIP
Connect to the Best

Designed, manufactured, tested and delivered with you in mind. For the name of your nearest distributor or rep. write Amphenol Spectra-Strip, 720 Sherman Avenue, Hamden, CT. Or call (800) 572-2253 in CT (203) 281-3200

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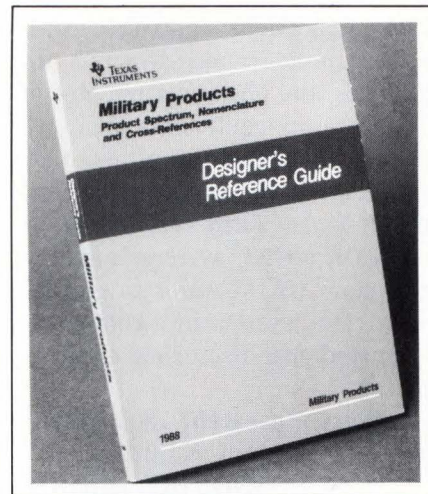
Listing of analog ICs

The vendor's product guide contains an assortment of proprietary and enhanced alternate-source analog devices. The 24-pg publication offers standard products for hard-disk-drive, computer/peripheral, telecom, communications, military, industrial, and automotive applications, as well as detailed descrip-

tions of ASIC development and tile-array specifications. The booklet provides selection guides for each product line, and its alternate-source cross reference lets design and component engineers specify direct replacement components.

Micro Linear Corp, 2092 Concourse Dr, San Jose, CA 95131.

Circle No 442



Military-product design guide

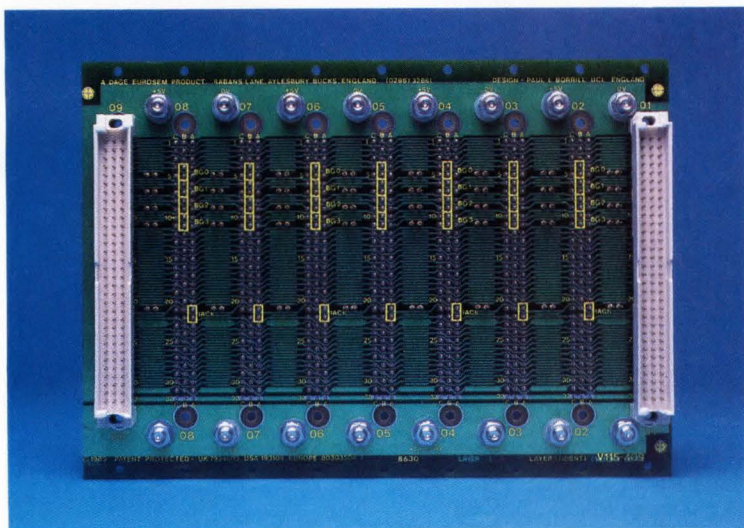
This military-product-design reference guide offers a wide selection of high-reliability ICs that meet semiconductor requirements for military equipment. The 350-pg guide examines the vendor's military products and provides information about nomenclature, symbols, cross-references, and ordering.

Texas Instruments, Semiconductor Group—SGYZ001B, Box 809066, Dallas, TX 75380.

Circle No 443

WHY WASTE ENCLOSURE SPACE?

Available In
VME
4,5,7,9,13,14,17 &
21 Slots



When placed next to your disk drives, Dage's NEW 13-Slot Backplane provides maximum use of space in a 19-inch rack.

For maximum power, standard input is via press-fit, threaded studs (spade lugs optional).

And, to meet your specific needs, Dage will customize

to meet your requirements.

Dage offers both J1 & J2 multilayer backplanes with the following exceptional characteristics:

- ☐ Impedance - $60\Omega (\pm 2)$
- ☐ Capacitance - $77 \text{ pF } (\pm 3)$
- ☐ Crosstalk - $<200 \text{ mV}$



DAGE PRECISION INDUSTRIES, Inc.

46701 Fremont Blvd.
Fremont, CA 94538 (415) 683-3930

Catalog presents prototyping products

The vendor's redesigned catalog provides a concise and easy-to-use source of prototype electronic circuits. The 102-pg, illustrated book examines general-purpose Vector-board prototyping boards and bus-specific prototyping boards (IBM, Apple, STD Bus, S-100 Bus, Motorola Exerciser, Multibus, Commodore, and DE \odot). It also includes Eurocard metric prototyping boards, packaging (Vector-Pak), and general-purpose backplanes. The publication features selector guides and index tabs to help you make your selection.

Vector Electronic Co, 12460 Gladstone Ave, Sylmar, CA 91342.

Circle No 444

Finally . . . PRECISION IN SURFACE MOUNT DEVICES

Yes, finally! Precision in a small package.

