APRIL 5, 1980

A CAHNERS PUBLICATION

EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

PASCAL begins to see use; standards still lacking

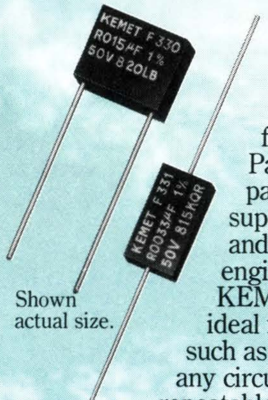
Up fiber-optic performance by mastering measuring methods

Double μP address capacity with dual memory mapping

Uncommitted IC logic permits multifaceted, flexible designs

THE 21st CENTURY IS HERE!

KEMET® Flat-Kap Precision Film Capacitors are an important part of it



Shown actual size.

The General Dynamics F-16—called "the fighter aircraft of the 21st century"—displays unmatched maneuverability, versatility and dependability.

Contributing to this outstanding performance are KEMET Flat-Kap Parylene Film capacitors—an integral part of the Hamilton-Standard JFC-90 supervisory control, which monitors and fine-tunes the fuel flowing to the engine.

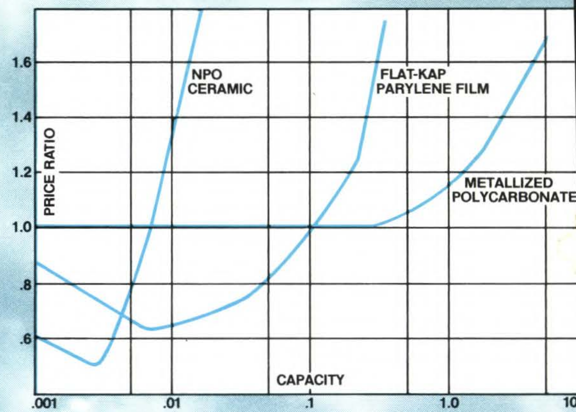
KEMET Flat-Kap capacitors are ideal for tight-tolerance applications such as this. In fact, they're ideal for any circuit where close tolerance, repeatable temperature coefficient and capacitance stability are essential. Because they combine small size, superior electrical characteristics, and the ultimate in stability in extreme environments.

They're available now in space-saving, rectangular hermetically-sealed or molded cases, with radial or axial leads, and extended values from 0.001 μF to 1.0 μF. Close tolerances to $\pm$ 1% are standard for molded parts, and to $\pm$ 0.5% for hermetically-sealed units.

Step up now to the next generation of ultra-stable capacitors—KEMET Flat-Kap Parylene capacitors, now available to R level per MIL-C-55514/3.

For more data, write to Electronics Division, Union Carbide Corporation, Box 5928, Greenville, SC 29606. Phone: (803) 963-6300; TWX: 810-287-2536; Telex: 57-0496. Or see your local KEMET representative.

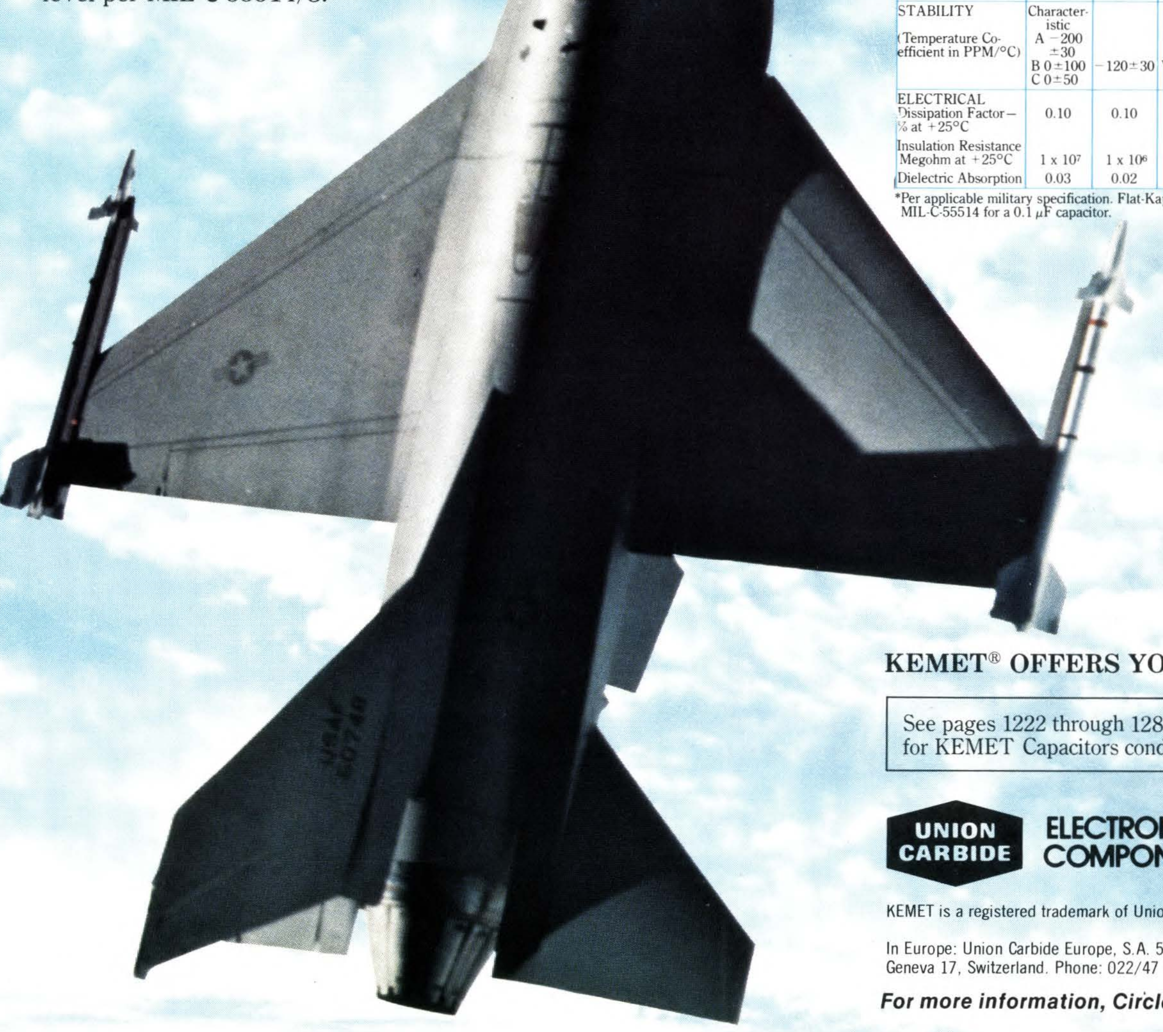
CAPACITANCE/PRICE COMPARISON
(For MIL Spec, 50 Volt, ±1% Tolerance Units)



PHYSICAL AND PERFORMANCE CHARACTERISTICS

PARYLENE VS. VARIOUS DIELECTRIC MATERIALS							
Characteristic	KEMET* Parylene	Polystyrene	Polycarbonate	Polyester	Mica	NPO Ceramic	Glass
*Size (P.C. Board Volume)	.0175 in³	.143 in³	.0164 in³	.044 in³	.141 in³	.0625 in³	.082 in³
STABILITY (Temperature Coefficient in PPM/°C)	Characteristic A −200 ±30 B 0±100 C 0±50	−120±30	Varies to ±350	+1150	Characteristic C +200 D ±100 F 0 to +70	0±30	+180
ELECTRICAL Dissipation Factor—% at +25°C	0.10	0.10	0.15	0.40	0.10	0.10	0.10
Insulation Resistance Megohm at +25°C	1×10^7	1×10^6	3×10^6	1×10^5	5×10^4	1×10^5	1×10^7
Dielectric Absorption	0.03	0.02	0.1	0.25	4.80	0.29	5.10

*Per applicable military specification. Flat-Kap Parylene capacitors are described in MIL-C-55514 for a 0.1 μF capacitor.



KEMET® OFFERS YOU MORE.

See pages 1222 through 1282 of EEM for KEMET Capacitors condensed catalog.

UNION CARBIDE

ELECTRONICS DIVISION
COMPONENTS DEPARTMENT

In Europe: Union Carbide Europe, S.A. 5, Rue Pedro-Meylan, Geneva 17, Switzerland. Phone: 022/47 4411. Telex: 845-22253.

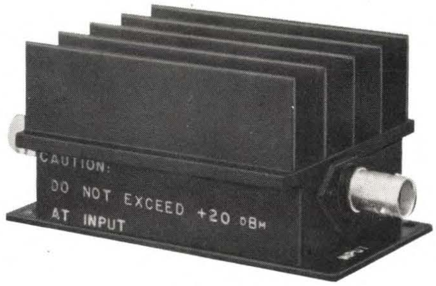
For more information, Circle No 1

Now Available...

1W AMPLIFIERS

0.05-1000 MHz from $199

- Broadband ... each model multi-octave (see table)
- High linear output ... up to 30 dBm (1 W)
- Gain ... available from 16 dB to 27 dB
- Very flat gain response ... ±1 dB
- Connectors ... BNC Std; SMA, TNC, N available
- Compact ... 3.75" × 2.60" × 1.92" (ZHL-A Models)
  4.75" × 2.60" × 2.22" (ZHL Models)
- Self-contained heat sink
- One-week delivery

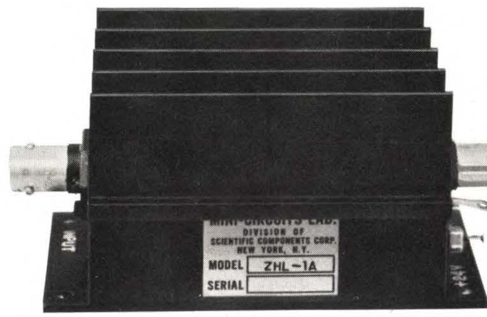


ZHL-2-8

If your application requires up to 1 watt for intermodulation testing of components ... broadband isolation ... flat gain over a wide bandwidth ... or much higher output from your frequency synthesizer or signal/sweep generator ... MiniCircuits' ZHL power amplifiers will meet your needs, at surprisingly low prices. Five models are available, offering a selection of bandwidth and gain.

Using an ultra-linear Class A design, the ZHL is unconditionally stable and can be connected to any load impedance without amplifier damage or oscillation. The ZHL is housed in a rugged ⅛ inch thick aluminum case, with a self-contained hefty heat sink. BNC connectors are supplied; however, SMA, TNC and Type N connectors are also available. Of course, our one-year guarantee applies to each amplifier.

So from the table below, select the ZHL model for your particular application now ... we'll ship within one week!



ZHL-1A

MODEL NO.	FREQ. MHz	GAIN dB	GAIN FLATNESS dB	MAX. POWER OUTPUT dBm 1-dB COMPRESSION	NOISE FIGURE db	INTERCEPT POINT 3rd ORDER dBm	DC POWER VOLTAGE	DC POWER CURRENT	PRICE $ EA. QTY.
ZHL-32A	0.05-130	25 Min.	±1.0 Max.	+29 Min.	10 Typ.	+33 Typ.	+24V	0.6A	199.00 (1-9)
ZHL-3A	0.4-150	24 Min.	±1.0 Max.	+29.5 Min.	11 Typ.	+38 Typ.	+24V	0.6A	199.00 (1-9)
ZHL-1A	2-500	16 Min.	±1.0 Max.	+28 Min.	11 Typ.	+38 Typ.	+24V	0.6A	199.00 (1-9)
ZHL-2	10-1000	16 Min.	±1.0 Max.	+29 Min.	18 Typ.	+38 Typ.	+24V	0.6A	349.00 (1-9)
ZHL-2-8	10-1000	27 Min.	±1.0 Max.	+29.5 Min.	10 Typ.	+38 Typ.	+24V	0.65A	449.00 (1-9)

Total safe input power +20 dBm, operating temperature 0° C to +60° C, storage temperature −55° C to +100° C, 50 ohm impedance, input and output VSWR 2.1 max.
For detailed specs and curves, refer to 1979/80 MicroWaves Product Data Directory, p. 364-365 or EEM p. 2970-2971.

World's largest manufacturer of Double Balanced Mixers

Mini-Circuits

MINI-CIRCUITS LABORATORY

A Division of Scientific Components Corp.

2625 East 14th Street Brooklyn, New York 11235 (212) 769-0200
Domestic and International Telex 125460 International Telex 620156

46 Orig

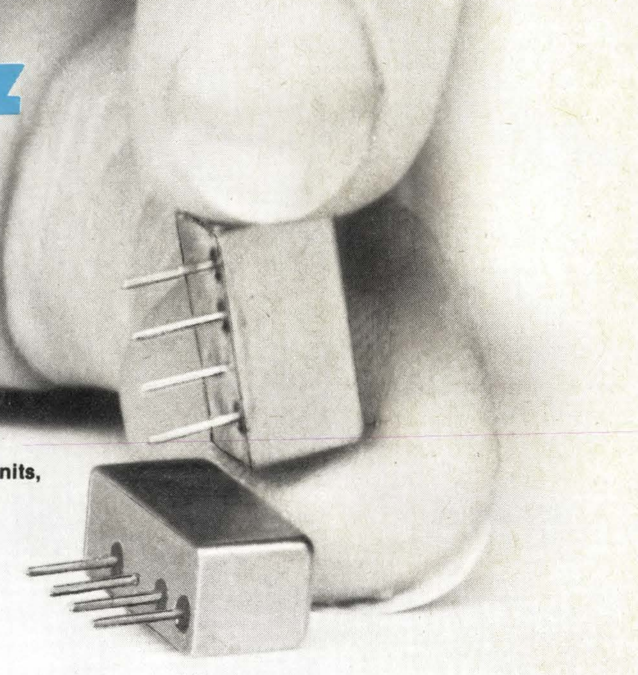
For more information, Circle No 2

Now available. . .the SMALLEST BROADBAND MIXERS available!

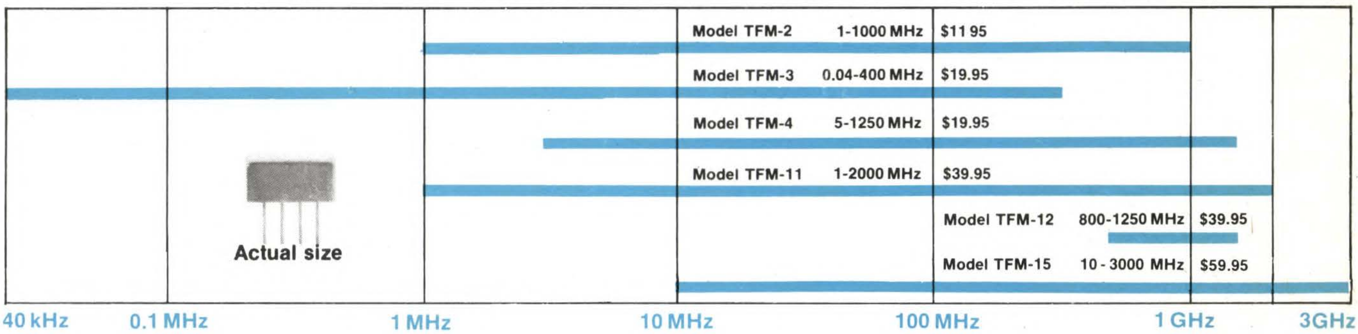
from Mini-Circuits of course.

40 kHz - 3 GHz

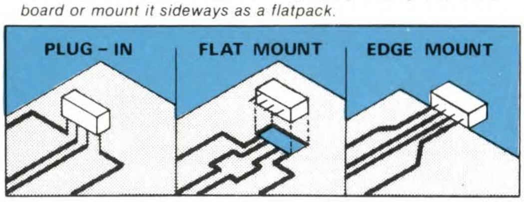
$11.95 MODEL TFM-2 $11.95 (6-49)



ACT NOW TO IMPROVE YOUR SYSTEM DESIGNS,
increase your packaging density, and lower your costs . . . specify Mini-Circuits new microminiature TFM series. These tiny units, 0.5" x 0.21" x 0.25" the smallest off-the-shelf Double Balanced Mixers available today, cover the 40 kHz - 3 GHz range and offer isolation greater than 45 dB and conversion loss of 6 dB. Each unit carries with it a 1-year guarantee by MCL. Upgrade your new system designs with the TFM, rapidly becoming the new industry standard for high performance at low cost.



Simple mounting options offer optimum circuit layout.
Use the TFM series to solve your tight space problems. Take advantage of the mounting versatility—plug it upright on a PC board or mount it sideways as a flatpack.



Model	Frequency, MHz			Conv. loss, dB				Isolation, dB												Cost	
				One Octave From Band Edge		Total Range		Lower Band Edge To one Decade Higher				Mid Range				Upper Band Edge To Octave Lower					
								LO-RF		LO-IF		LO-RF		LO-IF		LO-RF		LO-IF			
Model No.	LO	RF	IF	Typ.	Max.	Typ.	Max.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Typ.	Min.	Quantity	Price
TFM-2	1-1000	1-1000	DC-1000	6.0	7.5	7.0	8.5	50	45	45	40	40	25	35	25	30	25	25	20	6-49	$11.95
TFM-3	.04-400	.04-400	DC-400	5.3	7.0	6.0	8.0	60	50	55	40	50	35	45	30	35	25	35	25	5-49	$19.95
TFM-4	5-1250	5-1250	DC-1250	6.0	7.5	7.5	8.5	50	45	45	40	40	30	35	25	30	25	25	20	5-49	$19.95
TFM-11	1-2000	1-2000	5-600	7.0	8.5	7.5	9.0	50	45	45	40	35	25	27	20	25	20	25	20	1-24	$39.95
TFM-12	800-1250	800-1250	50-90	—	—	6.0	7.5	35	25	30	20	35	25	30	20	35	25	30	20	1-24	$39.95
*TFM-15	10-3000	10-3000	10-800	6.3	7.5	6.5	9.0	30	20	30	20	30	20	30	20	30	20	30	20	1-9	$59.95

Signal, 1 dB compression level +1 dBm. Impedance, all ports 50 ohms. Total input power 50 mW. Total input, current peak 40 mA. Operating and storage temperature −55° C to +100° C. Pin temperature 510° F (10 sec).
*LO power +10 dBm, 1 dB compression +5 dBm

World's largest manufacturer of Double-Balanced Mixers

Mini-Circuits
A Division of Scientific Components Corp

2625 East 14th Street Brooklyn, New York 11235 (212) 769-0200
Domestic and International Telex 125460 International Telex 620156

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B32/REV D

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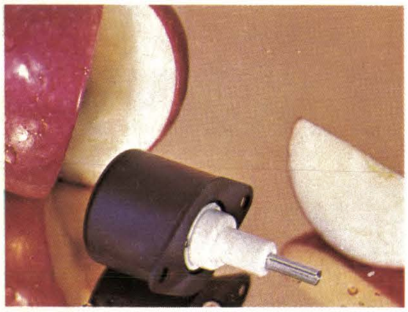
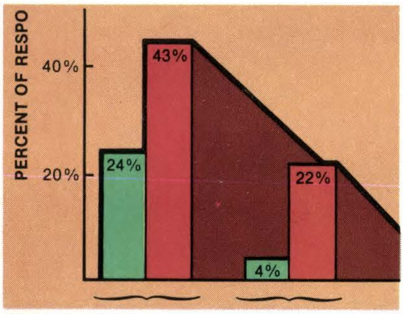


Stepping motors and controllers *go to the core of your incremental-motion-control needs (pg 37).*



PASCAL *begins to see wide use, but standards have yet to be finalized (pg 100).*

On the cover: *Versatile uncommitted IC logic helps designers keep from boxing themselves in (pg 88). (Photo by Mason Morfet, courtesy Fairchild Camera & Instrument Corp)*

DESIGN FEATURES

TECHNOLOGY NEWS

NEW PRODUCTS

DEPARTMENTS

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Scientists and engineers find computer systems powerful tools and control.

Why?

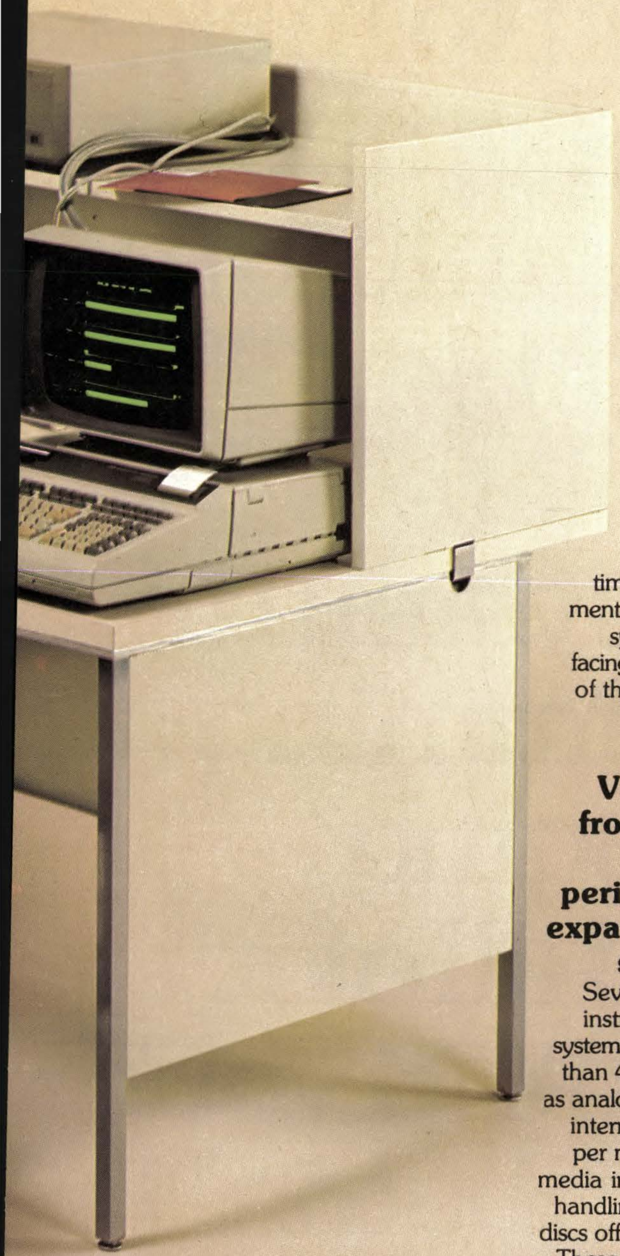
Interfacing power. Today's Hewlett-Packard desktop computers offer such features as buffered I/O, built-in I/O drivers, direct memory access (DMA), burst read/write, formatted read/write, and vectored priority interrupt. With DMA you can acquire up to 800K bytes per second. One model gives you up to 449K bytes of fully usable memory; another offers assembly language. Every one gives you a choice of four interface protocols on plug-in cards: HP-IB, Bit-Parallel, DCD and RS-232-C.

Days, instead of weeks. You can unpack a system and have it up and running on a production line, or in the lab in about one-third of the time you'd expect. Days, instead of weeks or even months.

From lab to production line. Once it's up, your test and control system can move with ease from one environment to another with no hardware or operating system changes. This kind of flexibility, coupled with the power and sophistication of today's models, makes an HP desktop computer the logical choice for your data acquisition and control needs.

Friendly. Together with the power to handle your big data acquisition and control problems, today's systems retain the reliability and ease of use that have always characterized HP desktop computers.

oday's desktop or data acquisition



DESIGNED FOR HP-IB SYSTEMS

HP-IB: Not just IEEE-488, but the hardware, documentation and support that delivers the shortest path to a measurement system.

HP-IB reaches beyond IEEE-488-78 to cover the operational area as well as the mechanical, electrical and functional specifications. For example, HP-IB systems incorporate a built-in, high level I/O language that saves you the time and expense of writing instrument drivers and configuring operating systems. It means powerful interfacing through a system in which a lot of the work has been done for you.

Versatile front ends and peripherals expand your system.

Several card-cage instrumentation subsystems are available from HP with more than 40 different cards for such tasks as analog and digital input and output, interrupt, counting, timing and stepper motor control. HP mass storage media include flexible discs capable of handling data at burst rates and fixed discs offering storage up to 120M bytes. These and other peripherals allow you to configure a system that meets your needs today and accommodates growth, as well.

A wide selection.

We build a broad range of desktop computers, with one just right for your data acquisition and control application. From the low cost HP 9815 through the HP 9825, the standard for HP-IB controllers; the HP System 35 with BASIC and assembly language; and the HP System 45B with advanced graphics capability, every HP desktop computer has superior interfacing characteristics in terms of human engineering, ease of use and power.

A growth path.

HP can meet expanding needs with communication links from desktop computers to HP 1000 series computers. For multiuser, multi tasking problems, HP 1000 systems offer a range of compatible RTE operating systems with software options for data base management, factory data collection and graphics.

For more information. Call 800-821-3777, extension 137, toll-free day or night (Alaska and Hawaii included). In Missouri, call 800-892-7655, extension 137. Or write 3404 E. Harmony Road, Fort Collins, Colorado 80525.

For a demonstration. Call the HP regional office nearest you: East 201/265-5000; West 213/970-7500; Midwest 312/255-9800; South 404/955-1500; Canada 416/678-9430.

400/1

HEWLETT PACKARD

For more information, Circle No 4

Mostek Z80 refinements:

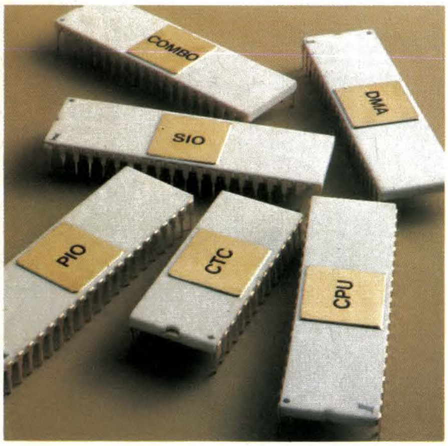
1 4MHz version to make it faster. 2 A Combo Chip to make minimum designs simpler. 3 A complete development system to make programming and debugging easier. 4 And all of it available now from your Mostek distributor.

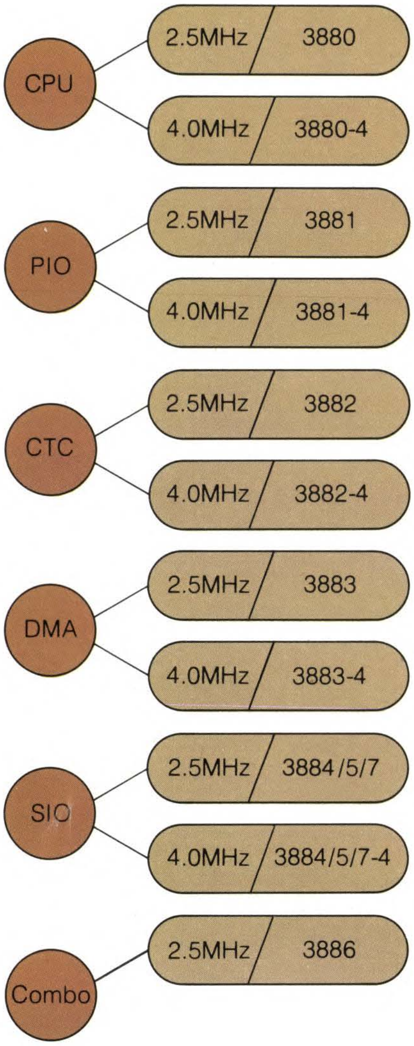
1 Now you can choose.

The choice? 2.5MHz or 4.0MHz parts from a full product line that includes the SIO and DMA. But other reasons to pick Mostek's Z80 family are equally impressive.

First of all, the Mostek Z80 is recognized and accepted as the industry's foremost 8-bit microprocessor. It's a proven design that's been in volume production for several years.

Then there's the inherent design advantages over the 8085: 158 instructions vs. 80. Fourteen 8-bit CPU registers vs. 7. Ten addressing modes vs. 7. An automatic dynamic RAM refresh. Enhanced 16-bit arithmetic ability. Automatic prioritization of interrupts instead of a separate control device. The list goes on.

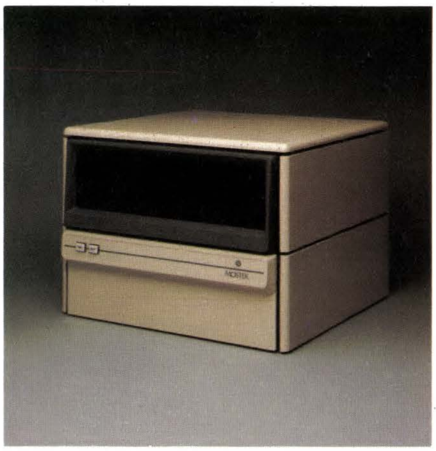




2 A practical solution for lower system cost.

Mostek's Combo™ Chip gives you more versatility with fewer parts. It's ideal for minimum chip configuration designs because this single 40-pin circuit contains 256 bytes of RAM with a low power standby mode for 64 bytes. A serial I/O port. Two programmable timers, one of which can be a programmable baud rate generator. Three external interrupts with a programmable vector for each channel. And, of course, a single +5 Volt power supply. So now you can design a complete system with just 3 chips: a Z80 CPU, ROM, RAM, or EPROM memory, and the Combo Chip.

3 A flexible development system.



Mostek's development support includes a variety of choices ranging from single cards to our Matrix™ floppy disk development system with 4.0MHz real time in-circuit emulation. The Matrix system offers a sophisticated resident software package that uses simple commands and comprehensive error messages to save valuable time during program development and debug. Macro Assemblers, BASIC, and FORTRAN are also available for use on the Matrix development system.

4 For all your Z80 needs.

Mostek's complete Z80 family is available now at your local Mostek distributor. So are factory-trained distributor FAEs and demonstration centers at most locations. Contact them for complete information and/or a product demonstration. Military versions are also available. For more information call or write Mostek, 1215 W. Crosby Road, Carrollton, TX 75006, phone 214/323-6000. In Europe, contact Mostek Brussels; phone 660.69.24.

MOSTEK®

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"For reliability I'll take AMP 160 Profile DIP Sockets every time."
Besides their proven reliability in tin or select gold-plated styles, AMP .160" DIP Sockets offer one of the lowest profiles in the industry. At a price to match. And with features that make them the intelligent choice for your low profile applications.
They're available with up to 44 positions. And have anti-wicking, anti-bridging contact design. Plus one piece housings with side chamfered lead cavities for easy IC insertion.
AMP 160 Sockets also feature a ladder design which allows for easy cleaning and viewing of the circuit traces after insertion. And for added versatility, styles are available in single row form for use with packages having non-standard spacings.
These sockets meet or exceed MIL-S 83734, and are available through our computer-linked regional inventory system. For the delivery details or for more information, call the AMP .160" Profile Socket Information Desk at (717) 780-8400. Or write us. AMP Incorporated, Harrisburg, PA 17105.
AMP & DIPLOMATE are trademarks of AMP Incorporated.
Closed entry design
Open ladder construction
Stand off
Retaining detent
AMP has a better way.
AMP
For more information, Circle No 6

Tektronix announces th

...next generation of scopes. The 7854.

Now Tektronix offers a new measurement tool for those who depend on oscilloscope measurements — the 7854. It is designed to improve measurement quality yet simplify measurements. Look at these features to see how you can put its measuring power to work for you.

Digital storage.

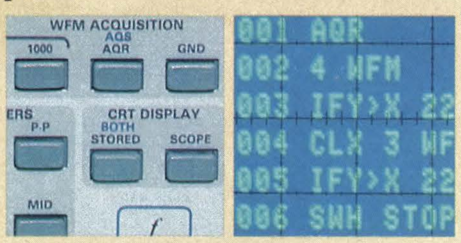
Digital storage lets you view the same node twice or compare waveforms without bothering with waveform photography or having to move probes and repeat control adjustments. Digital storage improves measurement quality, since resolution is increased to .01 division. Averaging improves measurement accuracy on signals buried in noise. With digital storage, you've got an open door to fast waveform processing and more repeatable measurements.

Waveform processing.

Solutions at the touch of a button.

At the touch of a button, waveform processing gives you solutions for common waveform measurements like rise time, period, frequency, RMS, energy, mean, max, and mid. Also, cursors aid in delta time and delta voltage measurements.

Within seconds, you can obtain repeatable answers like rise time without having to adjust position controls or determine the number of divisions between points.



Keystroke programming.

Like a handheld programmable calculator, the 7854 offers keystroke functions for storing, organizing, and reducing data. You can program the scope to acquire and monitor data without an operator's presence. You can even tailormake special functions to avoid manually repeating a series of keystrokes.

GPIB.

The 7854's GPIB interface provides access to processing in external controllers like the Tek 4050 Series. GPIB also allows mass storage and coordination with other instruments.

Part of the Plug-In Family.

The 7854 is the newest member of Tektronix' well-respected 7000-Series family of high performance scopes. Featuring a real time bandwidth of 400 MHz, it's compatible with 7000-Series plug-in units including differential amplifiers, samplers, DVM's, counter/timers, logic and spectrum analyzers, TDR's, and others.

Put the 7854's processing power to work for you. For more information on this new generation of oscilloscope from Tektronix fill out the coupon below or call your Tek Sales Engineer.

For the address of your nearest Tektronix Field Office, contact:

U.S.A.
Tektronix, Inc.
P.O. Box 1700
Beaverton, OR 97075
Phone: 503/644-0161
Telex: 910-467-8708
Cable: TEKTRONIX

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European Marketing Center
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Tektronix, Inc.
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Telex: 910-467-8708
Cable: TEKTRONIX

Tektronix
COMMITTED TO EXCELLENCE

Yes, I'm interested in the new 7854.

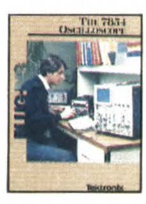
Name __________

Company's name __________

Title __________

Address __________

Phone (____) __________ ext _____



____ I'd like information on GPIB systems applications

____ Please send me additional information

____ Please contact me for a demonstration

The 7854 Oscilloscope brochure and accompanying specifications folder provide full details on this new instrument.

This Dual Floppy/LSI-11 does everything the 11V03-L will do in half the space...

and gives you RX02 software/media compatibility, too!

The MF-211 Dual Floppy/LSI-11/2 system, featuring the low-cost CRDS Double Density Controller, is functionally identical to the DEC 11V03-L, but uses only 10½" of rack space!

PLUS:

- KD11HA, DEC LSI-11/2 central processor
- Dual Shugart Drives
- Double and single density operation
- Complete LSI-11/2 software compatibility
- Over one megabyte of storage per system
- 4 Quad slot or 8 quad slot backplane
- Upgradable to LSI-11/23

- Unique CRDS controller with all interface, bootstrap loader and formatter electronics on one dual-height PC card, with complete RX02 software media/compatibility

. . . And for RX02 plug-replacement:
The FD-211 is a compact, low-cost, highly reliable plug-replacement for RX02 applications in 5¼" low-profile chassis.

PLUS:

- Complete PDP-11, LSI-11 compatibility
- Switch and photocell write-protect
- Bootstrap loader
- Self-test and formatter

Now available with double-sided floppies!

Charles River Data Systems, Inc.

4 Tech Circle, Natick, MA 01760 Tel. (617) 655-1800 TWX (710) 386-0523

CRDS

For more information, Circle No 7

Edited by Joan Morrow

News Breaks

8-IN.-HARD-DISC INTERFACE STANDARD NOT YET FINALIZED

Although members of the ANSI X3T9.3 8-in.-hard-disc interface-standard committee have agreed on almost all the electrical specs for the proposed hard-disc interface, further definition of the command structure remains to be ratified. Accordingly, committee members who attended February's proceedings in Deerfield, FL believe that the standard is still about a year and a half from completion.

More progress should be made at this month's meeting in Washington, DC. And notwithstanding the remaining problems, members representing disc-drive manufacturers feel confident that they can begin designing interfaces that will meet the proposed standard. Furthermore, controller and chip manufacturers claim that because of the committee's impetus, the definitions that they require will be determined by mid-year.—CW

MAJOR EUROPEAN SECOND SOURCE SET FOR TMS 9900 16-BIT μC

Another stumbling block to product acceptance and recognition has been cleared for Texas Instruments' 9900 family with the signing of Intermetall (Freiburg, West Germany) as a second source. The exchange agreement gets ITT into the 16-bit-μC business (Intermetall is ITT's worldwide marketing arm) and provides it with an in-house source to support 9900-family-based telecommunications programs.

Despite an installed base of 9900 customer applications that exceeds that of all other 16-bit families combined — with more than 1000 generated in just the last year — the TI 16-bit μC has suffered a recognition problem because of competition from the newer 16-bit families. This second source agreement could alleviate that problem.—WT

ONE IF BY LAND, TWO IF BY BASIC

The British have landed almost within musket range of the Old North Church. But this time they come not to tax the colonists, but rather to sell them computers from a Boston, MA-based office. The Sinclair ZX80 has been introduced in England and will soon be announced in New York; the holdup on its US entry arises from overwhelming demand — Sinclair just can't make the units quickly enough.

The (approximately) $200 unit connects to a TV via an internal modulator (awaiting FCC approval). It's a complete Z80-based μC that uses a proprietary BASIC made especially compact to suit the computer's 1k of RAM. The interpreter itself resides in 4k of ROM, providing an amazing degree of syntax checking and prompting: The software won't let you enter a syntactically incorrect line of code.—ET

1M BUBBLE-MEMORY PART AVAILABLE ON BOARD

Intel Magnetics (Santa Clara, CA) now offers an OEM version of its 1M-bit development board — the iSBC 250. The $4750 board houses a 7110 bubble-memory device, a 7230 current-pulse generator, a 7242 dual formatter/sense amp and 7250 and 7254 coil drivers. Featuring 128k bytes of completely assembled nonvolatile memory, the 250 also provides automatic error correction, power-fail reset, an average access time of 40 msec and a Multibus interface, plus compatibility with the 8086-μP family. Operating voltages spec at ± 12 and 5V, and the board can control an expanded system of up to 1M bytes of bubble memory. The company ships the system 6 wks after receipt of your order.—WT

BECOME A MASTER OF SOFTWARE ENGINEERING

The first school devoted solely to software engineering (although not the first to establish a graduate-degree program: see EDN, September 20, 1979, pg 33), the Wang Institute of Graduate Studies will offer a Master's degree in that specialty.

News Breaks

Enrolled at Wang's School of Information Technology in Tyngsboro, MA, 30 to 40 full-time-equivalent students will combine work on real-world projects with formal academic studies. The "ethical aspects" of the discipline will also be emphasized.—JV

MONOLITHIC POWER DARLINGTONS MEET UL CREEP, STRIKE SPECS

Announced by GE Semiconductor (Auburn, NY) at Powercon 7, Series D66DV (50A/450V continuous) and D67DE (100A/450V) npn devices feature packages that offer 2500V collector isolation from the heat sink, a nitrogen-filled environment for stress-free operation at temperature extremes and quick-connect or screw-type electrical terminals. Priced at $52.50 to $155 (100) depending on current rating, the discretes aim at applications in motor controls, switching power supplies, inverters and UPS systems.—WP

SIGN UP FOR AN INTENSIVE 1-DAY COURSE IN POLY PROCESSING

The growing use of polycrystalline silicon in IC manufacturing, and in particular for VLSI circuitry, has revealed some properties that could restrict future circuit designs and performance. A 1-day course covering the fabrication technology and the properties and limitations of polysilicon and refractory-metal silicides — a class of materials that could solve the problems with poly — will be held on April 21. The $150 course is part of a University of California at Berkeley College of Engineering program and will take place at Fairchild Semiconductor's training facility in Mt View, CA. For more information, write to Continuing Education in Engineering, University Extension, University of California, 2223 Fulton St, Berkeley, CA 94720 or call (415) 642-4151.—WT

RF POWER METER PERFORMS DUAL-CHANNEL MEASUREMENTS

Conventional setups for measuring insertion loss (or gain) call for two separate power meters, but one Boonton Electronics (Parsippany, NJ) Model 4200, equipped with a second channel Option -03, handles the job alone. Basically a self-calibrating 200-kHz to 18-GHz autoranging unit, the instrument displays measured power directly in mW, μW, nW, dBm or dBr with 0.01-dB resolution.—ED

CORRESPONDENCE-QUALITY MATRIX PRINTER SPACES PROPORTIONALLY

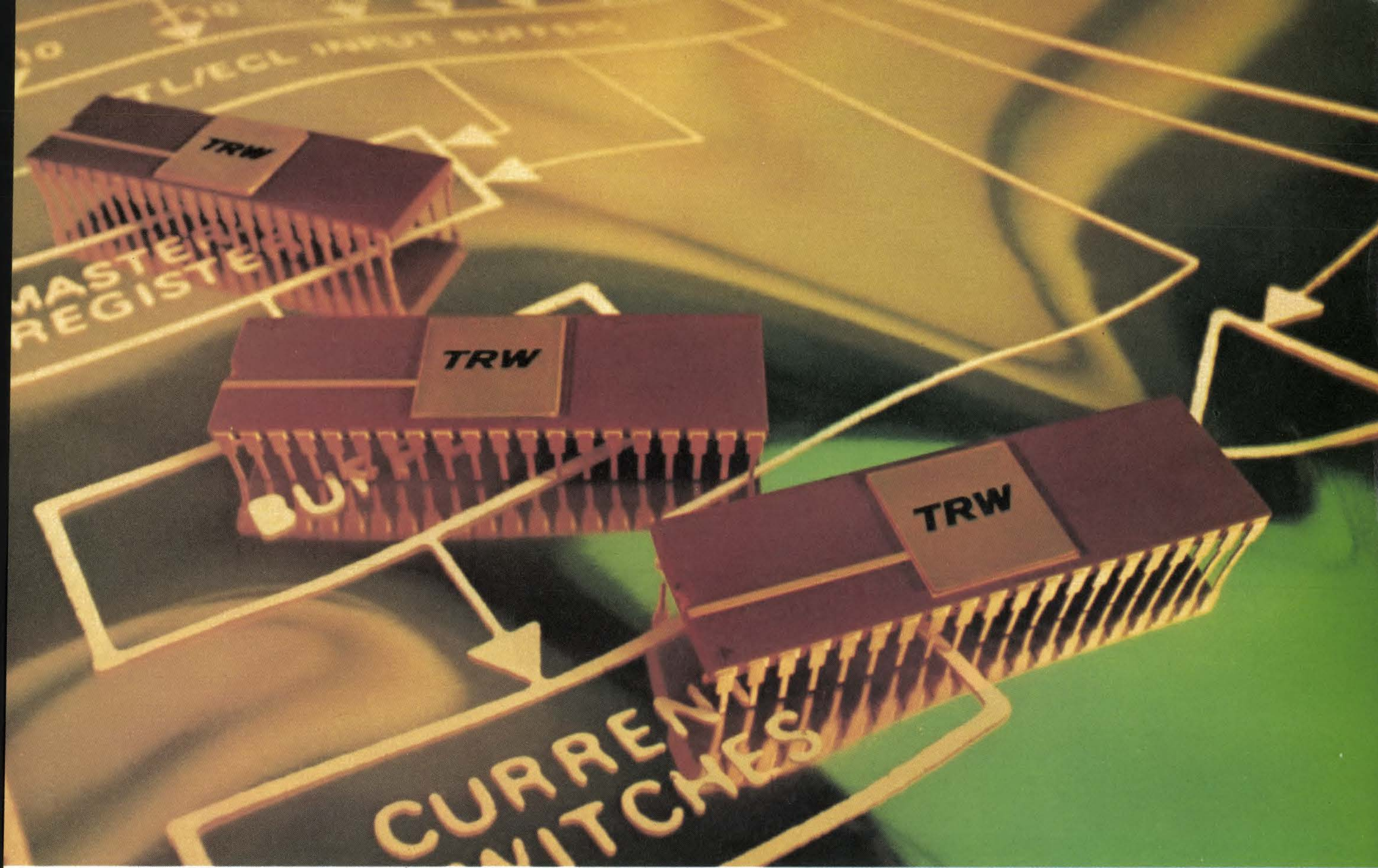
Printing an n × 9 (proportional) or 7 × 8 (monospaced) dot matrix, Centronics Data Computer Corp's (Hudson, NH) $995 Model 737 fills the text-processing niche in the company's product line. In it, a μP controller works with a 9-wire free-flight printhead and bidirectional paper control to furnish true underlining, superscripts and subscripts.—ET

BATTERY-DECHARGER IC OPERATES ABOVE 500°C

Packaged in a standard hermetically sealed TO-3 case with the leads cut off, Model BD-1 universal decharger can completely drain all the power from virtually any type of primary or secondary battery. Moreover, it incorporates a polarity-independence feature; i e, it works no matter which bolt hole is connected to the battery's positive or negative terminal.

Speaking on April 1st at National Semiconductor's Santa Clara, CA R&D laboratory, designer Robert C Dobkin stressed the BD-1's extreme versatility: Applications include the conditioning of batteries for use with darkness-emitting arsenic diodes (DEADs) and write-only memories (WOMs).

Dobkin pointed out the need for caution in the device's use: "The extreme operating efficiency of the BD-1 can cause some batteries to overheat and explode — a problem readily cured by adding a resistor in series with the IC." Emphasizing that National conducts extensive automatic testing to ensure the exceptional reliability of the BD-1, he noted that the device is fully specified up to 500°C and linearly derated above that temperature up to the softening point of steel.—WP



Now! 20MHz monolithic 10-9-& 8-bit D/A converters

(And they're glitchless.*)

Only TRW offers you all these features in a DAC.

Signal conversion is a guaranteed 20 megasamples/sec. Best rate yet for a monolithic 10-bit DAC.

*Glitches are barely measurable. Less than 100 picovolt-second on average. An internal input register and equalized delay circuitry eliminate the need for any external deglitching components.

Our DACs are compatible with TTL and single-ended or differential ECL. And handle a variety of inputs: 2's complement, inverted 2's, or binary.

A unique output clocking option offers the ability to zero the output at any time. It can be strobed with an independent clock. A 1V/75 ohm output directly drives a load without an op amp or buffer. For convenience, we included a Force High/Force Low control for calibration. It gives you full scale or zero output without changing the digital input. Physically, our monolithic/bipolar DACs in their 40-pin DIP demand less. They take up less space and require only 600mW (vs. 2-5 watts for module types).

The new DACs from TRW: they leave no reason to delay going monolithic. Not even price.

These high-speed high-resolution D/A converters are in stock at Hamilton/Avnet.

D/A Converter	Resolution (Bits)	Speed (MSPS)	Power (Watts)	Unit Price (in 100s)
TDC1016J-10	10	20	0.6	$98
TDC1016J-9	9	20	0.6	$51
TDC1016J-8	8	20	0.6	$38

For immediate information, call us at (213) 535-1831 or send in the coupon or just attach your business card to this page and mail it back to us.

TRW LSI Products
P.O. Box 1125
Redondo Beach, CA 90278

Please send data sheets on the family of **DACs.**

Name

Company

Div/Dept | Mail Code

Address

City

State | Zip

EDN-4-80

TRW LSI PRODUCTS
An Electronic Components Division of TRW Inc.

TRW keeps you ahead in digital signal processing

For more information, Circle No 8

Signals & Noise

A prospectus for Business Science 499

Dear Editor:
We have compiled some humorous notes about various personalities in our engineering company which EDN readers might find amusing. (Disclaimer: These descriptions were taken from an anonymous note on the company bulletin board. Names have been deleted to protect the innocent, the guilty and the authors.)

A full course outline will appear in a future issue of the *IEEE Communications Society* magazine.

1. *A Proposal Manager's Creed*—Carefully estimate hours by tasks and double the results.

2. *The Preacher's Solution to Engineering Problems*—If you have a problem to solve, lecture the office about it.

3. *A Concise Case for Software Sanity*—Put in your 8 hrs, pack your bag and go home.

4. *The Company Man's Approach to Management*—No problem is so large that it cannot be solved by an 80-hr week. *Corollary I*—If there is too much work to be done, do it yourself. *Corollary II*—Decisions made by subordinates cannot be trusted.

5. *The Office Cheapskate's Equity Plan*—If the price of coffee is raised to 15 cents a cup, invest in an oversized mug.

6. *The Research Department's Rationale*—One equation is worth 10^3 words.

Very truly yours,
John T Scully Jr
Frederick H Raab

Helpful hints

Dear Editor:
I'd like to comment on recent EDN articles that referred to the FCC's new Technical Standards for Computing Equipment.

First: The box on pg 50 in Carl Warren's February 5 news story on personal computers misstates the allowed RF emission limits. Class A (industrial) systems are allowed from 30 to 70 *micro*volts per meter field strength at 30m, depending on frequency. Class B (mass market or home

Solve design problems simply with 1.5 Amp Interface ICs for Negative Supply Applications.

You can use Sprague Electric's new Series UDN-2840B 1.5 amp monolithic quad power drivers in three basic versions to solve your circuit needs for (1) sinking applications, (2) source applications, and (3) combination sink-and-source applications.