PMI's precision bipolar analog and CMOS converter product line is now offered in SMD. Write for our SMD brochure which lists the availability of 65 devices in various surface mount packages.

PMI's precision SMDs are available in commercial and industrial temperature ranges. The surface mount offerings include SO, SOL, LCC, and PLCC versions.

To get your SMD brochure, circle the reader service number or call . . . 1-800-843-1515.

You'll also receive a free copy of our new 1988 Data Book!

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PHILADELPHIA: (215) 675-7600, BOSTON: (617) 794-0026

EDN February 16, 1989

CIRCLE NO 48



The precision solution.

215

12mA MAKES THE DIFFERENCE

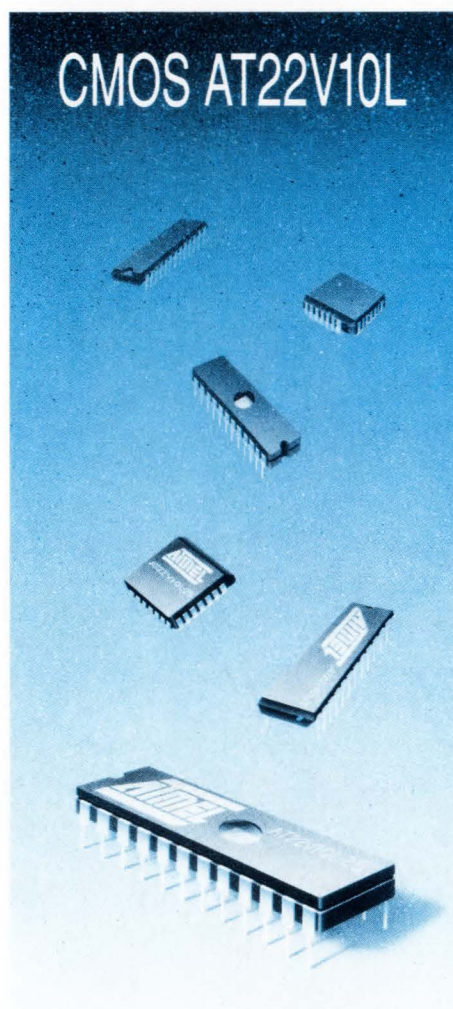
When your 22V10s are in standby, they just sit around and waste power. Those milliamps can add up to megabucks fast!

THAT'S CHANGED.

When you replace your standard 22V10 programmable logic devices with Atmel's new, proprietary low-power versions, you'll be cutting your standby power bill. Atmel's 22V10L needs only 12 milliamps (15 milliamps for the military version). That's about one-tenth of what you're used to. With Atmel, you lower costs, have less heat to worry about and improve your system reliability.

SPEED DOESN'T COST POWER.

And don't think you're going to compromise your processing speed just to pay for this power savings. The AT22V10L delivers a blazing 25 nanoseconds. This device can keep up with your microprocessor – not drag it down.



PUT THEM IN UNIFORM.

You can enlist these CMOS wonders for your military system as well. The Defense Electronic Supply Center (DESC) has approved Atmel's 22V10 and 22V10L low-power version on three different drawings. No one else scores that high!

DESC SMD Numbers

AT22V10	5962-87539	DIP/LCC (Windowed)
AT22V10	5962-88670	DIP/LCC (Non-windowed)
AT22V10L	5962-88724	DIP/LCC (Low Power)

For more information on the Atmel difference, call (408) 434-9201, or write:

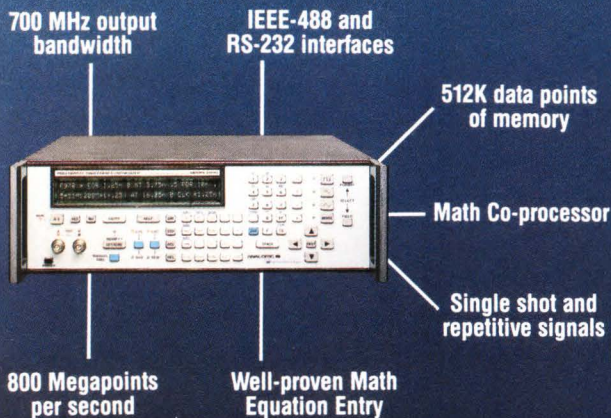
Atmel Corporation
2095 Ringwood Avenue
San Jose, CA 95131



The People Who Make The Difference.

Analogue Announces...

The World's Highest Performance Arbitrary Waveform Synthesizer



ANALOGIC 
The World Resource
for Precision Signal Technology

Analogue Corporation
Data Precision Products
8 Centennial Drive
Peabody, MA 01961
CIRCLE NO 85

At 800 Megapoints per second, the new Analogue/Data Precision Models 2040 and 2045 outperform the competition, delivering 4 times the data rate of the fastest polynomial waveform synthesizers.

With the Analogue Models 2040 and 2045, you can define and create any periodic or transient waveform.

You can use Analogue's well-proven ME² Math Equation Entry approach, entering any equations in the form $Y = f(t)$ from the keyboard. Or, you can download waveforms created on computers, graphic tablets, or oscilloscopes.

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The Model 2040 offers two outputs, each 1 V p-p, in phase opposition to provide both single-ended and differential outputs at a bandwidth of greater than 700 MHz.

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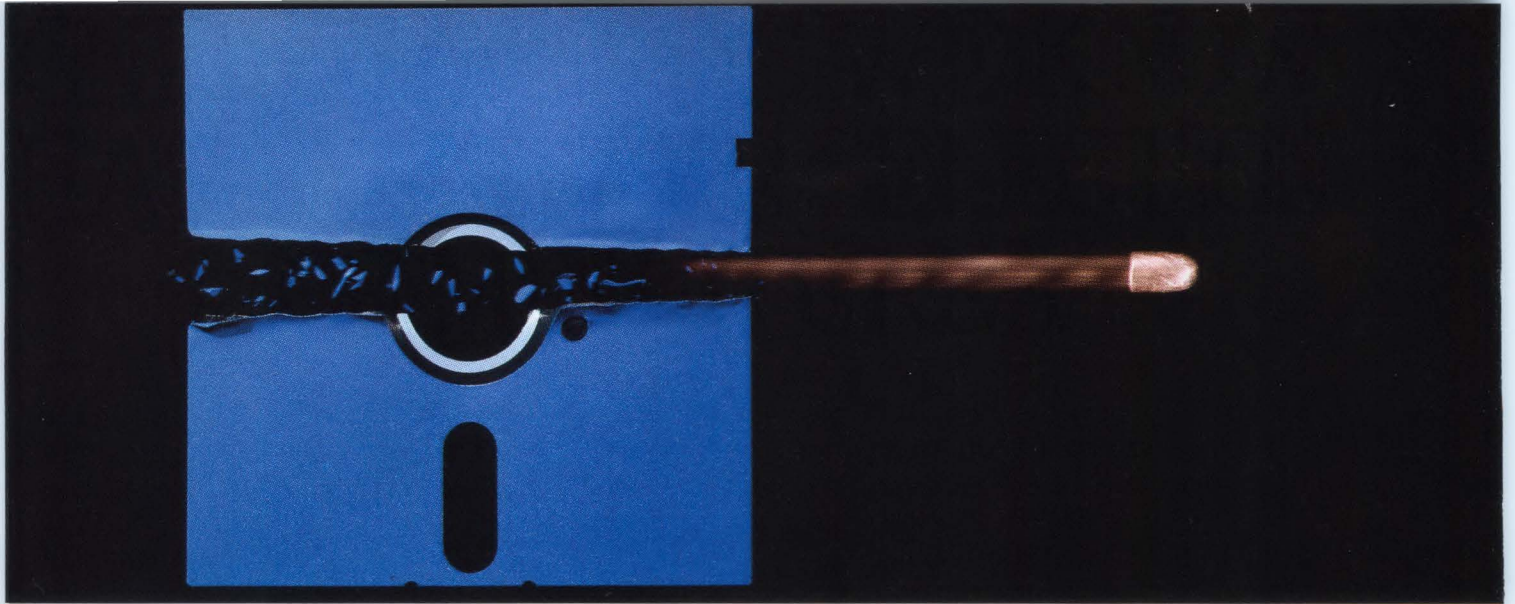
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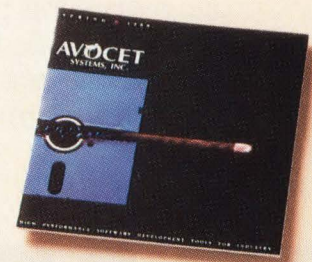