You can get this versatile IC family with either 5V logic compatibility or 12-15V MOS compatibility. Make your choice from these six types:

TYPE	I_{OUT}	$V_{OUT(OFF)}$	OUTPUTS	$V_{SUPPLY\ (TYP)}$	COMPATIBILITY	TYPICAL APPLICATIONS
UDN-2841B	1.5 A	−50 V	Sink (4)	0 V to 5 V	5 V Logic	electrosensitive printer interface
UDN-2842B	1.5 A	−50 V	Sink (4)	0 V to 12 V	PMOS, CMOS	
UDN-2843B	−1.5 A	−50 V	Source (4)	5 V	5 V Logic	solenoid, LED, or relay drive
UDN-2844B	−1.5 A	−50 V	Source (4)	5 V to 12 V	PMOS, CMOS	
UDN-2845B	1.5 A/−1.5 A	−50 V	Sink (2) Source (2)	5 V	5 V Logic	bridge motor drives
UDN-2846B	1.5 A/−1.5 A	−50 V	Sink (2) Source (2)	5 V	PMOS, CMOS	

All Series UDN-2840B power driver ICs include input current limiting, level translation, and sufficient amplification to operate high current Darlington outputs. The Sprague-originated 16-lead webbed dual in-line package is used for maximum power dissipation.

For application engineering assistance on these or other interface circuits, standard or custom, write or call Paul Emerald, Semiconductor Division, Sprague Electric Co., 115 Northeast Cutoff, Worcester, Mass. 01606. Telephone 617/853-5000.

For Engineering Bulletin 29314 and a 'Quick Guide to Interface Circuits', write to: Technical Literature Service, Sprague Electric Company, 491 Marshall Street, North Adams, Mass. 01247.

For the name of your nearest Sprague Semiconductor Distributor, write or call Sprague Products Company Division, North Adams, Mass. 01247. Telephone 413/664-4481.

FOR FAST INFORMATION, CALL YOUR NEAREST SPRAGUE SALES OFFICE:

ALABAMA, Sprague Electric Co., 205/883-0520 • **ARIZONA,** Sprague Electric Co., 602/244-0154; 602 966-7233 • **CALIFORNIA,** R. D. Miner Co., 714 421-5586; Wm. J. Purdy Co., 415/347-7701 • **COLORADO,** Wm. J. Purdy Co., 303/777-1411 • **CONNECTICUT,** Sprague Electric Co., 203 261-2551; Ray Perron & Co., Inc., 203 268-9631; 203/673-4825 • **DIST. OF COLUMBIA,** Sprague Electric Co. (Govt. sales only), 202-337-7820 • **FLORIDA,** Sprague Electric Co., 305/831-3636 • **ILLINOIS,** Sprague Electric Co., 312/296-6620 • **INDIANA,** Sprague Electric Co., 317 253-4247 • **MARYLAND,** Sprague Electric Co., 301 792-7657 • **MASSACHUSETTS,** Sprague Electric Co., 617/899-9100; 413/664-4411; Ray Perron & Co., Inc., 617/969-8100 • **MICHIGAN,** Sprague Electric Co., 517 787-3934 • **MINNESOTA,** HMR. Inc., 612 831-7400 • **MISSOURI,** Sprague Electric Co., 314/781-2420 • **NEW HAMPSHIRE,** Ray Perron & Co., Inc., 603/742-2321 • **NEW JERSEY,** Sprague Electric Co., 201 696-8200; 609 795-2299; Trinkle Sales Inc., 609/795-4200 • **NEW MEXICO,** Wm. J. Purdy Co., 505/266-7959 • **NEW YORK,** Sprague Electric Co., 516 234-8700; 914 834-4439; 315 437-7311; Wm. Rutt. Inc., 914/834-8555; Paston-Hunter Co., Inc., 315/437-2843 • **NORTH CAROLINA,** Electronic Marketing Associates, 919 722-5151 • **OHIO,** Sprague Electric Co., 513 866-2170; Electronic Salesmasters, Inc., 800/362-2616 • **PENNSYLVANIA,** Sprague Electric Co., 215/467-5252; Trinkle Sales Inc., 215 922-2080 • **SOUTH CAROLINA,** Electronic Marketing Associates, 803/233-4637 • **TEXAS,** Sprague Electric Co., 214/235-1256 • **VIRGINIA,** Sprague Electric Co., 703-463-9161 • **WASHINGTON,** Sprague Electric Co., 206/632-7761 • **CANADA,** Sprague Electric of Canada, Ltd., 416/766-6123 or 613/238-2542

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environment) devices are allowed between 100 and 200 μV/m at 3m—again depending on frequency of emission. TV games are now subject to the same limits as Class B.

Second: Readers of Walt Patstone's March 5 editorial and Andy Santoni's news story on the impact of the new standards (in the same issue, pg 47) might find the following additional information helpful:

- The quickest reference to the proposed rules is in the *Federal Register*, Vol 44, No 201, October 16, 1979.
- The FCC is most concerned about all types of electronic games and personal computers. Test data for these devices *must* be filed with the Commission. Other devices must be tested, but results of those tests need not be filed with the Commission.
- We have a simple remedy for the ambient - noise problem—we test after midnight, when ambient noise drops 20 to 40 dB and many broadcasting stations are off the air.

Sincerely,
Isidor Straus
RF Consulting Engineer
Malden, MA

"IT'S AN EXTRA, ENGINEERED RIGHT INTO THE UNIT FOR THE OLD TIMERS: TO START, YOU HAVE TO KICK IT RIGHT THERE."

Signals & Noise

He's no April's fool

Dear Editor:

I wrote this poem to glorify some of the favorite clichés of the engineers I have worked with. I hope EDN's readers appreciate it.

Yours truly,
Jeffrey Borish
Santa Clara, CA

The Saga of the Hairy Edge

Designing a circuit,
you give it your best.
It works on paper,
but then it won't fly.
You work through the night-
time without any rest.
In two hours more,
wave the deadline goodbye.
It's right on the hairy edge.

The gremlins just won't
leave your circuit alone.
It works for a minute,
and then it will die.
Your boss says your next raise
he'll have to postpone.
He's tired of hearing
that same tired lie:
It's right on the hairy edge.

Four months have gone by,
and your spirit is blue.
Your job is at stake now,
if not your career.
Your boss wants to know
if you'll ever be through.
But all you can offer
he won't want to hear:
It's right on the hairy edge.

You'd like to retire
to live on a boat,
and give up this life
with your back to the wall.
Just sunning and fishing
while at sea you float.
But how can you give up
right now, after all—
It's right on the hairy edge.

One morning you wake up
and realize that this
is the day you've awaited
for nearly a year.
You fly back to work
with a feeling of bliss,
and turn on the circuit
without any fear.
It's no longer stuck
on the edge!

The success of the product
restores you to grace.
The prez is so pleased
that he bumps you upstairs.
But as you depart
from the circuits rat race
you wave fond farewell
to that edge with the hairs.

The finish line

The photo caption on pg 81 of EDN's January 5 Programmable - Memory Directory noted that Texas Instruments was the first company to introduce a 64k UV-erasable EPROM. In fact, Motorola announced its MCM68764C 64k 24-pin device a few days earlier than TI.

308 DATA ANALYZER

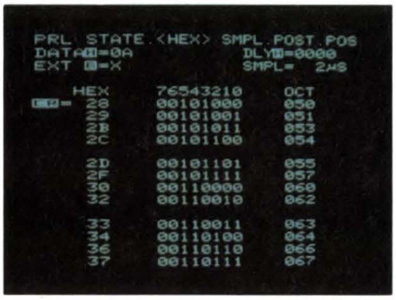
Easily acquire the data you need.

1\. Select parallel state, parallel timing, serial, or signature operation. Simply press the appropriate key.

2\. Choose synchronous or asynchronous sampling. Use the clock of the system under test or the 308's own internal clock. In either case, sampling rates up to 20 MHz are possible.

3\. Enter the word you want to use as a trigger to acquire data. Other keys let you select an external trigger and trigger delay.

4\. Press "start" and you're done. Now, you can view the acquired data in the format you want. Or, store the data in the reference memory by pressing the "store" key. Other function keys allow you to acquire new data and compare it with the reference memory.



In each data acquisition mode, all measurement parameters are displayed for your convenience.

Minimum keystroking with the new 308 Data Analyzer from Tektronix.

Of course, the 308 Data Analyzer can do a lot more than we've shown here. For example, there's a self-test routine at power-up, plus seven diagnostics, to ensure accurate results. And the 308 weighs only 8 pounds (3.6 kg), for easy portability.

For the full story, contact your local Tektronix Field Office, or write us.

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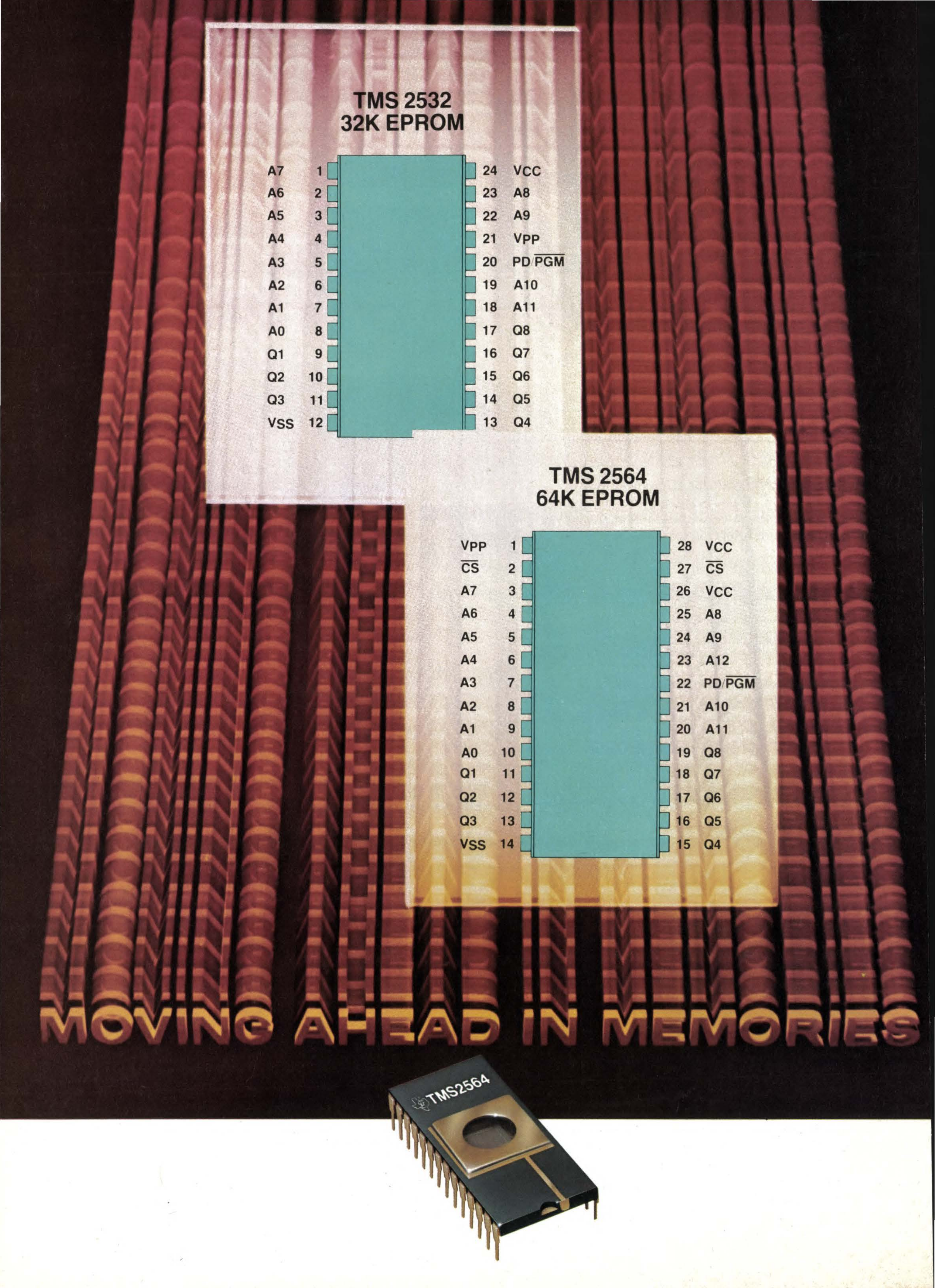


TMS 2532
32K EPROM
A7 1
A6 2
A5 3
A4 4
A3 5
A2 6
A1 7
A0 8
Q1 9
Q2 10
Q3 11
VSS 12
24 VCC
23 A8
22 A9
21 VPP
20 PD/PGM
19 A10
18 A11
17 Q8
16 Q7
15 Q6
14 Q5
13 Q4
TMS 2564
64K EPROM
VPP 1
CS 2
A7 3
A6 4
A5 5
A4 6
A3 7
A2 8
A1 9
A0 10
Q1 11
Q2 12
Q3 13
VSS 14
28 VCC
27 CS
26 VCC
25 A8
24 A9
23 A12
22 PD/PGM
21 A10
20 A11
19 Q8
18 Q7
17 Q6
16 Q5
15 Q4
MOVING AHEAD IN MEMORIES
TMS2564

8Ks, 16Ks, 32Ks, and now...

The first 64K EPROM. From Texas Instruments. Naturally.

Introducing the TMS2564. The industry's first 64K EPROM. The densest yet. With all the high-performance features of TI's 5-V EPROM family. Features like 8-bit word configuration, fully static operation, automatic chip-select/power down, and low-power.

Pin compatibility

TMS2564 is offered in a 600-mil, 28-pin dual-in-line package. But, it's compatible with industry standard 24-pin 64K ROMs, as well as less dense EPROMS.

This is because pins 3 through 26 of the TMS2564 are compatible with pins 1 through 24 of the 24-pin devices. Compatibility is enhanced by reserving both pins 26 and 28 for the 5-V supply. So, with a supply trace to pin 26, both 24 and 28-pin devices can be used, with no jumpering.

Fully static

Like all TI EPROMS, the TMS2564 maintains the fully static tradition that makes designing easier.

No timing signals. No clocks. No strobes. No refresh. No problems. Simply, cycle time equals access time.

Lowest power ever

Operating at an access time of 450 ns with a power dissipation of only 840 mW maximum or less than 13 μW per bit, it's the lowest power per bit ever achieved in EPROMS.

Easy programming

The TMS2564 is designed to facilitate rapid program changes in high density, fixed memory applications.

All that's needed for simple, in-system programming, is a single TTL level pulse.

You can program in any order. Individually. In blocks. At random. So, programming time is reduced to a minimum. And, you can use existing 5-V PROM programmers.

Erasing? Simple ultraviolet. Just like any other EPROM.

Widest choice

By adding the new TMS2564 to our fast-growing EPROM family, we offer the designer a product breadth unmatched by any other supplier.

All TI EPROMS are available in 600-mil packages with JEDEC compatible pin-outs.

And they all share the reliable N-channel process technology.

TI's growing EPROM family. For all your present and future memory requirements.

For more information about the first 64K EPROM, or any other family member, call your nearest field sales office or authorized distributor. Or write to Texas Instruments, P.O. Box 1443, M/S 6955, Houston, Texas 77001.

Fifty Years of Innovation

TI'S GROWING EPROM FAMILY

Device	Description	Power Supply	Max Power (0°C) Operating	Max Power (0°C) Standby	Access Time
TMS2564	64K	5 V	840 mW	131 mW	450 ns
TMS25L32	32K	5 V	500 mW	131 mW	450 ns
TMS2532	32K	5 V	840 mW	131 mW	450 ns
TMS2516-35	16K	5 V	525 mW	131 mW	350 ns
TMS2516	16K	5 V	525 mW	131 mW	450 ns
TMS2508-25	8K	5 V	446 mW	131 mW	250 ns
TMS2508-30	8K	5 V	446 mW	131 mW	300 ns
TMS2716	16K	+12, ±5 V	720 mW	—	450 ns
TMS27L08	8K	+12, ±5 V	580 mW	—	450 ns
TMS2708	8K	+12, ±5 V	800 mW*	—	450 ns
TMS2708-35	8K	+12, ±5 V	800 mW*	—	350 ns

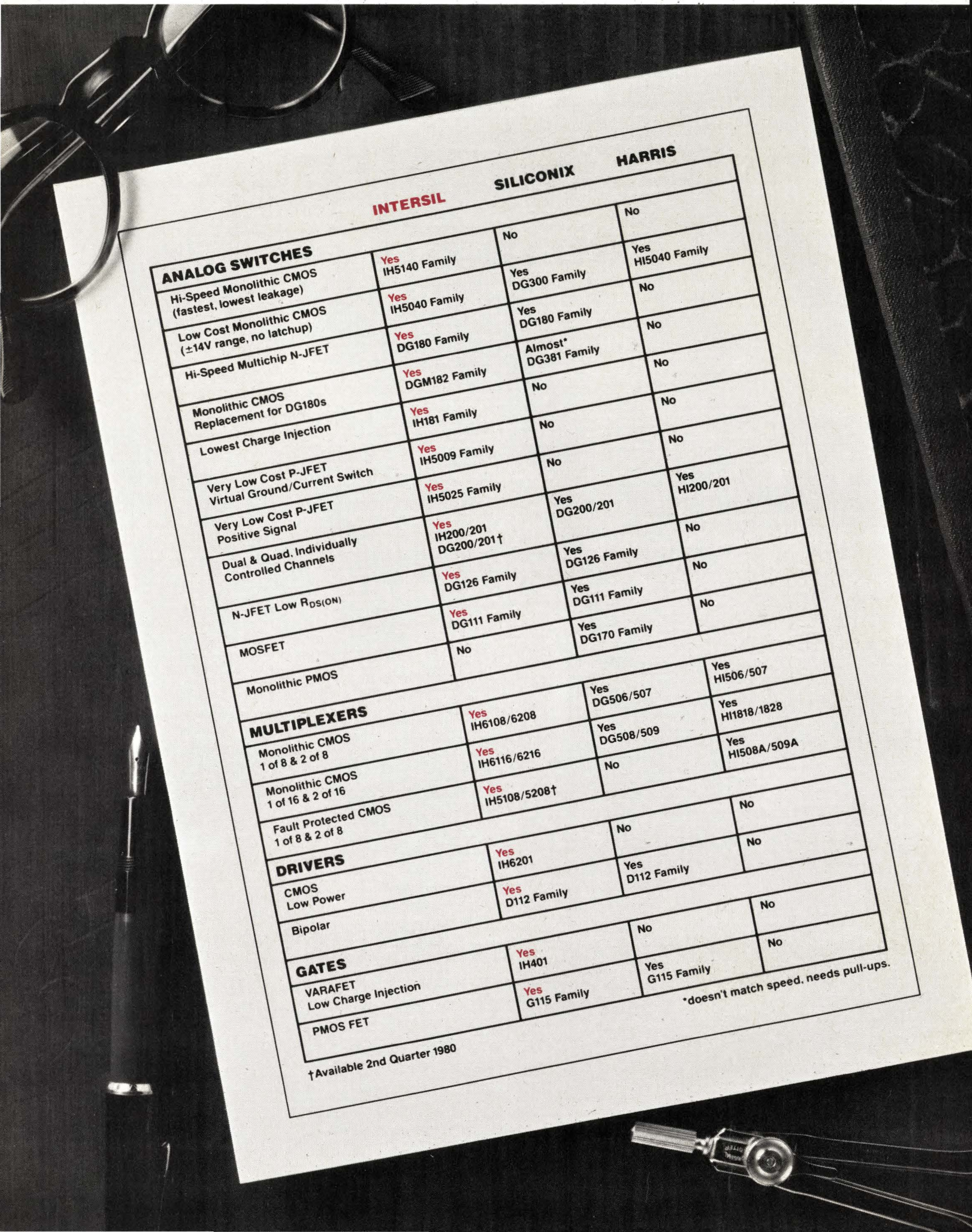
*$T_A = 70°C$

TEXAS INSTRUMENTS
INCORPORATED

85126 A

For more information, Circle No 106

AN OPEN-BOOK QUIZ: WHO'S



	INTERSIL	SILICONIX	HARRIS
ANALOG SWITCHES			
Hi-Speed Monolithic CMOS (fastest, lowest leakage)	Yes IH5140 Family	No	No
Low Cost Monolithic CMOS (±14V range, no latchup)	Yes IH5040 Family	Yes DG300 Family	Yes HI5040 Family
Hi-Speed Multichip N-JFET	Yes DG180 Family	Yes DG180 Family	No
Monolithic CMOS Replacement for DG180s	Yes DGM182 Family	Almost* DG381 Family	No
Lowest Charge Injection	Yes IH181 Family	No	No
Very Low Cost P-JFET Virtual Ground/Current Switch	Yes IH5009 Family	No	No
Very Low Cost P-JFET Positive Signal	Yes IH5025 Family	No	No
Dual & Quad, Individually Controlled Channels	Yes IH200/201 DG200/201†	Yes DG200/201	Yes HI200/201
N-JFET Low $R_{DS(ON)}$	Yes DG126 Family	Yes DG126 Family	No
MOSFET	Yes DG111 Family	Yes DG111 Family	No
Monolithic PMOS	No	Yes DG170 Family	No
MULTIPLEXERS			
Monolithic CMOS 1 of 8 & 2 of 8	Yes IH6108/6208	Yes DG506/507	Yes HI506/507
Monolithic CMOS 1 of 16 & 2 of 16	Yes IH6116/6216	Yes DG508/509	Yes HI1818/1828
Fault Protected CMOS 1 of 8 & 2 of 8	Yes IH5108/5208†	No	Yes HI508A/509A
DRIVERS			
CMOS Low Power	Yes IH6201	No	No
Bipolar	Yes D112 Family	Yes D112 Family	No
GATES			
VARAFET Low Charge Injection	Yes IH401	No	No
PMOS FET	Yes G115 Family	Yes G115 Family	No

*doesn't match speed, needs pull-ups.

†Available 2nd Quarter 1980

#1 IN ANALOG SWITCHES?

(HINT: IT'S NOT WHO YOU THINK.)

IERE'S THE STRAIGHT SCOOP.

ntersil is the leader in analog switching. 'e've got the broadest line in the business, the stest and most accurate devices in the business, nd the technological capabilities to stay #1. iliconix doesn't. Harris doesn't. We do.

ROADEST TECHNOLOGY.

Vhen it comes to analog switching technologies, obody beats Intersil: CMOS. P-JFET. IOSFET. VARAFET. Dielectric Isolation.

EST PERFORMANCE.

nd nobody beats us at staying out on that eading edge of performance:

'ake, for example, our IH5140 family of nonolithic CMOS switches—absolutely he fastest, lowest power, lowest leakage evices anywhere.

)r how about our DGM182 family. It happens o be the only true monolithic replacement for he DG180s and it meets *all* the specs.

)r if you want to talk accuracy—look at our H6116/6216 CMOS MUXs. They're at *rock ottom* in error, power and leakage.

IORE NEW GOODIES.

Ve admit it: we're out to stay #1 in this business.

Vhich is why we'll soon be introducing the H5108/5208 family of dielectrically-isolated ault-protected MUXs. With better fault protection and higher accuracy than the ompetition. Move over, Harris.

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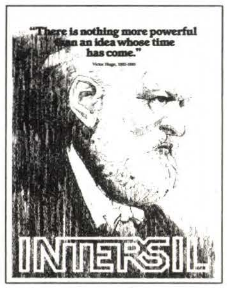

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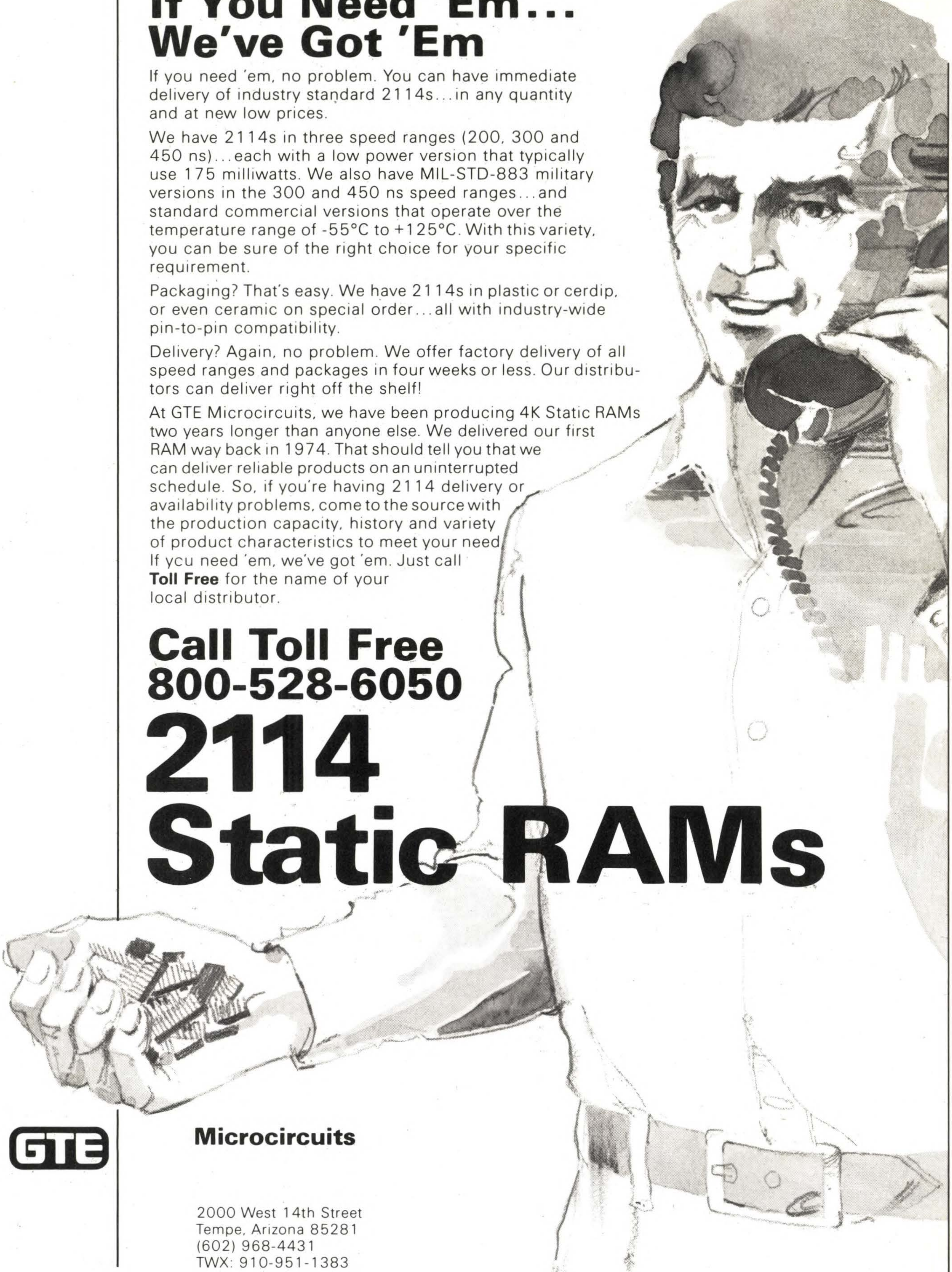

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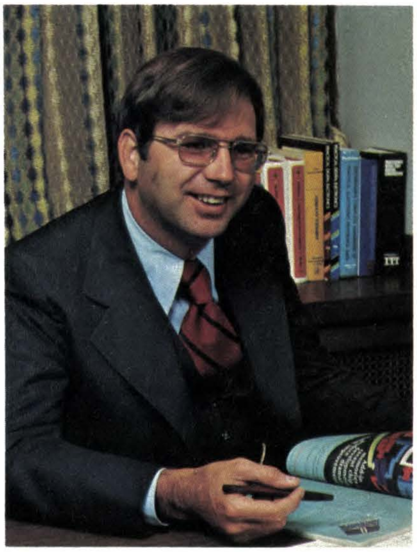
Editorial



What price pricing?

EDN has long held that price is one of the most important specifications of any product, a critical indicator of both the item's value and its suitability for a particular application. Therefore, we try to publicize only those items for which we can obtain pricing data, and we actively attempt to obtain such data. For example, if a press release doesn't include pricing information, we call the source directly. And if for any reason it's not practical to get specific prices (as in cases where many configurations of a basic model exist), we ask for a range of prices or (as a minimum) a ballpark estimate.

Recently, though, this policy has run head on into increasing manufacturer opposition, and we can readily understand why: In these days of high inflation and wild swings in precious-metal prices, firms are having an increasingly difficult time holding their prices firm. Thus, a new product's price can easily become obsolete in the period spanning the approval of a price list, the mailing of a press release and the publication of a product description in a trade journal.

Under these conditions, pricing information takes on new significance. Therefore, in order to keep our editorial policies in tune with your design-engineering needs, we have listed below five key questions that we believe go to the heart of the matter. Please circle the numbers on the Information Retrieval Service card that best reflect your views. And please feel free to make additional comments in the space provided on the card. We will report the results of this survey in a future issue.

Walt Patstone
Editor

	YES	NO
1. Pricing information is vitally important to my evaluation of a new product.	Circle No 380	Circle No 381
2. I will not circle the Information Retrieval Service number of a product description that doesn't contain price information.	Circle No 382	
3. If a product appears to be of sufficient interest to me, I'll circle its number regardless of whether or not I require pricing information.	Circle No 383	
4. Pricing information with a time qualifier (e g, "$2.85 as of March 5, 1980") or a precious-metal adder is much more preferable than a total lack of pricing data.	Circle No 384	Circle No 385
5. The selection of products for coverage in EDN should center primarily on the basis of technical detail; price is a secondary consideration.	Circle No 386	Circle No 387

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1978 Staff-Written Series —
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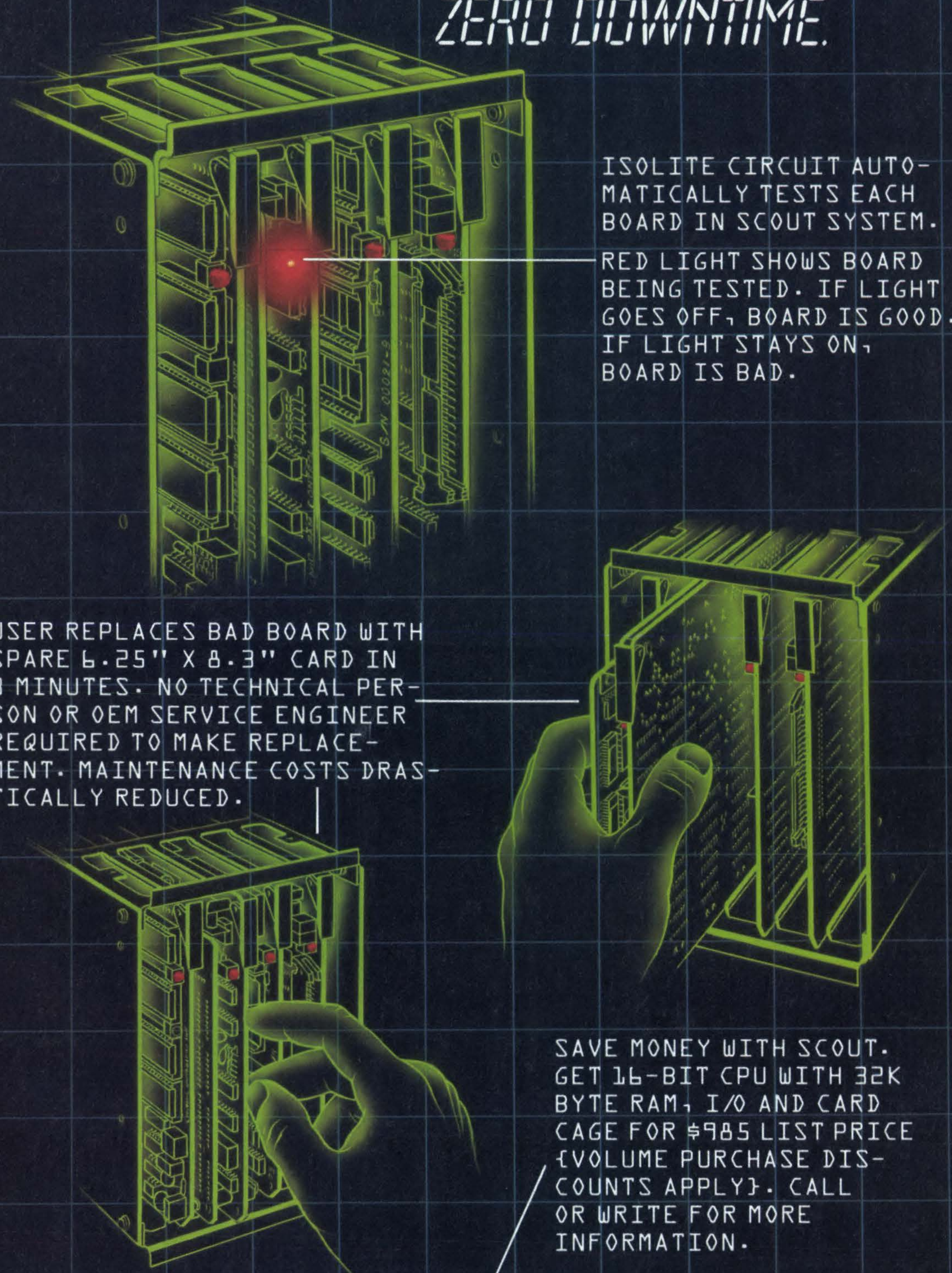

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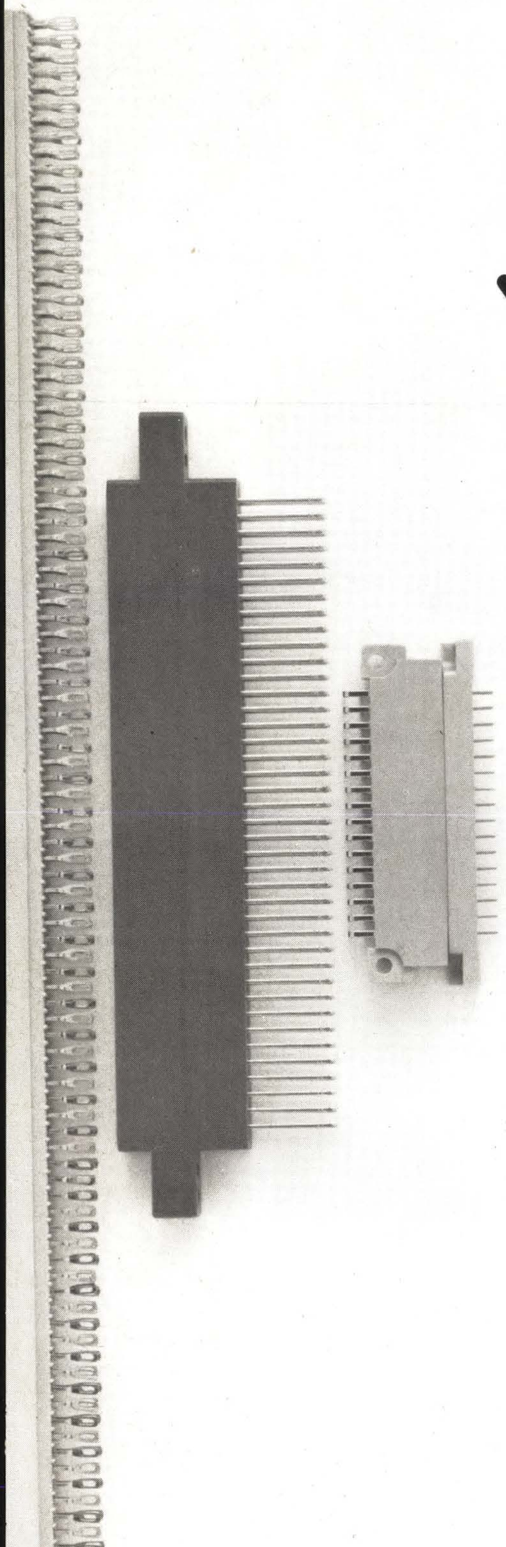
Leadtime Index

PASSIVE COMPONENTS

PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
CAPACITORS			
Ceramic, disc	12	16	up
Ceramic, monolithic	16	20	up
Electrolytic, aluminum	10	23	up
Electrolytic, tantalum	15	25	up
Film	12	17	up
Mica	20	30	=
Paper	16	20	=
Trimming	14	19	=
CRYSTALS, FILTERS AND NETWORKS			
Filter, active	16	20	up
Filter, EMI	12	18	=
Filter, lumped-constant	13	17	=
Filter, quartz (monolithic)	12	17	=
Freq. determining crystal	8	13	=
ENCLOSURES			
Custom	12	18	=
Modified standard	12	17	=
Standard	9	11	=
FANS AND BLOWERS	20	36	▼
FRACTIONAL HP MOTORS	17	22	=
INDUCTIVE COMPONENTS			
Coil	10	15	=
Solenoid	9	13	=
Transformer, power	11	14	up
Transformer, other	14	17	=
INTERCONNECTION COMPONENTS			
Back panel	8	14	=
Flat cable	12	26	up
Multipin circular high-density	25	42	=
Multipin circular standard	20	38	=
Packaging panel	6	8	=
PC, one-piece	8	13	=
PC, two-piece	8	18	=
Rack and panel	15	20	up
RF coaxial	13	30	=
Socket	7	10	=
PRINTED CIRCUITS			
Double-sided	9	13	=
Flexible	10	19	=
Laminates	12	26	=
Multilayer	9	13	=

PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
RELAYS AND TIMERS			
Single-sided	7	14	=
RELAYS AND TIMERS			
Crystal can	13	25	=
General purpose	7	13	=
Miniature (TO-5, square)	20	40	up
Reed, dry	9	13	=
Reed, mercury-wetted	11	16	=
Solid state	5	10	=
Telephone	10	16	=
Time delay and timer	14	18	=
RESISTORS, FIXED			
Carbon film	17	22	=
Composition	14	20	=
Metal film	12	17	up
Network	16	23	up
Wirewound	18	25	=
RESISTORS, VARIABLE			
Pot, nonprecision WW	12	20	=
Pot, precision WW	7	13	=
Pot, nonprecision comp.	11	19	=
Pot, precision comp.	9	15	=
Trimmer, WW	10	16	=
Trimmer, comp.	9	19	=
SWITCHES AND KEYBOARDS			
Circuit breaker	16	24	up
Dual in-line	9	12	=
Keyboard and keyswitch	8	13	=
Lighted pushbutton	12	18	up
Pushbutton	7	17	=
Rotary	9	14	=
Snap action	5	8	=
Thumbwheel	6	11	=
Toggle	7	16	=
TRANSDUCERS			
Pressure	7	14	=
Temperature	5	10	=
WIRE AND CABLE			
Coaxial cable	10	18	up
Flat and ribbon cable	6	9	=
Hookup wire	6	12	=
Multiconductor cable	8	13	=

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



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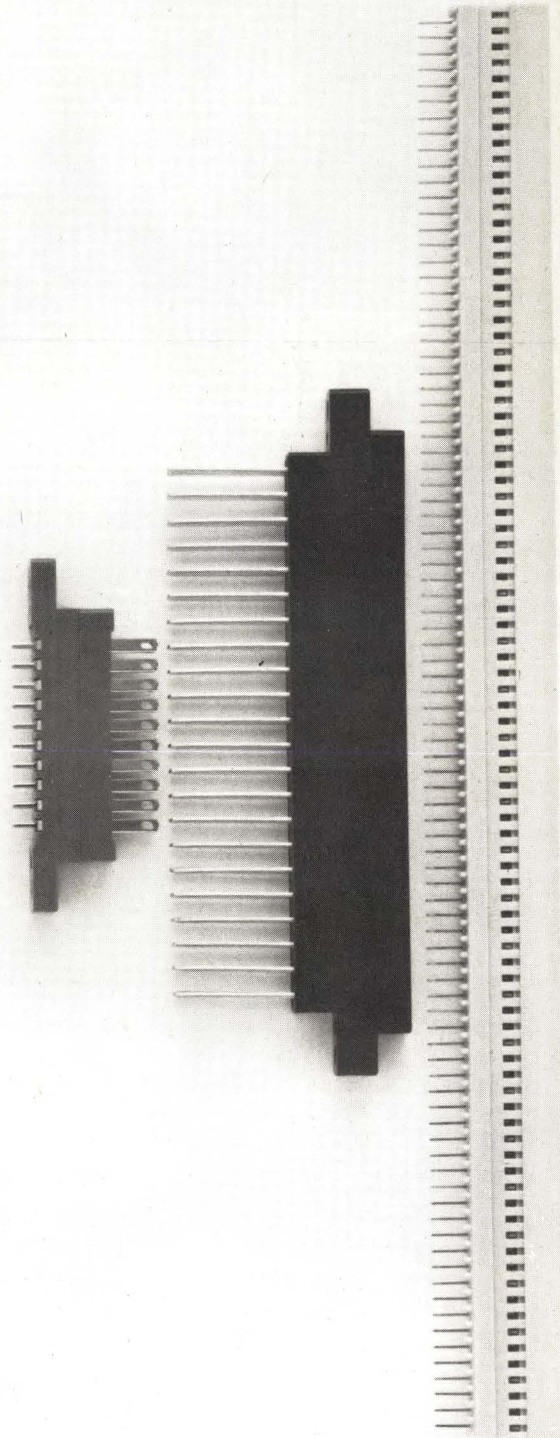

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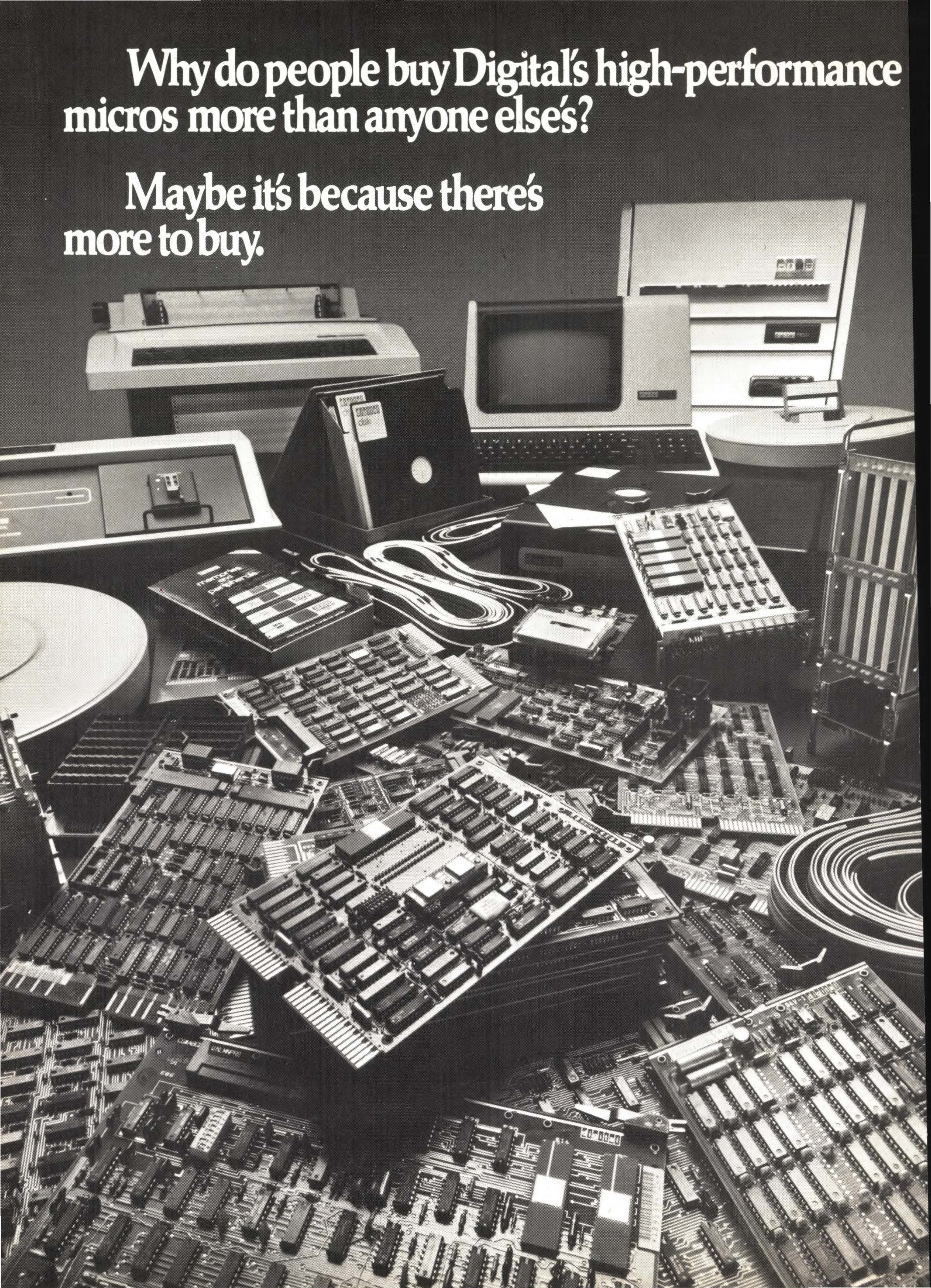
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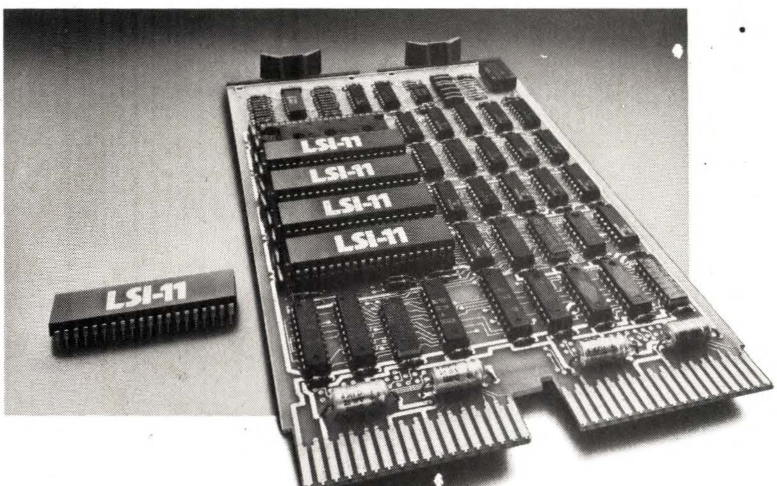

It took the minicomputer company to make micros this easy.

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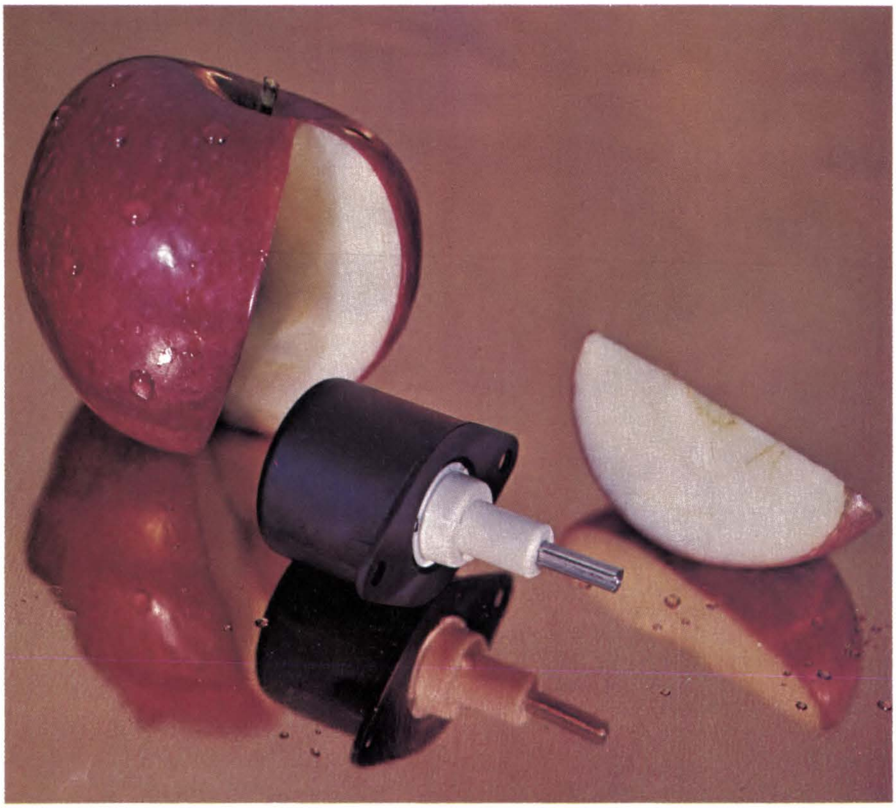
Technology News

Incremental-motion-control developments keep in step with user requirements

Rick Nelson, Associate Editor

Manufacturers of stepping motors and controllers are providing an increasing array of choices to help you meet your incremental-motion-control requirements. While thrusts toward higher torque and improved resolution head these firms' development efforts, designs for specific applications also yield an array of innovative problem-solving devices.