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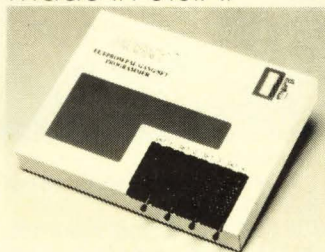
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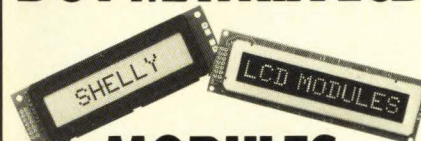
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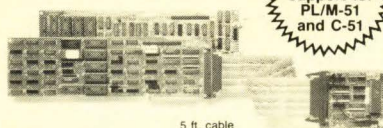
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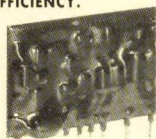
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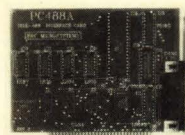
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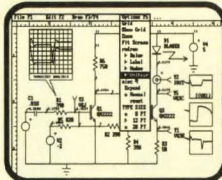
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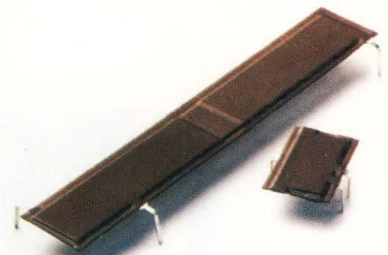
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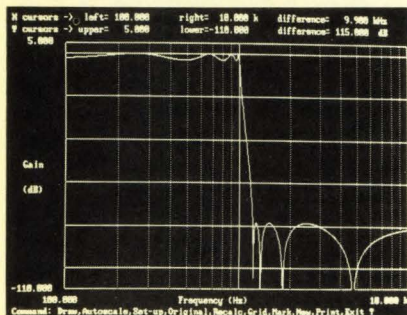


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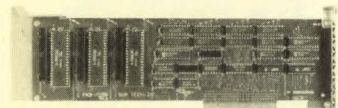
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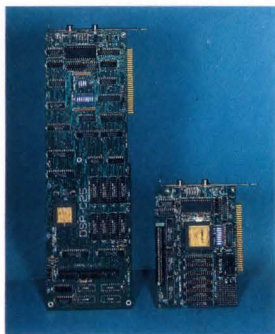
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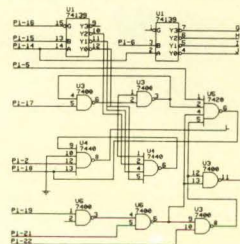
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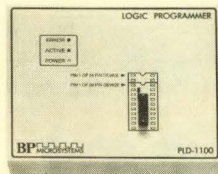
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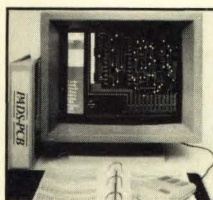
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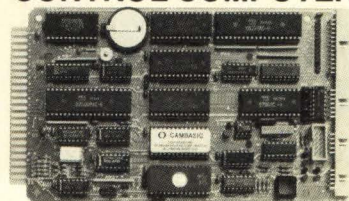
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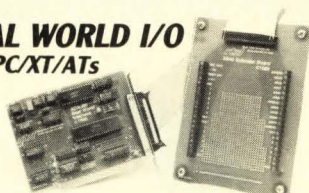