Units now offered include precise linear positioners and motors constructed to limit magnetic interference; manufacturers are willing to customize when standard products can't provide the features you need. The choice among controllers is similarly wide, ranging from 1-chip pulse-to-step converters to complete preset indexing systems.



The apple of its designer's eye, *this stepping-motor offspring provides precise linear positioning in valve-control applications. Termed digital linear actuators, a series of these devices, offered by Airpax/North American Philips Controls, provides linear forces to 19 lbs and resolutions to 0.001 in./step.*

Motors offer variety

Motor innovations fall into two classes. On the one hand, packaging additions such as lead screws, clutches, mounting provisions and magnetic shielding ease customers' interfacing problems. On the other, modifications in motor operation provide increased torque, reduced size and a wider variety of step angles.

Airpax/North American Philips Controls Corp, for example, provides a packaging innovation in its digital linear actuators. Developed for carburetor-valve adjustment in μP-based emission-control systems, each of these automotive-grade devices consists of a stepping motor with an internally threaded rotor and integral lead-screw shaft. The largest version delivers 19 lbs of force over its 3-in. travel and operates at a maximum rate of 0.7 ips with 0.002-in./step resolution. A 75-oz linear-force version provides 0.001-in./step resolution.

Applications requiring prevention of motor reversal upon de-energization can benefit from another packaging concept. A stepper manufactured by Singer Co's Kearfott Div incorporates an integral roller clutch, which permits shaft rotation in only one direction. Developed for use in paper-tractor mechanisms, this unit prevents unwinding of a take-up reel without the need for an external brake or clutch. The variable-reluctance (VR) motor provides a 15° step angle, 480-step/sec max stepping rate and 40-oz-in. holding torque.

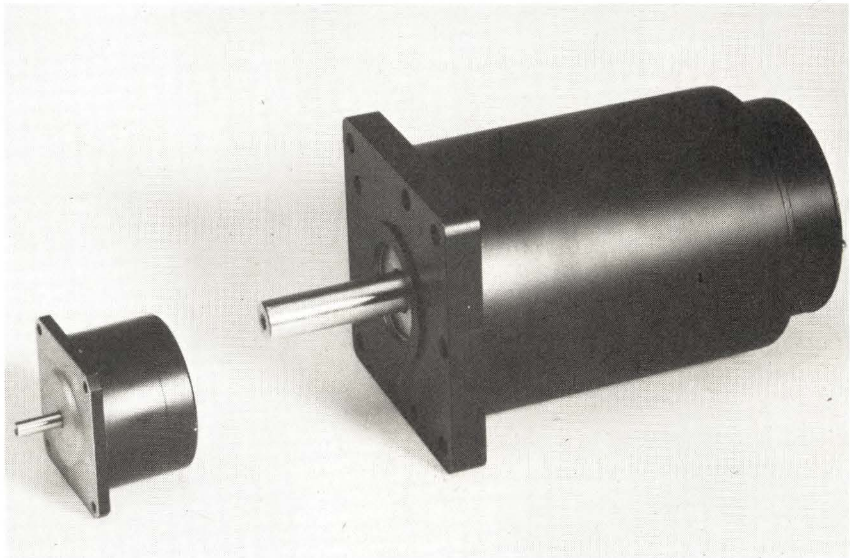
Mounting schemes vary

The variety of available stepper mounting schemes includes a through-the-bulkhead stepper from Singer whose design permits location of the stator (with associated windings and leads) in a benign atmosphere, while the rotor operates in a hostile environment. This 45°-per-step VR motor delivers 2.5 oz-in. of holding torque and can operate at pressures up to 3000 psi.

Other mounting innovations include servo-mount steppers from Sigma Instruments Inc (permitting angular alignment during installation) and square-face motors from Berger-Lahr Corp (permitting high component densities in computer-peripheral applications).

Versions of the Sigma and Berger-Lahr motors also offer (through steel-end-cap construction), magnetic-interference reduc-

A preset indexer *from Superior Electric, Model IK600 drives a 0.8-hp stepper in response to an operator keyboard command. This µP-based controller features adjustable minimum/maximum frequencies and acceleration/deceleration rates for optimizing motor performance.*



A line of 5-phase stepping motors *from Berger-Lahr offers 0.72° step angle for high accuracies, fast response and improved resonance control. The smallest motor in the line (left) delivers 35-oz-in. holding torque from a 2.36-in.-diameter package; the largest (right) measures 4.33 in. in diameter and yields a holding torque of 1100 oz-in.*

tion in addition to their mounting features. For example, the Berger-Lahr unit proves useful in applications involving magnetically sensitive materials; delivering 7.8 oz-in. of holding torque, it limits magnetic-flux density at its surface to 5G, according to the firm, compared with 50G for a functionally identical version with aluminum end caps.

More twist per cubic inch

Airpax/NAPC's 15°-per-step Model L82102 permanent-magnet (PM) motor characterizes a trend toward greater torque in smaller packages. This 1.005-in.-diameter × 0.525-in.-long stepper delivers approximately twice the holding torque (0.8 oz-in.) and up to five times the running torque (0.29 oz-in. at 480 steps/sec) of the company's older 1-in.-diameter×0.4-in.-long Model K82102.

Step-angle selection in today's stepping motors is more diverse; this increased capability serves a wide range of applications:

- Berger-Lahr's 0.72°-per-step, 5-phase PM motors provide high accuracies (±0.05° noncumulative), resonance control and fast settling times in high-speed printers and phototypesetting equipment. And the firm's 3.6°-per-step square-face motors provide positioning for 100-character daisy-wheel printers.
- Litton Systems' Clifton Precision Div 1.875°-per-step motors operate 96-character daisy wheels at 2 steps/character for improved accuracy (±5% per step noncumulative).
- Sigma's 1.8°-per-step servo-mount motors (also available with flange mounts) provide 1.8° step angles in 2.2-in.-diameter×1.4-in.-long packages, rivaling the compactness of large-angle (typically 7.5 to 15°) steppers. With these devices, Sigma aims at meeting disc-drive equipment's requirements for compact motors with small step angles as data densities increase.
- TRW/Globe Motors' 1.8° steppers serve uses in computer-peripheral, automotive and medical equipment. And Sigma's 2.5° steppers and Airpax/NAPC's 7.5, 15 and 18° motors find use in similar markets.

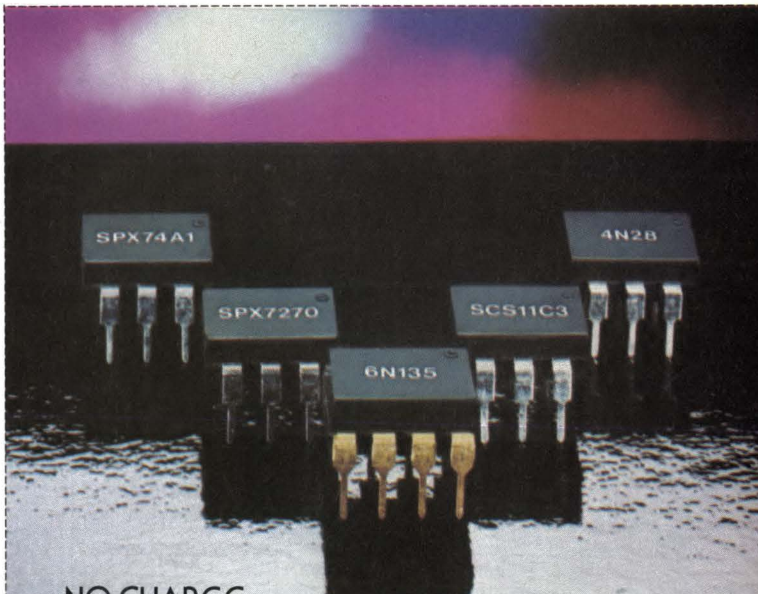
Flexibility highlights control

The controllers that drive these motors also exhibit innovative design advances.

Stepper control involves the generation of appropriate stepping-motor-format excitation in response to a command indicating the number of steps to be taken. Commands can be pulse trains, digital words or operator keyboard entries, and a controller can buffer the motor from a command by providing preset speeds and acceleration/deceleration rates. During winding energizing, the controller must limit phase currents by means of series resistances or a chopping scheme.

For users applying pulse-train inputs, the Airpax/NAPC Model SAA 1027 16-pin-DIP driver provides pulse-to-step conversion with 18V, 375-mA/phase max excitation. A pc-board version

THE FIVE BEST WAYS TO ISOLATE A PROBLEM.



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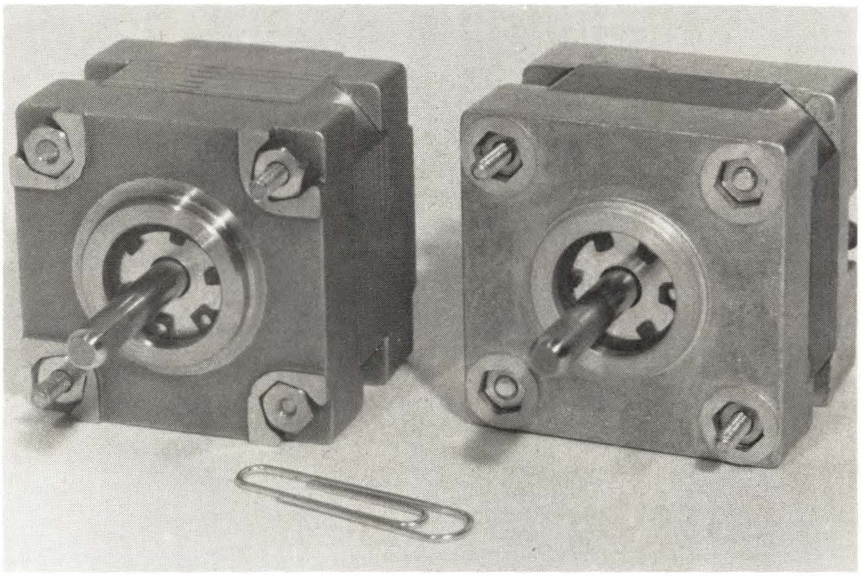
Technology News



These motors look the same and are functionally identical, *but their manufacturer claims that the steel end caps on one of them provide a 10:1 reduction in magnetic-flux density at the motor surface compared with the aluminum-end-cap unit. Both 3.6° Berger-Lahr steppers deliver 7.8 oz-in. of holding torque.*

increases output capability to 40V, 2A/phase; series resistance provides current limiting.

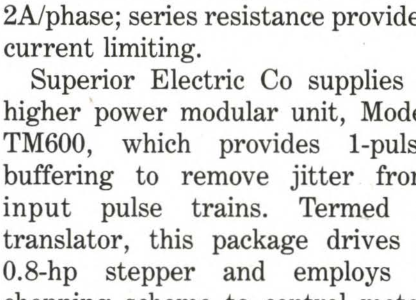
Superior Electric Co supplies a higher power modular unit, Model TM600, which provides 1-pulse buffering to remove jitter from input pulse trains. Termed a translator, this package drives a 0.8-hp stepper and employs a chopping scheme to control motor current.

Adjustable pulse rates

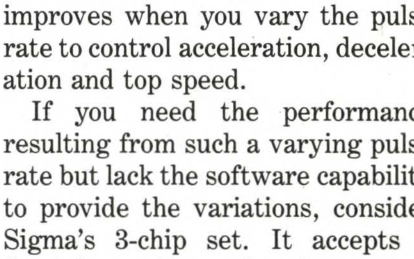
If the SAA 1027 driver or TM600 translator receives a fixed-frequency pulse train, the pulse rate must be sufficiently slow to permit the motor, with associated load friction and inertia, to start without error (loss of a step). Performance improves when you vary the pulse rate to control acceleration, deceleration and top speed.

If you need the performance resulting from such a varying pulse rate but lack the software capability to provide the variations, consider Sigma's 3-chip set. It accepts a fixed-frequency pulse input and generates a stepping-motor-format output with potentiometer-adjustable minimum/maximum frequencies and ramp rates to rotate the motor the required number of steps.

Two of the chips accept a fixed-frequency pulse burst and generate the same number of pulses, spaced for optimum motor



Through-the-bulkhead mounting capability *permits mounting this Singer stepper's rotor in a hostile environment, while the motor's stator, with associated wiring, remains in a clean atmosphere.*



Suited to paper-tractor mechanisms, *this Singer stepper incorporates an integral roller clutch to prevent motor reversal. The stepper features a 15° step angle, 40-oz-in. holding torque and a maximum stepping rate of 480 steps/sec.*

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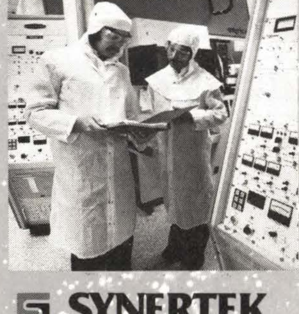

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Technology News

performance. The third decodes these pulses into a selectable stepping-motor format. You must add external phase drivers, however, because the CMOS decoder chip only provides logic-level outputs.

Another control alternative, preset indexers accept a digital word rather than a pulse train and then provide the appropriate motor excitation. For example, a 6800-μP-based Superior Electric modular unit accepts a serial BCD input and provides motor excitation (for 0.8-hp steppers) based on potentiometer-adjustable ramp rates and frequencies. Another version accepts operator pushbutton inputs rather than a BCD word; both types provide electronic damping for resonance control.

Take a very small step

As mechanical costs rise and electronics costs fall, manufacturers see an increasingly important role for microstepping, a control method for subdividing a motor's step angle. And although this method poses potential application problems (stemming from differences in holding torque and accuracy between successive step positions), the technique's benefits include gear elimination and improved resonance control.

One such microstepping control unit, manufactured by Muirhead Vactric, provides 12,800 steps/revolution when employed with a Berger-Lahr 5-phase motor, which delivers up to 1000 oz-in. of running torque.

Rare-earth magnets

In the future, stepper manufacturers expect further emphasis on improved resolution and resonance control, achieved through such microstepping schemes or through step-angle reduction. And they see more torque in smaller packages, achieved through the use of rare-earth magnetic materials. For example, based on work performed in satellite-solar-panel positioning applications, IMC Magnetics plans a general introduction of samarium-cobalt PM steppers.

Also expected is an extension of stepping-motor horsepower levels. Currently, the cost effectiveness of stepper/controller systems ends near the 1-hp mark—Superior Electric cuts off its line at 0.8 hp, while Sigma extends its offerings to 1.33 hp. But future advances should generate increased competition between stepper and dc-servo systems in machine-tool and process-control applications above 1 hp. **EDN**

For more information...

For more information on the stepping motors and controllers described in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Airpax/North American Philips Controls Corp
Cheshire Industrial Park
Cheshire, CT 06410
(203) 272-0301
Circle No 430

Berger-Lahr Corp
Peterborough Rd
Jaffrey, NH 03452
(603) 532-7701
Circle No 431

IMC Magnetics Corp
6058 Walker Ave
Maywood, CA 90270
(213) 583-4785
Circle No 432

Litton Systems Inc, Clifton Precision Div
Marple at Broadway
Clifton Hts, PA 19018
(215) 622-1000
Circle No 433

Muirhead Vactric
1101 Bristol Rd
Mountainside, NJ 07092
(201) 233-6010
Circle No 434

Sigma Instruments Inc
170 Pearl St
Braintree, MA 02184
(617) 843-5000
Circle No 435

Singer Co, Kearfott Div
1150 McBride Ave
Little Falls, NJ 07424
(201) 256-4000
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Superior Electric Co
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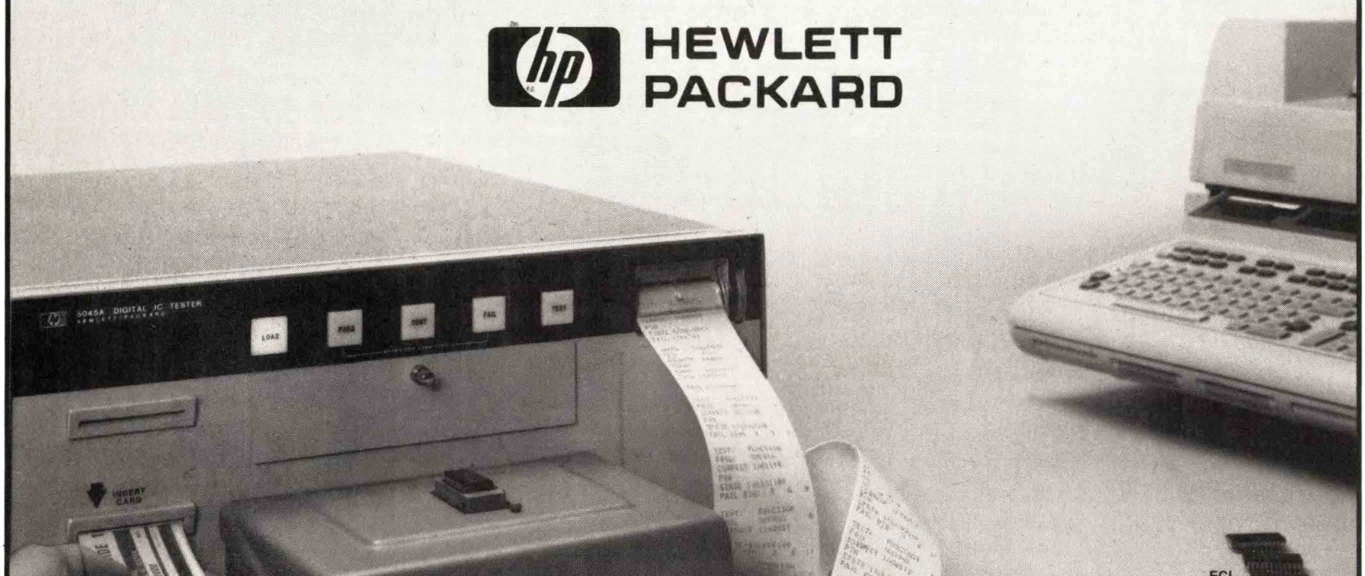

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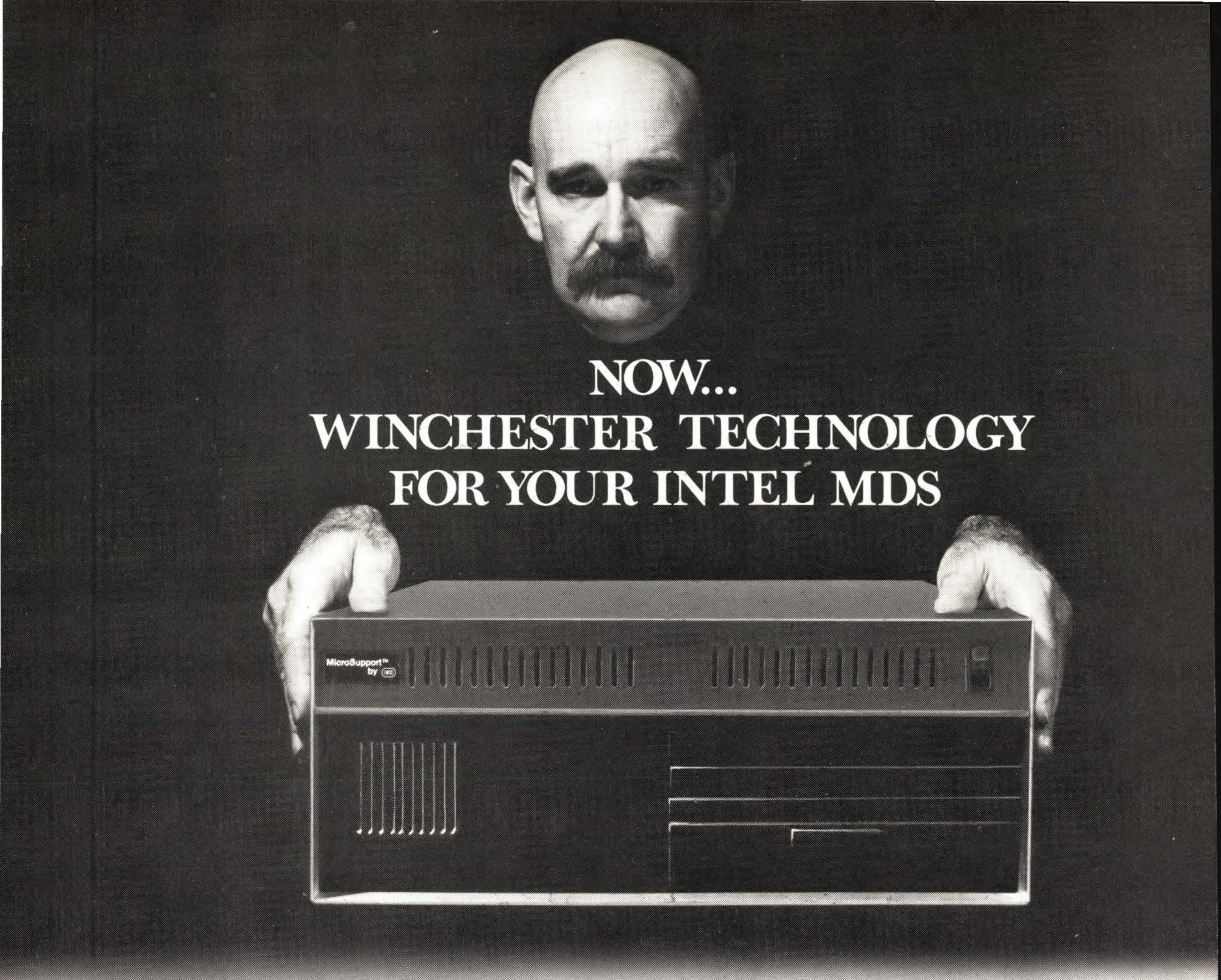

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Cost and performance improvements spark new interest in tape storage

Carl Warren, Western Editor

In several key data-processing and data-acquisition application areas, magnetic-tape recording is experiencing a renaissance. For example, ½-in. tape has carved out a new niche as backup for Winchester drives in the 10M- to 30M-byte capacity range (EDN, February 5, pg 104). And ¼- and ⅛-in. tape, in the form of Philips-type cassettes and 3M-type cartridges, is finding use in a variety of applications ranging from backup to data logging (EDN, February 20, 1978, pg 40).

Unlike floppy discs, tape exhibits reliability attributes that make it easy to use in less-than-ideal environments. But in addition to this functional reliability, tape offers several other important features that add value to a data-processing operation:

- Effective backup capabilities for primary storage systems
- Low-cost off-line storage of both passive (archival) and active (current) data
- Easy storage and interchangeability (interchangeability applies primarily to ½-in. 7- and 9-track tapes recorded in IBM format; cassettes and cartridges are for the most part not system interchangeable, being designed more for dedicated operations such as small-system backup or data acquisition)
- A variety of product configurations, ranging from large vacuum-column drives to small Philips minicassette systems
- Fast data-transfer rates in streaming configurations.

These features might themselves appear to provide unchallengeable advantages to tape in some applications, but even more effective advances in memory and storage technology could be on the way in the next 6 yrs, says Control Data's manager of OEM market requirements, Ron Benton. Such advances will come not only in solid-state devices, but also in moving-head discs and in tape-subsystem design.

A sure trend is toward more cost-effective systems. **Fig 1** shows

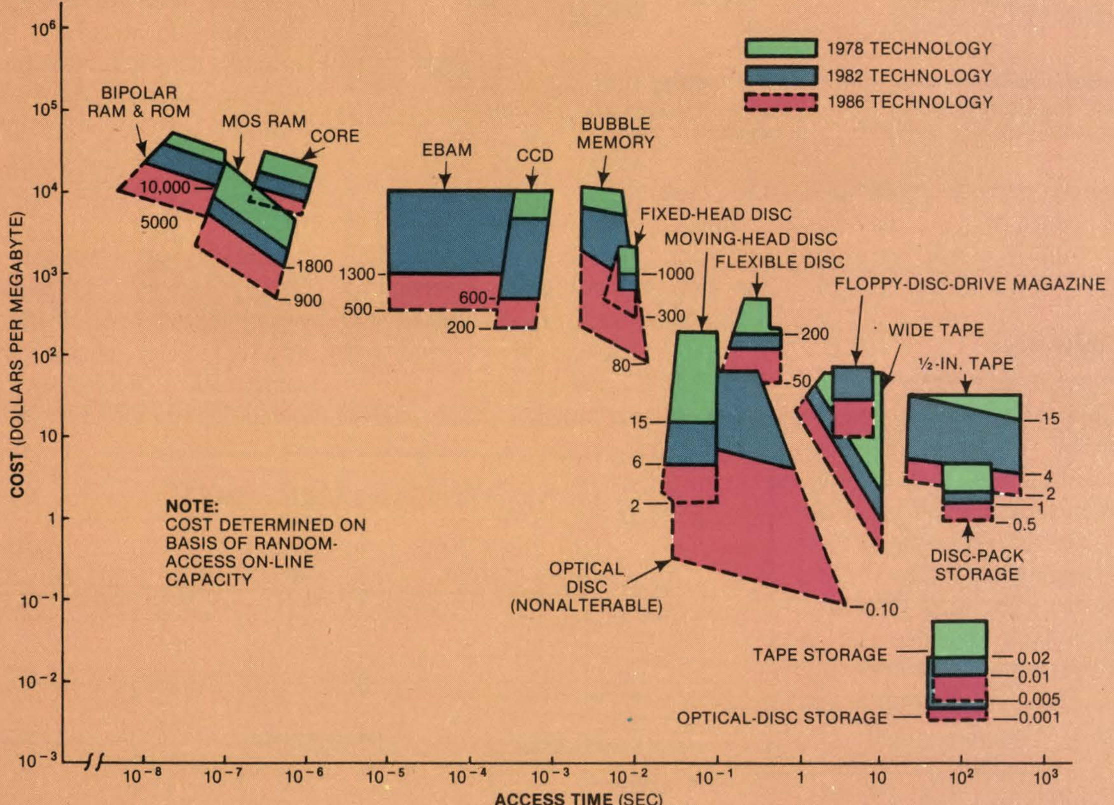
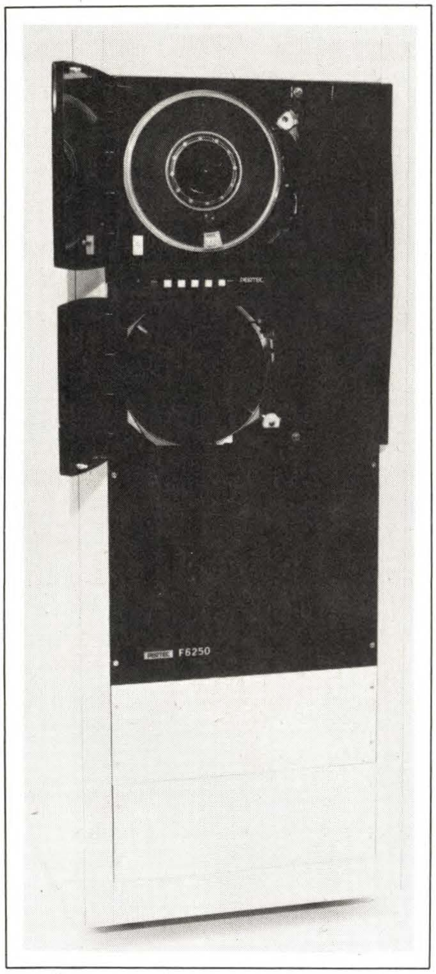


Fig 1—Computer storage technologies *will continue to include tape systems in the 1980s. (Courtesy Control Data Corp)*



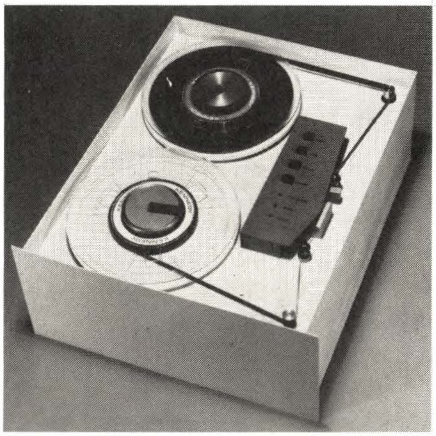
For minicomputer backup, *Pertec's F6250 transport features a bit error rate of 1 in 10^{10} and extensive error-recovery capability.*

this projected growth; note that tape will continue to play an important role in the storage hierarchy.

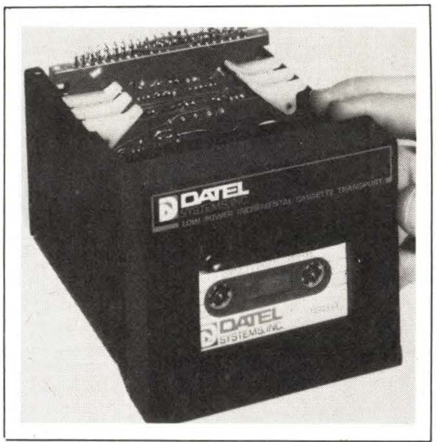
Streamer advances

In large-scale tape systems, the major advances have centered on the adoption of streaming or on-the-fly technology for backup. This technique, developed by IBM, moves tape at very high speeds (100 ips) to capture data being "streamed" from the host system.

The important feature of a streaming system is that once the data has started to "dump," the dump isn't stopped until the transfer is complete. (In most conventional drives, transfer occurs in a start/stop mode.) Thus, with a streaming tape drive, you can back up on-line data in short periods of



Employing µP control, *Kennedy's Model 6809 Data Streamer transport eliminates conventional tape-tensioning elements.*



A complete data-logging system, *Datel's cassette-based unit can record up to 16 analog channels.*

time **(table).**

Most streaming systems utilize IBM- and ANSI-compatible 1600-cpi phase-encoding (PE) recording techniques to ensure data integrity. Exotic error-correction methods provide bit error rates of 1 in 10^{10}.

Several companies have added streaming systems to their product lines. For example, Kennedy's Model 6809 Data Streamer employs µP control to eliminate the costly mechanical or vacuum-column tape-tensioning elements, drive capstan and analog circuit devices usually associated with tape servo mechanisms. Its takeup and supply-reel motors handle tape-speed and tension control.

The 6809 utilizes an encoder mounted on an idler roller to monitor tape movement and provides source signals describing various tape positions. Kennedy has incorporated firmware algorithms in the system to allow the µP to calculate the radii of the tape on both reels and thus supply the servo-motor signals necessary to maintain constant tape tension at both 100 and 12.5 ips (with a speed variation of ±5%). All timing is referenced to a quartz-crystal-controlled oscillator, and the unit rewinds at 200 ips.

The µP also handles error detection and correction. When it discovers an error, it ramps the tape to a stop and reverses it at 12.5 ips to a position from which it can ramp up to 100 ips just prior to the block in which the error occurred. That block can then be rewritten at 100 ips.

Embodying the same streaming concept but configured with a new twist, Cipher Data Products' F880X Microstreamer is also IBM/ANSI compatible, achieving recording speeds of 100 ips in the PE mode. It

TYPICAL BACKUP TIMES

	TIME FOR TOTAL CAPACITY (MIN)	TIME TO BACK UP 10M BYTES (MIN)	TIME TO BACK UP 30M BYTES (MIN)
1M-BYTE FLOPPY	1	20	60
17.3M-BYTE CARTRIDGE	12	7	23
46M-BYTE STREAMING TAPE	4.8	1	3

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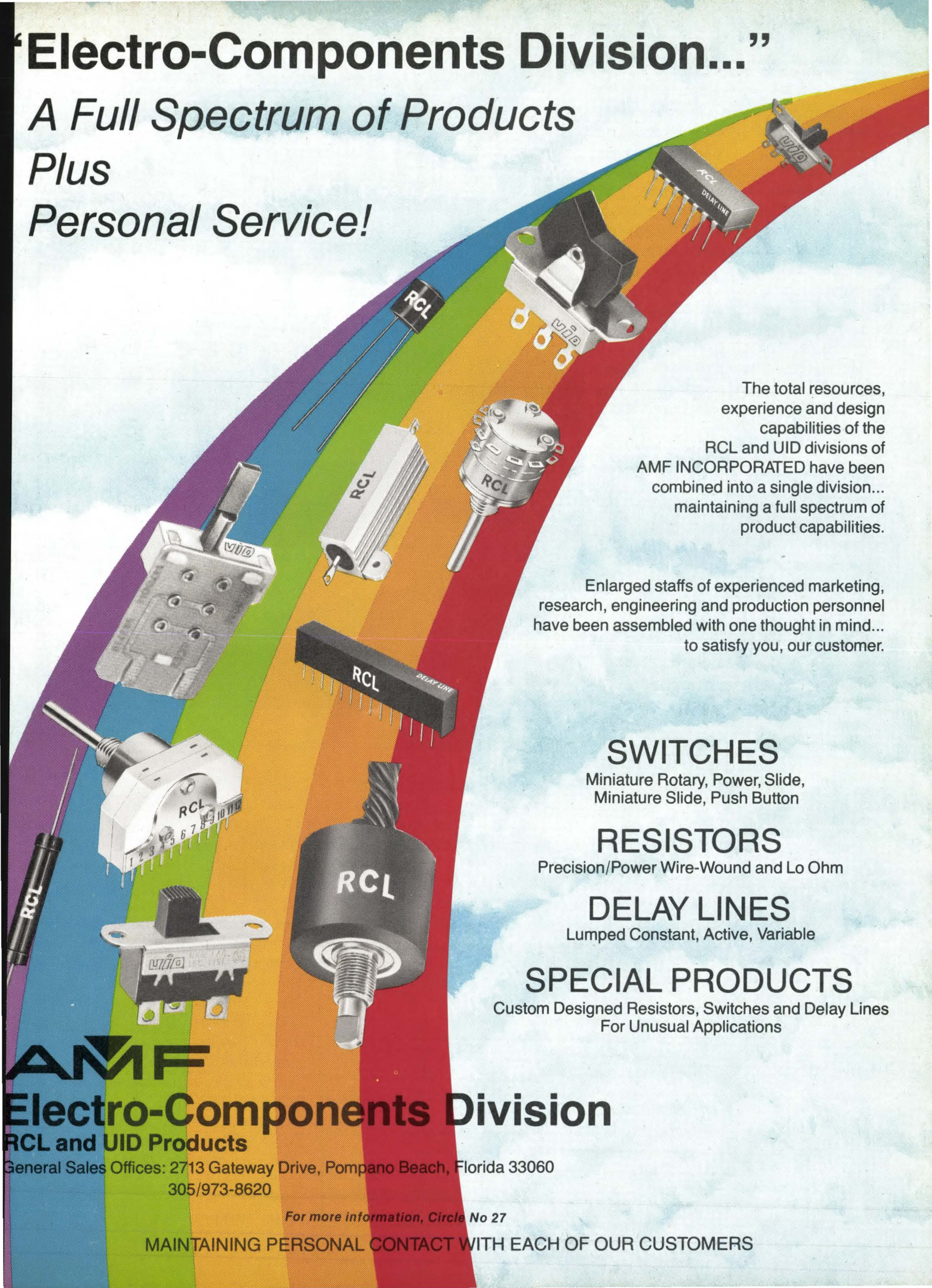

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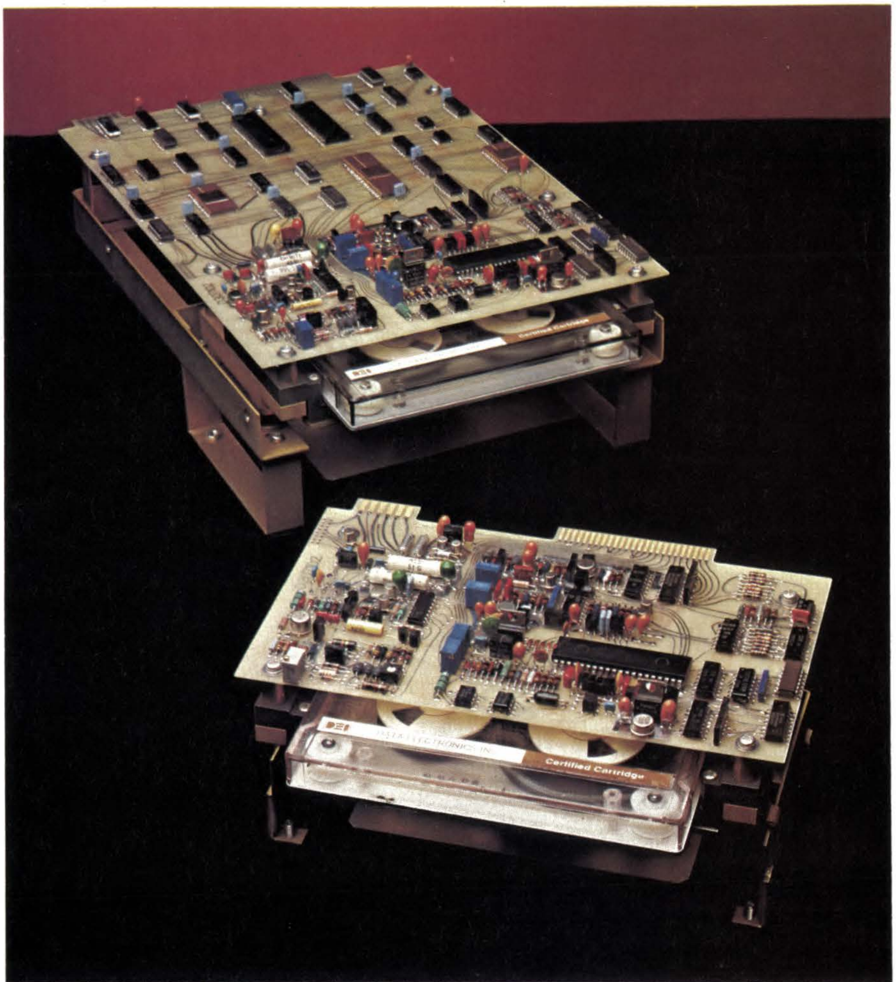
accommodates up to a 10.5-in. reel and features a fully automatic front-loading mechanism (almost like that of a cartridge tape drive) that reduces tape wear and handling. The F880X also employs μP (Z80) control to handle sensing functions and tape tensioning.

Carrying the streaming concept even further, Data Electronics Inc has developed a streaming drive that records data on ¼-in. ANSI/ECMA 3M-type cartridges. Termed the Streamer, this transport is designed to back up Winchester drives storing 10M to 20M bytes.

The firm's approach provides performance comparable to that of ½-in. units like Kennedy's and Cipher's. Recording bidirectionally in a serpentine track arrangement **(Fig 2)**, the Streamer employs a 4-track head and operates at 90 ips with a transfer rate of 675k bps. By means of a proprietary error-detection scheme, it reportedly achieves a bit error rate of 1 in 10^{12}.

3M Co also offers a cartridge drive aimed at backup applications. Model HCD-75 employs serpentine coding and achieves an average data-transfer rate of 20k bytes/sec in its Streaming mode. It costs $2150 with controller, $1050 without.



Aimed at disc-backup applications, *this ¼-in. cartridge drive from Data Electronics Inc comes in two versions. The Streamer model (top) is supplied with a formatter/controller, while the stripped-down Streaker is a low-cost configuration.*

Tension-arm developments

Although streaming technology's the current rage, conventional vacuum-column or tension-arm drives also find use in storage and backup applications. As noted, these drives operate in a start/stop blocked mode, utilizing either group-coded-recording (GCR), nonreturn-to-zero-inverted (NRZI) or PE techniques.

These ½-in. 7- or 9-track transports are specially designed to provide backup capability for minicomputers; OEM drive and electronics costs range from $6500 to $9000—a reasonable price considering the units' capabilities. Recording densities of the IBM/ANSI-compatible drives range from 800 to 6250 bpi, depending on the recording mode employed.

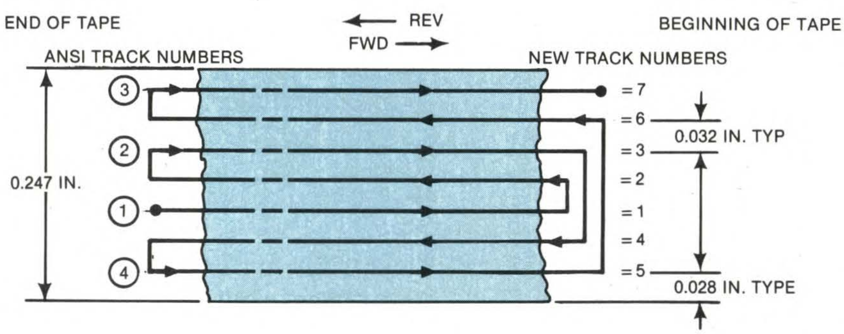
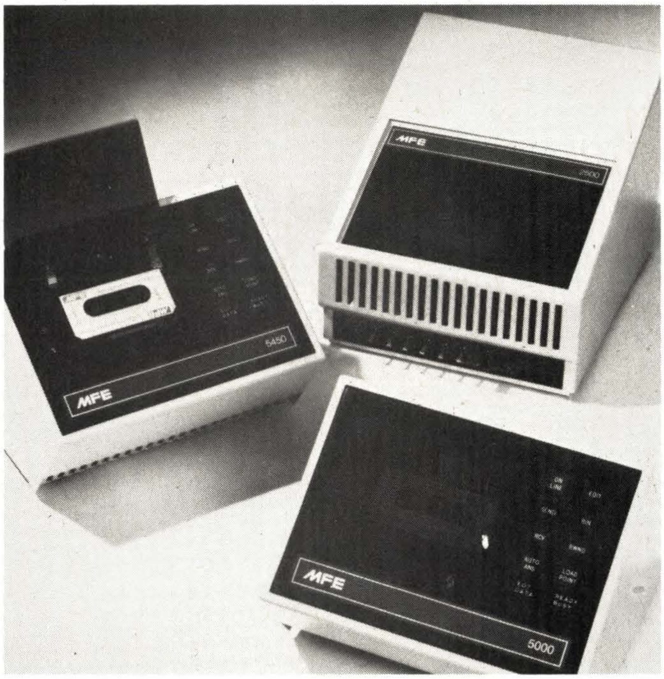


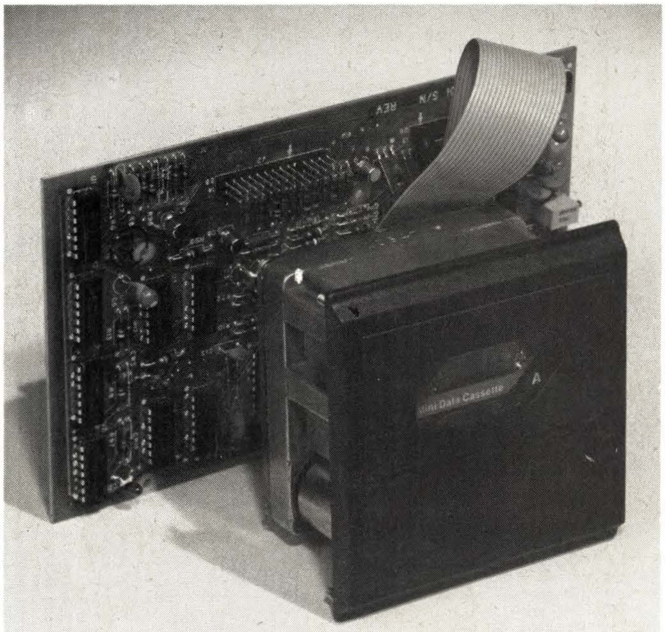
Fig 2—A serpentine track arrangement *characterizes Data Electronics' Streamer ¼-in. cartridge tape drive.*

Among the firms offering tape transports in this category is Storage Technology Corp, whose Model 1921 GCR/PE transport is a lower cost version of its popular 1950 Series units. The IBM-compatible 1921 sells for $6535 (100) and features recording densities of 1600 and 6250 bpi.

Pertec, which has developed many of the standards associated with tape systems, offers the T1000 Series for the minicomputer market. This 9-track unit costs $8245 (100) and features a vacuum



Microprocessor control and variable file lengths *highlight MFE Corp's line of cassette-based terminals.*



Utilizing Philips-type minicassettes, *Raymond Engineering's Mini Raycorder measures 3×3×1.8 in. and provides an unformatted storage capacity of 960k bits recorded at 800 bpi.*

capstan, optional self testing and extensive error correction. Bit error rates stand at 1 in 10^{10}.

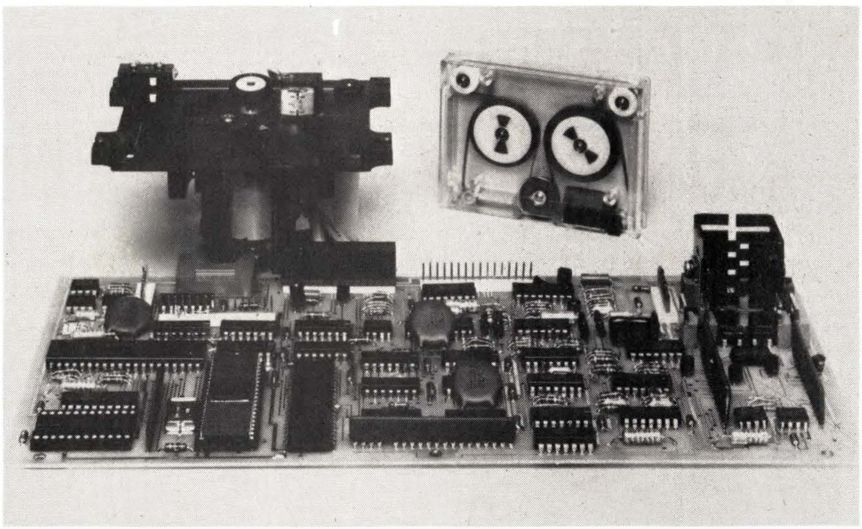
Another minicomputer drive is Ampex's TM 100+ tape transport system, which utilizes a buffer-arm assembly to permit control of the reel drives and ensure a nominal tape tension of 8 oz. It also incorporates a single-capstan motor with an integral tachometer that accelerates or decelerates the capstan, maintains it at a constant speed or stops it.

Finally, the Mod 10 ½-in. 9-track transport from Perkin Elmer employs a 10.5-in. reel and rewinds at 150 ips. It also comes in a 7-track version, is IBM compatible and operates in both the NRZI and PE modes.

More than backup

Tape technology today serves more than minicomputer and μC backup applications, though. Some tape units aim primarily at providing low-cost program loading and data acquisition. Datel, Braemar, Raymond Engineering and Memodyne, among others, offer such low-cost tape units.

The primary advance in this digital-recorder field is one of lowered cost and higher capacity: Drives are available for less than $100 and store as much as 5.76M bits. And although they don't compete with the more expensive



A low-cost component-level data-storage system, *DECtape II provides auxiliary data storage of up to 262,144 bytes/cartridge.*

A 7- or 9-track tension-arm unit, *Ampex's TM-E Mod 5 records in NRZI or PE modes and reads bidirectionally.*

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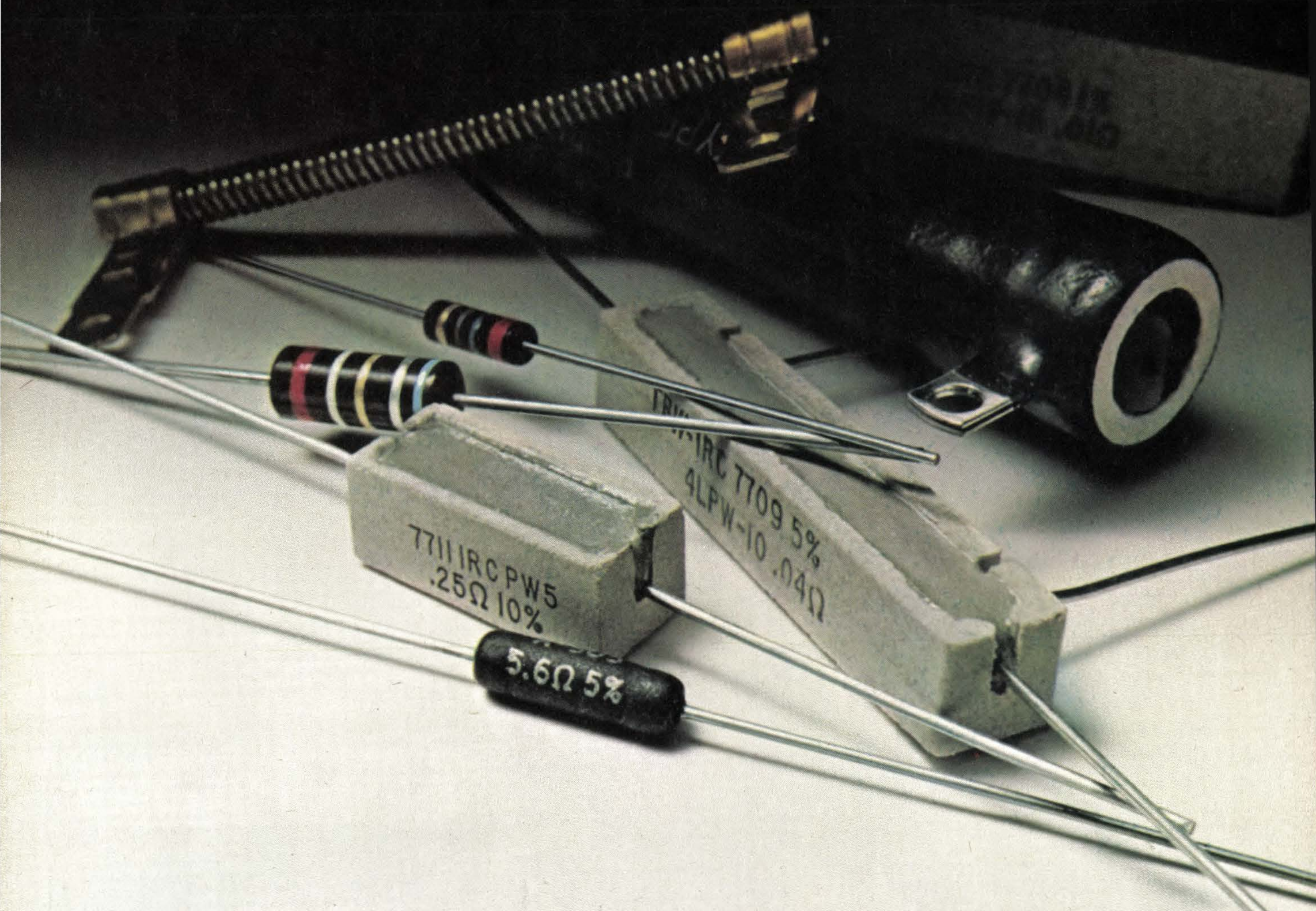

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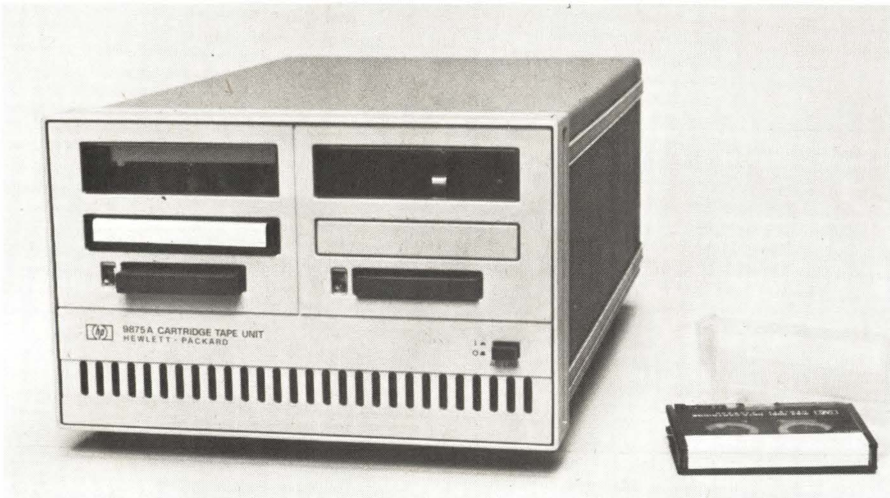
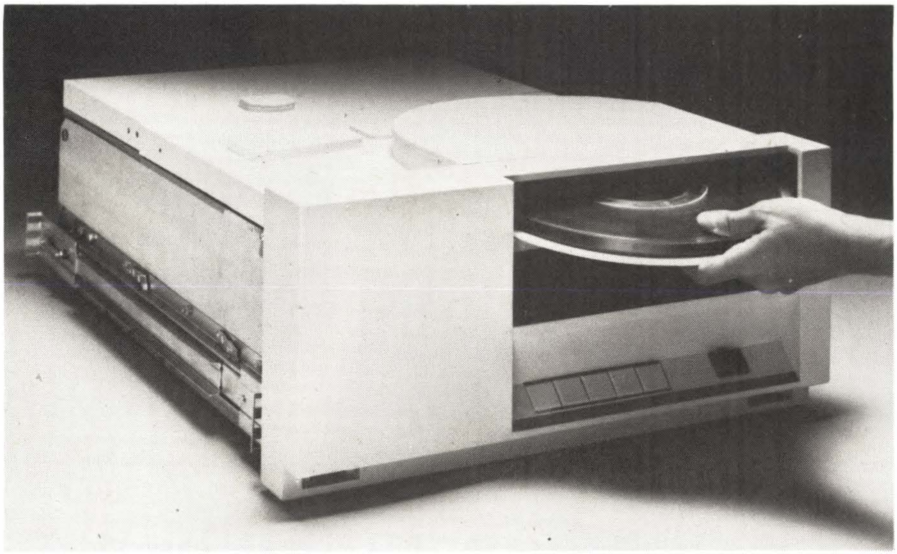


Designed for both primary and secondary storage, *Hewlett-Packard's 9875A cartridge tape unit provides file- and record-type structures.*



Operating at 100 ips in Streaming mode, *Cipher Data Products' F880X Microstreamer features a front-loading mechanism.*

backup units, their manufacturers tout their almost indestructible program-loading and data-acquisition capabilities as ideal for µC systems.

These cartridge and cassette digital recorders are designed to solve problems that for various reasons—usually cost—other recording systems can't. Because of their fairly straightforward design and the low cost of the medium, the drives are versatile enough to suit a variety of applications, including:

- Paper-tape replacement in both minicomputer and µC systems
- Data logging in such diverse applications as weather stations and POS terminals
- Peripheral storage in terminals interfacing to a host via a telecommunications link
- Software distribution in some computer systems (not to be confused with the IBM/ANSI compatibility that provides data interchange in ½-in. tape systems).

Among the manufacturers serving the cassette and cartridge recorder field is Innovative Data Technology (formerly Tandberg Data Inc), which offers a ¼-in. 3M cartridge drive designated Model 3000. Rack mountable or usable as a table-top unit, it has a built-in formatter and power supply and

News

packs 1600 bpi in PE mode, sporting a 48k-bps data rate at 30 ips. The drive's maximum unformatted capacity with a 450-ft cartridge equals 34M bits—approximately 960k bytes/track.

Model 3000 interfaces easily to a host via an RS-232 or IEEE-488 bus. You can use it to generate IBM-compatible tapes for use on a larger system, and it features built-in diagnostics.

Also in the cartridge-tape-drive business, Digital Equipment Corp offers the TU58 drive, which provides an asynchronous full-duplex serial output and connects to either of the interfaces DEC offers for the LSI-11 μC. The TU58 incorporates a built-in μP to handle tape motion and assist the host operating system.

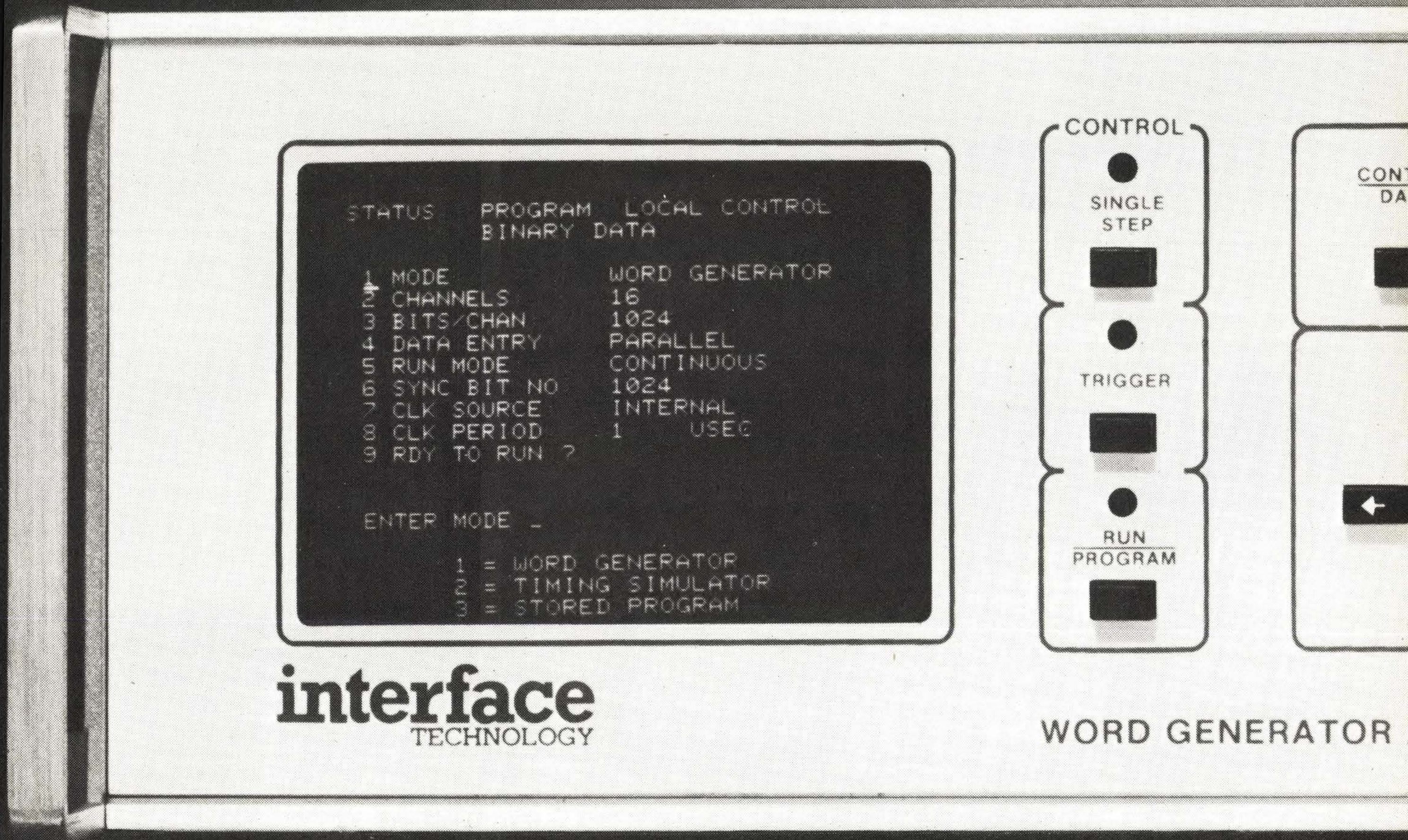
Hewlett-Packard also offers a cartridge drive with some especially noteworthy features. The 9875A cartridge-tape unit, designed to provide mass storage for HP's 9800 Series desktop computers, holds one or two cartridges and features a 225k-byte capacity per cartridge (1600 bpi), a file and record structure and built-in self test.

Braemar's CM600 Mini-Dek cassette drive is inexpensive—it costs less than $100 in OEM quantities. This unit works well in μC systems as a program loader, mass-storage device or data-acquisition unit; it utilizes a certified Philips-type minicassette, recording data through a 1-track head on two tape tracks. Data capacity equals 1.6M bits on a 100-ft tape recorded in 800-bpi PE format.

Aiming at the same applications as Braemar, Raymond Engineering offers both standard ANSI X3.55/56 ¼-in. cartridge drives and minicassette drives, both of which employ NRZ encoding and offer bit error rates of 1 in 10^8—the limiting value with today's drive technology and media, according to the firm.

Designed to meet instrumentation needs, Datel's micropower digital cassette recorders feature the ability to work continuously in

The last word in word generators.



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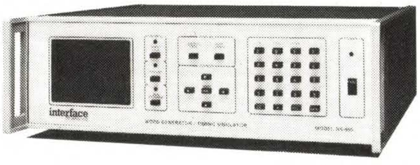

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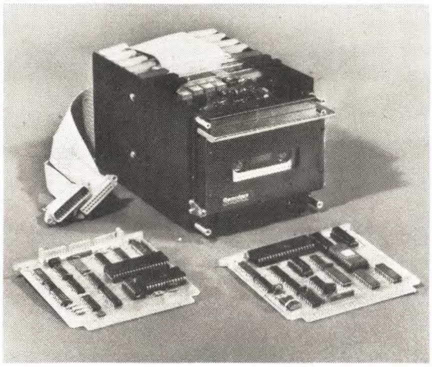

For use in storage, acquisition, buffering and communications applications, *Memodyne's M-80 Cassette Computer incorporates a Z80 CPU and measures 5×5×8.5 in.*

unattended remote settings. They record in the firm's 2-track complementary NRZ format, achieving typical bit densities of 615 bpi.

Similar units come from Memodyne Corp, which has defined its market as encompassing data logging, paper-tape replacement and acquisition systems. The firm's units exhibit capacities of 200k bytes at 1000-bpi recording density on a 300-ft Philips cassette; error rates spec at 1 in 10^7.

Within the same family of digital recorders are the μP-based cassette terminals offered by MFE Corp. These units feature an 800-bpi recording density, a 12-ips read/write speed and a typical bit error rate of 1 in 10^8. Their interface to a host CPU is RS-232/CCITT compatible, allowing data rates of 110 baud with an 11-bit code to 2400 baud with a 10-bit code. Additional features include variable-length-file capability, string search and line and character editing functions. The MFE units utilize PE recording and are designed for use in stand-alone data-acquisition applications. They range in price from $835 to $1400 (100).

Finally, Meca and Environmental Technology offer digital recording systems that utilize Triple-I Corp's Phi-Deck cassette drives. Both systems are intelligent and operate under μP control, and both easily interface to a host via RS-232 serial or 8-bit unlatched parallel ports.

An interesting feature of these drives is that they must raise and lower their head mechanisms to read or write data—a source of potential timing problems, which the firms appear to have solved. The drives find use in data logging and mass storage for μC systems. In fact, Meca's unit (the Beta-1) was designed specifically to provide low-cost mass storage for Apple and TRS-80 μCs.

Mixed opinions

The projected future of digital tape systems varies, depending on whom you talk to. In the backup market segment, there are three factions: Those who say GCR is the only way to go, the ones who tout streaming technology in reel-to-reel-type machines, and the cartridge makers, who want to see 3M-type cartridges used in all applications.

Of course, the marketplace will be the final arbiter. Some studies show cartridge tape drives achieving acceptance at the same rate as 10M- and 30M-byte Winchester disc drives. Could cartridge drives be the high fliers of the '80s? **EDN**

For more information....

For more information on the magnetic-tape recording systems described in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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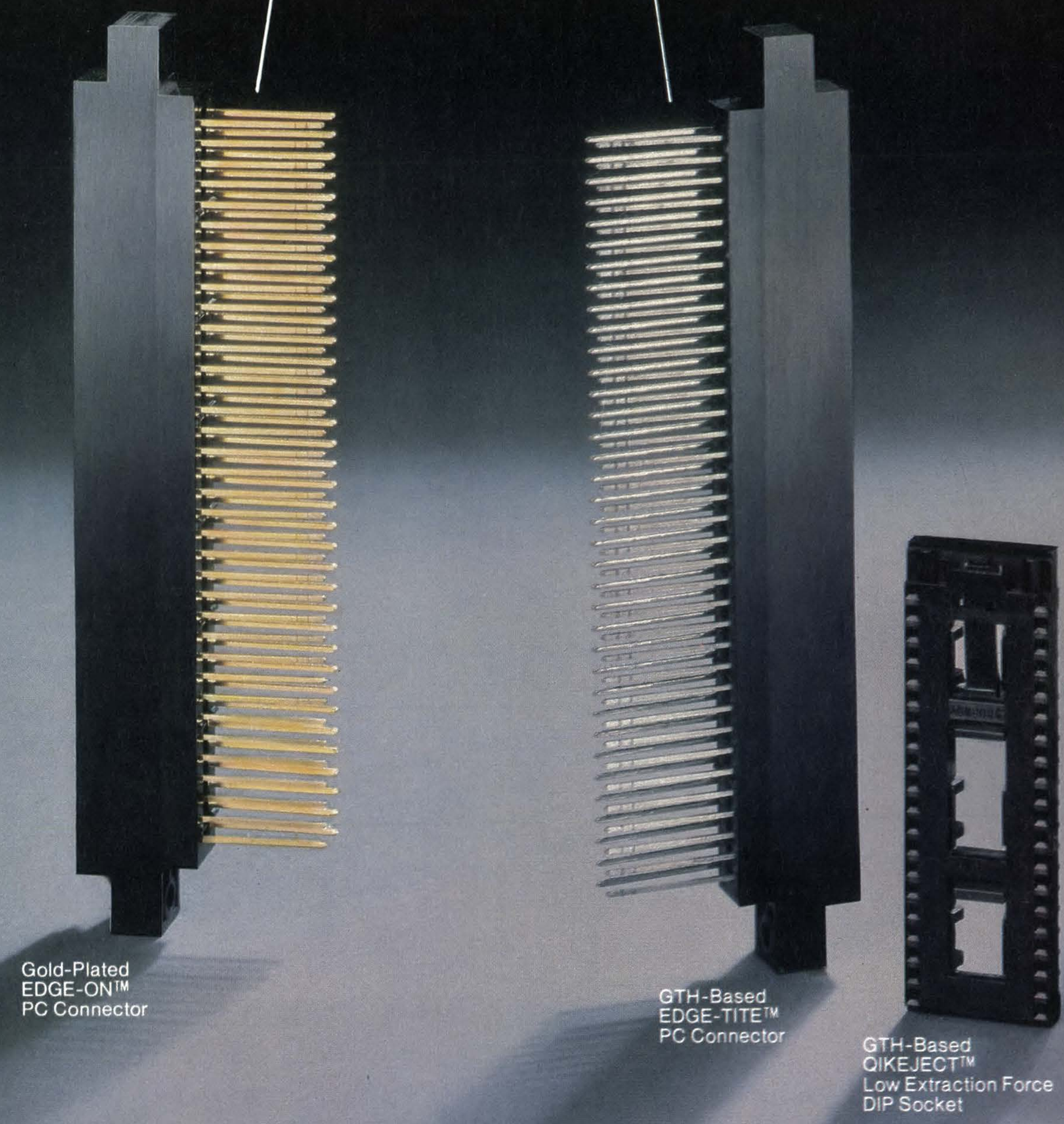

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Materials, methods and growing markets combine to improve RF diodes

George Huffman, Associate Editor

Spurred on by expanding markets in UHF mobile communications, electronically tuned TVs and radio-controlled toys, manufacturers are developing PIN diodes and tuning varactors that provide higher performance than previously available units—and at lower prices.

Considering today's state of the circuit-design art, you might find uses for these devices outside the usual RF application areas. Compare their operating frequencies with those of other, more common devices: monolithic linear op amps providing gain-bandwidth products greater than 1 GHz, 1-chip digital UHF frequency dividers operating at input frequencies up to 1.2 GHz and monolithic IC voltage comparators exhibiting propagation delays shorter than 8 nsec. While the tuning varactors and PIN units discussed in this article represent only a portion of the RF diodes available, they are the device types most likely to serve as control elements in applications such as TV sets, adaptive filters and CB radios.

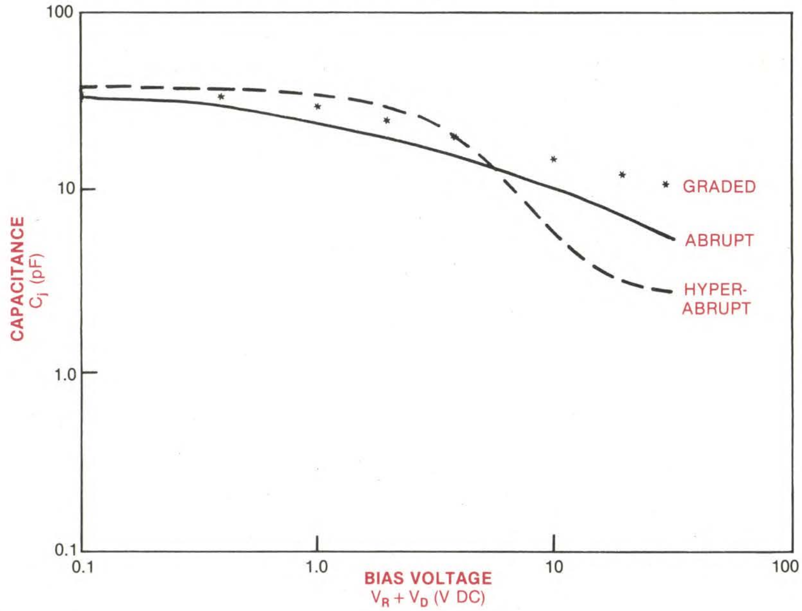

Fig 1—Varactor capacitance/voltage curves *graphically demonstrate the major differences among device types. The lower tuning sensitivity exhibited by the abrupt-junction device suits designs in which relatively large RF signals could generate undesirable distortion products.*

Utilizing a fault

Varactors are semiconductor diodes whose reverse-bias junction capacitance serves a useful purpose. By careful, controlled processing, manufacturers intentionally enhance this otherwise troublesome characteristic, creating a device especially suited for tuning frequency-sensitive networks.

As depicted in **Fig 1,** varactors with differing tuning characteristics have evolved—termed graded, abrupt and hyperabrupt after the apparent impurity profile across their junctions (see **box,** "Varactor junction capacitance"). While all three types perform practical functions, abrupt and hyperabrupt devices most often serve in voltage-tuned applications.

Over a limited voltage range, hyperabrupt varactors offer the highest tuning sensitivity ($\Delta C/\Delta V$) of the three types; some even yield a straight-line frequency characteristic when employed to tune an LC-resonant circuit **(Fig 2).** The drawback to hyperabrupt devices lies in their somewhat lower Q compared with abrupt types. In addition to high Q, abrupt-junction devices offer a much wider range of junction - capacitance / breakdown-voltage combinations than hyper-abrupt parts.

Interchangeability among parts from different manufacturers is another important hyperabrupt-device consideration. You can obtain these varactors from more sources than ever before, but the complex

Varactor junction capacitance

A varactor's junction capacitance, C_j, depends upon two factors: the applied reverse bias voltage V_R and device class (graded, abrupt or hyperabrupt). Thus,

$$C_j = C_{j0}/(1 + V_R/V_D)^n$$

Where C_{j0} equals zero-bias junction capacitance, V_D is junction-barrier voltage (~0.7V for silicon) and n depends upon the device's impurity profile and determines its classification:

n=0.45 to 0.48—abrupt junction
n=0.33—graded
n=f(V_R)—hyperabrupt (n is a function of reverse bias).

nature of the process used to fabricate them might make such interchangeability a problem.

Hyperabrupt junctions are generally formed by ion implantation—a very exacting process still undergoing refinement by manufacturers. In fact, Jerry Hartke, president of KSW Electronics, indicates that the improved performance of his company's devices results from careful attention to all manufacturing steps rather than from any single technological breakthrough.

Another varactor manufacturer, GHZ Devices Inc, intends to introduce a family of grown-junction, hyperabrupt silicon tuning varactors in late spring. The firm's technical director, Dr Walter Niblack, reports that this grown-junction, passivated mesa structure has two advantages: "It yields a higher Q than the planar structure (by a factor of two in many cases) and allows us to offer any capacitance the customer wants." The first series will offer C_{T4}/C_{T20} ratios (total capacitance at 4V compared with total capacitance at 20V) in the 5:1 to 7:1 range.

The GaAs advantage

GHZ is also currently marketing a line of grown-junction, abrupt gallium-arsenide (GaAs) tuning diodes. As in the silicon versions, these parts' grown junction furnishes a very high Q (near theoretical limits)—a value three to four times higher than that of similar silicon devices. In addition to higher Q, this technique yields higher, more uniform breakdown characteristics, which in turn allow higher junction capacitances.

Until recently, virtually all tuning varactors were silicon devices; GaAs-based units were generally employed only when an application demanded their higher Q. This picture is changing because of the increasing supplies of uniform, high-quality gallium arsenide.

Hyperabrupt GaAs tuning varactors now becoming available carry high price tags, but they do provide

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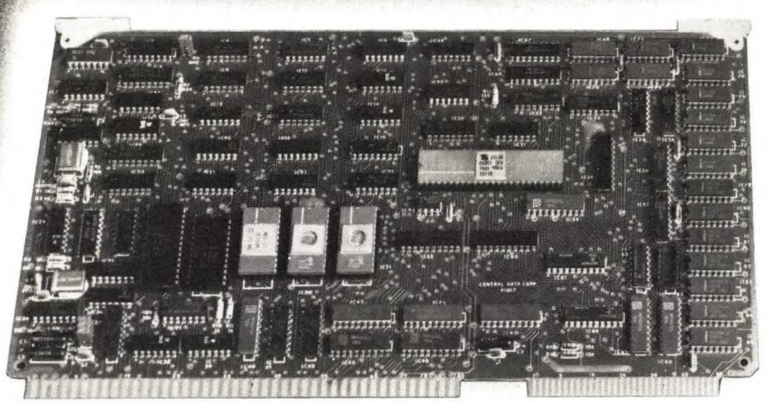

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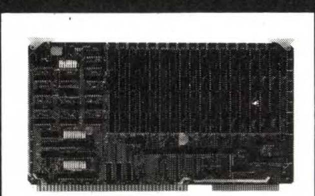
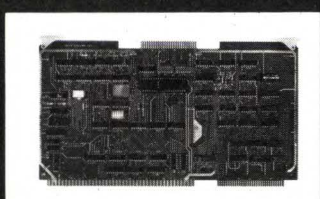
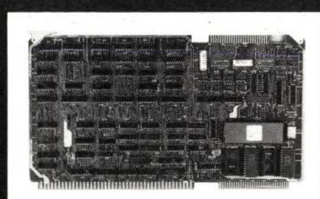


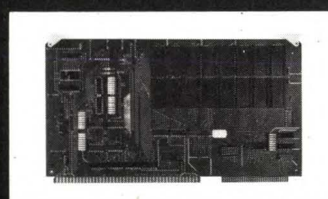
Static Ram Board adds either 16K or 32K of static memory to a Multibus system. 16K—$495. 32K—$880.



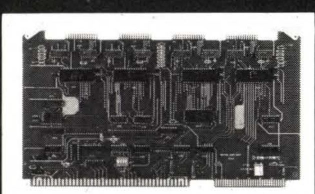
Double Density Floppy Disk Controller adds from one to four double density standard sized floppy disk drives, either single or double-sided. $255.



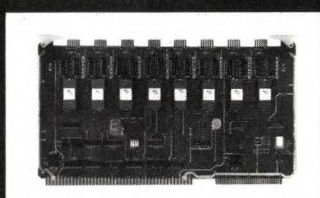
Cartridge Disk Controller Board provides DMA transfers to or from cartridge disk drives with capacities of 10 or 20 Mbytes. $335.



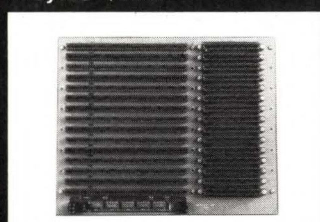
PROM Board allows the user to hook between 1k and 128K of PROM to a Multibus system. $110.



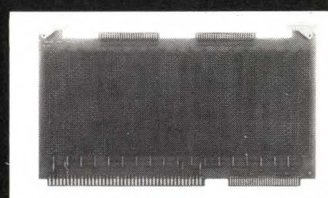
Quad Serial Interface Board hooks up to four EIA RS-232 interfaces to your system. $225.



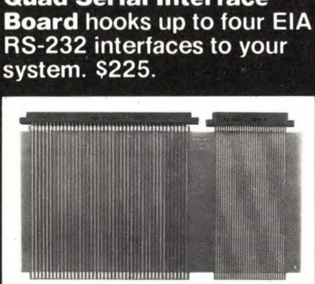
Octal Serial Interface Board allows up to eight EIA RS-232 interfaces. $265.



Mother Board can hold up to 15 Multibus cards with both P1 and P2 provided for each card position. $255.



Prototyping Board will accommodate up to 95 16-pin sockets, allowing the user to wire wrap a prototype circuit. $45.



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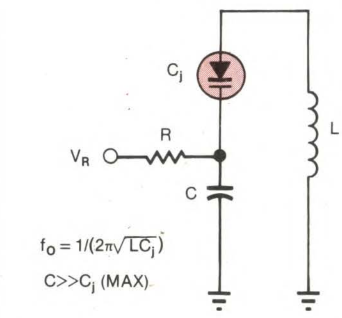

Fig 2—Varactor-tuning resonant circuits *is an easy task—until you attempt to achieve octave or better ranges. The equation shows why: A 2:1 frequency change requires a 4:1 junction-capacitance variation. Hyperabrupt devices accomplish this performance easily enough with limited bias requirements; however, their lower Q restricts usage in UHF applications.*

high tuning sensitivity and high Q—Qs high enough to make them useful in the above-1-GHz range (an area not open to silicon-based devices). As with almost everything else, though, as usage and production volumes increase, device costs should decrease.

In addition to improved performance parameters such as Q, hyperabrupt devices now offer an even wider range of other characteristics from which to choose: Parts with a 1V junction capacity of 1000 pF suit voltage-tunable adaptive filters in the audio-frequency range, while units with 5-pF ratings meet the requirements of 1-GHz designs. Additionally, several manufacturers, including Motorola and Microwave Semiconductor Corp, have indicated that they're working on low-cost, high-performance packages for nonmilitary applications.

In contrast to hyperabrupt varactors, abrupt- and graded-junction devices are formed by diffusing controlled impurities into the base material—a better understood and more controllable technique than ion implantation. Here too, however, the gradual but persistent adjustment of existing processes has enhanced device performance—most notably provid-

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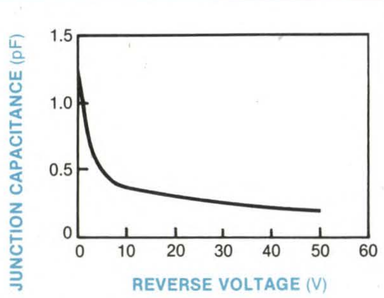

Fig 3—PIN diodes' junction capacitance *is intentionally made insensitive to reverse bias voltage. The devices' low, constant capacitance yields high isolation in series-type transmission-line switches.*

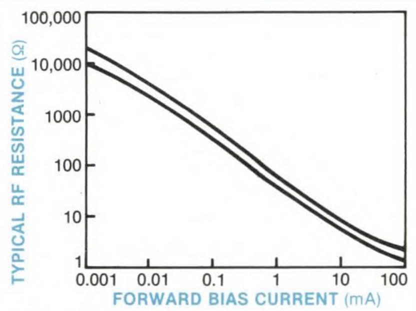

Fig 4—Some PIN devices' nearly linear forward-biased junction resistance *makes them ideal for RF-attenuator applications. Devices with 1A ON resistances as low as 0.1Ω are available.*

ing higher Qs, much lower leakage-induced noise and greatly reduced post-tuning drift.

Control microwatts or kilowatts

The other RF-diode type considered here, PIN diodes for all intents and purposes provide characteristics opposite to those of tuning varactors. Rather than changing the frequency or phase of an RF signal, they most often control the signal's amplitude—functioning either as an ON/OFF switch or a linear attenuator. The devices can also serve in phase or frequency shifters, but generally only to switch lengths of transmission line.

The most obvious difference between PIN and varactor parameters appears in their junction-capacitance characteristics. As shown in **Fig 3,** the PIN diode's junction is designed to provide a very low capacitance insensitive to bias voltage. Why? At 1 GHz, the devices' 0.2-pF capacitance exhibits an impedance of nearly 800Ω; in a typical 50Ω transmission-line circuit, that's nearly equivalent to an open circuit. But these same diodes, when forward biased at, say, 100 mA, might well show an effective series resistance of 0.5Ω—very nearly a short circuit in the same 50Ω system.

With slightly different processing, the PIN diode's forward-conduction characteristic becomes that of an almost log-log linear current-controlled resistor; a 5-decade resistance change in response to a 6-decade current change isn't unusual **(Fig 4).** And even at −55°C, these diodes exhibit a forward voltage drop with 100 mA of only about 1V.

Working in transmit/receive (T/R) switches, a PIN unit must meet several conflicting requirements: In the transmit mode, it must withstand and/or control high RF power levels (perhaps as high as 10 kW), while as a receive switch, it must pass microvolt signals with the lowest possible loss. Additionally, the diode's carrier lifetime must be long enough so that the RF carrier's modulation doesn't also modulate the device's ON resistance (a sure source of distortion), and reverse recovery time must be short enough to permit fast diode turn-off. Does any manufacturer make a diode meeting all these requirements? No—But here as in other cases, the constant refinement of existing

Data-base update

The following references should prove useful to you in applying the types of devices described in this article.

Varactor applications

1. Application notes AN-178A, AN-210, AN-249
Motorola Semiconductor Products Inc
Box 20912
Phoenix, AZ 85036.
2. Application note No 18
TRW Power Semiconductors
14520 Aviation Blvd
Lawndale, CA 90260.
3. Application notes AN-201, AN-202, AN-203
KSW Electronics Corp
S Bedford St
Burlington, MA 01803.

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1. *PIN Designer's Handbook & Catalog*
Unitrode Corp
5 Forbes Rd
Lexington, MA 02173.
2. Application notes 922, 929, 936, 957-1, -2, -3
Hewlett-Packard Co
Microwave Semiconductor Div
350 W Trimble Rd
San Jose, CA 95131.

General theory and design

1. Howes, M J, and Morgan, D V, *Variable Impedance Devices,* John Wiley and Sons, New York, 1978.

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3. Watson, H A, *Microwave Semiconductor Devices and Their Circuit Applications,* McGraw-Hill Book Co, New York, 1969.

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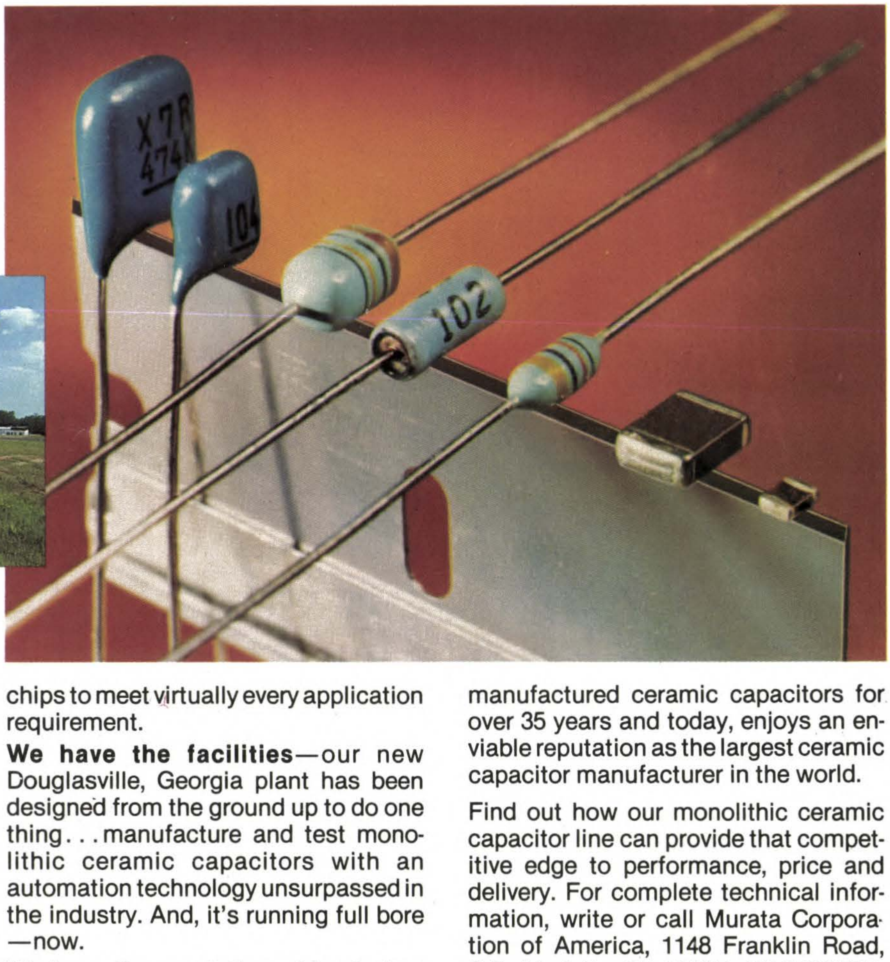

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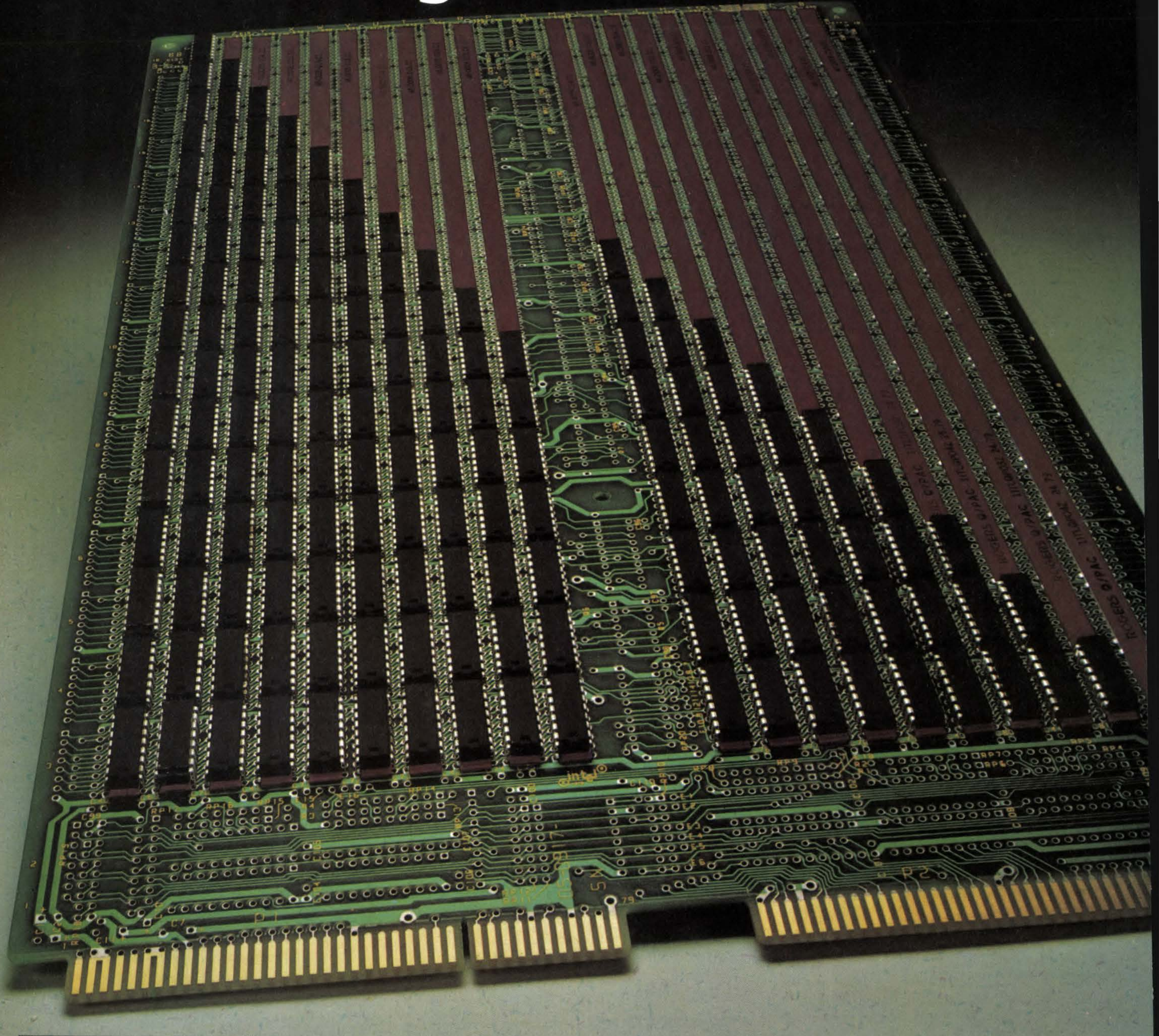

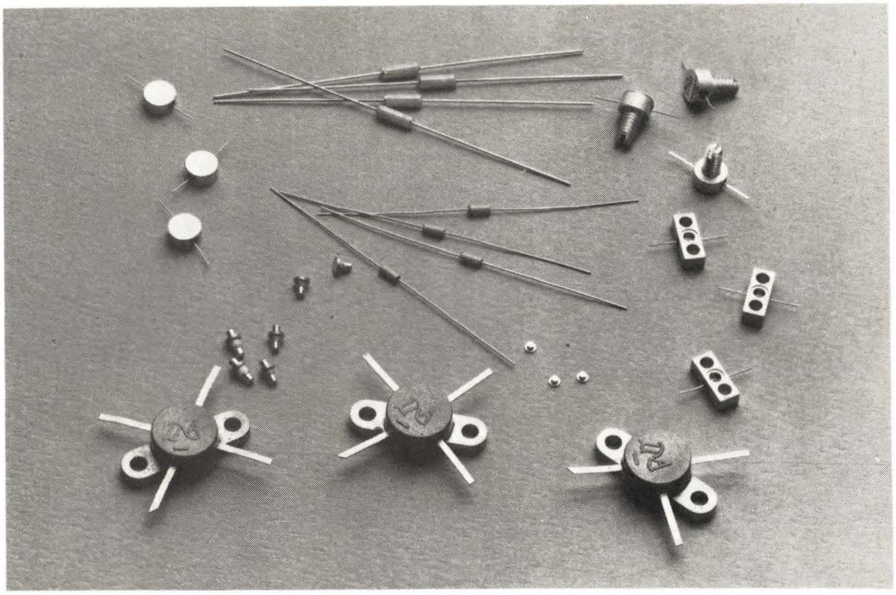

Package characteristics *for RF diodes such as these Microwave Associates models are as important as device parameters at frequencies above a few megahertz. The inductance of axial-lead packages (above center), for example, can slow down PIN-diode switching speed or form the complete tank circuit in tuning-varactor designs. The high-power stud and flange packages are designed to match 50Ω transmission lines.*

methods and materials results in improved device parameters and a wider range of available parts.

High-power PIN diodes, in particular, seem to be more readily obtainable: Microwave Semiconductor Corp's Rich Jerome indicates that because of the increasing supply of high-quality, 2000-Ω-cm silicon, the firm is now producing devices with a 1-kV breakdown voltage. Already available from another manufacturer (KSW) is a family of devices capable of switching 1 kW of RF power in the 2- to 30-MHz range.

A different classification of PIN diodes, current-controlled attenuators involve somewhat fewer conflicting operating requirements. Often found in receiver automatic-gain-control loops and as output levelers in test equipment, PIN diodes for such applications operate in their forward-biased region. When they're employed in this fashion, high breakdown voltages and very short reverse-recovery times become less important.

Manufacturers of current-controlled attenuators seem to be concentrating on improving production yields and developing lower cost packages to meet the rapidly growing mobile-communications market. **EDN**

For more information...

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

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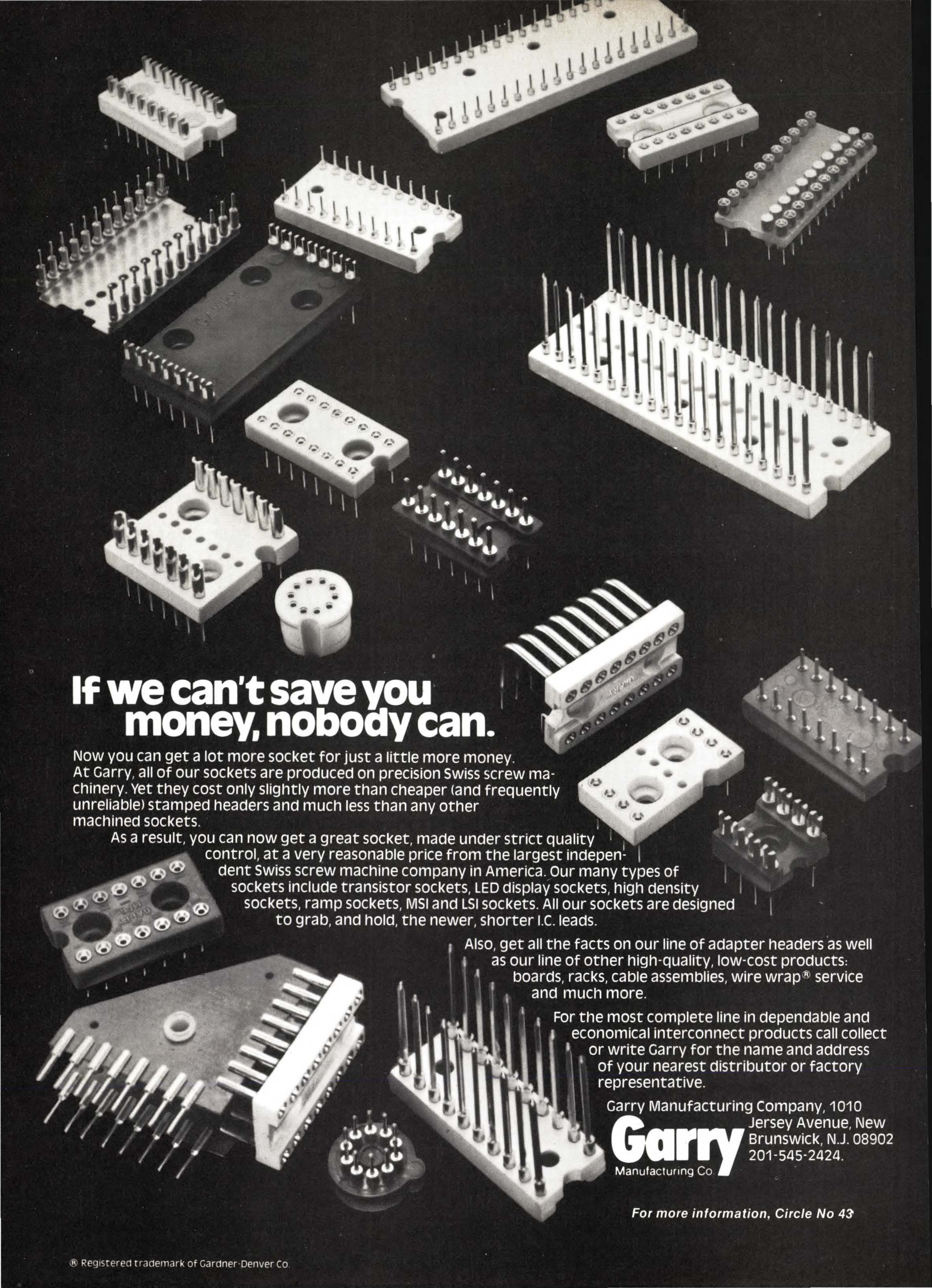
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Sadistical design philosphies yield prototype 64-bit, 10-μsec ADC

Designers familiar with the most common methods of analog-to-digital conversion—successive approximation, flash (parallel) comparators and dual-slope integration—must now become familiar with a revolutionary new technique characterized as sadistical (*sta*tistical *d*igital *i*ntegration*s* by crit*ic*al an*al*ysis). This brilliant technique has profound implications; it has already produced prototype converters that achieve an unprecedented 64 bits of resolution.

News of this development was inadvertently released on April 1st by the primary theoreticians involved. William Ravist, principal researcher, and John Unnm, principal scientist—both members of the faculty at Iabsy University—indicate that the converters' projected cost should be \$200 to \$300 in OEM quantities.

As revealed in the **figure,** the design employs virtually standard off-the-shelf components—it's the circuit realization that makes the concept unique. The input current is summed with the output of a digital notch filter, which derives its input from the clocked white (or pale pink, depending on desired resolution)-noise generator. The notch frequency is determined by the output of an n-bit (n=12 in the prototype version) up/down counter, whose count has been previously determined by the output of a 1-bit ADC driven by the summing amp.

The innovative digital integrator and the 3-input Boolian NOT gate (Trinot) account for the unbelievable performance of this design—64 bits (±4 LSD) in 10 μsec. The gate's powerful decision-making abilities are well understood by most designers and so won't be reiterated here.