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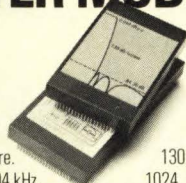
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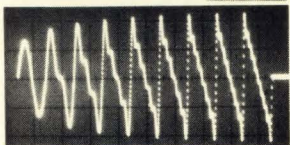
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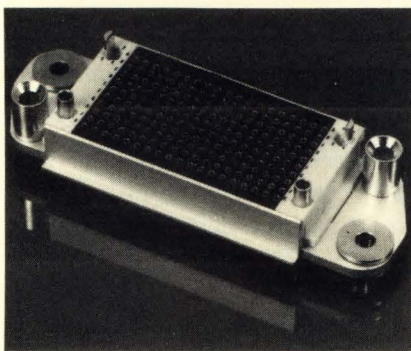
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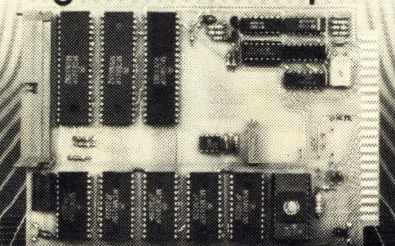
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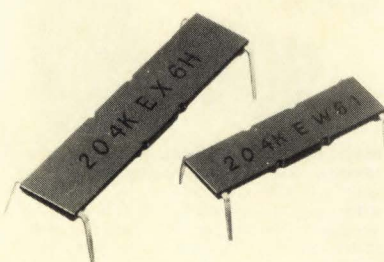
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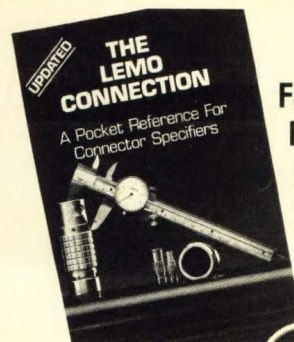
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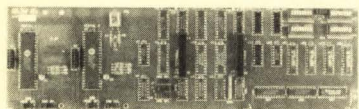
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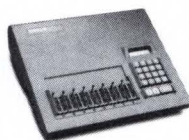
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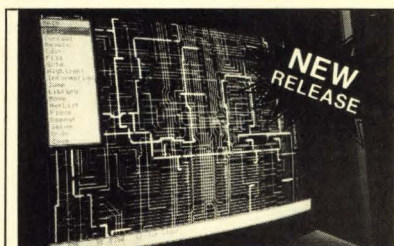
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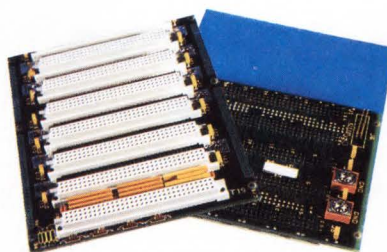
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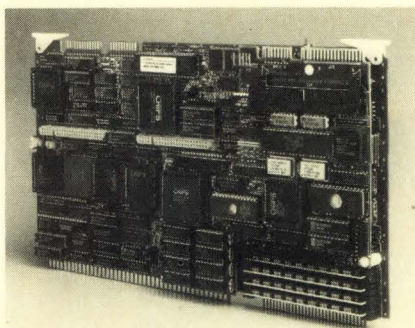
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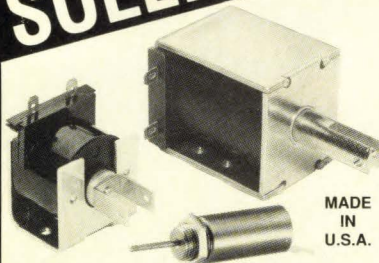
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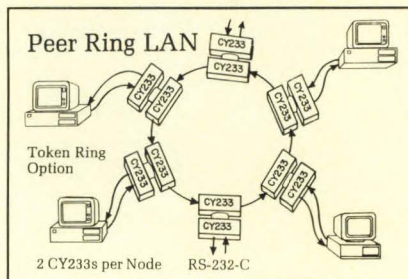
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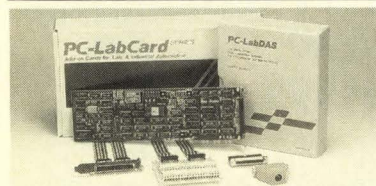
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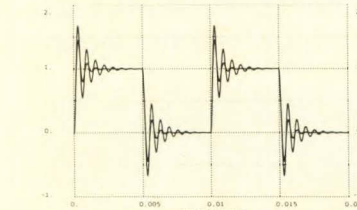
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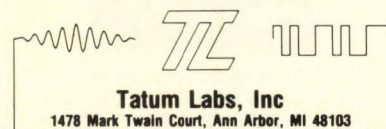
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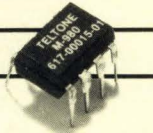
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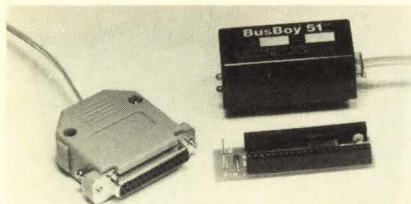
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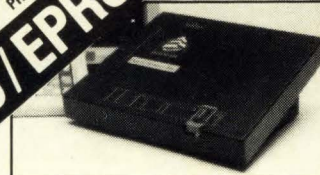
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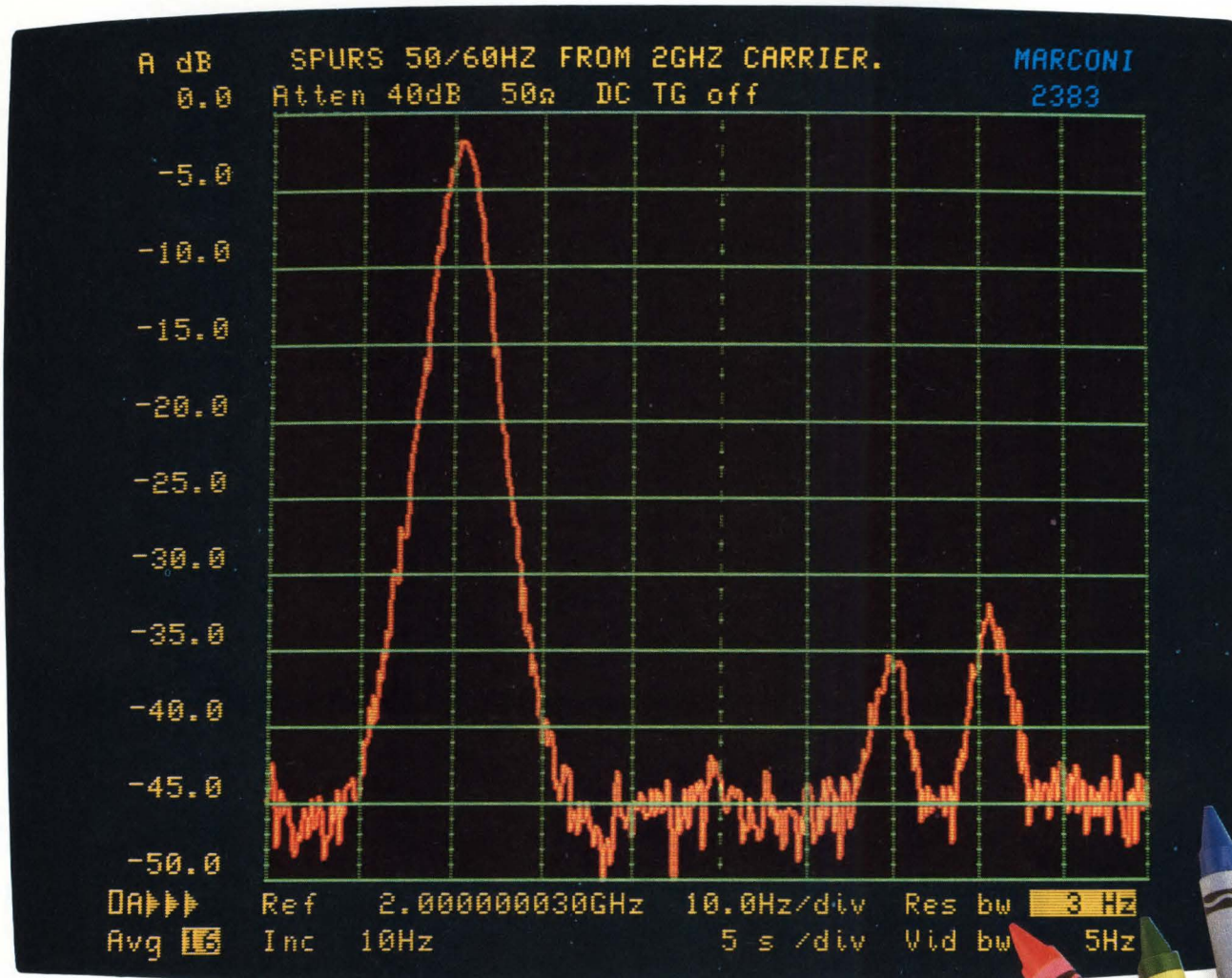
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Issue Date	Recruitment Deadline	Editorial Emphasis	EDN News Edition
Mar. 16	Feb. 23	CAE, Analog ICs	Closing: Mar. 3 Mailing: Mar. 23
Mar. 30	Mar. 9	Integrated Circuits, Computer Boards	Closing: Mar. 17 Mailing: Apr. 6
Apr. 13	Mar. 23	Test & Measurement, Digital ICs	Closing: Mar. 31 Mailing: Apr. 20
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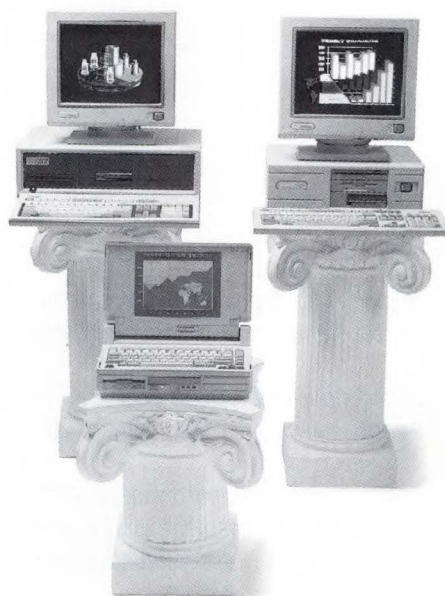
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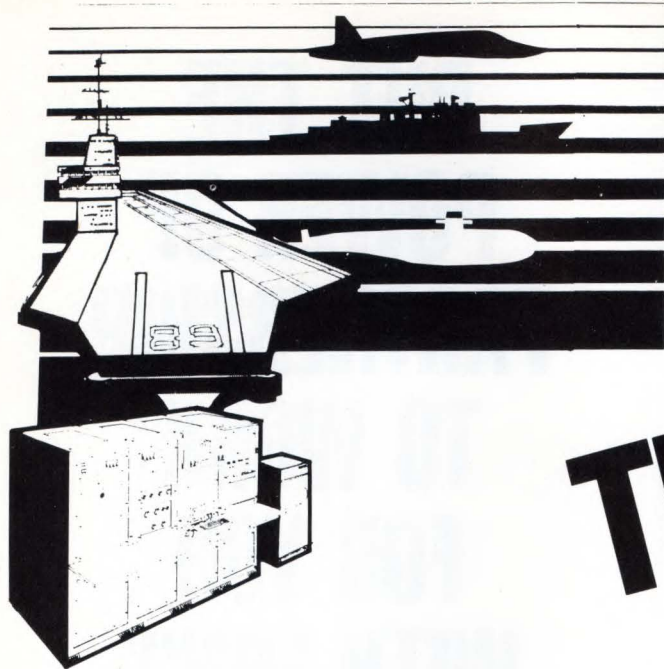


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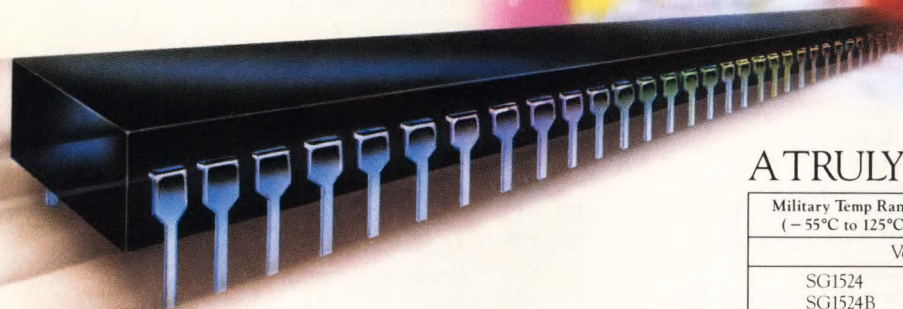
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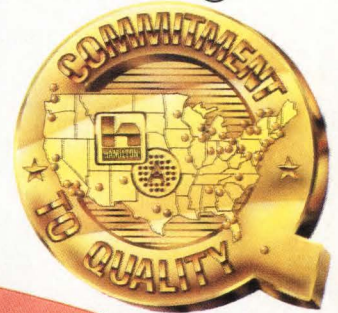
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LOOKING AHEAD