Equation bares all

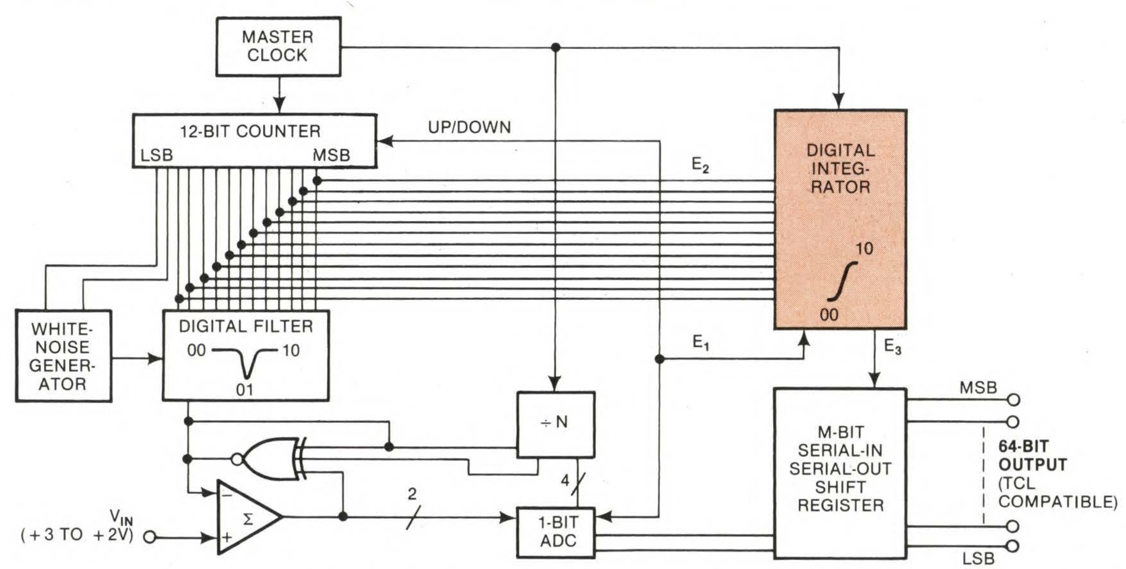
The mathematical foundation of digital integration using the Master Correlation Integral is readily apparent from this equation:

$$E_3 = K\int_{MSB}^{LSB}(E_1E_2)^n dE$$

where E_1 is the 1-bit ADC output (ZERO or ONE), E_2 is the 12-bit-counter output (100 to $A1J_{16}$) and K is some constant.

The function's hardware realization has, however, never before been attained, and the circuit developers were not available for comment when asked to detail the integrator's operation. (A highly placed source—who prefers to remain anonymous—has obtained a very revealing schematic, which was unfortunately unavailable at press time.)

Housed in a 67-pin triple-in-line package (TIP), the ADC requires +7.9V (114 mA), +11.4V (5.5 pA) and −17.0V (287 mA). Supply regulation is not critical because the design dissipates only 57 mW. There are no missing codes over the −5 to +5°C range, and the designers hasten to point out that any eight ISBs can be ignored in most applications because all of the bits are insignificant anyway. **EDN**



The application of sadistical concepts *has yielded this 64-bit, 10-μsec ADC design. With the exception of the digital integrator, all ICs are standard off-the-shelf devices. The integrator represents the first hardware realization of a long-standing but abstruse mathematical theory.*

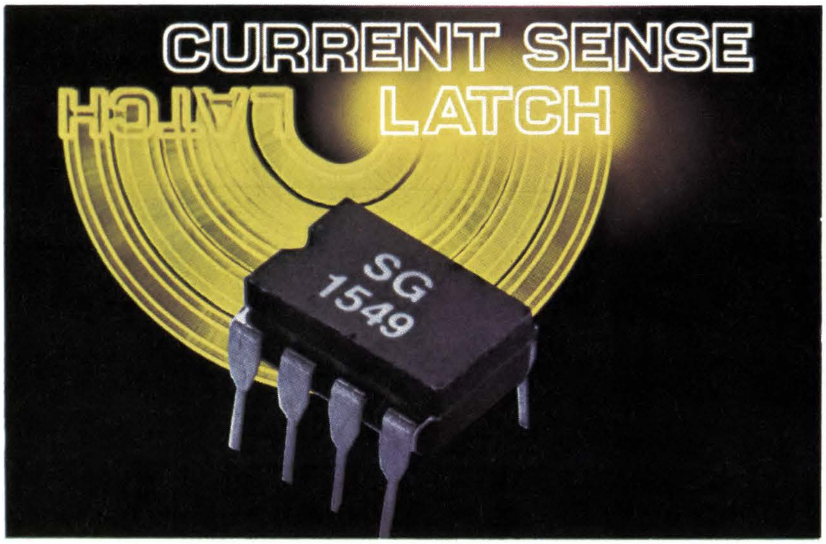
Editor's Choice: New Products

Current-sense latch provides pulse-by-pulse control

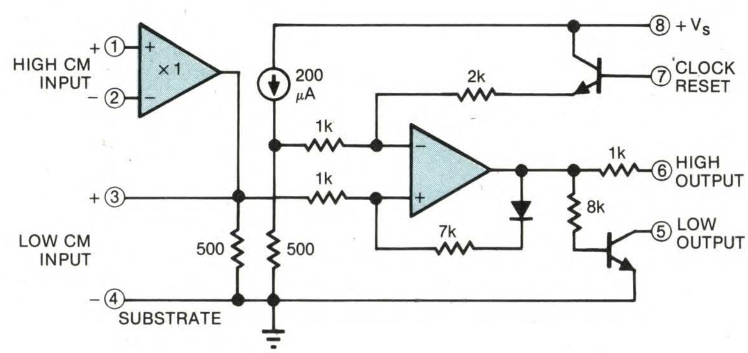
Primarily intended for applications employing switch-mode power supplies, the SG1549 current-sense latch employs digital current-limiting techniques to overcome the speed and stability problems inherent in linear approaches.

The device treats each ON cycle separately; it senses current buildup each time a supply's switching transistor conducts. Upon experiencing an overcurrent condition, it immediately turns the transistor off and holds it off for the duration of the normally ON period.

The latch that holds the turn-off signal has a reset pin to allow conduction on the next pulse. But if the overcurrent condition still exists then, the SG1549 again shuts the transistor off and continues to do so in subsequent cycles until the overcurrent condition is removed.



Taking a digital shortcut *to faster switch-mode current limiting, the SG1549 provides pulse-by-pulse sensing to reduce reaction time to less than 200 nsec.*



Complementary outputs and a latch with reset *form part of the SG1549's circuitry.*

Serves many PWM ICs

The SG1549 is compatible with many commonly used PWM control ICs, such as the SG1524, MC3420 and TL494. Such chips can provide both the supply voltage and the reset signal for the current-sense latch, because it requires only 2 mA of supply current for operation.

The device includes a comparator with positive feedback for latching, a current source that fixes the input reference threshold at 100 mV, a reset circuit, complementary outputs and a high-voltage level-shifting circuit. You can reference the input threshold to a common-mode input voltage ranging from ground to 40V.

Typical delay from Low input to Low output equals 180 nsec—30 nsec less when using the High output. This latter output can source 2 mA; the Low output can sink more than 10 mA. Power-supply voltage can range from 5 to 20V, but using voltages other than 5V changes the input threshold.

The device comes in a ceramic or plastic 8-pin mini-DIP and in three temperature grades: −55 to +125°C, −25 to +85°C and 0 to 70°C. $1.45 (100) for plastic DIP.

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Editor's Choice: New Products

High-performance microcomputer board serves many applications

Emphasizing design flexibility, the Z8000 μC board can function as either a stand-alone system or as a master unit when combined with a series of peripheral cards. You can employ it as a front-end data concentrator or in system-design, process-control or data-acquisition applications.

The basic board incorporates a Z8001 segmented μP, operating at 4 MHz, which provides addressing access to 8M bytes (divided into 128 64k-byte segments). It uses an instruction-prefetch mechanism (rather than a pipeline architecture) to enhance throughput—executing most instructions in 1.25 to 5.25 μsec.

The board also includes a serial dual-channel communications interface, controlled by a Z80A SIO. This chip handles all standard bit- and byte-oriented protocols (HDLC, SDLC, Bisync and CCITT) and supports the EIA RS-422/423 interface standards while maintaining compatibility with RS-232 devices.

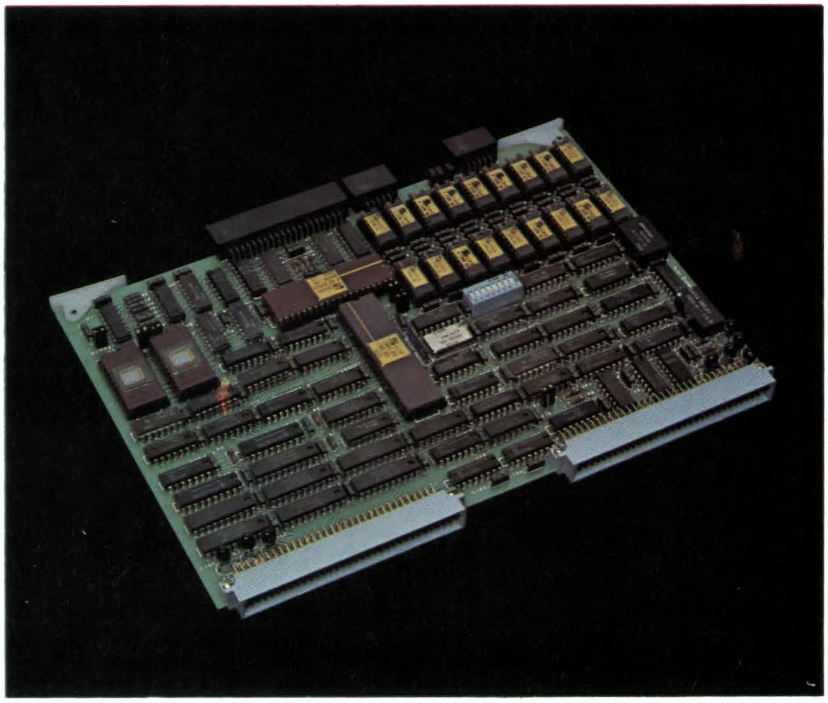
A bus-independent 2.45-MHz crystal oscillator provides timing for the communications channels. Data rates (selectable via DIP switches) range to 19.2k baud in synchronous operation and more than 30k bps in the synchronous mode. And you can substitute an external clock on one channel to increase the synchronous data rate to 800k bps.

32k on-board RAM

The μC incorporates 32k bytes of 16k×1 dynamic RAM, with facilities for 8k bytes of PROM or ROM.

The RAM provides byte-oriented parity protection for high reliability and data integrity. It resides in the upper half of the board's segmented address space, with user segment selection (segment 0 or 1) achievable via a simple jumper connection. PROM or ROM resides in segment 0, starting at address 0000. You can install 2732 or 2716 EPROMs or equivalent bipolar devices; jumper connections are available to select PROM type.

To facilitate expansion in master-unit applications, the μC includes two 96-pin connectors with all predefined bus signals available. All I/O signals go to the board's top.



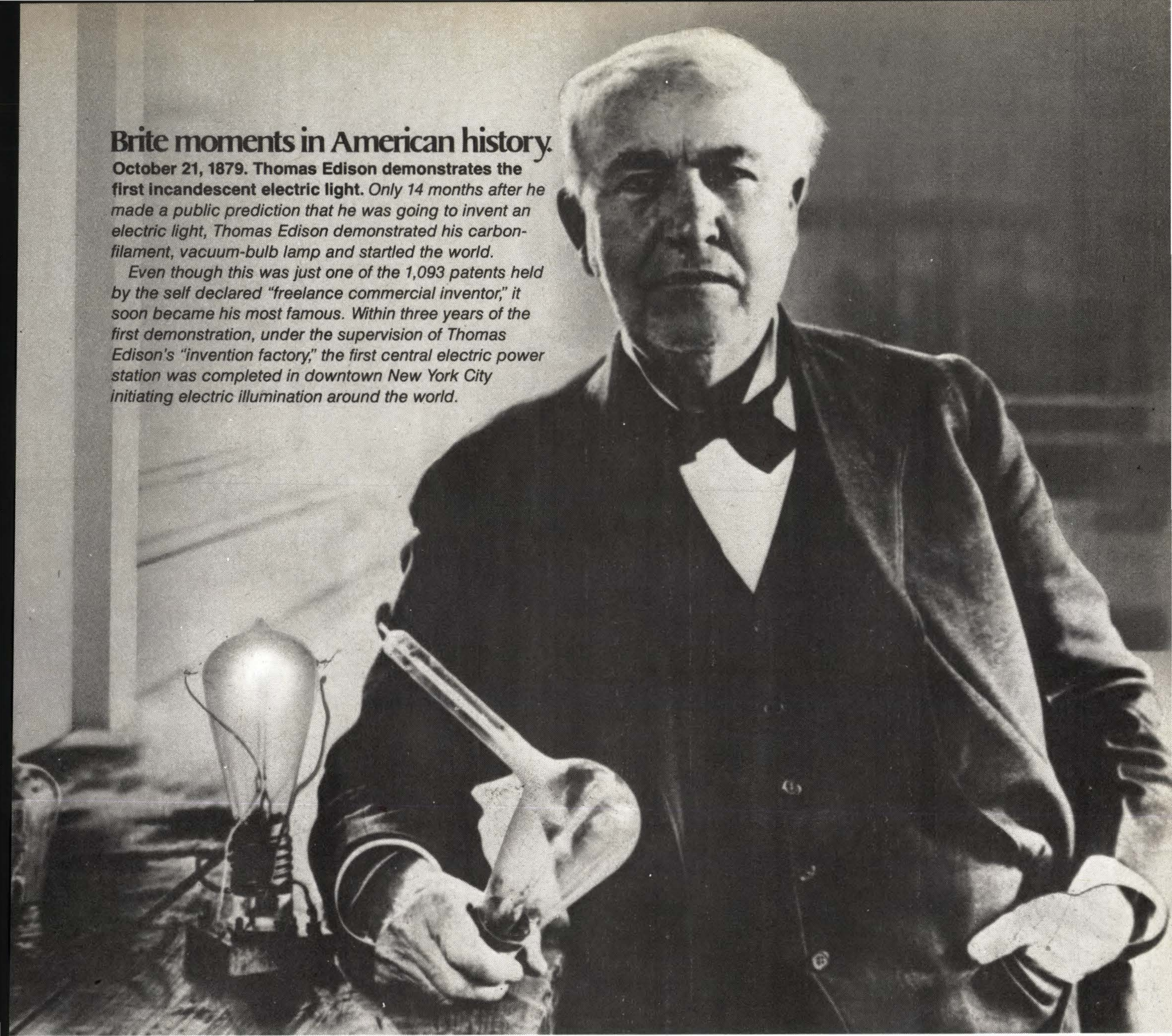
Features that enhance the flexibility *of the Z8000 μC board include a segmented Z8001 μP, a dual-channel communications interface and 32k bytes of on-board dynamic RAM.*

Has real-time clock

A key factor in the unit's stand-alone operation capability, an on-board real-time clock also permits management of multitasking operations with real-time software. To simplify the task-switching function, the clock generates an interrupt every 13.3 msec—a feature that simplifies control-software programming.

The board requires 5V at 1.25A, 12V at 650 mA and −5V at 4 mA. The latter voltage provides both a bias for the dynamic RAMs and a reference source for the −5 to +5V level shifts required by the communications interface. $2260.

***Zilog Inc, 10460 Bubb Rd, Cupertino, CA 95014. Phone (408) 446-4666.* Circle No 372**



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μComputerist Corner

Programmable port outputs tones

R T Carter
ARO Inc, Arnold AF Stn, TN

You can output several simultaneous frequencies under program control with a μC that operates a bit-programmable I/O port.

The **figure** shows a program that generates a musical-tone triad, coded for a KIM-1 μC operating in conjunction with a National Semiconductor INS8154 bit-programmable I/O port. The X register cyclically points to the locations of frequency number FREQ, period-decrementing register DECR and output OUT. Five clock-cycle-length output pulses appear at I/O-port bits B_0, B_1 and B_2. Hexadecimal numbers chosen for locations 24 through 26 produce output-tone pitches close to A_3, C_3# and E_2 on the musical scale. EDN

STEP	OPCODE			OPERATION	COMMENTS
00	A9	FF		0 A#FF	
02	8D	23	11	STA@1123	Set Port B output
05	A2	03		LDX#03	Reset Pointer
07	D6	20		DEC@DECR(x,z)	Decrement period register
09	A9	00		LDA # 00	Test content = 0
0B	D5	20		CMP@DECR(x,z)	
0D	D0	0A		BNE	0
0F	9D	17	11	STA@1117(x)	= 0
12	9D	07	11	STA@1107(x)	Generate output pulse
15	B5	23		LDA@FREQ(x,z)	Reload decrementing register
17	95	20		STA@DECR(x,z)	
19	CA			DEX	
14	E0	00		CMX #00	
1C	D0	E9		BNE	
1E	4C	05	00	JMP	
21	= DECR(1)				Period-decrementing registers
22	= DECR(2)				
23	= DECR(3)				
24	= FREQ (1) = 20_H				Period-length registers
25	= FREQ (2) = 33_H				
26	= FREQ (3) = 55_H				

A musical-tone triad *outputs from one bit-programmable I/O port.*

Regulate pressure with a μC

Duane Tandeske
National Semiconductor, Santa Clara, CA

Pneumatic systems usually require some form of pressure regulator; for systems utilizing more than one pressure or vacuum, though, you need multiple regulators. But a microcontroller equipped with a pressure transducer and suitable valving can control multiple values of pressure as well as vacuum.

Fig 1 depicts a closed-loop system that implements such a μP-based pressure regulator. The μP alternately measures the chamber pressure and

Continued on pg 82

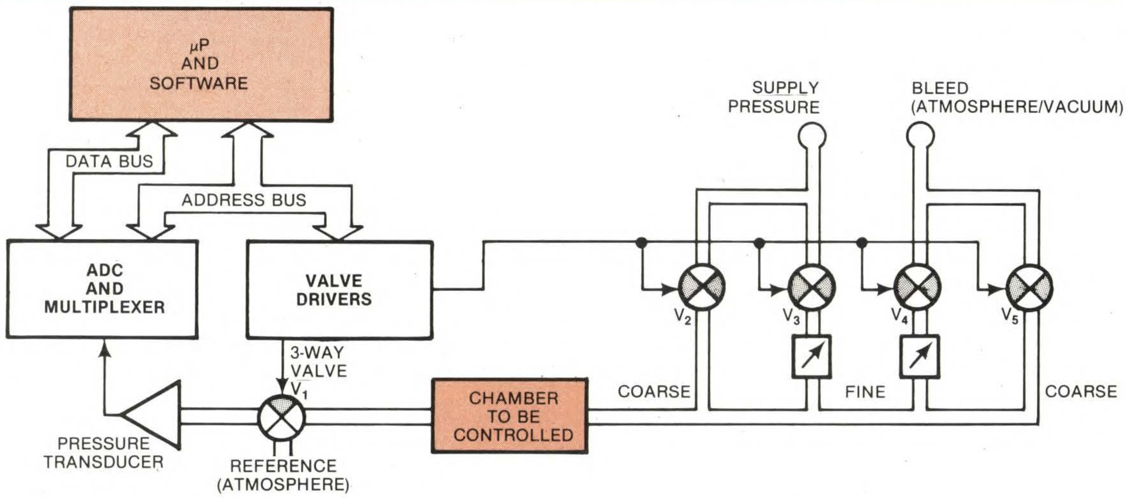

Fig 1—Multiple regulators *control both pressure and vacuum in a μP-controlled pneumatic system.*

pulses the appropriate supply and bleed valves to adjust its value. Each pressure measurement compensates for measurement-offset errors by means of autoreferencing; a coarse/fine valve system allows a simple μP interface to maintain system speed and accuracy.

Operation proceeds as follows: A pressure transducer, connected to the chamber via a 3-way valve, feeds the chamber's pressure value to an ADC. The program required for autoreferencing via the 3-way valve (**Fig 2**) automatically corrects each measurement for errors arising from time and temperature variations. The microcontroller then corrects the chamber pressure by pulsing solenoid valves, either bleeding off excess pressure or supplying additional pressure. **EDN**

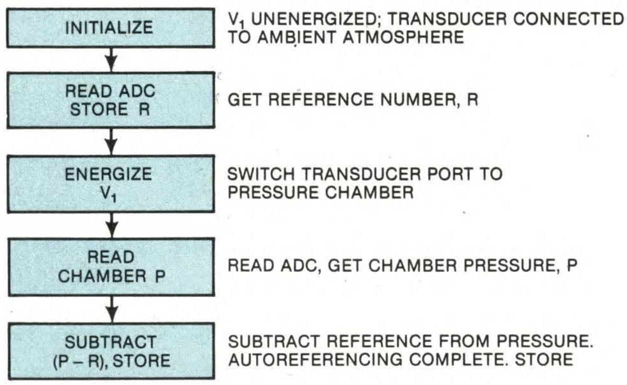

Fig 2—Autoreferencing *automatically corrects each measurement for time- and temperature-based errors.*

EDN Software Note #47

32-bit arithmetic serves 16-bit languages

Robert D Grappel
Hemenway Associates Inc, Boston, MA

Microcomputer implementations of high-level languages frequently limit integer-arithmetic operations to 16-bit signed values—a major stumbling block in applications requiring greater precision. The design of a cross assembler written in PASCAL for the Motorola 68000, for example, could employ a PASCAL allowing only 16-bit signed integer arithmetic. But the 68000 requires 32-bit arithmetic in its addressing. The two procedures shown in the **figure** deal with this problem; they provide 32-bit addition and subtraction functions.

The method stores the 32-bit values in several integer variables. Because this PASCAL uses signed integers, you can store only 14 bits in an integer without risking arithmetic overflows. Thus, a 32-bit value requires three integer variables: 12 bits in the first, 12 in the second and eight in the third.

You can expand these procedures to handle up to 42-bit values (14 bits in each variable) by changing the constants: 4096 applies to 12 bits, and 256 is related to eight bits. Note that no overflow check occurs; values are merely truncated to 32 bits.

You can also fabricate multiplication and division procedures from the procedures shown; multiplication is merely repeated addition, while division is repeated subtraction. Such procedures are slow but easy to write and debug. The algorithms are readily generalizable to any extended-precision arithmetic you require. **EDN**

```
P-6800  RUN-TIME  SYSTEM  V 1.1   : COPYRIGHT C 1978 LUCIDATA
USABLE CONTIGUOUS MEMORY  $7000
DEFAULT STACK RESERVATION $1000
CHANGE VALUE ?

PASCAL P-COMPILER  ( VERSION 1 )  : COPYRIGHT C 1978 D. R. GIBBY

   0 PROGRAM MATH32;  (* 32-BIT ADD/SUBTRACT IN 16-BIT PASCAL *)
   0
   0 VAR
   0        V1,V2,V3: INTEGER;   (* GLOBAL 32-BIT "VARIABLE" *)
   0
   0 PROCEDURE ADD32(A1,A2,A3,B1,B2,B3: INTEGER);
   4
   4 (* 32-BIT ADDITION V1,2,3 = A1,2,3 + B1,2,3 *)
   4
   4 BEGIN
   4        V2:=0; V3:=0; V1:=A1+B1; (* FORM FIRST SUM *)
  36        IF V1>4095 THEN  (* CHECK FOR FIRST CARRY  *)
  48              BEGIN
  48              V1:=V1-4096; V2:=1;
  68              END;
  68        V2:=A2+B2+V2;     (* FORM SECOND SUM *)
  92        IF V2>4095 THEN  (* CHECK FOR SECOND CARRY *)
 104              BEGIN
 104              V2:=V2-4096; V3:=1;
 124              END;
 124        V3:=A3+B3+V3;     (* FORM THIRD SUM *)
 148        IF V3>255 THEN V3:=V3-256;
 172 END;
 176
 176 PROCEDURE SUB32(A1,A2,A3,B1,B2,B3: INTEGER);
 176
 176 (* 32-BIT SUBTRACTION V1,2,3 = A1,2,3 - B1,2,3 *)
 176
 176 BEGIN
 176        V1:=A1-B1; IF V1<0 THEN
 204              BEGIN
 204              V1:=V1+4096; A2:=A2-1 (* FIRST BORROW *)
 224              END;
 228        V2:=A2-B2; IF V2<0 THEN
 256              BEGIN
 256              V2:=V2+4096; A3:=A3-1 (* SECOND BORROW *)
 276              END;
 280        V3:=A3-B3; IF V3<0 THEN V3:=V3+256;
 320 END;
 324
 324 BEGIN
 328
 328 (* USER PROGRAM HERE *)
 328
 328 END.
 332 BYTES
 END OF PASS 1
 END OF PASS 2
 OK  TO RUN

END OF PROGRAM EXECUTION.
```

Addition and subtraction procedures *let you perform 32-bit arithmetic with a PASCAL implementation that limits integer operations to 16-bit signed values.*


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2149HL-3	55ns	25ns	125mA
2149H	70ns	30ns	180mA
2149HL	70ns	30ns	125mA
2148H-3	55ns	55ns	180mA/30mA
2148HL-3	55ns	55ns	125mA/20mA
2148H	70ns	70ns	180mA/30mA
2148HL	70ns	70ns	125mA/20mA

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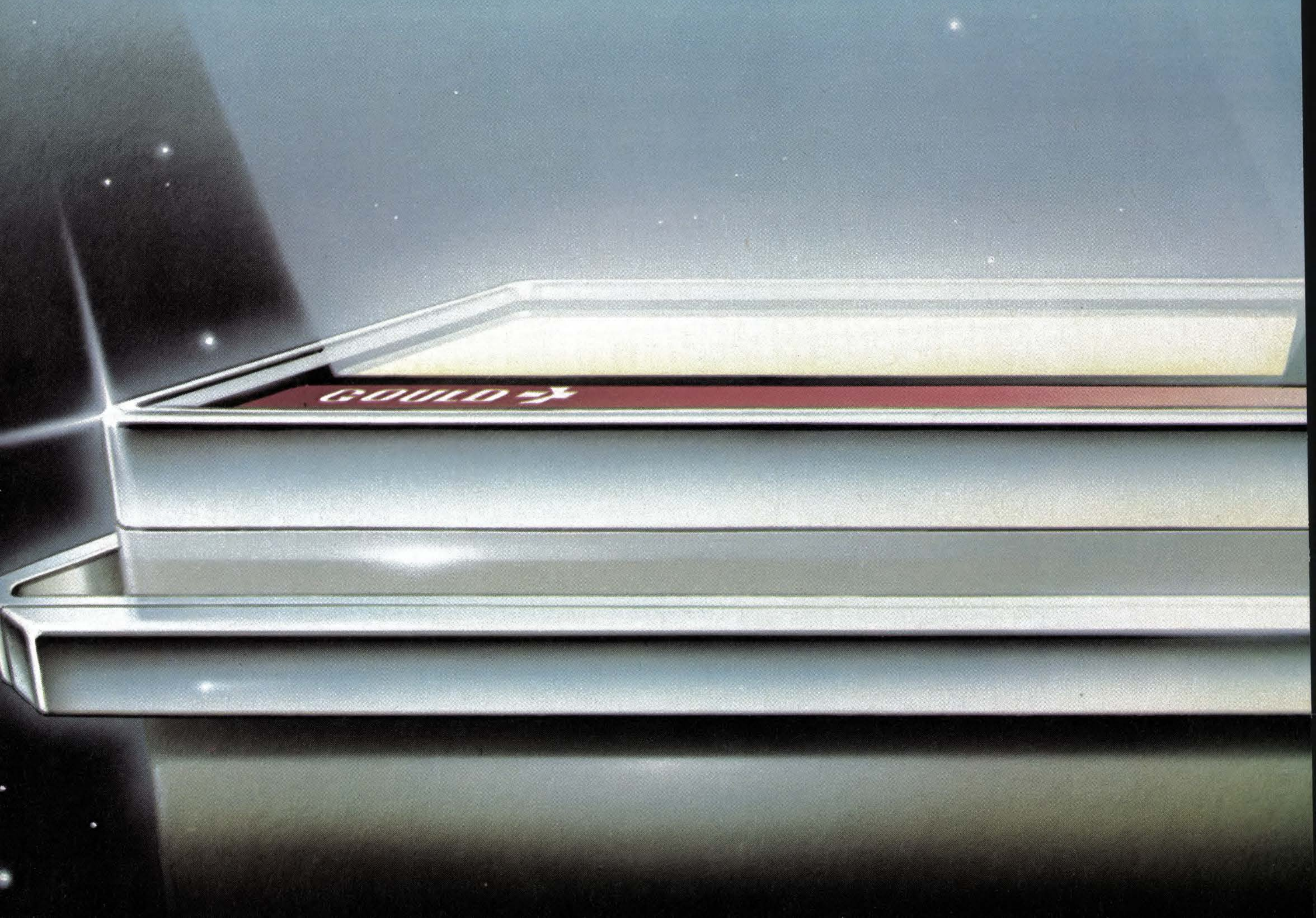

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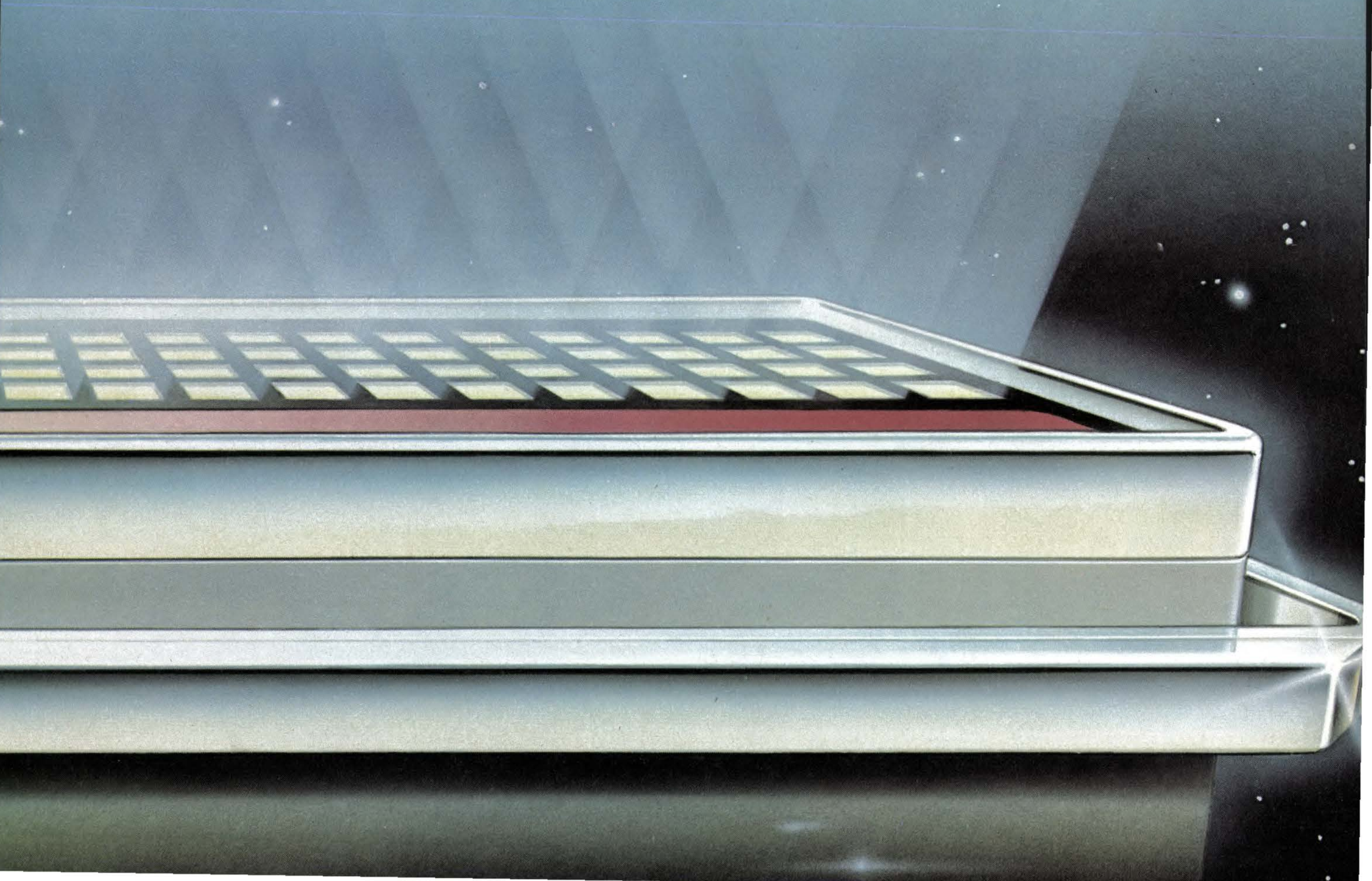
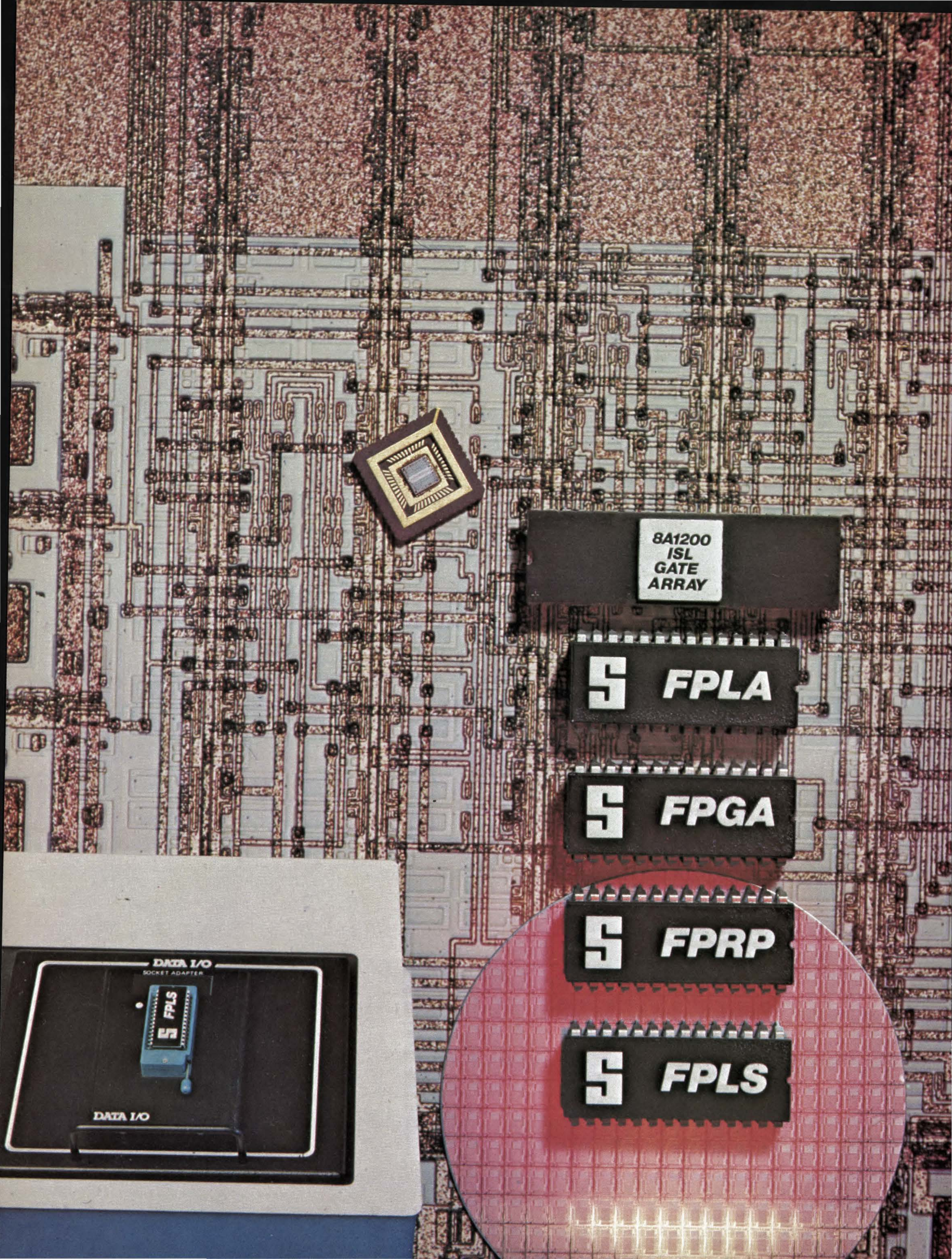



8A1200
ISL
GATE
ARRAY
FPLA
FPGA
FPRP
FPLS
DATA I/O
SOCKET ADAPTER
FPLS
DATA I/O

Uncommitted IC logic

Be they fuse programmable or mask programmable, uncommitted logic arrays and ICs are gaining both sophistication and acceptance.

William Twaddell, Western Editor

Technology and processing advances in semiconductors don't only benefit the glamour products, such as high-density memories and minicomputers on a chip. Rather, these improvements also gradually trickle down to the bread-and-butter devices—only without much fanfare. Case in point: uncommitted logic.

Unable to compete because of large die size and insufficient complexity, semicustom devices have until recently been obscured in the μP's shadow. And fuse-programmed logic has suffered much the same fate. But both logic types are now experiencing a revival of interest, based on improved architectures and logic density.

Several developments herald this revival:

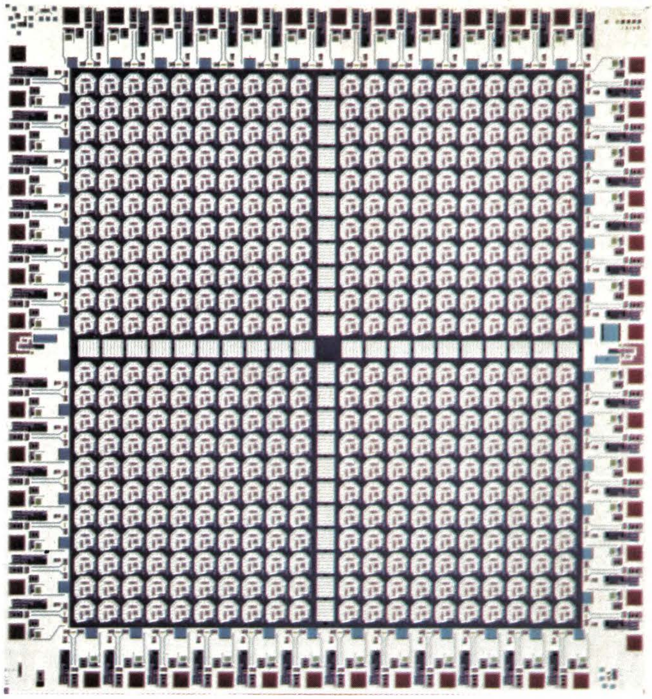
- The venerable field-programmable logic array (FPLA) now has some younger and smarter brothers. At the top of the line stands the field-programmable logic sequencer (FPLS)—basically an FPLA redesigned as a state machine by the addition of a 6-bit state register with feedback to the inputs, along with an 8-bit output register—both tied to a clock line. Also available is the field-programmable ROM patch (FPRP), which can disable a ROM upon selection of an address with faulty information and substitute the correct information stored in its own summing matrix. Other members of this group are the field-programmable gate array (FPGA), which has a programmable product matrix but no summing matrix and serves for random-logic replacement, and the PMUX, a programmable multiplexer. (See **box**, "A review of field-programmable logic.")
- A class of programmable logic termed PALs (programmable array logic) has also appeared. Smaller and faster than FPLAs, these Monolithic Memories Inc devices incorporate a fixed summing matrix with a programmable product matrix. The 15-member family includes parts with registers and feedback provisions and has just picked up a major second source—National Semiconductor. (See **box**, "A PAL review.")
- Semicustom arrays now have vastly improved density and functionality—array sizes stand in excess of 3000 gates, and the 5000-gate level is easily within reach and now under development. Manufacturers produce these semicustom ICs in virtually every silicon technology, allowing customers to optimize their products by employing a particular logic family or process. (See **box**, "The semicustom concept.")

But who gets the socket?

The advances in all of these product areas often seem to place semicustom and fuse-programmable logic in competition, at least at the lower levels of integration. However, opinions of manufacturers on both sides vary widely concerning the degree of this competition.

On the whole, though, the semicustom-IC people hardly see any overlap. Typical of their comments are those of Frank Deverse, president of International Microcircuits, who views fuse-programmable logic's current level of complexity and configurability as suiting it primarily for low gate densities. On the other hand, he sees semicustom arrays covering the entire range of densities and technologies, including linear. Deverse does note, however, that fuse logic enjoys an advantage with respect to development time and that

There's little overlap between semicustom and fuse logic



Capable of 20-MHz clock rates, *the Ferranti ULA5C000 employs current-mode logic (CML) and provides an equivalent gate count of 880 2-input gates. Internal gate delays equal 8 nsec with a speed-power product of 0.25 pJ for 4-μm minimum features. The chip sports 48 interface cells at its periphery and provides both linear and digital translation capabilities.*

the economies of semicustom devices are fully realized only at higher levels of gate utilization and volume.

Robert Lipp, president of California Devices, agrees and adds that semicustom logic can directly replace all of a system's random logic without requiring a redesign. He also points out other features of semicustom arrays that fuse logic can't provide—not all on a single chip, anyway: interface capability among virtually any logic families, logic levels or power-supply levels; pull-ups; pull-downs; 3-state I/O; Schmitt triggers; oscillators; comparators; detectors; debounce control; and voltage regulation.

Dr Charles Allen, president of Master Logic Corp, emphasizes the security aspect of semicustom arrays when employed in proprietary products. Programmable devices can find use in such individualized systems as electronic keys or serialized products, but Allen maintains that the ease with which persons can copy fuse-programmed parts effectively takes them out of the proprietary-product business. Semicustom arrays, on the other hand, are as difficult to copy as

A brief history of uncommitted IC logic

The origin of semicustom devices is the subject of some dispute and several claims. As near as can be determined, the first available gate arrays came from Fairchild in 1967. This Micromatrix family began with a 32-gate DTL array with 20-nsec delays, fabricated on a die measuring 80×110 mils. The next two devices were introduced in the following year, but by then size and complexity had risen, and the technology was TTL. The largest product covered a die measuring 145×145 mils and had 144 gates and internal delays of 18 nsec.

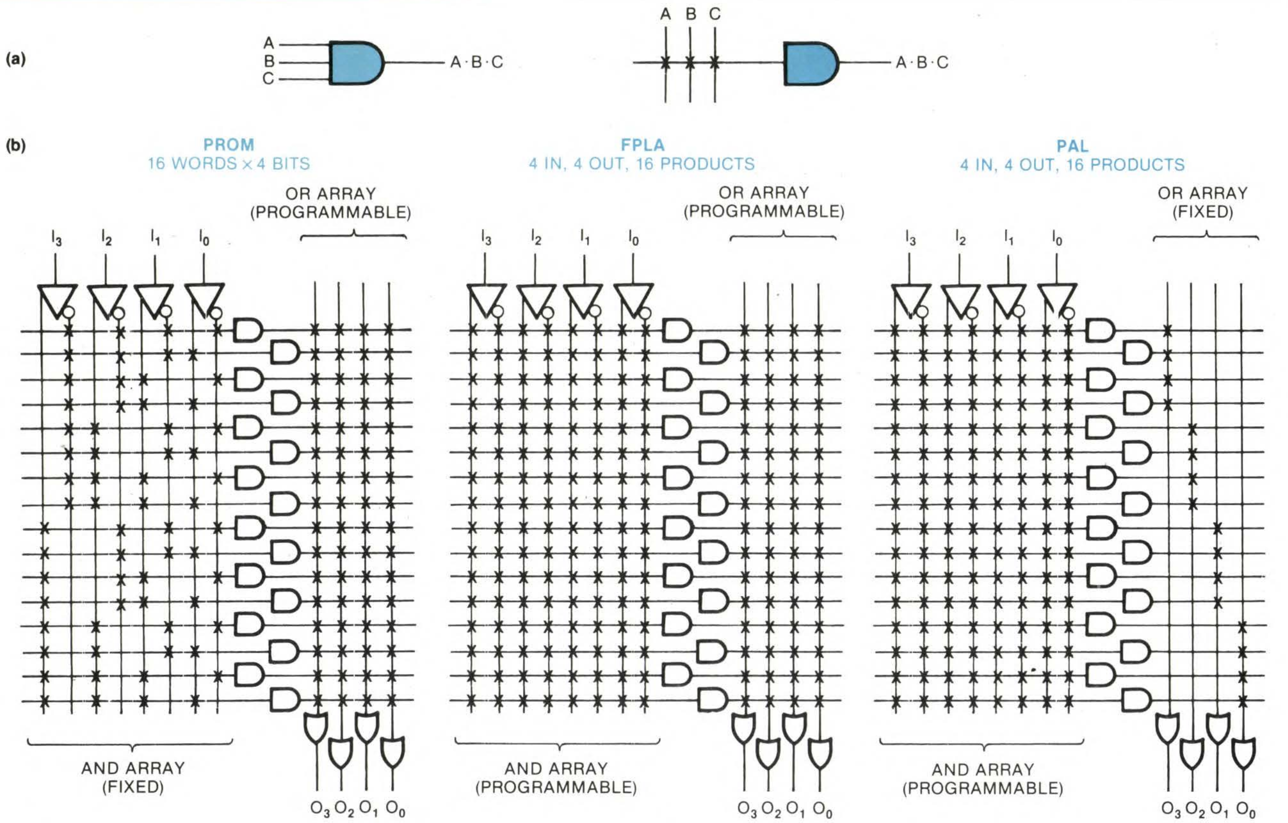
That same year (1968), three other companies announced TTL arrays. Sylvania produced the SL80, which had 30 cells, each containing four 4-input gates; customization required up to three layers of metal. Motorola introduced 25- and 80-gate arrays with propagation delays of 5 nsec and dissipation of 7.5 mW/gate. And Texas Instruments came out with its Master Slice, having several cells (each containing 16 gates) that could be connected (by means of two metal masks and a via mask) into logic functions.

In 1971, Raytheon began marketing TTL gate arrays and by 1973 had produced the RA-116 Schottky TTL array, which it still sells. Also around this time, more of the big manufacturers (such as RCA and Hughes) moved into the business, while most of the pioneers dropped out. In this same period, three new companies specializing in custom arrays—Interdesign, Exar and International Microcircuits—helped take up the slack. Additionally, in 1972 the British-based Ferranti Electronics Ltd introduced its ULA (uncommitted logic array) line and has been a major force in semicustom logic ever since, especially following its acquisition of one of the other market leaders—Interdesign.

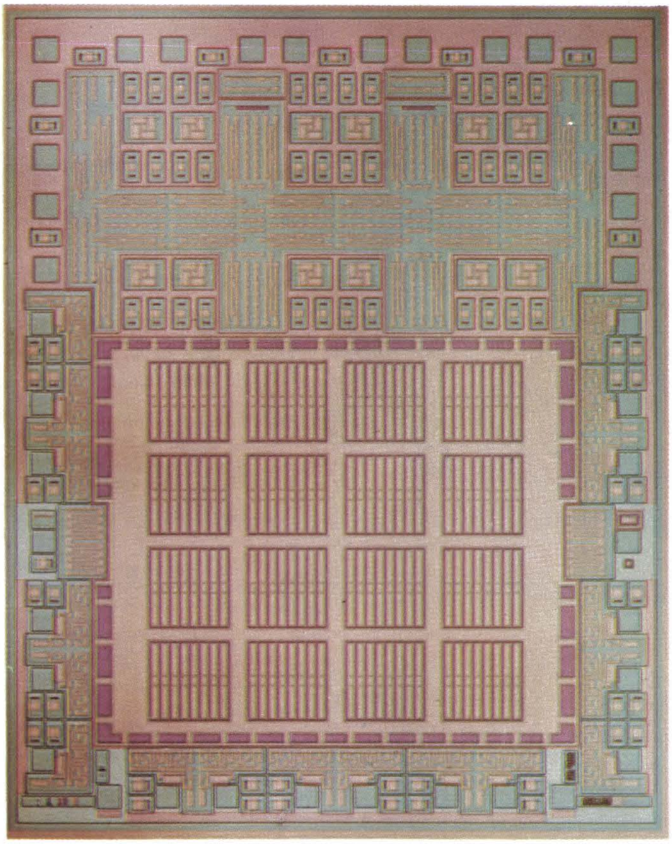
With renewed interest in semicustom ICs evident since 1976, Fairchild, Texas Instruments and Motorola have returned to the market—Fairchild and Motorola in ECL arrays and Texas Instruments in I^2L and STL (Schottky transistor logic), a technology similar to ISL (integrated Schottky logic) but said to be faster. Interest has not been confined to the US, either; Europe has at least four manufacturers (Ferranti, Philips, Plessey and Siemens), while in Japan, Fujitsu, Hitachi and NEC are prominent.

In the other main area of uncommitted logic, the fuse-programmable FPLA got its start at Signetics in 1975 as an outgrowth of the chrome fuse processing employed in bipolar ROMs. The same period saw the introduction of the μP, and debate raged over which would supplant the other.

The μP has taken center stage until now, but the newer versions of fuse-programmable logic are gaining a piece of the action from both μPs and semicustom gate arrays. Current manufacturers of FPLAs and related devices include Signetics, Intersil, Monolithic Memories, Fairchild, National Semiconductor and Raytheon Semiconductor.