EDITED BY CYNTHIA B RETTIG AND JOHN A GALLANT

Thermal printing technique improves resolution

A new printing process may revolutionize the current standards for electronic color printing. ICI Imagedata (Wilmington, DE) has developed a technique called dye-diffusion thermal transfer (D2T2) that promises near-photographic quality from digitized signals. D2T2 can print 150 pixels/in. from a palette of 16.7 million colors. It offers continuous-tone printing from digital signals. Eventually, the company expects the applications to range from desktop publishing to electronic photography.

Until now, electronic printing has relied on dithering to control picture contrast by manipulating dot density; this method compromises resolution for contrast. Because the D2T2 printer controls the intensity of each dot to achieve picture contrast, it doesn't have to sacrifice resolution. The printer receives digital data, which allows it to produce slightly differing colors in consecutive pixel positions on the page. The technique can thus produce continuous-tone effects that result in life-like images.

The D2T2 technique can work with simple digital signals generated, for example, using a computer graphics program, or it can take digitized signals produced by a scanner or a charged couple device from analog sources. It uses a color ribbon in a thermal printer (Fig 1). By controlling the energy emitted at each digital printing position, it diffuses a certain amount of color into the paper, turning the dye from a solid state to a liquid one. It prints yellow first, then magenta, and then cyan to create full-color prints. The process is essentially dry and can complete a print in less than a minute. The printer can use a variety of papers, including transparencies. Because the printing occurs



The dye-diffusion thermal-transfer (D2T2) process produces continuous-tone color prints with a resolution of 150 pixels/in.

in—not on—the paper, the resulting prints are immune to surface damage.

ICI says that the end-user cost for a 3×5-in. print is \$1; it expects the price to decrease to about 30¢/print by the mid '90s. An 8½×11-in. print costs about \$3; that price should go down to about \$1 by the mid '90s.

Because the D2T2 method works just as well for transparencies as it does for opaque prints, ICI expects one of the early markets for the technique to be business applications, where presentation materials

are widely used for overhead transparencies and hard-copy handouts. The fact that the dye is diffused in the paper to make very sturdy prints will also make the technique attractive to security departments and companies for manufacturing simpler, nonlaminated ID cards. Several companies, including Sharp, NEC, Oki, Fuji, and Fujitsu, already have cameras available to digitize photographic images for D2T2 printing. Four companies, Kodak, Sony, Mitsubishi, and Hitachi, currently are prepared to sell printers.