FPLAs and PALs *are both outgrowths of PROM technology. Use of the shorthand notation in* **(a)** *simplifies the drawings in* **(b)** *for easy comparison.*



Combining linear and digital sections *on one chip, Exar's XR-400 I²L Master Chip contains 256 5-output gates and 18 Schottky bipolar I/O interfaces. It incorporates 40 bonding pads on a chip measuring 119×156 mils. The device's linear portion incorporates 45 npn transistors, 12 4-collector pnp transistors and more than 340 resistors. Maximum operating voltage can be either 6 or 12V.*

standard ICs.

Motorola's Bill Blood stresses fuse-programmable products' rigidity of patterns and logic functions. How, for example, do you configure an LSI circuit that requires a 10-bit shift register if your field-programmable logic only contains eight flip flops? Similarly, you can't build an LSI part incorporating multiphase clocking on an array that connects all flip flops to a common clock line. Blood, manager of bipolar-LSI system engineering at the firm, does admit that creating a custom metal mask is a more complex operation than programming fuses at a user's site. But he stresses that manufacturers of semicustom arrays are addressing this problem with sophisticated CAD interfaces to cut development time and complexity.

Pick your technology

The upshot of all this is that if you decide the semicustom route is for you, you can choose among a variety of vendor capabilities. **Table 1** outlines the technologies employed by each firm in the semicustom-IC business, and **Table 2** elaborates on the basic characteristics of some firms' product offerings. Once you've determined the companies that produce ICs in the technology you need, you can use the following information, presented alphabetically by company name, to better understand each firm's package of design and development assistance spanning the product-development cycle. On the other hand, if you decide that the fuse-programmed approach better suits your needs, refer to **Tables 3** and **4** and the previously

Programmable array logic provides cost, size advantages

referenced **boxes** for additional data.

California Devices will take a design at any stage of development, from basic specification onward, and deliver working semicustom parts. Layout cost, including interconnect routing, digitization of the pattern and computer verification of design rules, runs from $600 to $6000 or more, depending on chip complexity. From mask generation through final test, prices start at $2400 (CDI50, CDI100) and range to $4800 (CDI800).

Development time from logic drawing to prototype delivery ranges from 5 to 10 wks, again depending on complexity and customer involvement. Currently, CDI's metal-gate CMOS family comprises eight devices, and the company is also introducing a high-speed silicon-gate CMOS line with chip complexities ranging from 300 to 1200 gates.

The CS-2000 and CS-3000 constitute **Cherry Semiconductor's** Genesis Linear Master Circuits; these 20V bipolar transistor/resistor arrays contain 187 and 437 components, respectively. The CS-3000 is a functional equivalent of the Exar XR-F100 and Interdesign Monochip MOF.

In specifying these products, you model a design in a discrete-component or transistor-array breadboard, then sketch the interconnect pattern for digitizing. (Cherry supplies a design package that includes a circuit schematic, final-layout sheet, test-program sheet and packaging-instruction sheet.) The firm then tools a metallization mask and completes processing and assembly. With orders of 50k or more, Cherry offers an optoelectronic transparent 8-lead DIP into which it will package a silicon photodiode plus a CS-2000 or CS-3000 design. The firm is also developing a combined I^2L/linear array—the CS-4000.

If I^2L alone meets your technology needs, consider

TABLE 1 — CAPABILITIES OF US SEMICUSTOM-IC MANUFACTURERS

SUPPLIER	TECHNOLOGIES
CALIFORNIA DEVICES	CMOS (METAL-GATE, SILICON-GATE)
CHERRY SEMICONDUCTOR	LINEAR AND I^2L/LINEAR
DIONICS	I^2L
EXAR	LINEAR, I^2L AND I^2L/LINEAR
FAIRCHILD	ECL
HOLT	CMOS
HUGHES	TTL
INTERDESIGN	LINEAR, I^2L, RTL, CMOS, NMOS, CML (FERRANTI)
INTERNATIONAL MICROCIRCUITS	LINEAR, CMOS (METAL-GATE, SILICON-GATE)
MASTER LOGIC	CMOS
MICROCIRCUITS TECHNOLOGY	CMOS, NMOS
MOTOROLA	ECL
RAYTHEON	TTL
SIGNETICS	I^2L, ISL

TABLE 2 — CHARACTERISTICS OF SEMICUSTOM DEVICES

MANUFACTURER	DEVICE	TECHNOLOGY	DIE SIZE (MILS)	I/O PADS	NO OF CUSTOM MASKS	GATE POWER (mW)	GATE DELAY (nSEC)	GATE COUNT	TEMP RANGE (°C)	
CALIFORNIA DEVICES	CDI800	CMOS	203 × 261	84	1	0.5	23	800	−55 TO +125	
DIONICS	SWAP-24A	I^2L	135 × 149	22	2	0.08	150	400	−55 TO +125	
EXAR	XR-500	I^2L	122 × 185	40	3	0.1	50	520	−55 TO +125	
FAIRCHILD	F200	ECL	130 × 173	48	3	29	0.75	168 TO 300[1]	0 TO 75	
INTERDESIGN	MUA-225	RTL	131 × 131	40	1	2.5	25	225	−55 TO +125	
(FERRANTI) INTERDESIGN	ULA5C000	CML	NA	52	1	0.19	8	880	−55 TO +125	
INTERNATIONAL MICROCIRCUITS	HS-MASTERMOS 1960	ISO-CMOS	300 × 300	116	1	0.5	5	1960	−55 TO +125	
MASTER LOGIC	ML350	CMOS	175 × 175	51	1	0.5	23	350	−55 TO +125	
MICROCIRCUITS TECHNOLOGY	MASTERCHIP 737	NMOS	216 × 203	48	1	0.25	45	400	−55 TO +125	
MOTOROLA	MACROCELL ARRAY	ECL ARRAY	221 × 249	60	3	4.4	1.3	904 TO 1192[2]	0 TO 70	
RAYTHEON	RA-116	STTL	160 × 160	56	4	3	6	300	−55 TO +125	
SIGNETICS	8A1200	ISL	175 × 190	38	5	0.25	8	1144	−55 TO +150	
						NO OF SMALL NPN	NO OF LARGE NPN	DUAL PNP	NO OF N-DIFFUSED RESISTORS	NO OF 30k PINCH RESISTORS
INTERDESIGN	MONOCHIP MOF	LINEAR	91 × 110	24	1	92	4	36	280	9

NOTES:
1. DEPENDS ON EMITTER AND COLLECTOR DOTTING
2. DEPENDS ON MACROS USED

TABLE 3 — AVAILABLE FIELD-PROGRAMMABLE LOGIC

GENERIC NAME	PROGRAMMABLE AND	PROGRAMMABLE OR	REGISTERS (OUTPUT/TOTAL)	PROGRAMMABLE ACTIVE-LEVEL OUTPUT?	OUTPUT OPTION (OC = OPEN COLL TS = 3-STATE)	PART NUMBER
FPGA	16	—	—	YES	OC/TS	82S102, 82S103 (SIGNETICS)
FPLA	14	8	—	YES	RES PULL-UP	IM5200 (INTERSIL)
	16	8	—	YES	OC/TS	82S100, 82S101, 93458, 93459 (FAIRCHILD)
FPRP	16	9	—	FIXED HIGH	OC/TS	82S106, 82S107
FPLS	16	15	8/14	YES	OC/TS	82S104, 82S105
PALXXHX	10-16	—	—	FIXED HIGH	TS	PAL10H8, PAL12H6, PAL14H4, PAL16H2, PAL16C1[1] (MMI)
PALXXLX	10-16	—	—	FIXED LOW	TS	PAL10L8, PAL12L6, PAL14L4, PAL16L2, PAL16L8
PALXXRX	16	—	4 TO8/4 TO 8	FIXED LOW	TS	PAL16R8, PAL16R6, PAL16R4, PAL16X4, PAL16A4

NOTE:
1. HAS COMPLEMENTARY OUTPUTS

TABLE 4 — A COMPARISON OF SEMICUSTOM AND FIELD-PROGRAMMABLE LOGIC

	LEAD-TIME (WKS)	APPROXIMATE COST PER UNIT	DESIGN TIME (MAN-WKS)	OVERHEAD	BOARD SPACE ($IN.^2$)	SERVICEABILITY/ REPLACEMENT COST	ITERATION TIME FOR DESIGN CORRECTION (DAYS)
HYBRID THIN FILM ONE LAYER[1]	20 TO 30	\$200 TO \$300	7 TO 10	\$20,000	2.5	\$200 TO \$300 (REPLACE)	21 TO 35
METAL-MASK ARRAY	15 TO 25	\$15 TO \$50	10 TO 15	\$10,000 TO \$30,000	2.5	\$15 TO \$50 (REPLACE)	70 TO 95
FIELD-PROG LOGIC ARRAY	<1	\$20 TO \$40	1	\$3000 TO \$5000[2]	2.5	\$5 TO \$20	1

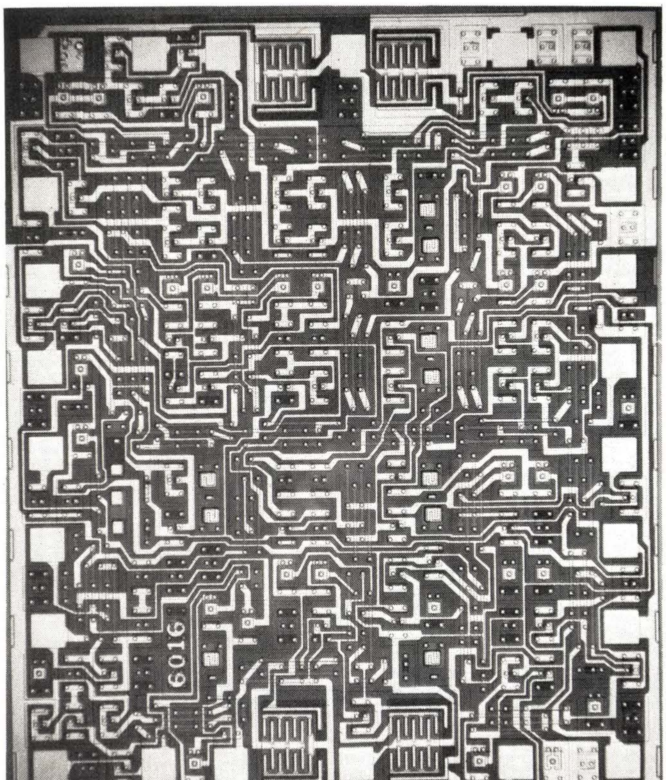
NOTES:
1. ABOUT 20 MSI/SSI TTL CHIPS
2. 1-TIME EXPENSE FOR PROGRAMMING EQUIPMENT

DATA: S CASH OLSEN, APPS MANAGER, BIPOLAR MEMORIES, SIGNETICS CORP. BASED ON ACTUAL EXPERIENCE OF SOURCE, GAINED ON PROJECTS COMPLETED BEFORE BEGINNING WORK FOR CURRENT EMPLOYER.

Dionics' three circuits: the SWAP-16, -24A and -24B, offering up to 400-gate complexity. Three development plans with varying levels of customer participation start at $2800 (least complexity, least Dionics participation) and range to a negotiable price that will certainly exceed $5000 (most complexity, most assistance).

Elapsed development time, exclusive of user tasks, is 6 to approximately 10 wks; production quantities can be ready 8 wks after prototype approval. Unit cost for a SWAP-24A in 10k quantities stands at $3.64, plus about $0.025 per gate or I/O circuit used.

One of the oldest companies in the semicustom-IC



Utilizing most of the components *on a Monochip F bipolar chip, Interdesign has put a complete audio-compression system for a citizens-band transceiver in a 24-pin DIP. The design incorporates a power-supply regulator, audio preamp, AGC amplifier, dc volume control and a headphone-amplifier output stage. The circuit required only one redesign to meet desired performance specs.*

business, **Exar** started production in 1971. With a stable of seven linear circuits and four I^2L (one a combination I^2L/linear) configurations, this company has completed more than 300 semicustom designs covering a wide range of applications.

Exar has developed a 6-step design cycle involving three steps by the customer and three by the manufacturer. For a nominal added charge, it will undertake five of these steps—you need only provide a breadboard of your design. Assuming, however, that you execute just the three basic customer steps, development costs for a linear chip will range from $3000 to $5000 above design and layout expenses. I^2L-chip development costs start at $5000 and range to $10,000—depending, as always, on complexity and the part employed. Linear development times usually range from 6 to 8 wks after pencil layout, while I^2L programs take 8 to 14 wks (this technology requires two additional masks).

Utilizing the fastest ECL family for its F200 gate array, **Fairchild** maintains F100K compatibility in the F200 to permit use of those standard-function parts. Designing with an F200 array, however, can be an expensive proposition: Development proceeds almost totally by computer.

Fairchild charges an entry fee of $20,000 to $25,000 and provides training (2 to 8 wks) in the use of software contained on Cybernet. Network design, employing macro-function cells, occurs by hand, but the next steps (test-vector generation and design verification) employ the TEGAS program on Cybernet. Macro interconnect and placement are partly manual and partly computer aided; design-rule checks are computer executed. Charges for computer time range from $5000 to $15,000, depending directly on your experience level.

Basic mask fabrication for an F200 array costs $10,000 to $15,000; Fairchild will also perform design and layout for an added $25,000 to $30,000. (Now you know why mainframe computers aren't cheap!)

The F200 is also available in an alternate low-power version, the F201, which consumes only 40% as much power. And now in development and planned for introduction in the first quarter of next year, Fairchild's 2000-gate F300 will feature eight times the complexity of the F200 and come in three power levels: 8, 4 and 2W. Propagation delays for this high-power part will drop to 400 psec; it will come in a leadless 150- to 180-pin package.

Also in the works at Fairchild is a part fabricated in I^3L (an I^2L technology developed by the firm) with 4000-gate complexity, whose target speed for gate delays stands at 6 nsec. Designated the 9480, it will replace entire boards of 74LS devices. To aid in the design of these complex units, Fairchild is working on software to accomplish autorouting, autoplacement, autotest and simulation.

CMOS packs 'em in

When it comes to technology, no firm can match **Interdesign** for sheer diversity—the company offers

Field-programmable logic can furnish a competitive edge

designs executed in six different logic families. Not surprisingly, Interdesign has integrated more than 1000 designs, not including those produced by its parent company, Ferranti.

No matter which technology you choose, Interdesign charges $2800 for its services, which include taking a completed 200× interconnect layout to completion of prototypes and final testing. Time for the company's part of the development—4 to 6 wks.

As an aid, Interdesign provides a Monochip design kit ($59), consisting of a design handbook, kit parts for breadboarding and layout drawings. And one of the nicest features of the firm's policies is a redesign charge of only $900, at least on linear chips—a provision that takes a lot of the pain out of making a design error.

Interdesign's digital gate arrays utilize CMOS—the most widely used technology in the industry. Employed in both metal-gate and silicon-gate families, it seems to have an assured VLSI future. And because the technology combines low power, wide operating-voltage range, reliability, simplicity of design and densities that approach those of NMOS, it's no wonder that five other semicustom-IC manufacturers also employ it.

For the last 6 yrs, **International Microcircuits** has marketed an 11-member family of metal-gate CMOS, termed MasterMOS, with complexities of 50 to 550 gates. And in 1978, the firm introduced a silicon-gate CMOS line: the HS-MasterMOS family. In line with the drive toward greater density, product complexity in this latter family ranges from 200 to 2000 gates. The

A review of field-programmable logic

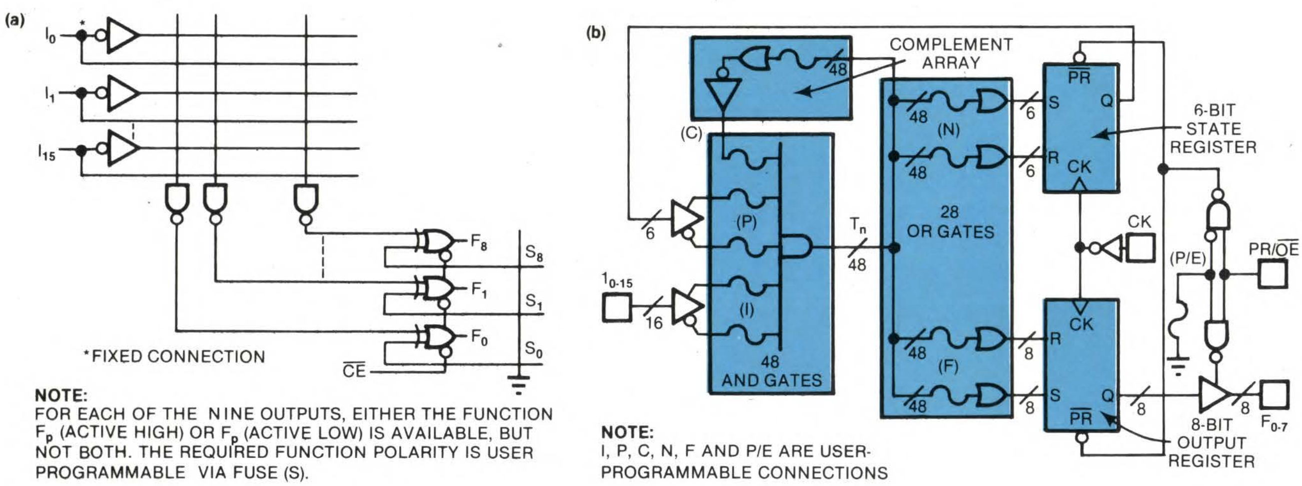
Napoleone Cavlan,
Signetics Corp

With the large-scale integration of memory, processor, control and I/O functions, a vast array of devices is now available for combining, in a few chips, system architectures that once required dozens or even hundreds of discrete-logic circuits. Yet despite a wide choice of standard functions, it's still virtually impossible to complete a design without employing some discrete logic to support the main framework.

Spurred by the trend toward distributed processing, mask-programmable bipolar and MOS gate arrays have emerged in densities up to about 5000 gates/chip. With nearly total design flexibility, these devices are tailorable into low-cost, high-performance custom functions for data computation, data movement and translation in distributed-intelligence networks.

But the use of this technology entails a substantial investment in time and resources; you must collaborate with a semiconductor house in setting up compatible development systems to generate system logic diagrams, functional-test sequences, logic conversions to gate-array patterns, software and/or hardware simulations, gate-interconnect diagrams, mask development, prototype fabrication and evaluation.

The design cycle can take 6 to 12 months and can be further delayed by the inevitable iterations arising from intervening design modifications. And there is no recourse for errors discovered after commitment to production. Thus, gate arrays are mainly suited to large, well-defined systems slated for high-volume production.

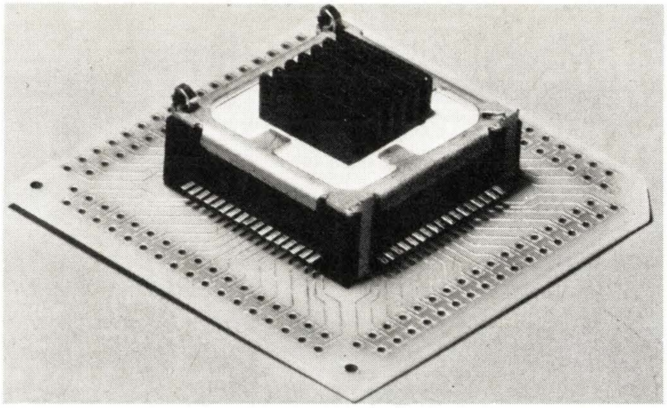


The newest members of the FPLA family *from Signetics are the FPGA (field-programmable gate array)* ***(a),*** *the FPLS (field-programmable logic sequencer)* ***(b)*** *and the FPRP (field-programmable ROM patch)* ***(c).*** *The gate array has no summing matrix and finds use in less complex applications to replace random TTL. The logic sequencer is a state machine; in it, the present state (held in the state register) feeds back in combination with the inputs to determine the next state in the state register and the output register. The ROM patch can serve to provide correct data to a system while disabling faulty data from main ROM.*

devices operate at 5V, and gate delays equal less than 5 nsec, allowing toggle rates to reach 30 MHz. The second quarter of this year will see this family expanded to 2000- to 5000-gate levels and providing 5V gate delays of less than 3 nsec.

Complete service from International Microcircuits, ranging from specification and logic-diagram stages to design of production-test hardware, takes almost all of the load off any customer who needs such treatment. The only step you need take is manual layout check; ultimate responsibility for layout correctness rests with you. A typical womb-to-tomb service package for the MasterMOS-550 chip runs about $16,000 and takes between 6 to 8 wks, exclusive of manual layout check.

Two other companies in the CMOS field, **Master Logic** and **Microcircuits Technology**, produce arrays with approximately 600-gate densities. Master Logic, in fact, designed the CMOS devices being produced by



The 68-pin JEDEC package *for Fairchild's F200 array is designed for use in air-cooled systems. Mounted in a socket with a heat sink and an air flow of 1000 linear ft/min, it exhibits a Θ_{JA} of 13°C/W. Total array power dissipation equals 4.5W through eight power pins and 48 I/O pins. The part includes 144 internal switches with a speed-power product of 6.5 pJ.*

Whether you employ standard functional logic blocks or custom gate arrays, today's design trends yield recurring patterns of large functional islands, coupled by logic bridges. Because of complexity, performance or uniqueness requirements, designing these bridges usually involves nontrivial random-logic configurations relying upon clusters of discrete MSI and SSI arrays with fixed functions and configurations.

Recently, a new degree of flexibility has appeared in this area, in the form of a field-programmable logic family (FPLF) consisting of fast user-programmable logic devices with memory. These devices can streamline logic design by integrating the functional equivalent of hundreds of TTL gates in a few compact and flexible elements.

Signetics' FPLF consists of single-level, 2-level and registered logic elements of increasing logic power and complexity. It currently includes eight devices, each housed in a 28-pin package. A 20-pin chip set, based on a similar architecture, is in the works to cover lower-end applications requiring less I/O capability.

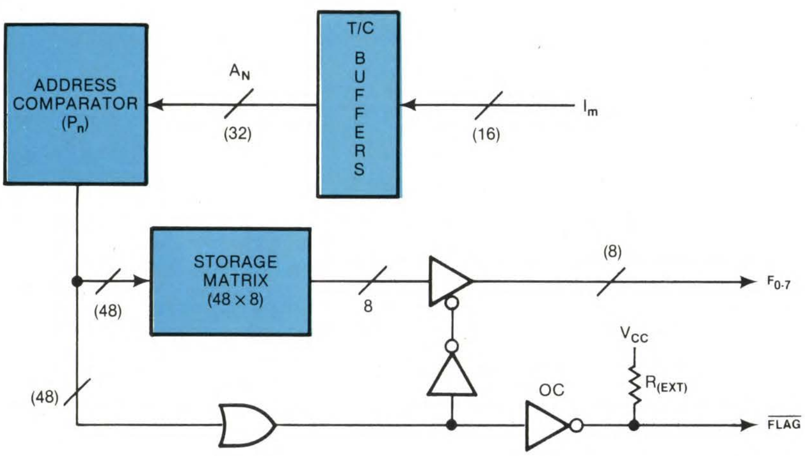
The devices in the current Signetics FPLF contain such logic elements as AND gates, OR gates, S/R flip flops, true/complement buffers and XOR gates. Programming proceeds via Ni-Cr fusible links that couple the inputs and outputs of on-chip AND, OR and XOR gate arrays. These links form arrays of cross-point connections which are initially intact; you obtain the desired logic function by selectively fusing links open as required, using readily available programming equipment.

At each level of complexity, all elements in the family incorporate features that maximize user flexibility in tailoring each device to the requirements of a specific application. Such applications include fault monitors, memory-protect logic, priority encoders, bus protocols, sequence detectors, bit/byte synchronizers and peripheral controllers.

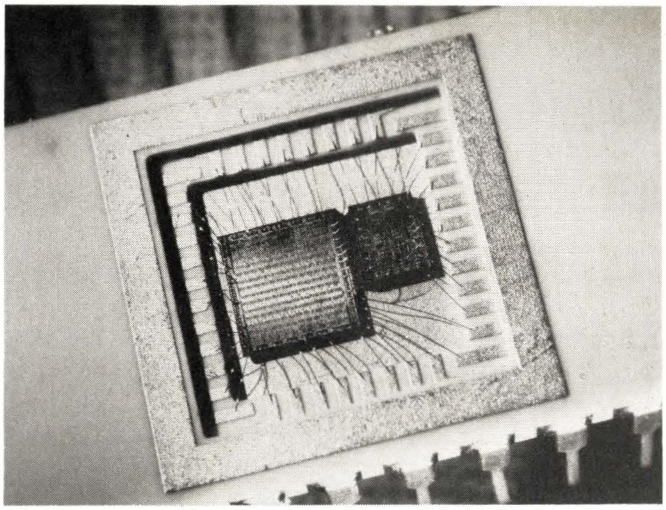
Because all devices can be programmed and modified in the field, you can plan a flexible logic system that's updateable to meet new customer requirements or specifications or to recover from design errors discovered after delivery to the field. The approach also provides a competitive edge, not only by furnishing more functions along with speed and cost advantages, but by speeding your development cycle.

Napoleone Cavlan *is product marketing manager at the Sunnyvale, CA manufacturer.*

(c)



CMOS technology's used by six semicustom firms



This 2-chip combined digital and analog system *from International Microcircuits replaces a 12×6-in. pc board containing 55 digital SSI and 6 linear packages. The larger chip is a MasterMOS-350 circuit; the smaller one, an Omnichip I device. Total development time for this custom system was 8 wks from logic schematic to first production units.*

Interdesign under a nonexclusive license; the firm's ML100, 150 and 350 are identical with the MCA, B and D from Interdesign.

Master Logic also likes to get involved in the development cycle at an early stage and will perform prelayout engineering for $1500 to $4000. From layout to prototype, parts for the ML600 run to $20,000, and production hardware for some of the less dense circuits costs $1500 to $4000.

Design procedures at Microcircuits Technology essentially follow those in the rest of the industry. Charges for service on the company's high-density Masterchip 636 reach $12,500.

Library of macros

Anticipating the move to fully computerized design

The semicustom concept

Derek Bray,
Interdesign Inc

Semicustom ICs are designed and fabricated utilizing "standard" wafers consisting of predesigned component arrays. These arrays can be interconnected in many different ways by means of one or more steps; the most common interconnection procedure utilizes single-layer metal patterning of the wafers, although customization of contact locations is also possible.

The component arrays are usually designed to serve particular applications. Processes currently employed include:

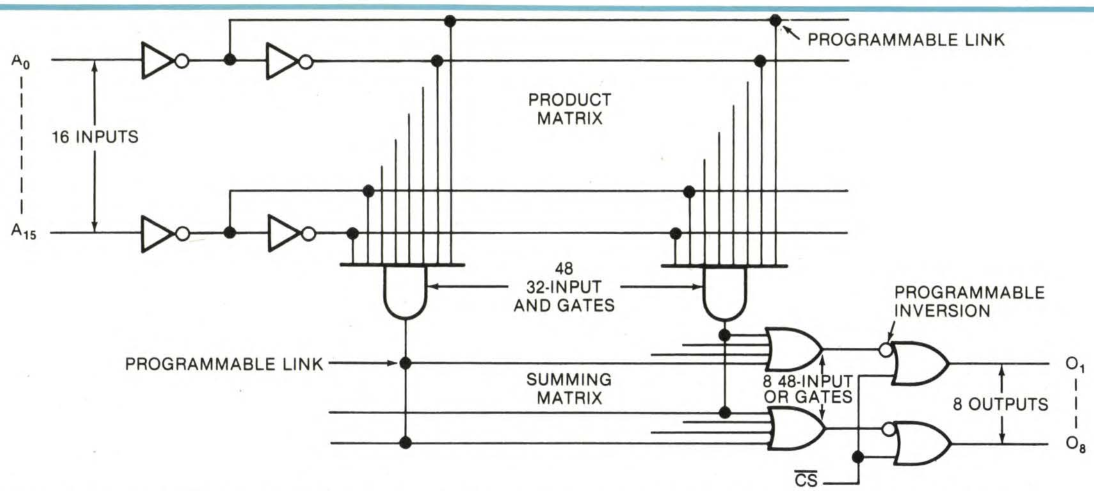
- **Standard bipolar**— Primarily used for linear/analog circuits, although digital functions can also be implemented
- **NMOS**—Suitable for gate-array configurations employed in general-purpose digital applications and for high-density use.
- **CMOS**—Mainly designed for general-purpose and low-power applications in gate-array configurations, but also applicable to linear circuit configurations
- **Collector diffusion isolation (CDI)**—Configured in both resistor-transistor-logic (RTL) and current-mode-logic (CML) gate arrays; reasonably good linear capability
- **Integrated injection logic (I^2L)**—Designed for circuits requiring both linear and digital functions on the same chip; employs modified bipolar technology
- **Emitter-coupled logic (ECL)**—Designed for high-speed computer-mainframe applications requiring a gate-array format
- **Integrated Schottky logic (ISL)**—Organized in a gate-array format with high-speed and high-packing-density capability.

The advantages of the semicustom concept are significant when compared with other approaches. They include:

- Complete design information is available, allowing customer engineers to do their own designs.
- Complete design service is provided by the IC supplier.
- Inventories of "standard" wafers guarantee product availability.
- Design and engineering-tooling costs are low.
- Designers obtain fast turnaround on prototype samples and production orders.
- Pricing is cost effective at all production-volume levels.
- Designers can make changes quickly, even in production.
- Standard processing guarantees a highly reliable product.
- Second-sourcing is available quickly when required.
- Products are fully compatible with standard IC assembly and testing capabilities.
- Confidentiality is maintained on all designs—units are difficult for competitors to copy.
- Complete system "debugging" is possible at the IC level before consideration of an expensive full-custom program.

The approach's viability has been demonstrated by wide industry acceptance in automotive, telecommunications, industrial, military, consumer, medical and computer applications. Present applications cover the full range of analog, digital and combination analog/digital circuits. Production volumes can range from 100 to one million devices per year.

Derek Bray *is vice president for engineering at the Sunnyvale, CA firm.*



The flexibility *of a typical FPLA results from its wealth of on-chip programmable options. The 32×48 product matrix serves as a programmable address decoder, while the 48×8 summing matrix serves as a data store. Outputs are programmable as either inverters or buffers.*

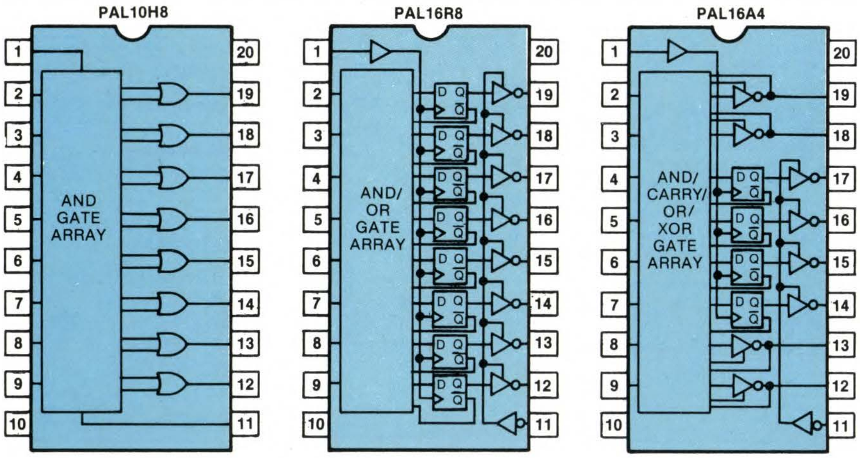
aids, **Motorola** has built its Macrocell Array from cells containing transistors and resistors not connected into gates. To configure these cells into SSI and MSI blocks, you choose among a library of macros that define functions ranging in complexity from a flip flop to a combination full adder and half adder. The computer

A PAL review

John Birkner,
Monolithic Memories Inc

PAL stands for "programmable array logic"; there are currently 15 devices in the PAL family manufactured by Monolithic Memories and second-sourced by National Semiconductor. The devices range in complexity from combinatorial to sequential and arithmetic; they replace conventional 7400 Series TTL gates, MUXs, decoders, encoders, flip flops, shift registers and counters and achieve a fourfold to twelvefold package-count reduction. Features include:

- **Speed.** Propagation time through three logic levels equals 40 nsec max over voltage and temperature ranges; clock-to-output time equals 25 nsec max.
- **Small size.** All 15 devices are packaged in the popular 20-pin, 300-mil-wide Skinny-DIP.
- **Fast design turnaround.** Boolean equations specify the design and are converted to a fuse pattern by the PAL assembler (PALASM). A PROM programmer thus becomes a custom-LSI design center: With a PAL personality module, Data I/O, Pro-Log, Stag and other PROM programmers can blow a PAL's titanium-tungsten fuses according to the specified logic equations. Editing the equations and blowing a new part easily corrects design errors.
- **Cost effectiveness.** Compared with 7400 Series TTL, PALs save pc-board space and provide single-board design solutions. Compared with custom logic, they are a high-volume, off-the-shelf, multiple-sourced standard family. Die sizes range from 13,000 to 19,000 mil^2—comparable to those of standard 2k and 4k bipolar PROMs. Devices employ standard bipolar-PROM Schottky TTL manufacturing processes.
- **Conversion capability to HALs.** PAL is to hard-array logic (HAL) as PROM is to ROM. Thus, the fuse pattern for a PAL can generate a metal mask for a HAL. The cost of manufacturing a HAL is significantly less than that for a PAL for quantities greater than 1000 devices per pattern.



A representative sample of the PAL family *includes the 10H8, a simple PAL with 10 inputs to a programmable product matrix and eight outputs from a fixed summing matrix. The 16R8 has 16 inputs and eight outputs, but the outputs are registered and can feed back internally. The 16A4 adds XOR and carry capabilities for arithmetic applications.*

John Birkner *is manager of product planning for programmable logic at the Sunnyvale, CA company.*

Several firms provide CAD-software aids

stores the internal connection pattern for these macros and automatically generates the pattern for a chosen function; your job centers on macro placement and interconnection.

The Macrocell Array contains 106 cells; presently, you can choose among 85 different macros. The ECL product is MECL 10K compatible. Using a hookup to Motorola's Western Area Computer Center, you do most of the development work, while Motorola does the tooling, production and testing. The charge for services is $40,000, exclusive of computer time and terminal rental.

Designers employing any of **Signetics'** arrays (I^2L and ISL) will also find themselves hooked to a computer, though not to the exclusion of manual layout and checking. Actually, the company offers four different customer-interface plans, depending on your resources and equipment.

Services charges for a Signetics I^2L design run to $30,000, including 150 min of computer time to run TEGAS test-vector generation and simulation. Signetics' primary efforts, however, lie in ISL arrays. A variant of I^2L, ISL combines the low power and packing density of I^2L with the speed of Schottky TTL—obviously making it another VLSI-technology candidate. A 1200-gate array is now in production, and a 2000-gate chip is in development.

The more the merrier

The resurgence of interest in uncommitted logic is drawing new companies into both the semicustom and fuse-programmable fields. For example, look for an announcement from AMI in about the third quarter of this year regarding a line of silicon-gate CMOS semicustom arrays. And expect some words from Harris Semiconductor on an FPLA.

Also note that National Semiconductor is covering all bets: It announced a marketing agreement with Motorola concerning Macrocell Array-derived parts last November and has recently announced its intention of producing some of the PAL device types. Pricing on those PAL products selected will start at about $50 but should drop substantially when National goes into full production. **EDN**

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

Manufacturers of semicustom and fuse-programmable logic devices

For more information on the products or services described in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

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Intersil Inc
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Master Logic Corp
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Microcircuits Technology Inc
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(408) 988-7771
Circle No 421

Monolithic Memories Inc
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(408) 739-3535
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Motorola Inc
Box 20906, MS 370
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(602) 962-2689
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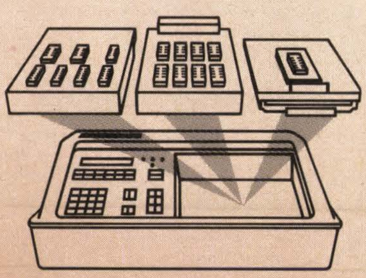

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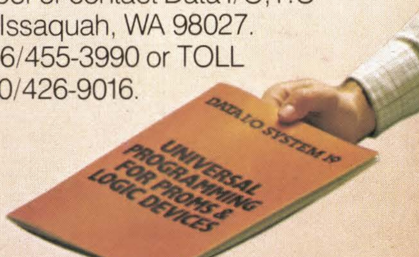


DATA I/O

For more information, Circle No 53

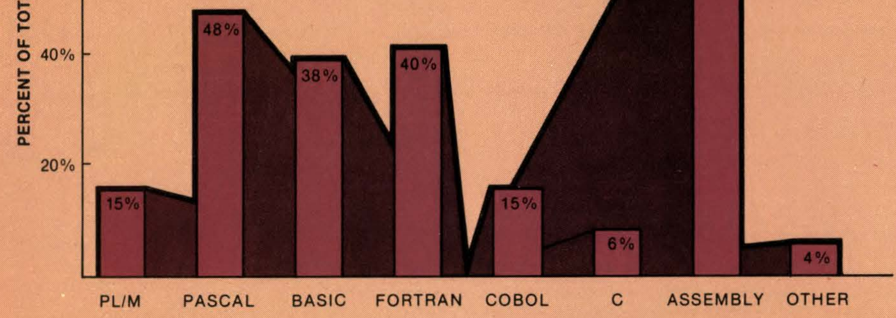
PASCAL update

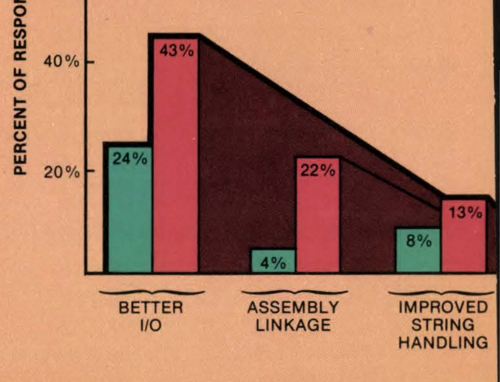
A year ago, the big news about PASCAL centered on the chaos involved in defining it. The language still hasn't been standardized, but it is starting to find use.

Jack Hemenway, Consulting Editor
and **Edward Teja,** Associate Editor

The host of PASCAL implementations currently offered continues to cloud the issue of what PASCAL actually is. Efforts to standardize the language clearly show the amorphous nature of the problem—PASCAL means drastically different things to different users. Unfortunately, when users (and potential users) discuss the benefits of PASCAL, the terminology they employ makes it sound as

PASCAL—WHAT USERS LIKE .





though agreement exists where there really isn't any.

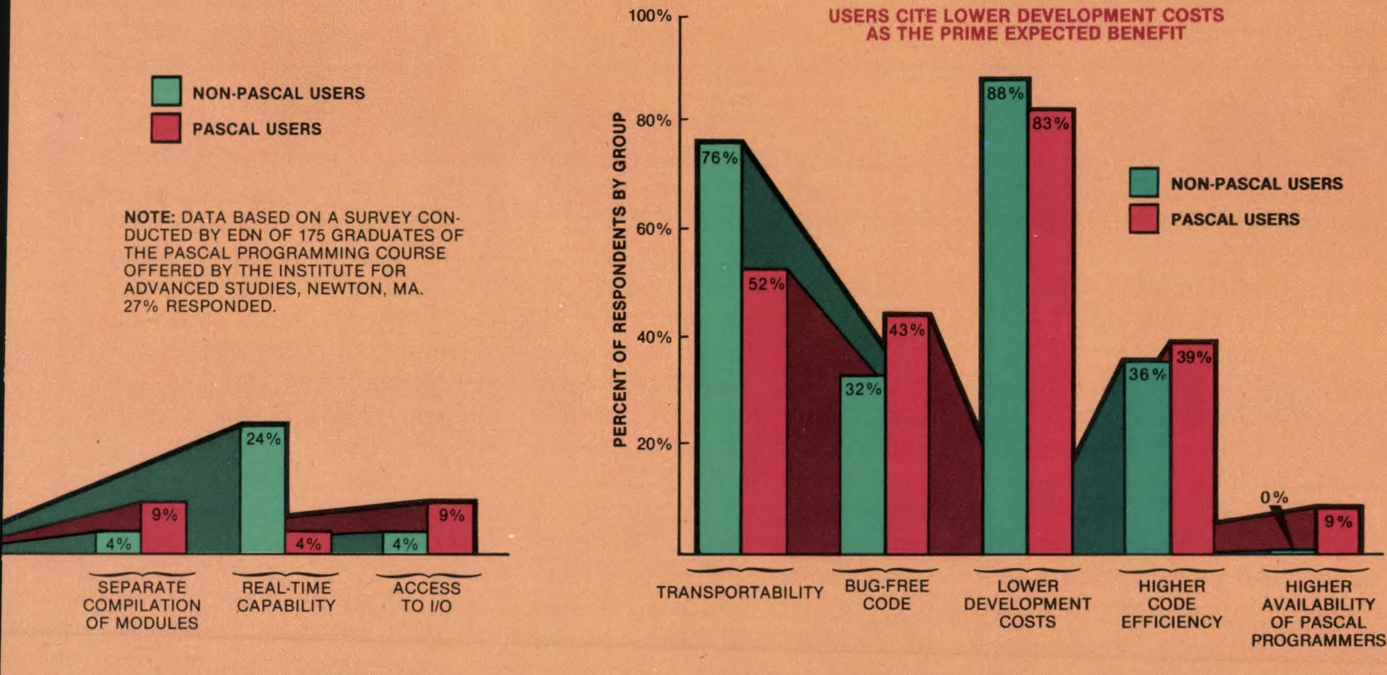
The most general attitude toward PASCAL comes from its association with the term "structured programming." Indeed, Jensen and Wirth embodied their own value judgments concerning structured programming in their original definition of the language—an act that has resulted in unfortunate confusion. Now, whenever people discuss the advantages of structured programming, the discussion sounds like a sales pitch for PASCAL.

But it isn't. Most programming *can* be structured, while PASCAL *must* be structured. And therein lies the difference: PASCAL forces the issue;. it doesn't make the virtue possible.

A survey attempts to define usage

To gain perspective on how working EEs and programmers are using PASCAL, EDN created a questionnaire. Then, with the assistance of Dr Donald French, president of the Institute for Advanced Professional Studies, we put the questions to 175 professionals who graduated from the Institute's

WHAT THEY WANT



Transportability of source code isn't restricted to PASCAL

PASCAL programming course. The results, cited throughout this article, proved highly interesting.

In creating the questionnaire, we started with the following assumptions, guesses and assorted biases:

- A survey of persons who have spent money to take a PASCAL course is more useful than one of EEs in general.
- It should prove enlightening to find out how many of these people are actually using PASCAL and what kinds of programming they are performing with it.
- Companies that send programmers to school are more likely to have standardized internally on PASCAL.
- A difference exists between the arguments in favor of PASCAL presented by those expecting to use it and by those already using it.
- Few programmers use PASCAL for systems programs (as opposed to applications programs).
- Everyone wants to see extensions to the language; the extensions desired are a function of the language implementation used.
- Most programmers aren't satisfied with PASCAL's I/O characteristics as defined by Jensen and Wirth.

As you'll see, the responses bore out some of these assumptions but not others.

We were gratified that 27.4% of the group surveyed found the time to answer our questions. As expected, the majority of these respondents are primarily applications programmers. Unexpectedly, less than half are actually using PASCAL for anything at all.

Keeping the machine at arm's length

For persons accustomed to programming in assembly language, switching to PASCAL can come as a shock. For after spending hours evaluating the various μPs on the market and finally selecting one, you find that much of your effort is wasted: PASCAL, in its Jensen/Wirth incarnation, makes all machines look alike. As a result, the very benefits that made you choose a particular μP are rendered inaccessible with PASCAL.

And what about PASCAL's use in real-time applications? P-code implementations don't generally offer any method of programming in real time, and any other implementation destroys PASCAL's almost legendary transportability benefit. It is, after all, the P code that's supposed to allow you to write programs on an IBM 370 and execute them on a TRS-80. (Of course, no one has ever satisfactorily explained why you would want to.)

Taking transportability to its extreme in this manner stresses that all it really accomplishes is to limit the capability of the most powerful machines to that of their lowest common denominator. Indeed, the term "transportability" often merely refers to the more pragmatic source-code-level compatibility.

At Loral Electronic Systems' Atlanta Div, for example, senior programmer analyst Harold Bray began writing an assembler for Texas Instruments' 9900 in TI's Microprocessor PASCAL. Part way through the project, he transferred the source code to a PDP-11 system and continued writing the cross assembler in Oregon Minicomputer Software Inc's (OMSI) PDP-11-resident PASCAL. The transfer required a few minor modifications to accommodate discrepancies between the two PASCAL implementations. Calling this feature "transportability" makes it sound as though it's a unique benefit of PASCAL. Yet source compatibility exists in any ANSI-standard language.

But transportability at any other level might be no more than a Holy Grail for standards committees. As Jim Isaak, Data General's product manager for general systems software, points out, the crucial question is

The PASCAL potpourri

PASCAL's efficiency, rules, syntax and execution speed vary among its many implementations. You have a choice of extremes that range from People's PASCAL I, which runs on any 16k TRS-80 Level II system ($15 from Computer Information Exchange Inc), to PASCAL-80, designed for Intel's Intellec development systems ($975 on single- or double-density floppy disc), to PORTAL—a PASCAL-based language designed for writing real-time, concurrent process-applications packages (Landis & Gyr Central R&D Laboratory, Zug, Switzerland). In fact, it's dangerous to assert that you're limited to even this wide spread of choices—there's a new one born every minute, it seems.

If you're interested in adhering to the current International Standards Organization's idea of what PASCAL is supposed to be, you can get help. The ANPA Research Institute offers a collection of 283 programs that test an implementation's compliance with the standard; the programs are authored by Prof A H J Sales of the University of Tasmania, Australia.

This $50 package comes on 9-track tape and tests conformity, deviance, error handling, quality and features related to the particular implementation. You can obtain a copy of the source code for consideration (not use—you must buy a tape for that) from the PASCAL User's Group, c/o the Atlanta Sales Office of Digital Equipment Corp ($3). Ask for the October 1979 issue of *Pascal News*.

"How big is the P-code set and what P code are you using? You can't even begin to say until you know what machine you're talking about."

Accommodating reality

These problems have led PASCAL vendors to supply industrial programmers with implementations of the language that take advantage of each machine's particular architectural strengths. Taking a realistic view of the programmer's needs, these firms typically don't offer just an interpreted implementation **(Fig 1)**; some provide compiler versions that output native-machine code, allowing a programmer to capitalize on existing libraries of commonly used routines written in assembly language **(Fig 2)**. On the other hand, some vendors leave P-code generation intact to permit quick, interactive program writing, testing and debugging but add a "second stage"—a native-code generator that translates P code into native-machine code **(Fig 3)**.

Additional extensions improve PASCAL's performance in the industrial world. For example, the full-strength versions come with multiprocessing capability because some applications require concurrency. When a processor must handle several processes in real time, there's no way to fake it—the software must be designed to provide the proper performance level.

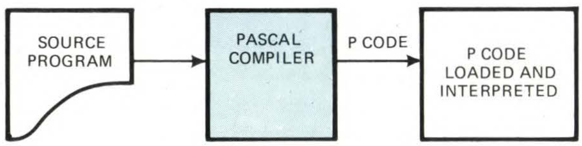


Fig 1—Interpretive PASCAL implementations *often compile source code into a P code that gets loaded and interpreted.*

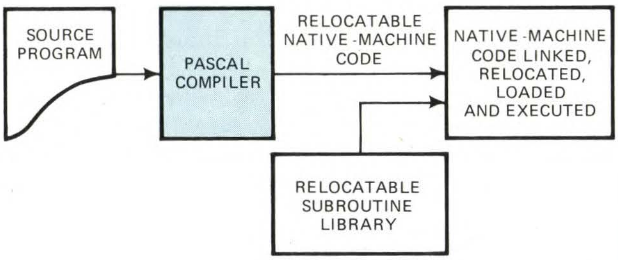


Fig 2—Some PASCAL compilers produce native code, *making it simpler to interface PASCAL programs to a library of routines written in assembly (or other) language.*

The literature describing these industrial PASCALs typically terms them "a superset of the Jensen/Wirth PASCAL." But this distinction is misleading; it's true only in the sense that the source program contains statement types that form a superset of Jensen/Wirth PASCAL; their execution isn't even close to that of the academic standard.

Putting PASCAL to work

Although there are undoubtedly some applications employing "standard" University of California at San Diego (UCSD) PASCAL or its equivalent, none that relate to serious engineering work surfaced in our survey. Rather, the applications we uncovered employ implementations such as Texas Instruments' Microprocessor PASCAL—a system that offers concurrency (EDN, October 20, 1979, pg 325), among other extensions.

In this regard, note that Mostek Corp offered a PASCAL that was based on UCSD's but took it off the market—it didn't satisfy the needs of Mostek's μC customers. As manager of strategic marketing Jerry Winfield points out, "The product wasn't useful for development work. You need PROMable code for the applications our customers are developing."

Winfield's list of desirable extensions, which you can expect to see implemented in Mostek's new PASCAL later this year, includes:

- Interrupt capability
- Control over port I/O
- Control of PEEK- and POKE-type functions.

Linkage to assembly language, he adds, is a must for any serious development language.

The use of non-UCSD PASCAL characterizes a particularly interesting engineering application uncovered by our survey: Westinghouse's Advanced Energy Systems Div, Pittsburgh, PA, is developing a set of solar-power controls that operate under computer control. A minicomputer down-line loads to a central μC system, which in turn controls μC-controlled heliostats; PASCAL is the programming language for the supervisory μC. The heliostats must track the sun with extremely high accuracy, and all of their control

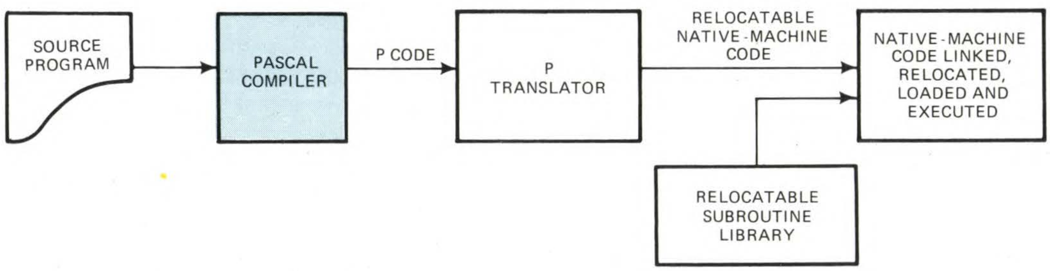


Fig 3—Translating P code into native code *furnishes the flexibility of a system that supports interpretive or native-code execution.*

Many engineering problems require real-time operation

processes must operate concurrently. The main μC controls all software storage in its bubble memory, as well as the communications protocols employed to talk to the mini.

Although the application isn't up and running yet, principal EE Gio Mutone feels confident that Texas Instruments' Microprocessor PASCAL suits it. Although Mutone might be forced to write some interrupt-handler routines in assembly language to maintain real-time accuracy, this PASCAL implementation provides the necessary linkages to accomplish that task. Mutone also awaits TI's introduction of its native-code generator for Microprocessor PASCAL, which promises to improve execution speeds as much as sevenfold.

What extensions are now offered?

The Westinghouse story involves a design that faces real-world problems—problems largely ignored by those who would keep PASCAL pure and free of unsightly extensions. Thus, it came as no surprise that EDN's survey uncovered striking similarities between the respondents' PASCAL-extension "wish list" and the extensions actually offered by vendors. These are, after all, the same sort of extensions that form the basis for competition among PASCAL implementations.

Data General, for example, offers versions of its MP/PASCAL for use with its MICRON operating system (for Micronova systems) and Advanced Operating System (AOS), which supports Eclipse configurations. The firm's extensions include dynamic-string data types, separate compilation modules, file-I/O extensions and an assembly-language interface.

According to Data General's Isaak, the strategy is to offer a version of PASCAL that does take advantage of a machine's architecture. With Mostek's Winfield, he maintains that sticking to the Jensen/Wirth standard won't satisfy his customers. "You cannot get your hands on good random-access files," Isaak complains about standard PASCAL. "Files can't be opened for both input and output or modified." A useful PASCAL, he says, needs strengths in three areas: I/O, performance (including multitasking capability) and standardized set size and file interfaces.

Rational Data Systems sells a competing PASCAL in versions that suit use with Data General's AOS, RDOS and three versions of RDOS/DOS. It, too, provides segmentation—you can divide a program into as many as 16 pieces, which can be automatically loaded on call. This compiler furnishes random file access, decimal and string variables and access to the host operating-system facilities, all for $2500 to $4000, depending on the version selected.

What extensions do users want?

Echoing vendors' sentiments, EDN's 48 respondents requested 45 extensions, some overlapping, to standard PASCAL. Those currently using PASCAL (sometimes called PASCALers) requested two extensions on average: The minimum number of requested extensions per person was zero; the maximum, six. Non-PASCALers proved more complacent, averaging one extension request, with a minimum of zero and a maximum of three.

As expected, improvements in the area of I/O head the list; fully 33% of the respondents cited improved I/O as an extension they want to see. Few users are satisfied with tape I/O; most feel that their systems could be improved with the addition of random-access files—a total no-no, according to the Jensen/Wirth standard. (For a comprehensive discussion of random-access files and file management in general, see EDN, November 20, 1978, pg 281, and June 20, 1979, pg 153.)

Second on the wish list (15%) was a request for real-time extensions; closely related was the third-place insistence on linkages to assembly-language routines (13%). Apparently, there are many programmers involved in time-critical applications for whom PASCAL isn't adequate—unless they can write assembly-language routines for situations such as interrupt handling and can interface to the real world in real time by means of multitasking capabilities. As Loral's Harold Bray says, "For what PASCAL is supposed to be, you have to have a linkage to a lower level like assembly language for some critical sections."

The fourth most frequent weakness users reported centers on PASCAL's string-handling capabilities. As Terry Layman, senior software engineer at Omex, Santa Clara, CA, points out, "Most of the PASCAL users in the world agree that the biggest problem with 'standard' PASCAL is its inability to handle variable-length strings in an efficient way. When you're working with input typed by a user and messages sent to a terminal, this is a serious problem." Layman's group had to invent a local string handler (coded partially in assembly language!) to solve it.

The remainder of the extensions cited in our survey

PASCAL as traffic cop

One of PASCAL's less publicized features is its extensive compile-time error checking—a feature that ensures that the language's rules are enforced. For example, in a call to a procedure, a passed parameter's type must be explicitly given and must match the corresponding dummy parameter's type in the procedure declaration. If it doesn't match, the compiler issues an error message.

Not all programmers want this traffic-cop function. Terry Layman, senior software engineer at Omex, for example, says, "I also see a need for the user to be able to explicitly suppress type checking in procedure/function parameters. The examples I've seen of ingenious variant record structures designed to bypass the ever-watchful eye of the PASCAL compiler are wondrous to behold."

had more scattered support. Of our sample, 6% wanted separate compilation of program modules, 6% desired a data-base-management-system interface, 6% wanted lower level access to I/O and 4% called for an ELSE/OTHERWISE on CASE statement form. These requirements appear to reflect the needs of particular applications.

Few internal standards—yet

Last year, when researching PASCAL, EDN was told by many firms that they intended to make the language their internal standard. But our survey revealed only two companies that have done so, and one of those has only managed to standardize in one of its divisions.

Even PASCAL vendors haven't necessarily standardized on the language. For example, Hewlett-Packard Co, purveyor of PASCAL for its HP 1000 computers, employs MICROL, which is similar to PASCAL, for its internal standard. MICROL's exact degree of similarity to PASCAL remains unknown at this time, though.

More information is available, however, on HP's $4000 PASCAL/1000, available this month. Its compiler runs in the multiuser environment of HP's disc-based RTE-IVB operating system; you can link its PASCAL programs to external PASCAL, FORTRAN or assembly routines as well as HP's proprietary IMAGE/1000, GRAPHICS/1000 and DATACAP/1000 software. HP has added separate compilation, direct-access I/O and double-word-integer and double-precision-real data types to the standard language definition.

Death of UCSD PASCAL?

Although manufacturers might not yet have standardized internally on PASCAL, many have been busily offering PASCAL implementations implying that the UCSD PASCAL system has indeed become a de facto standard. To the contrary: The term has become meaningless; UCSD PASCAL is no more.

The University of California at San Diego, originators of this P-code embodiment of the Jensen/Wirth standard, has cancelled all existing licenses to users of the software. Thus, all those who thought they were buying a future μC-standard package bought nothing but air. As of this writing, Softech Microsystems Inc is the university's sole licensee.

But while the debate concerning the legitimacy of UCSD's actions and those of Dr Kenneth Bowles rages on, manufacturers are readying new PASCAL implementations that they can be sure of selling. The caveat is simple, therefore: Beware of UCSD PASCAL lookalikes; they could come under future legal fire. Perhaps avoiding university-created software would prove prudent as a general rule.

There is also some question concerning the ownership of software developed on projects supported by government money. In the October 3, 1979 issue of the *Intelligent Machine Journal* (pg 16), the principals and interested parties to the UCSD argument discuss the assertion that such software should be in the public domain. The criterion this proposition hinges on is "public money, publicly owned software." But the issue is far from settled. **EDN**

Acknowledgements

Special thanks to the people mentioned in this article and to Pete Zieblemann of Texas Instruments, for their help.

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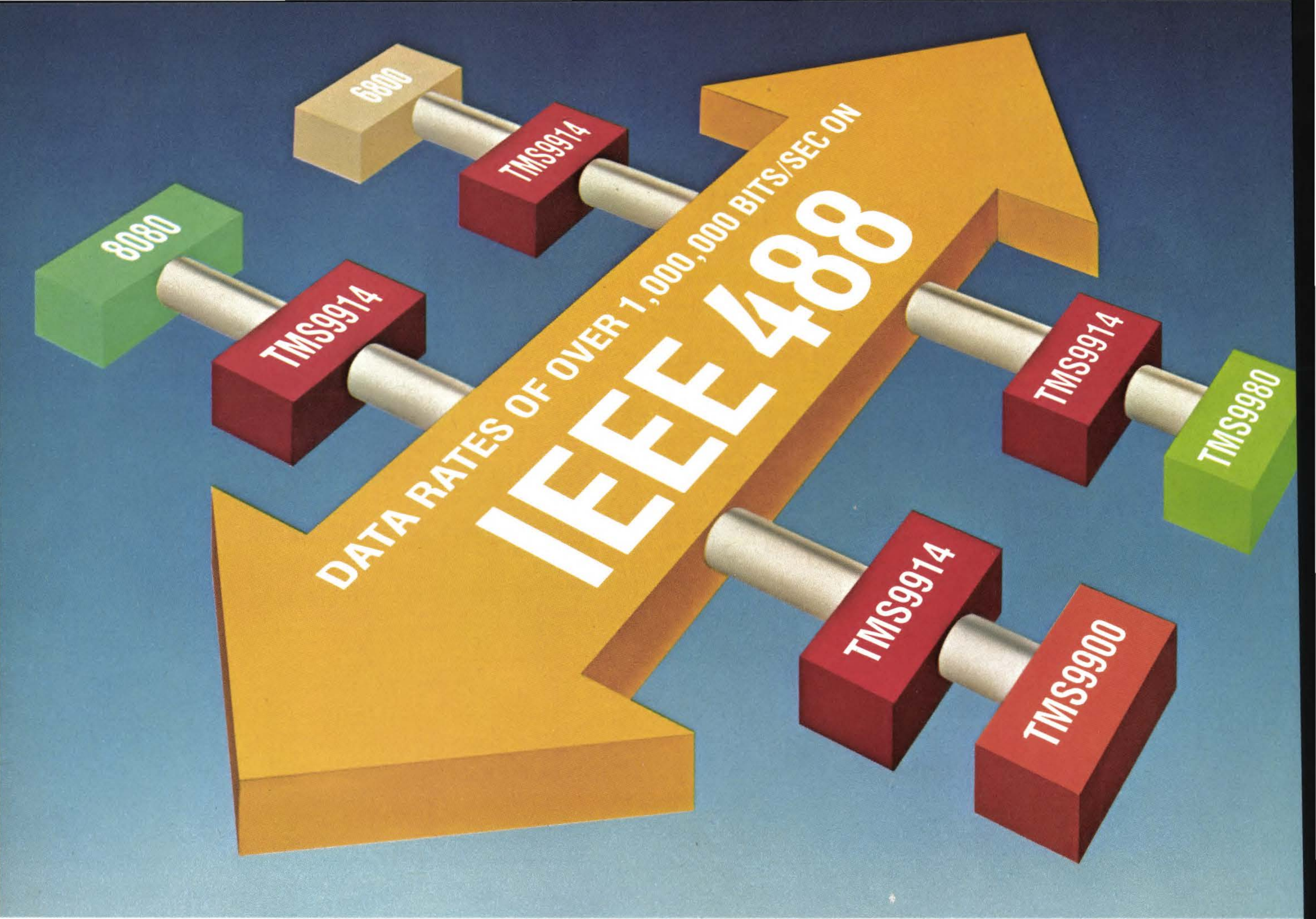

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Optical-waveguide performance hinges on manufacturing variables

Until optical fibers become standardized, designers must consider the effects of variations in both dimensional and optical properties to realize optimum system performance.

David Charlton, Corning Glass Works

Today's doped, deposited-silica optical-waveguide manufacturing processes produce fibers with variations in core and cladding geometry, coating, numerical aperture and alpha value. To properly specify such products, you must evaluate manufacturing inconsistencies and understand their impact on total system performance (**Table 1**).

To that end, this article considers these fiber parameters, briefly discusses their associated manufacturing processes and suggests ways to correctly specify your fiber requirements. For a look at the measurement techniques that can help characterize fibers once you've acquired them, see the article on pg 117.

Start with physical factors

One important fiber characteristic, core geometry, generally encompasses three factors—ellipticity (circularity), concentricity within the fiber's outer diameter (OD), and diameter. Factors involved in preparing a preform (the glass rod that's drawn into a fiber) largely determine these core parameters.

Core-geometry variations play a big part in system performance with regard to system interconnects. Studies (**Refs 1** and **2**) have shown that lateral offset of cores strongly affects splice and connector performance, introducing insertion losses caused by conversion of desirable signals into highly attenuated high-order modes in the receiving fiber. Lateral core offset also produces cross-sectional loss arising from missed overlap of the cores.

Then, too, if a fiber core isn't concentric, it will probably be offset relative to a second core—leading to increased splice loss. This consideration becomes particularly important in long lengths of fiber; if a fiber is long enough to achieve its expected Gaussian transmission characteristic (equilibrium modal distribution), a small cross section of fiber core supports propagation.

Unfortunately, you can't do much about this problem: Typical core-diameter specs call out a nominal value

TABLE 1 — EFFECTS OF FIBER MANUFACTURING VARIATIONS ON SYSTEM PERFORMANCE

PARAMETER	SPLICING AND CONNECTING	CONNECTORIZING	CABLING	TEMPERATURE VARIATION	STRENGTH
CORE GEOMETRY					
ELLIPTICITY	●				
CONCENTRICITY	●				
DIAMETER	●				
CLADDING GEOMETRY					
ELLIPTICITY	●	●	?		
DIAMETER	●	●	?		●
COATING					
ELLIPTICITY		●	●	●	
CONCENTRICITY		●		●	
DIAMETER		●	●	●	●
NUMERICAL APERTURE	●		●		
ALPHA PROFILE	●				

Narrow tolerance bands decrease fiber selection, increase costs

plus or minus a tolerance, and quality-control measurements of core geometry are usually made on one end of a fiber. It's not very practical to measure core geometry continuously along a fiber's length, so specifications that contain such a requirement aren't realistic.

Cladding variations produce optical problems

When considering another fiber variable, cladding geometry, remember that while most drawing processes ensure a nearly circular cladding OD, the control methods used by manufacturers aren't perfect. Although researchers have demonstrated improved results in the lab **(Ref 3)**, production systems can control OD variations only to within less than 5%.

Cladding-OD variations affect a system through splice and connector losses, problems in connectorizing (physically applying a connector to the bare fiber) and multifiber-cable manufacturing problems. Fortunately, connectorizing problems are usually minor; because fiber-OD variations tend to occur over short lengths **(Ref 4)**, you can usually break back a poorly sized fiber a few centimetres and successfully insert it into a ferrule or other type of connector.

Fiber-OD variations can cause optical problems, however. Severe diameter deviations can exhibit localized attenuation factors greater than that of the adjoining fiber. Furthermore, large diameter irregularities might reduce fiber strength—geometrical upsets caused by foreign matter tend to focus stress at those points.

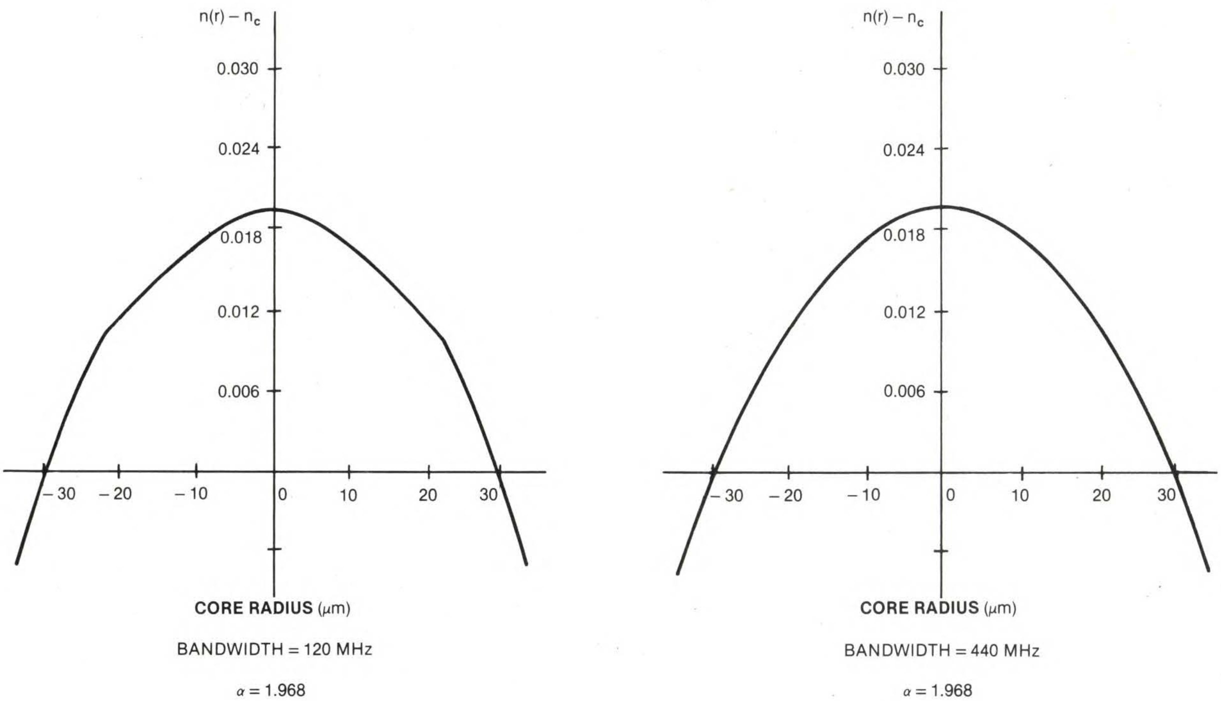
Coating considerations round out optical fibers' physical problem sources. Coating variations occur in drawing processes as a result of die wear, coating-material nonuniformity or poor curing and tend to affect a fiber's temperature-related attenuation change. And inside a nonuniform polymer coating, microbending can result when temperature changes cause coating-material contractions.

In general, the more uniform the coating, the better a fiber performs under temperature changes. And you need not worry about coating ellipticity and concentricity in connectorizing; you normally strip the coating away during connector installation.

To minimize the effects on system performance arising from these physical variations, some specification methods utilize concentric circles to describe both coating and fiber geometry. In general, though, measurement-technique limitations make such specification approaches impractical; you'd be wiser to specify temperature performance and diameter excursions.

Optical parameters also vary

Other manufacturing variations can affect fiber optical parameters such as attenuation and bandwidth. The bandwidth-related index-profile parameter (α), for example, determines the rate at which the refraction



***It's risky** to use the index-profile parameter (α) as a figure of merit when selecting optical fibers: A given value might represent many "best-fit" index-of-refraction curves, and bandwidths can vary widely for identical α values.*

TABLE 2 — ALTERNATIVE FIBER SPECIFICATION

PARAMETER	SPLICING AND CONNECTING	CONNECTORIZING	PROCESSING	TEMPERATURE VARIATION	STRENGTH
CORE GEOMETRY	•				
CLAD GEOMETRY	•	•	?		•
COATING		?	•	•	•
NUMERICAL APERTURE	•		•		
ALPHA PROFILE	•				
SPECIFY	JOINING LOSS	CORRELATION LENGTH	EXCURSIONS	TEMPERATURE STABILITY	MIN STRENGTH

index changes radially across a fiber core. When measured, however, a given alpha can represent many "best-fit" index-of-refraction curves, resulting in different calculated bandwidths **(Ref 5)**. Fibers described in the **figure,** for example, exhibit the same best-fit alpha value but markedly different bandwidths. This spec's use as a figure of merit thus carries some risk. It's probably much more effective to disregard alpha and specify a bandwidth performance at a certain wavelength.

Associated with a fiber's attenuation characteristics, numerical-aperture (NA) variations stem from composition changes along the length of a preform. These inconsistencies can increase a fiber's sensitivity to microbending, and when combined with core-diameter variations between spliced fibers, can cause intrinsic losses. Reducing the acceptable tolerance band relative to core diameter and NA can reduce these variations' contribution to total splice loss **(Ref 6)**.

But while this approach can result in modestly improved performance, in actual use, propagation effects minimize such contributions to the level of intrinsic splice loss in any event. Measured core-diameter and NA values tend to be smaller than calculated specs for long fibers. While this effect can vary from fiber to fiber, over a distance of 1 km a 10% reduction in these parameters is common. Such a reduction can result in lower splice losses than those predicted **(Ref 7)**.

Such effects create a dilemma for the system designer. Narrow tolerance bands decrease the number of fibers you can choose among, and they increase cost. And like those for other fiber parameters, NA and core-diameter measurements are frequently made at only one end, so their values might not represent performance along the fiber's length. Furthermore, as noted, tighter tolerances in NA and core diameter might not substantially improve splice performance.

No method exists to fully resolve the tradeoffs among such considerations. To specify an optical system, then, you could simply cite to a vendor the conditions under which splices will be made in the field and request that certain performance levels be met.

All the factors considered in this article point to the need for designers to work carefully with suppliers. Examine the measurement methods used by each manufacturer and determine whether or not they represent your final system-performance requirements; no single measurement value for attenuation and bandwidth will accurately serve for a fiber under all conditions.

A better way to specify fiber?

This article has centered on specifying fiber attributes, but you could alternatively specify fiber performance **(Table 2)**. For example, instead of concentrating on core and NA variations, you could specify splice loss under some representative conditions. And this approach could describe most of a fiber's physical attributes.

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Alternative spec'ing procedure quantifies fiber performance

Using such a procedure, the fiber-specification section of a proposal could appear as follows:

Attenuation	per quotation
Bandwidth	per quotation
Intrinsic splice loss	<0.2 dB with input length >1 km, fusion spliced, random matings
Coating-OD excursions	10% nominal
Screen-test level	per quotation
Temperature variation	per quotation

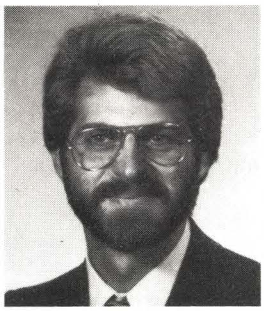
Such a description simplifies fiber-parameter specification to a consideration of system performance requirements and reduces the risk of overspecification in the final product. EDN

Acknowledgement

This article is based on a paper presented at the National Electronics Conference in October 1979.

Author's biography

David Charlton is a product planner at the Electronic Products Div of Corning Glass Works, Corning, NY. Formerly an applications engineer, he now handles new-product introduction, planning and scheduling. A member of the IEEE, David enjoys bicycle touring in his spare time.



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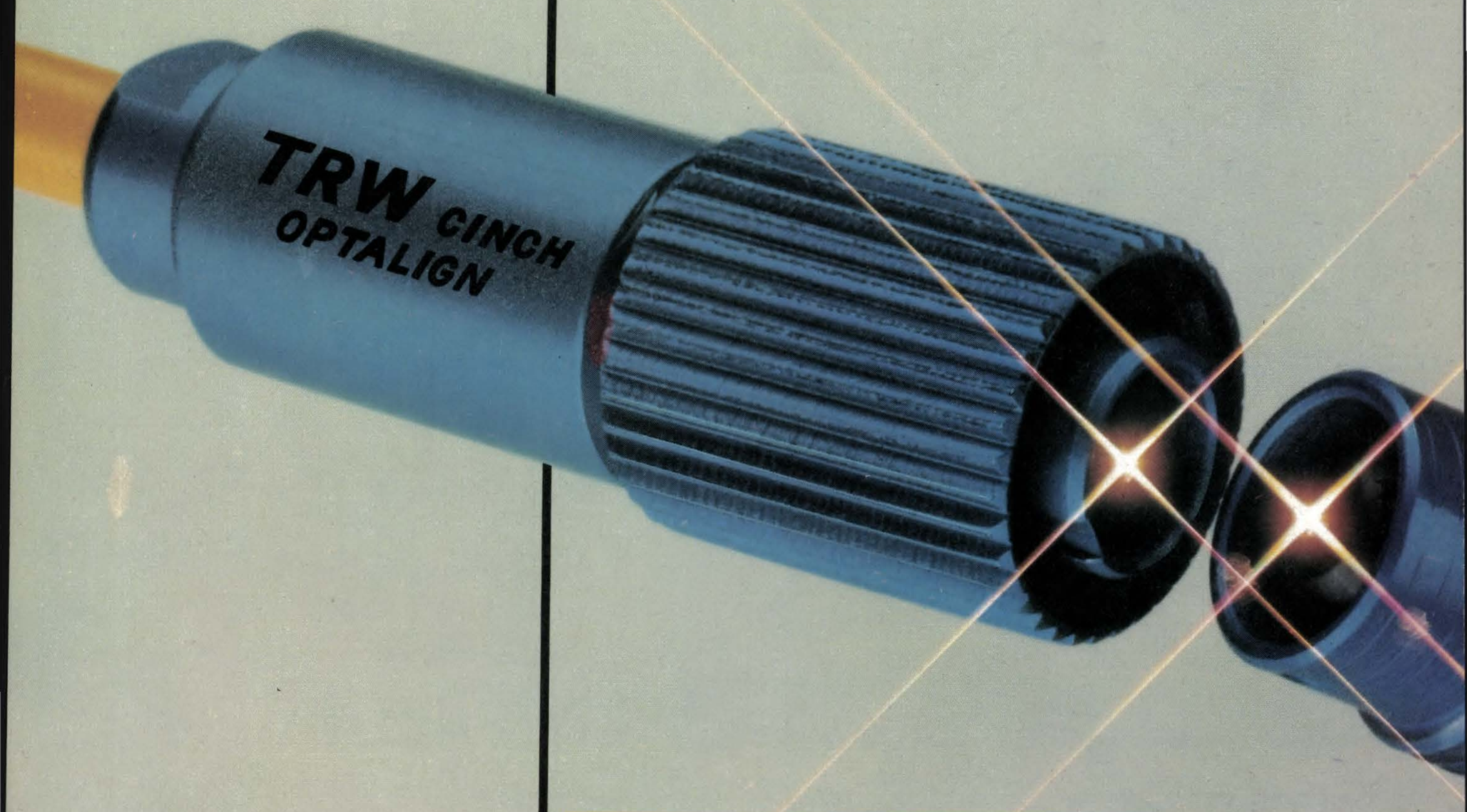
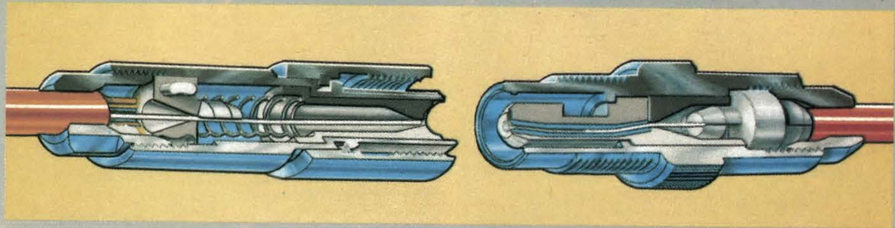
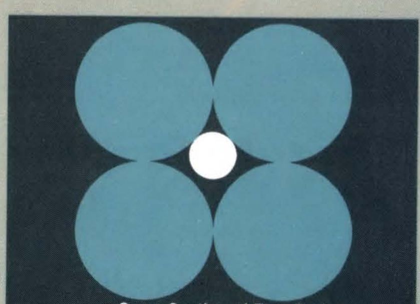
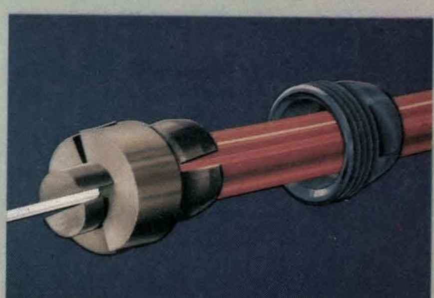





Cross Section of Four Rod Glass Alignment Element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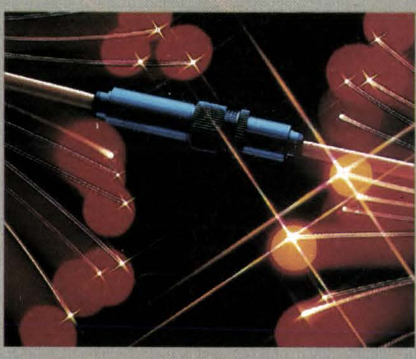

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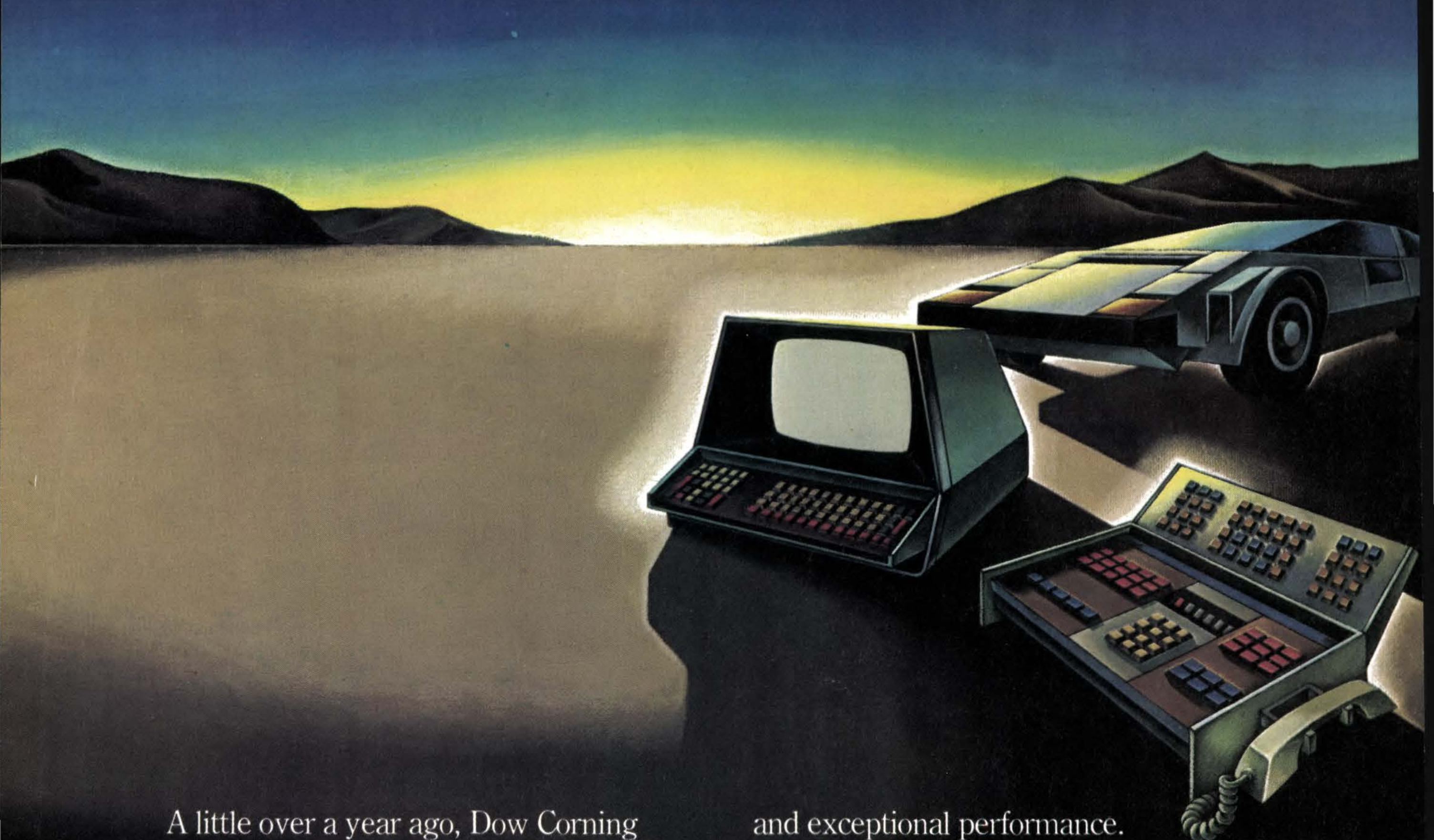

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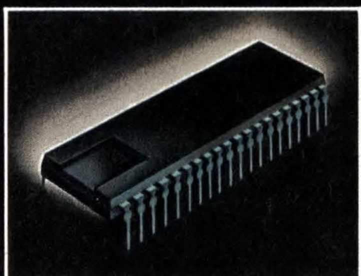

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Master measurement techniques to polish fiber-optic performance

Fiber-optic measurement techniques are still in their infancy, but you can cut the cost and raise the capabilities of your system by studying the methods researchers have already developed.

Andy Santoni, Western Editor

Characterizing optical fibers is much more difficult than measuring the parameters of analogous components for systems operating in other portions of the electromagnetic spectrum. The result? A need for caution, both in specifying fiber-optic components and in establishing system margin requirements.

The characterization task is complicated by the unstandardized state of current measurement techniques (see **box,** "The problems with fiber-optic measurements"). Consequently, several groups of researchers have responded to the need for improved fiber-optic measurements by developing procedures that they hope will become industry standards. Right now, though, each manufacturer of optical fiber uses its own procedures to specify its products, so published data from different firms isn't always comparable.

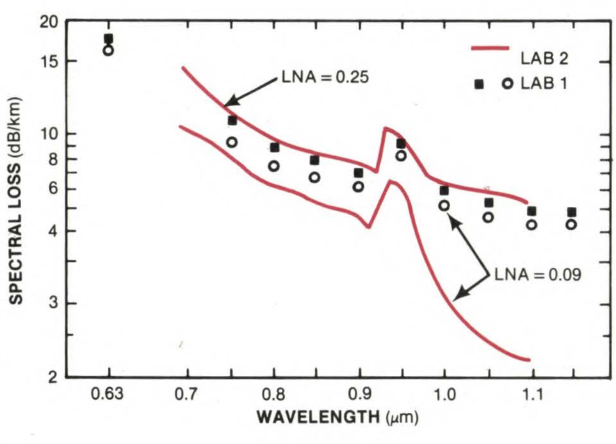


Fig 1—Launch numerical aperture (LNA) *has a significant effect on measurement precision. The data shows the results obtained by two labs that measured fiber attenuation at two different LNAs. When the aperture was small (so that not all fiber modes were excited), agreement was poor. When the aperture was widened so the core was completely illuminated and a full distribution of modes excited, agreement was much better—within 0.1 dB.*

Understanding the manufacturing techniques involved in producing optical fibers helps remove some of the confusion caused by this lack of specification standardization. (For a further discussion of this topic, see the article on pg 109 of this issue.) But the problem of adequately characterizing an optical fiber once you've acquired it still remains. Thus, to get the most out of fiber-optic components, you must understand the differences among the measurement techniques available today. The methods for determining fiber attenuation and delay distortion are particularly important, because these parameters have the greatest impact on system design.

Attenuation measurements involve two techniques

Today, you can employ one of two basic methods to measure the attenuation of an optical fiber. The most common approach involves determining the optical-power output at one end of each of two different lengths of cable with the same input and output couplings. The alternative technique is optical time-domain reflectometry (OTDR).

The first method is straightforward: You launch a signal into each of the cables and measure the resulting outputs, then calculate the fiber's attenuation in decibels per kilometre.

But this approach has problems. For one thing, because the fiber has different attenuation characteristics at different signal wavelengths, the measured loss depends on the source's output wavelength or on the combination of wavelengths present in the source's signal. To deal with this variability, you can use a monochromator to obtain a spectrally narrow source that's continuously variable over a range of frequencies, or else utilize filters to narrow the source's output to the frequency of interest.

But that isn't the end of the problem. Most optical fibers are multimode systems: The optical signal is transmitted both directly and via reflections from the cladding material surrounding the core. Thus, a given input signal can propagate down a cable in thousands of different modes, each with its own attenuation **(Fig 1).**

Measuring attenuation can be easy, but beware of complex waveforms

A source such as a surface-emitting LED has a broad beam that excites more of these modes than do narrow-beam sources, such as injection-laser diodes. And the LED source tends to excite higher loss modes, so the output power you measure with its help will be lower than the value determined with an injection laser—even if the cable and input power are identical in both cases. The multimode characteristics of such fiber-optic systems also mean that attenuation doesn't vary linearly with cable length.

A fiber's so-called "leaky" and cladding modes can also contribute to error in attenuation measurements. For example, some of the power that's measurable at the end of a short length of cable is eventually absorbed by the cladding and thus doesn't reach the detector in a long-haul system. Thus, if you're comparing the loss in a short cable with that in a long one to determine fiber attenuation, you must eliminate the effects of these modes by forcing them to radiate out of the fiber.

One solution involves immersing the fiber (after removing its jacketing) in a fluid with a refractive index higher than that of the cladding—a technique that induces radiation by eliminating total internal reflection within the cladding. If you employ a visible source, you'll be able to watch the cladding modes radiating out of the fiber.

Another way to avoid cladding-mode effects in attenuation measurements involves using long (0.5 to 1 km) fiber lengths in those measurements. But while this technique does a good job of stripping away cladding-mode signals, it's obviously more expensive than using shorter fibers.

You can eliminate these multimode-related problems altogether, of course, by utilizing single-mode fibers in your system designs. With diameters of approximately 2.5 μm, (compared with the 50- to 60-μm core of multimode units), these fibers propagate only a single axial ray, exhibiting no modal distortion at all. However, they are difficult to splice, and it's difficult to launch a narrow light beam into such a small core. Thus, the mere fact that single-mode fibers simplify

The problems with fiber-optic measurements

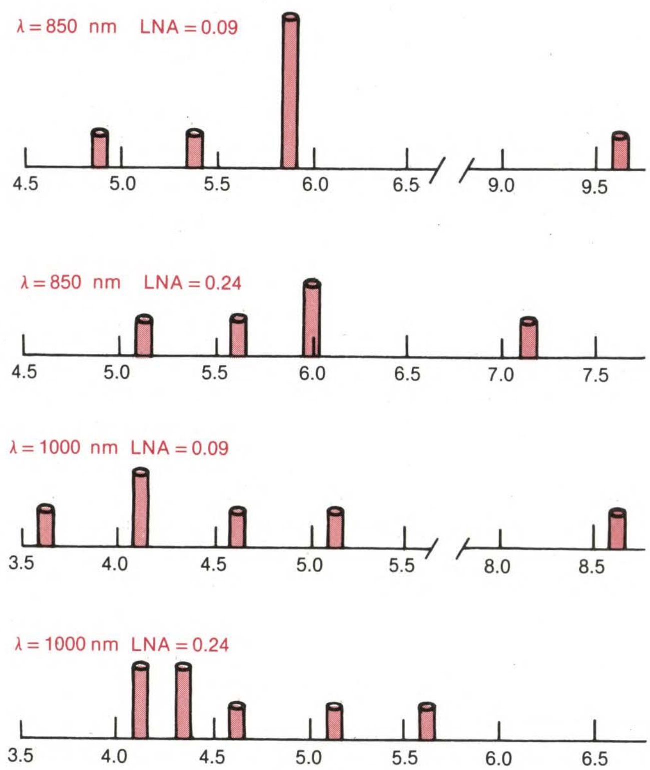
Fiber-optic signals are so complex that changing the method employed to make a measurement can change the resulting value by a few decibels or more. And because there's no standard technique for making measurements of such parameters as attenuation and distortion in fiber cables, there's no "right" answer.

With no right answer, the term "accuracy" becomes meaningless. How can you determine a measurement's uncertainty—how far from the "correct" value the measured value is—if you can't even define "correct"?

You can't. Instead, you must compare the quality of fiber-optic measurement techniques in terms of their precision, or repeatability: The best techniques yield the closest agreement in measured values, regardless of who makes the measurement or when that measurement is made.

Unfortunately, today's measurements aren't precise. Last year, the National Bureau of Standards, Boulder, CO, published a study comparing the results from eight laboratories that had measured the attenuation of the same two optical fibers **(figure).** While the attenuation of each fiber was only approximately 3 to 7 dB/km, the variation among the results was 1 to 1.5 dB/km.

Only you know how much uncertainty you can tolerate in your fiber measurements, but



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some measurements might not be a sufficient reason for employing them.

Using reflection to measure losses

Two-ended attenuation-measurement techniques suffer from additional shortcomings. In some cases, for example, it's impossible to gain access to both ends of a fiber you want to test. And at best, it might be a logistical nightmare to have someone make measurements at one end of an in-service cable while you set up the source at the other end.

Additionally, while 2-ended attenuation-measurement techniques provide an insertion-loss figure for a given fiber length, they give no information about the length dependence of that loss. If the loss varies with length in a nonlinear manner, quoting attenuation in decibels per kilometre as determined by insertion-loss measurements proves meaningless.

The other major attenuation-measurement technique, OTDR (**Fig 2**), permits the display of this length dependence. Hinging on the analysis of backscattered light in a fiber, OTDR requires neither cutting the fiber nor gaining access to both ends of the link.

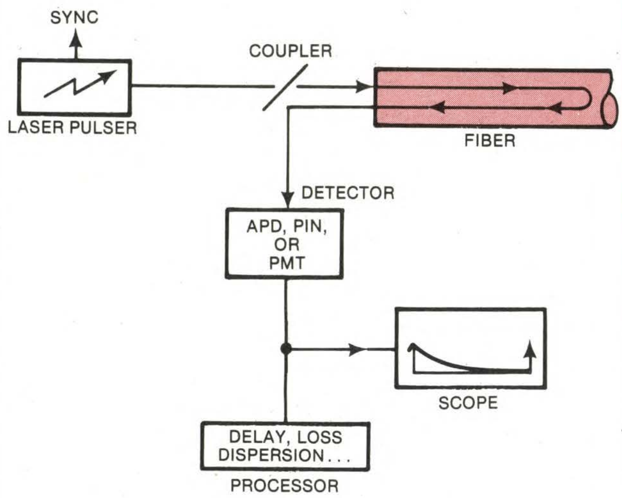
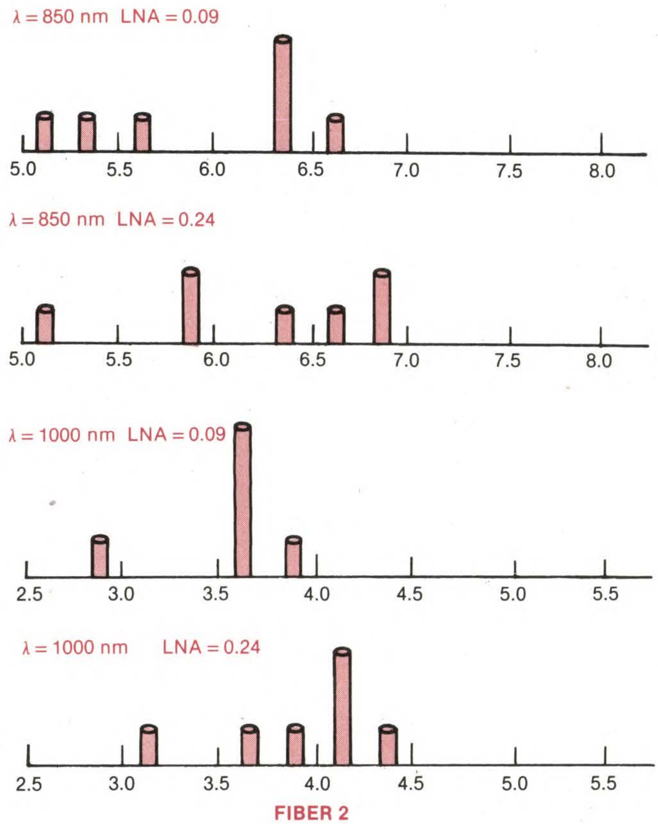


Fig 2—Optical time-domain reflectometry (OTDR) *is a quick, convenient way to measure fiber characteristics. It only requires access to one end of a fiber; reflections help determine attenuation and the location of discontinuities.*



Fiber measurements aren't very precise, *as these histograms illustrate. The data shows the attenuation in decibels per kilometre of two fibers, as measured by eight different laboratories at various frequencies (λ) and launch numerical apertures (LNA).*

you'll probably agree that these variations are unacceptable. Faced with such values, you might not only have to compensate with more repeaters than are really necessary, but you might also end up paying an exorbitant premium over the fiber's true value—the difference in price between two fibers differing in attenuation by 1 or 2 dB/km can be significant.

Three categories of problems lead to the measurement discrepancies. One is lack of control on the systems and procedures used by the participants in the study. The second is the fundamental difficulty associated with establishing and maintaining reproducible mode distributions in highly multimode transmission elements like optical fibers. And the third is a lack of stability of the components themselves, resulting in performance changes dependent on handling, temperature and other variables. (Instability is a relatively small problem that only affects this type of comparison test. It can be minimized by better selection of the fiber and fiber buffering.)

OTDR is a simple but expensive measurement procedure

OTDR involves launching a light pulse into a fiber, by means of either a directional coupler (such as a taper) or a system of external lenses and a beam splitter. A photodetector then detects the returning light pulse, and an integrator processes this waveform.

The waveform consists of three distinct segments: an initial pulse (resulting from reverse scattering from the input coupler and mounting), a long tail (caused by the distributed scattering that occurs as the input pulse propagates down the fiber) and further pulses (arising from discrete reflections that can occur along the fiber length as a result of fiber imperfections, in-line connectors or reflection at the fiber's end).

This scattered return proves useful in extracting the required attenuation information. Specifically, you can convert the time dependence of the detected backscattered power into a length dependence by multiplying it by the velocity of light in the fiber core.

A typical OTDR measurement setup and its results appear in **Fig 3.** This experiment employs step-index fibers that exhibit very little mode mixing. Four 100m series-connected fibers are coupled through 150-μm (ID) stainless-steel tubes containing a small amount of index-matching oil; the splices' throughputs aren't optimized. The average 2-pass insertion loss in each fiber segment results from measuring the magnitude of the appropriate discontinuous step in the backscattered returns; it varies from 2.7 to 1.1 dB.

While OTDR techniques provide more attenuation information than 2-ended measurements, they also require more complex and expensive instrumentation. And neither approach is extraordinarily precise: Agreement between the values found by any two engineers performing a measurement on the same cable is rarely better than 0.5 dB, and the best repeatability you can expect, even in your own lab, is about 0.1 dB.

Distortion limits cable length

The other key fiber parameter whose measurement you must master is delay distortion. When you launch a narrow pulse of optical energy into a fiber, it generally spreads out with time as it propagates down the fiber. The reason? Each mode has its own propagation time. As a result, a fiber cable's maximum length could be limited by the cable's bandwidth, not by its attenuation.

You can measure delay distortion by means of several techniques, either in the time domain (impulse-response measurements) or the frequency domain (transfer-function measurements).