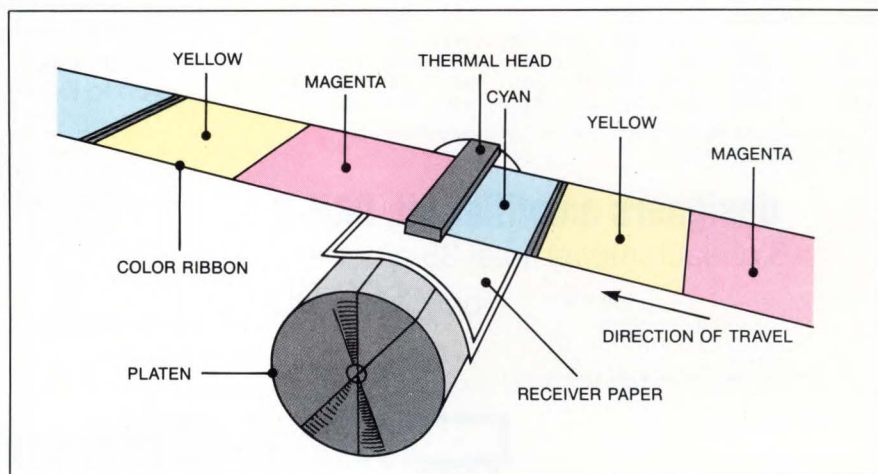


Fig 1—The D2T2 technique uses a special color ribbon in a thermal printer to diffuse color in a 3-step process into the medium. The process requires no screens or dithering.

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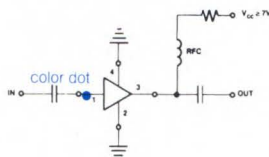
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		100 MHz	1000 MHz	2000 MHz (note)				
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MAR-3	DC-2000	13	12.5	10.5	8.0	+8 □	6.0	1.70 (25)
MAR-4	DC-1000	8.2	8.0	—	7.0	+11	7.0	1.90 (25)
MAR-6	DC-2000	20	16	11	9	0	2.8	1.29 (25)
MAR-7	DC-2000	13.5	12.5	10.5	8.5	+3	5.0	1.90 (25)
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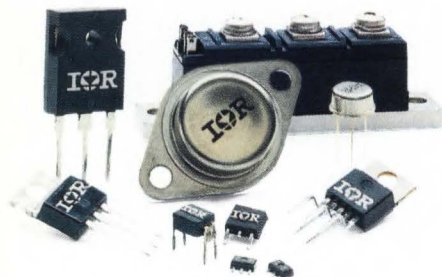
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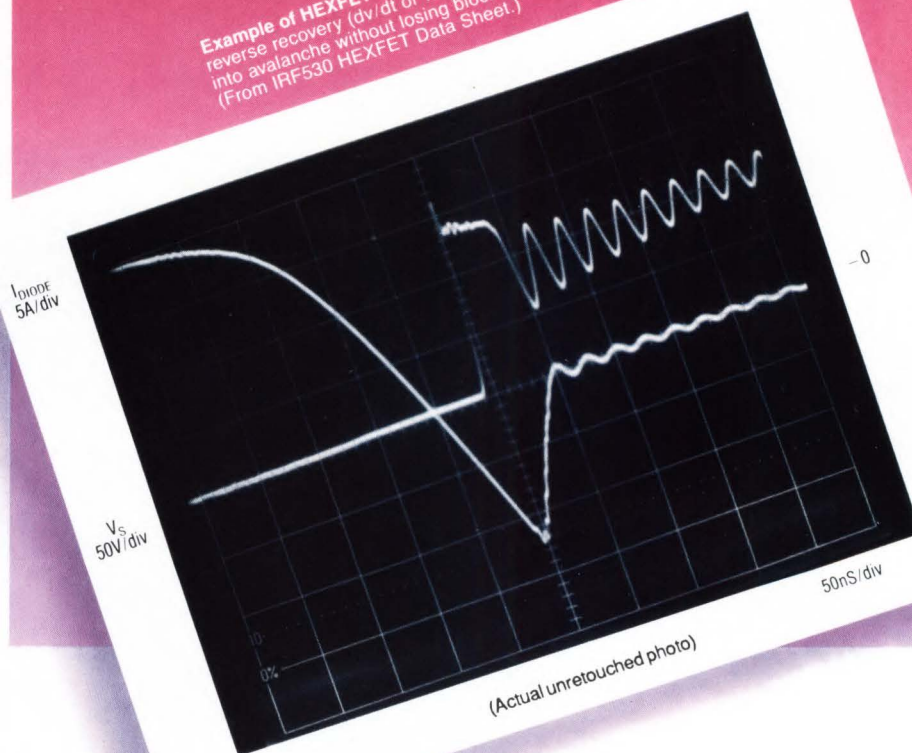
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