In the time domain, a single-pass impulse-response measurement involves injecting a narrow light pulse

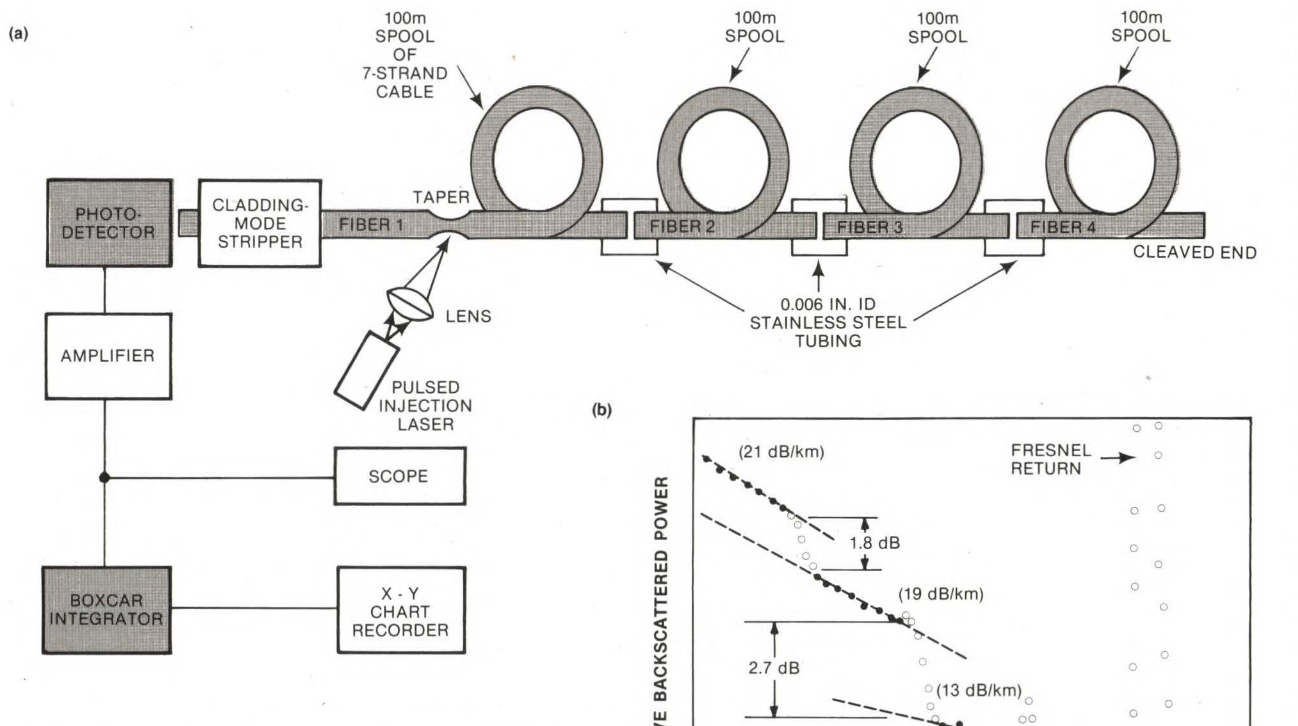


Fig 3—A taper couples light *into the fiber in an OTDR setup* ***(a).*** *A photodetector detects the waveform of the return light pulse; a boxcar integrator processes the pulse. Backscattered returns obtained with this setup* ***(b)*** *clearly show the differences in attenuation among the four 100m fiber lengths. Discontinuities occur at the junctions between fiber segments.*

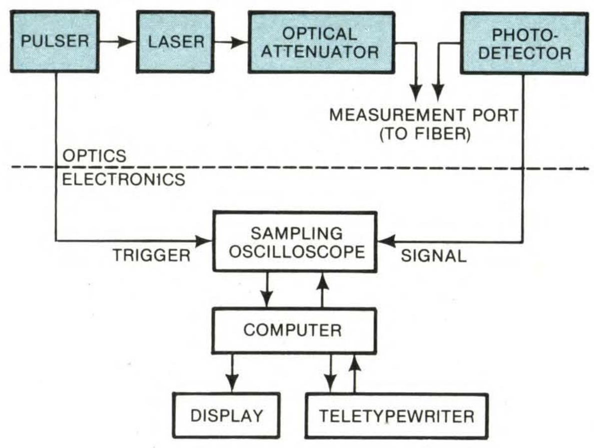


Fig 4—Delay-distortion measurements *are possible with this test set. The single-pass impulse-response test employs a narrow light pulse injected into one end of the fiber; the output pulse is detected at the other end. Deconvolving this pulse from the pulse received through a short reference fiber yields the cable response.*

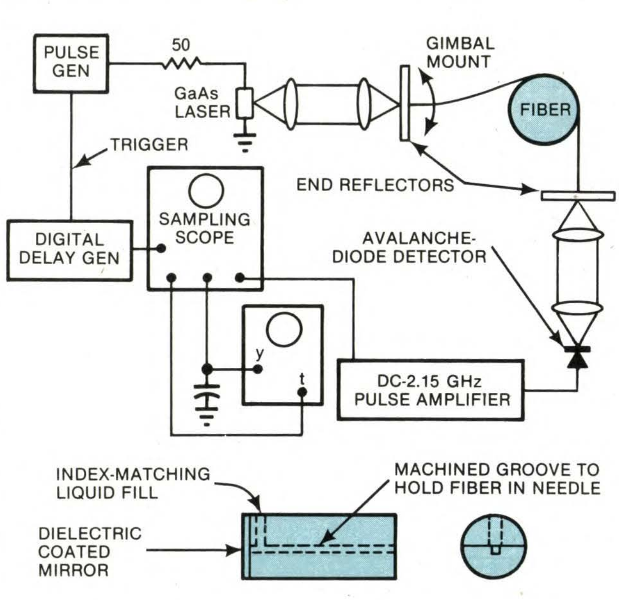


Fig 5—Shuttle-pulse measurements *pass a pulse many times through a short fiber, either to simulate the response of a longer one or to increase the distortion in a short path to measurable levels.*

into one end of a fiber and detecting the resulting broadened output pulse at the other end **(Fig 4).** This approach requires a generator capable of producing pulses with high peak power and narrow width. It also calls for a sensitive and linear fast detector and computational facilities for deconvolving the pulse received through the unknown fiber from the one received through a short fiber substituted for the unknown. The short fiber has a larger bandwidth; thus, the pulse detected at its output is usually narrower than the one detected at the output of any of the fibers to be measured.

Such measurements usually employ injection-laser sources with large optical cavities. The peak power launched into the fiber can be more than 100 mW, and pulse widths can be less than 200 psec. Detectors can be PIN or avalanche types; inexpensive units are available with response times of less than 200 psec. You can couple signals into and out of the fiber with lenses, although better repeatability results if you attach the fibers directly to the source and detector.

Launch conditions prove as important in dispersion measurements as they do in attenuation measurements: Because the launch condition affects the energy distribution in various modes, it also affects the related impulse-response (or transfer-function) measurement. Ideally, then, you should measure impulse response under various launch conditions to obtain a complete fiber characterization.

But making such detailed measurements can prove too time consuming; an alternative approach that provides realistic and repeatable results employs mode mixers at the transmit end to launch a signal that drops off linearly with length. This appears to be the best method currently available for achieving repeatability and eliminating operator bias.

If a fiber is very short or exhibits a small delay distortion, that distortion proves especially hard to measure. Sometimes, though, simulating a long fiber by passing a pulse many times through a shorter one proves desirable **(Fig 5).** With this "shuttle-pulse" technique, the signal reflects from mirrors at each end of the cable, permitting you to measure the impulse response for an odd number of passes through the fiber.

Frequency domain provides advantages

The frequency-domain alternative to measuring distortion with narrow pulses of high-intensity light involves determining a fiber's transfer function directly with a continuous-wave light signal sinusoidally modulated around a fixed level. The reduction in modulation index resulting from propagation through the unknown fiber, compared with the modulation index of a short "control" fiber, represents the roll-off of the transfer function at the modulation frequency.

This technique offers several advantages. First, you obtain the transfer function directly, without the need for Fourier transformation of time-domain data. Second, the range of light levels is narrower than with a pulse input, so nonlinearities have less of an effect on the measurement. Third, it might prove easier to modulate the light source sinusoidally at high frequencies, rather than producing a narrow pulse. Finally, cw sources with limited output into a fiber (such as narrow-band, incoherent units), still have reasonable signal-to-noise ratios at the receiving end.

Thus, this technique can measure a fiber transfer function at various wavelengths with the aid of an incoherent light source, narrow-band optical filters and an optical modulator to generate the sinusoidally varying light power. However, because the power that can be coupled into a fiber from an incoherent source is

Distortion limits cable lengths, even in low-attenuation fibers

limited, the method calls for use of a fast photomultiplier tube as a detector.

In such measurements, injection lasers or band-limited incoherent sources can often serve to make the material dispersion effect negligible so that you measure only the mode-delay spread effect. Likewise, there are also ways to separately measure the material dispersion effect; one involves injecting laser pulses into the fiber at two different wavelengths in the frequency band of interest, then measuring the difference in the propagation delay through a fiber of known length. You can inject the pulses simultaneously and measure the change in time separation, or else inject them consecutively.

A variation on these techniques centers on measuring impulse response and transfer function first with a narrow-band source and then with a broad-band incoherent one; the change in the impulse response then depends on material dispersion.

With time-domain techniques, you can determine the 3-dB points for a fiber cable with a precision of a few percent, and the amplitude response at a particular frequency (say, 500 MHz) to about 0.1-dB precision. The precision of frequency-domain techniques has not yet been determined. **EDN**

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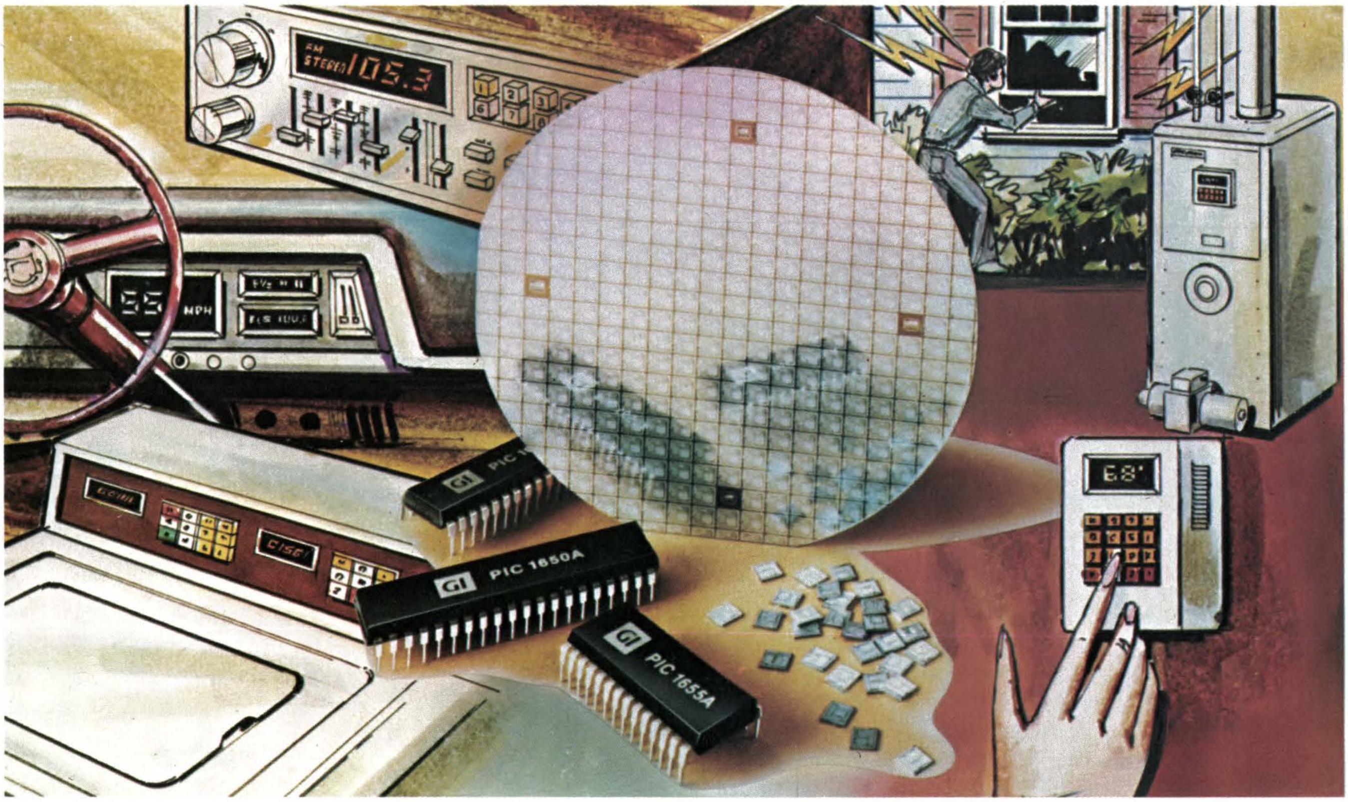

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Potent visual aids get your message across

Nervous about making that required speech? Visual aids not only focus attention away from you, they make for a more effective oral presentation. But be sure to create and use them properly.

Harley Bjelland, Teledyne Inet

Sooner or later you will have to give a talk, perhaps at a program-review meeting or technical conference, in a discussion with a customer on a proposal's technical aspects or as part of a major presentation to management. And when you do, you'll discover that visual aids, in conjunction with your oral presentation:

- Provide an outline of your talk for you and your audience to follow
- Help keep the audience's attention
- Make your presentation easier to understand
- Give your audience a change of pace from the job of constantly listening to and looking at you
- Present data that words cannot easily convey
- Increase audience retention of your speech (studies show that 3 days after a speech, retention stands at 65% if visuals are used, compared with only 10% if they are not)
- Focus attention away from you if you're nervous about public speaking.

Unlike a written report, a talk is a 1-time learning experience. And therein lies the real importance of visuals. Thus, this article covers

ALL ASPECTS OF VISUALS
Planning
Creating
Presenting

Devise a game plan

An oral presentation usually consists of three parts: the introduction (you tell them what you're going to tell them), the body (you tell them) and the summary (you tell them what you've told them). The introduction orients the audience with a summary of the speech's topic. The body expands each main point (approximately six to eight) listed in the introduction. The summary is especially important, because people usually remember best what they hear last.

Once you've chosen your subject, plan the length of your talk, heeding the wise advice of an old proverb: "Recipes for the best speeches should always include shortening." Any talk longer than 10 min is a long one, although a 20-min presentation with good visuals and a good delivery is acceptable. Keeping an audience enraptured for 30 min or more calls for a Herculean effort—good visuals notwithstanding.

So you've got your topic and approximate length; now how do you figure out how many visuals you'll need? Experts recommend about a 1½-min viewing time per visual. Each visual should cover only one idea, and it usually takes 1 to 2 min to get an idea across to an audience. Therefore, a 20-min presentation, which is equivalent to a 10-pg double-spaced manuscript or about 2500 words, requires 12 to 14 visuals. Of this number, one should be a title, one an introduction and a third a summary, leaving about 10 visuals for the body.

Your next step is to write out the speech in full—a procedure that helps you plan, organize and time your presentation. Observe the rule of thumb that an average written paragraph in a technical document contains about 100 to 150 words and that each paragraph introduces one idea. Thus, if you speak at about 125 words/min, you'll explain one new idea every minute or two—and use one visual every 1 to 2 min. (Of course, this rough guideline varies with the complexity and variety of the subject matter.)

Creating visuals: the dos and don'ts

Engineering often incorporates such complex ideas that speakers must "draw and describe" to allow the audience to understand them. Thus, your visuals must

Each paragraph and visual should explain only one idea

add to, reinforce and expand your spoken message. Keep these guidelines in mind when creating visual aids:

- Don't make visuals directly from engineering drawings or typewritten material; the letters in such formats are much too small and the lines too thin and indistinct. Furthermore, typewritten pages contain about 10 times as much information as should appear in a visual.
- Avoid equations whenever possible. If they *are* necessary, use simple ones, because it's too difficult to explain complex engineering derivations and symbology to a diversified audience in a few minutes. You'll lose listeners and probably end up confusing yourself, too.
- Don't use Roman numerals—they're outdated and confusing to today's audiences. Everyone you'll have to talk to understands English alphanumerics.
- If you have a choice between a table and a graph, opt for the graph. Engineering audiences accept graphs because they're much easier to comprehend than columns of figures. Just leave a minimum of one-third of the area around such a visual blank, so the presentation won't appear too crowded.
- Because visuals increase in cost with the square of their complexity and can range in cost to several hundred dollars, keep them simple. Review all of your artwork in draft form before it goes into production—changes in finished artwork often cost up to 50% as much as doing the artwork all over again.
- Most companies prefer a leadtime of 1 or 2 wks to prepare visuals, to allow them to schedule the work without premium charges. This schedule also permits you to review the art before actual production.

Take your pick among several visual types

With these guidelines in mind, you can put theory into practice and choose the best type(s) of visuals to enhance your speech's subject matter. Choices range from simple word charts to complex multicolor presentations:

THE MOST COMMON VISUALS
Word charts
Graphs
Sketches and drawings
Photos
Bar charts
Pie charts
Tables

Word charts are the simplest to make, the easiest to use, the least expensive and the most often abused of the various types. Prepare these important visuals with extra care, using no more than 20 to 30 words and never exceeding eight to 10 lines. The less copy, the better the visual. Avoid complete sentences—key words get the message across:

WORD CHARTS ARE:
The simplest to make
The easiest to use
The lowest in cost
The most often abused

WORDY WORD CHART

WORD CHARTS
Simple
Easy
Low cost
Often abused

CONCISE WORD CHART

Most visuals have a width-to-height ratio of 4:3, the same used in photographs, TV and movies, so use this familiar figure in all of your presentations. Additionally, write big. One useful rule states that a visual's lettering should not be less than $\frac{1}{40}$th of the visual's height. For example, in a 30×40-in. flip chart, lettering should be greater than $\frac{30}{40}$ or $\frac{3}{4}$ in. high.

As another aid to determining lettering height, consider the following equation:

$$\text{letter height} = \text{viewing distance}/250.$$

Thus, if the audience is 25 ft away, letters should be 25/250=0.1 ft, or 1.2 in. high. Combining these two rules results in:

$$\text{visual's height}/40 = \text{maximum viewing distance}/250.$$

Alternatively,

$$\text{visual's height} = \tfrac{1}{6}(\text{maximum viewing distance}).$$

To summarize these rules:

RULES OF THUMB FOR LETTER & VISUAL HEIGHT
min letter height/visual's height = $\frac{1}{40}$
min letter height/max viewing distance = $\frac{1}{250}$
visual's height/viewing distance = $\frac{1}{6}$

With regard to line widths in word charts and other visuals, use these rules:

RULES OF THUMB FOR LINE WIDTH

Line Type	Line Width / Character Height	Uses
Light	$\frac{1}{16}$	Leaders, graph grids, center lines, arrows
Medium	$\frac{1}{6}$	Graph borders, all lettering
Heavy	$\frac{1}{3}$	Curves, main signal paths

Graphs displaying a continuous function of two variables are the most widely used form of chart presentation. Of course, their data-presentation capability isn't as precise as tables', but communicating your speech's idea is usually more important than showing actual data points.

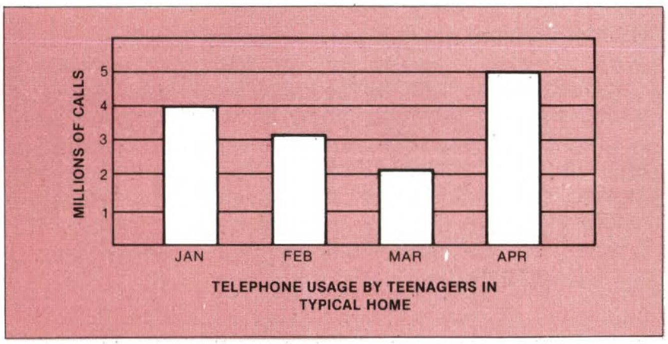
When constructing a graph, label all coordinates simply. Use a minimum number of grid lines and plotted points. And label curves directly rather than using a key. Furthermore, plot no more than three curves on a graph to minimize clutter and confusion, and don't run the curves to the end of the grids: Leave a 10 to 15% space.

To highlight multiple curves, you can color-code each one. If your graph contains only one curve, you can add another dimension of information by coding, coloring, shading or cross-hatching the area between the curve and the X axis. With regard to color, note that a light-colored or light-gray background is preferable if you're projecting a graph; a white one sprays too much light into the audience's eyes.

Drawings in the form of block diagrams should contain no more than six to eight blocks. If your subject is overly complicated, break each complex diagram up into two, three or four simpler ones.

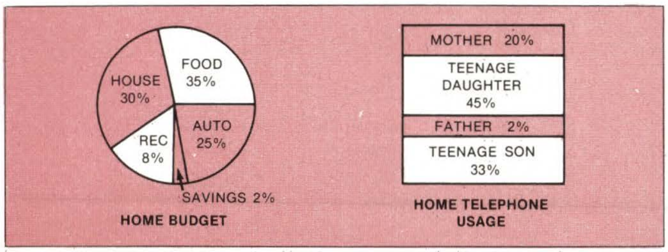
Photos can provide drama and informational impact. But they usually prove effective only in settings relying on projection methods.

Bar charts basically represent a graphical method of displaying tabular data and prove particularly useful for dramatically showing relationships between different sets of data. For purposes of clarity, it's best to separate the individual bars. If you draw the bars and spacings with equal widths, they look attractive and prove easy to understand at first glance:



As with graphs, you can subdivide each bar by shading, coloring or cross-hatching to add another dimension of information.

Pie charts provide an easy-to-understand and dramatic picture of how the parts constitute the whole. Don't cut them up into too many pieces, though—about eight is enough. Additionally, the smallest piece should be greater than about 2% of the whole to maintain effectiveness. For emphasis, you can shade individual elements. Note, too, that the circular form isn't the only one possible:



In charts like these, make sure the various portions are labeled with their categories as well as the percentage of the whole they represent. And be sure that the sum of all parts is 100%—audiences love to catch this mistake.

If there's no other way to present your data, use a *table*. To keep it simple:

- Leave a lot of white space.
- Align columns of numbers on the decimal point.
- Clearly label all columns, don't overabbreviate and don't use too many columns or rows.
- Underline each row so people sitting many feet away can follow the data columns.

When presenting such tables, don't read the numbers out to your audience—they can read for themselves. Point out only highlights, trends and relationships.

Guidelines for specific visual equipment

Now you've determined the type of visuals to use; the next step centers on how to actually present them. Several methods are available.

The biggest advantage of *blackboards* is that they always work. They're also good for ad libbing. But try to avoid the type that requires grease pencils or felt pens—they're too messy and hard to erase. If you plan to use a sketch or a lot of printing in your talk, prepare the blackboard ahead of time, cover it up and unveil it when necessary. It's unfair to make an audience wait while you stand with your back to it and complete your drawings or printing.

Also generally prepared in advance, *flip charts* and *chartboards* prove ideal for small groups of perhaps 25 to 30 people. The smallest size (15×10 in.) is best for a group of less than a half dozen; the next (28×34) suits about five to 15. For groups of 10 to 30, use the 30×40-in. size.

You can update flip charts and chartboards as you talk, but limit the amount of updating because you'll be writing with your back to your audience. Note that you can hang these devices in strategic places around a room if you wish to simultaneously display several ideas.

When using a flip chart, it's usually a good idea to alternate a blank page with each chart page. This procedure allows you to pause in your presentation, get your audience's attention and save the next chart until you're ready for it. The blank sheets also shield the next page from showing through.

An *opaque projector* employs a reflective optical system to project data from an opaque object (such as a page in a report or book) onto a screen. It's the only projection medium that requires no transparency; thus, it's ideal for use when you make a presentation with little or no notice. You can also use it to project small 3-dimensional objects. The disadvantages? Because of the optical system's inefficiency, opaque projectors require a very dark room. They are also bulky, heavy and clumsy and employ large-wattage lamps, which generally require a noisy fan for cooling and could damage your copy.

Word charts are easiest to use, but prepare them with care

Also termed transparency projectors, *viewgraphs* incorporate highly efficient optical systems and don't need as dark a room as opaque projectors. Because a viewgraph must be close to the screen, a speaker can operate it and face the audience (10 to 100 people) at the same time.

Viewgraphs offer certain advantages: For example, you can design five or six overlays and build up to a solution by successively uncovering these overlays. Also, because you are the projectionist, you can update the picture with a grease pencil as you talk. Viewgraph projections are inexpensive and easy to make on standard repro machines, and they can be in color.

Slide projectors best serve audiences of 40 or more people. But their use often decreases the speaker/audience intimacy of a lighted room: The speaker frequently seems to be only a voice. (Still, when using a slide projector, try not to turn the room lights on and off too many times in an attempt to regain that intimacy—it takes the eye time to recover from the shock.)

Although lantern slides (3¼×4 in.) can accommodate an audience of up to 1000, they can't be used with the sophisticated, automatic equipment applicable to 35-mm (2×2 in.) slides. Therefore, the smaller slides are rapidly becoming the standard.

35-mm slide projectors suit audiences of up to about 200 people. When not using a carousel, be sure to mark your slides plainly so they're inserted in the projector in the right order. Glass rather than cardboard mounting eliminates the focus shift caused by projector heat.

35-mm slides reproduce excellent color on a 30×40-in. screen, and their resolution is outstanding for most applications. Portable, professional in appearance and inexpensive, they permit the luxury of skipping back and forth during your presentation. But don't overdo it and irritate your audience.

The nearby **table** summarizes the tradeoffs among various visual-aid presentation methods.

Putting it all together

Assuming you've gotten your visuals together and decided how to present them to an audience, what's the best way to proceed?

First, remember that effective visuals complement your presentation—but don't rely on them to do the talking for you. Speak plainly, slowly and distinctly, avoid jargon, and above all, don't read your speech from a text or try to memorize it.

Instead, after you've written out your speech in full to determine where to insert your visuals, prepare an outline from it on 3×5-in. cards and speak from these. Be sure to number the cards, and use big letters because the lighting in many presentation rooms leaves much to be desired. Refer to the file cards, not the visuals, to preserve the continuity of your speech. That way, if one visual is misplaced or if your visual equipment malfunctions, you'll still be able to go on. Additionally, avoid reading off your visuals, or the audience will begin to feel that your presence is unnecessary. Merely restate the visuals' messages in other words.

One last piece of advice: Don't talk to your visuals. Face and project to your audience—they came to hear *you*. **EDN**

Author's biography

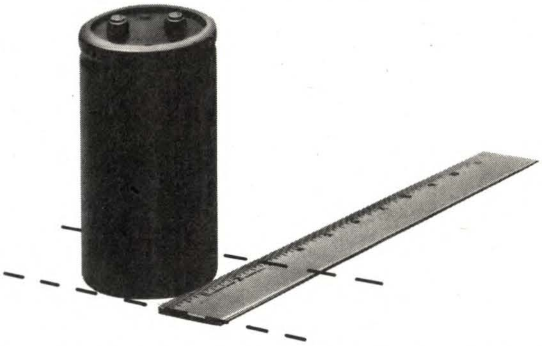
Harley Bjelland, engineering writer at Teledyne Inet, Torrance, CA, oversees the preparation of technical literature for use with his company's products. Before joining the firm last December, he was employed by Hughes Aircraft and NCR. Author of two nonfiction books and numerous articles, holder of two patents and a member of the Society for Information Display, Harley received a BSEE from the Milwaukee School of Engineering. His leisure-time activities include writing, reading and dancing.

VISUAL-AID PRESENTATION-METHOD TRADEOFFS

	BLACKBOARD	FLIP CHART OR CHARTBOARD	OPAQUE PROJECTOR	VIEWGRAPH	SLIDES
SIZE OF AUDIENCE	TO 25	TO 30	TO 50	15 TO 50	40 TO 200
AUDIENCE CONTACT	GOOD	EXCELLENT	POOR	GOOD	POOR
ROOM LIGHTING	BRIGHT	BRIGHT	DARKENED	LIGHTED	DARKENED
PORTABILITY	POOR	EXCELLENT	POOR	POOR	GOOD
UPDATABLE?	YES	YES	NO	YES	NO
COST	LOW	LOW TO MED	MED	MED	MED
CAN PRESENT PHOTOS?	NO	LIMITED	YES	LIMITED	YES
VARY TALK SEQUENCE?	YES	YES	LIMITED	YES	LIMITED
COPIES OF PRESENTATION*?	NO	NO	YES	YES	YES
LEADTIME	NONE	MED	NONE	MED	LONG
ASSISTANT REQUIRED?	NO	NO	YES	NO	NOT IF REMOTE CONTROL AVAILABLE
COLOR POSSIBLE?	LIMITED	YES	YES	LIMITED	YES
SPECIAL EQUIPMENT REQUIRED?	CHALK/ERASER	EASEL	PROJ/SCREEN	PROJ/SCREEN	PROJ/SCREEN
RELIABILITY	HIGH	HIGH	MED	MED	MED

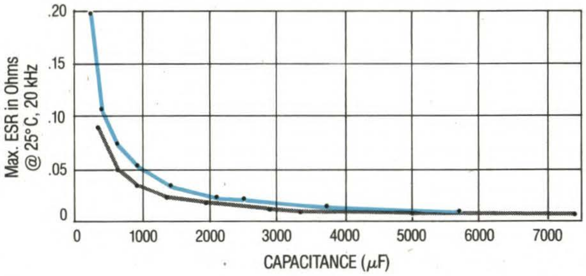
*UNLESS SEPARATELY PREPARED AND DISTRIBUTED

HIGH CAPACITANCE PER CASE SIZE



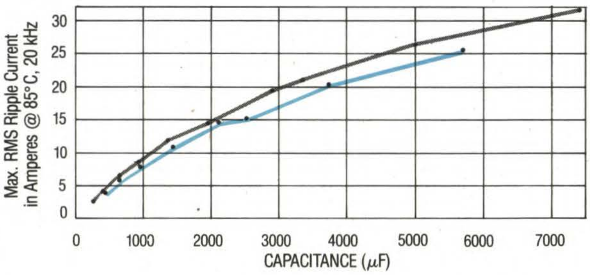
Values as high as 7,400μF @ 200 VDC in a 3″ x 5.625″ case.

LOW ESR



Curve plotted in gray represents capacitors rated at 200 VDC.
Curve plotted in blue represents capacitors rated at 250 VDC.

HIGH RIPPLE CURRENT CAPABILITY



Curve plotted in gray shows ripple current capability for capacitors rated at 200 VDC while curve plotted in blue shows ripple current limits for capacitors rated at 250 VDC.

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Multiplexed-memory technique doubles µP's addressing capacity

Memory-map switching extends an 8-bit µP's storage access to 128k—increasing application possibilities without sacrificing processing efficiency or capabilities.

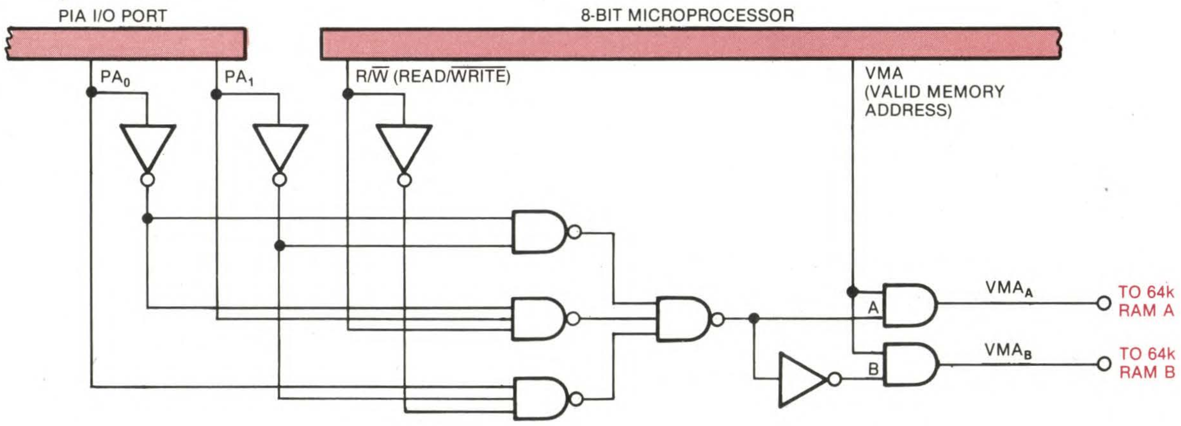
Stephen Strom, Motorola Semiconductor Products Inc

When an 8-bit µP's 64k-byte memory-addressing capability begins to cramp your programming prospects, don't assume that you must necessarily upgrade to a 16-bit device. The software-directed dual memory-mapping approach described here allows you to expand an 8-bit µP's addressing range to 128k bytes by multiplexing two 64k RAMs. This unified hardware/software approach lets you incorporate more processing functions and support more complex and efficient functions in an 8-bit system.

The dual-RAM mapping approach suits both long programs and short ones that need excessive buffer space during execution—two conditions that often occur in applications such as word processors, text editors and RAM/ROM testers. With enlarged memory, you can also overcome the size constraints of a combined operating-system, I/O and control program. In fact, you can assign an entire 64k map to the operating system and control program and reserve the second map for the program buffer. This broad storage allocation permits you to add numerous program features without infringing on buffer space.

Simple concept demands design care

To implement the dual-memory-map approach, merely multiplex an 8-bit µP to two identical 64k RAMs. This seemingly elementary method requires careful consideration of several hardware/software design factors, however. At any instant, for example, the µP can access only one RAM; the entire workspace thus splits into two independent 64k blocks (memory maps). For proper hardware operation, the µP must retain each memory map's identity and correctly transfer control and data between maps. Software must



I/O PORT PA_0	I/O PORT PA_1	READ/WRITE ($R/\overline{W}$)	A (ENABLE)	B (ENABLE)	ADDRESS MODE
0	0	X	1	0	1
0	1	1	1	0	2
0	1	0	0	1	2
1	0	1	0	1	3
1	0	0	1	0	3
1	1	X	0	1	4

Fig 1—Decode logic *connects a µP and a PIA to two 64k RAMs and transfers data and instructions under software control. Various logic-state combinations determine the source and destination of code-storing, loading and executing operations.*

govern these map transfers and allow the µP to access memory without loss of processing efficiency.

To satisfy these hardware/software design constraints, memory-map multiplexing calls for software-driven decode logic connected between the µP's I/O port and two 64k RAMs **(Fig 1).** Although this particular hardware configuration relies on a 6800 µP and a 6820 peripheral interface adapter (see **box,** "6800-µP definitions"), the memory-map switching principles involved apply to most 8-bit µPs with little modification.

In **Fig 1,** note that the µP's Valid Memory Address (VMA) output, in conjunction with the decode logic, produces RAM-selector signals VMA_A and VMA_B. When VMA_A goes HIGH, the decode logic switches RAM A to the µP; similarly, when VMA_B goes HIGH, RAM B comes under µP control.

By storing data via a properly designated I/O port, the µP selects one of four addressing modes:

- Mode 1—Load, execute and store code in RAM A
- Mode 2—Load and execute code from RAM A and store in RAM B
- Mode 3—Load and execute code from RAM B and store in RAM A
- Mode 4—Load, execute and store code in RAM B.

While Modes 1 and 4 concentrate on an individual RAM, Modes 2 and 3 direct the µP to load programs from one memory map to the other as well as pass

6800-µP definitions

Address bus (A_0 to A_{15})—Accesses memory and peripheral devices for µP; a 16-bit, 3-state bus.

Data bus (D_0 to D_7)—Allows data to pass between memories and µP's programmable registers; an 8-bit, 3-state, bidirectional bus.

Read/$\overline{\text{Write}}$ (R/$\overline{\text{W}}$)—3-state output-control signal. When HIGH, it indicates that the CPU is reading PIA data from the data bus. When LOW, it indicates that the CPU is writing data onto the data bus for delivery to the PIA. Normal standby state is HIGH.

Valid Memory Address (VMA)—CPU output-control signal; goes HIGH whenever a valid address appears on the address bus. When either A or B enable or decode logic also goes HIGH, RAM A or RAM B switches into operation under µP control.

6820 peripheral interface adapter (PIA)—Provides 16 pins configured as two 8-bit I/O ports (PA_0 to PA_7 and PB_0 to PB_7). Each I/O-port line operates as either input or output but does not support bidirectional data transfers. The PIA's 3-state, bidirectional data bus (D_0 to D_7) carries all transactions to and from the 6800 CPU.

Software mnemonics—

JMP—Jump to designated address
JSR—Jump to subroutine
ORG—Originate starting program location
LDAA—Load accumulator A
LDX—Load index register
RTS—Return from subroutine
STAA—Store accumulator A.

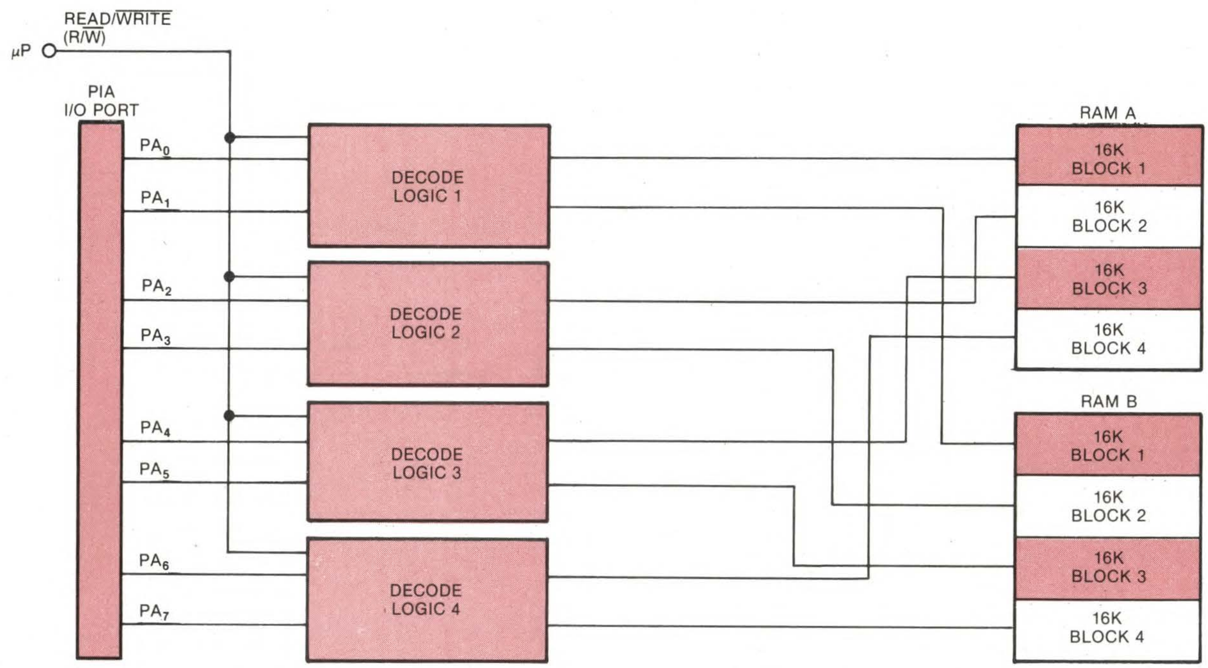


Fig 2—For tighter memory control, *four decode-logic units access 128k of total memory as eight 16k memory maps, divided equally between two 64k RAMs. The resulting software flexibility simplifies memory-map transfers, program loading and common buffering.*

6800 software transfer routines

The following routines prove useful if you implement the memory-mapped approach described in this article on a 6800-μP-based system.

```
ORG  $F000    (RAM A or RAM B)
```

Location $F000 lies within the user's program area; $0000 represents the initial transfer-routine location. To change control from one map to another, the program jumps to the map-transfer routines (see example routines below).

```
LDX      #ADDR
JSR      TRNSFR
```

A TRNSFER routine transfers μP control from one memory map to another. It then proceeds to branch to the address stored in the index register. By branching, the subroutine call stores the last address on the program stack.

```
JMP      RETURN
```

A RETURN routine also transfers μP control from one memory map to another. It then proceeds to branch to the address stored in the program stack by executing an RTS statement.

Map-transfer routines:

```
         ORG  $0000    (RAM A)
TRNSFR   LDAA #03
         STAA PIA0
         ORG  #0000    (RAM B)
TRNSFR   LDAA #00
         STAA PIA0
```

After one map's data accumulates in the PIA, control automatically transfers it to the other map. Operand PIA0 is dedicated to map transfers.

```
         JMP  0,X
RETURN   LDAA #03
         STAA PIA0
         RTS
         JMP  0,X
RETURN   LDAA #00
         STAA PIA0
         RTS
```

parameters between them. The Read/$\overline{\text{Write}}$ (R/$\overline{\text{W}}$) line activates these latter two modes as follows: When the line goes HIGH, the μP executes a read cycle and transfers code from one map into its CPU; when the line goes LOW, the μP executes a write cycle and stores code in the other memory map (see **box,** "6800 software transfer routines").

The software aspect of dual-map switching yields several advantages: The μP performs all relocations automatically; program parameters and control pass easily between maps; memory maps exchange at any time during the program's execution no matter which map or memory location resides in the CPU; and processing efficiency does not degrade.

Smaller maps offer program versatility

For even tighter memory control, you can subdivide the 128k of total memory into eight 16k memory maps, distributed as four maps in each 64k RAM **(Fig 2).** This subdivision mandates a fourfold increase in decode-logic hardware, but the advantages of increased software flexibility greatly outweigh the extra expense.

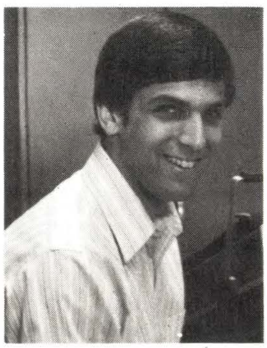
One application of this memory arrangement, for example, places a μP's operating system, program stack and transfer routines in a common memory. In this manner, you eliminate most of the map-transfer software complexities.

Another application employs two operating systems with a common program buffer. In this example, you load a disc operating system into one 16k block of RAM A and a BASIC program into the corresponding block of RAM B. You can then readily transfer control from the low-level language to the high-level one, and vice versa. This loading technique also permits you to program a variety of complex operations within the same buffer space. A variation on this approach provides a choice of program modes by allowing map or mode transfers by means of software or a set of hardware switches.

You can extend a μP's addressing range even further by multiplexing address lines to switch several 64k memory blocks. With only a slight modification of the decode logic, you can thus structure the μP to address 128k, 192k or 256k bytes. For such multiple-map switching, adapt the same hardware/software considerations utilized for the dual-map configuration.

In each case, keep track of the program stack in some common memory set aside for this purpose, because the stack-pointer register within the CPU does not change during map-transfer operations. Locating the stack in common memory permits access of the entire stack by subroutines in all memory maps. **EDN**

Author's biography



Stephen Strom, a design engineer engaged in microcomputer system development at Motorola Semiconductor Products Inc, Mesa, AZ, previously worked at Harris Corp and earned a BSEE at Carnegie-Mellon University. Stephen's hobbies include tennis, raquetball and carpentry.

For more information, Circle No 68

Simple fix cuts display-driver dissipation

M Ranjan and **K Karunakar**
National Aeronautical Lab, Bangalore, India

The Intersil 7107 3½-digit A/D converter employs 8-mA constant-current sinks in its LED-display controllers. Typical displays employed with this chip have a 2V drop, which means that the remaining 3V of the 5V supply is absorbed by the 7107's output transistors. The resulting 600-mW worst-case power dissipation causes considerable heating, producing variations in the chip's internal reference and instability of the last digit.

The **figure** depicts a simple method for correcting this problem without overly reducing the display's brightness. The three diodes decrease the maximum drop across each segment to 0.6V; worst-case dissipation then equals only 120 mW. You can add the switching arrangement shown if you require brightness control. **EDN**

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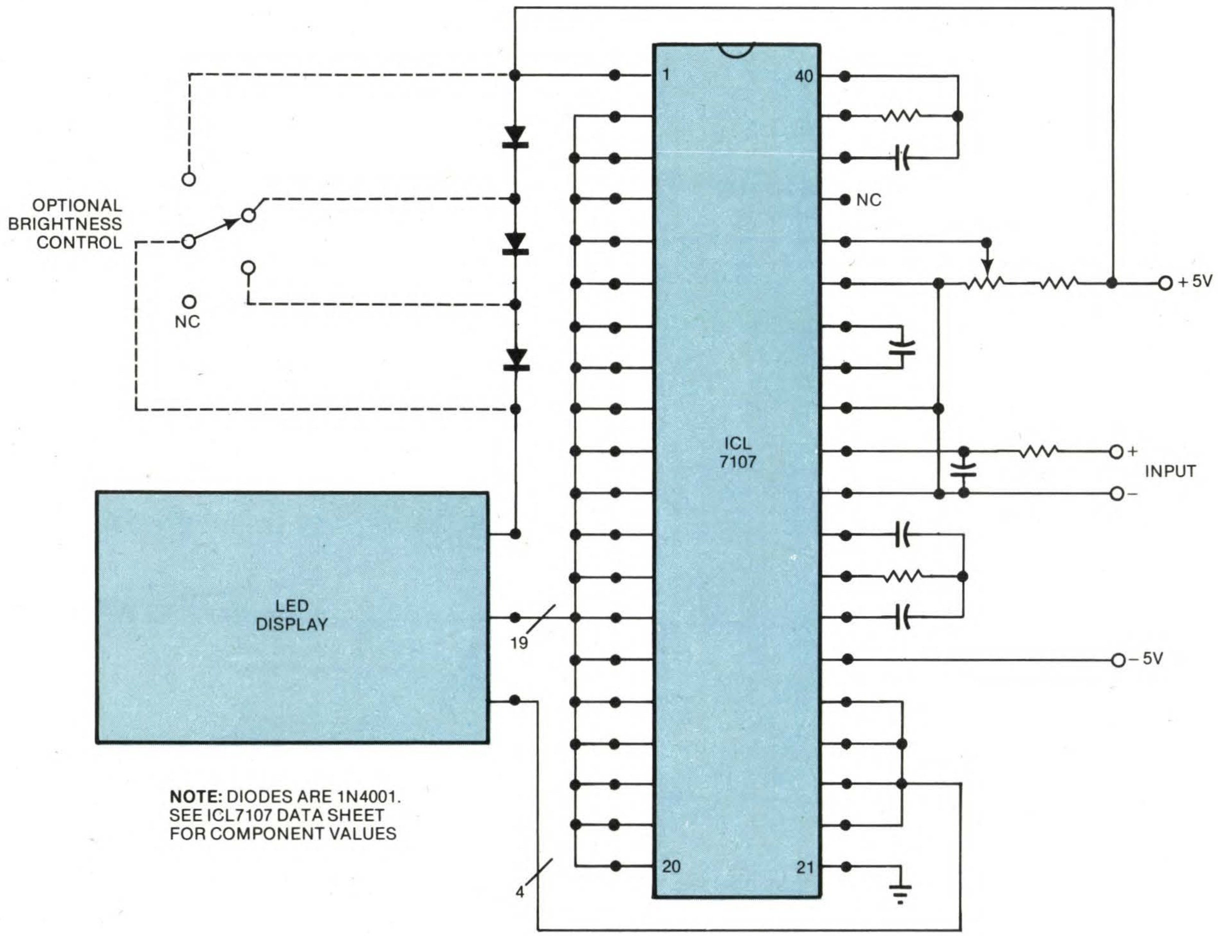


This simple 3-diode scheme *reduces the ICL7107's internal power dissipation fivefold without overly dimming the display. You can add the indicated manual brightness control or a phototransistor-based, automatically compensating version.*

Graphs speed up Bode analysis

James C Anderson
Acton, MA

Regardless of how often you've worked with Bode plots, this quick-and-easy design aid will prove helpful. And if you're new to this stability-analysis technique, the ability to easily see the effects of component values could prevent your amplifier design from becoming an oscillator.

Fig 1 depicts the Bode plots for all possible first-order transfer functions; **Fig 2,** the corresponding phase information. You can plot higher order

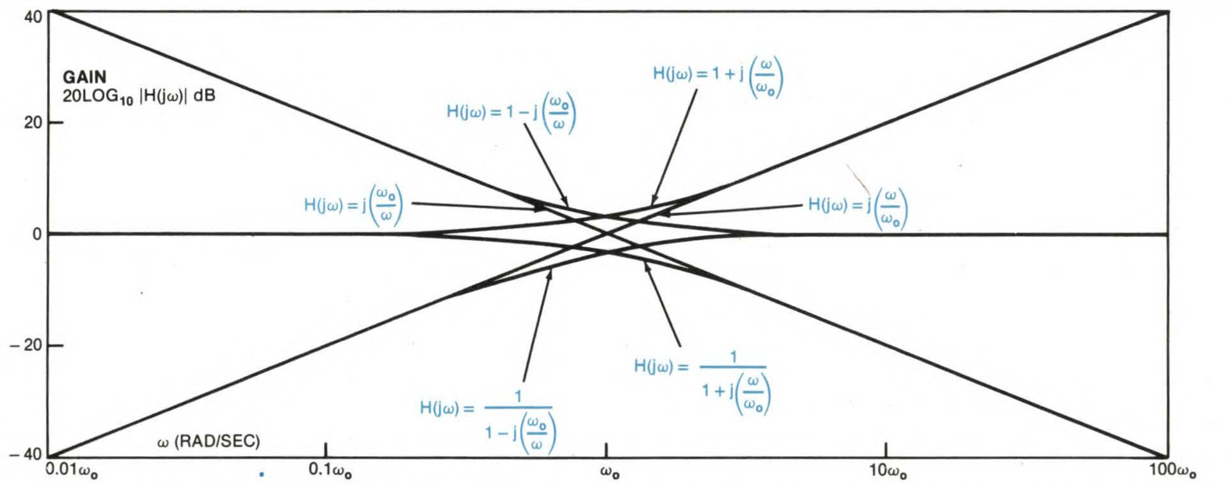


Fig 1—This Bode plot for the gain term *of a circuit transfer function doesn't include curves for negative resistances. A nonpositive solution for H(jω) usually signifies an algebraic error.*

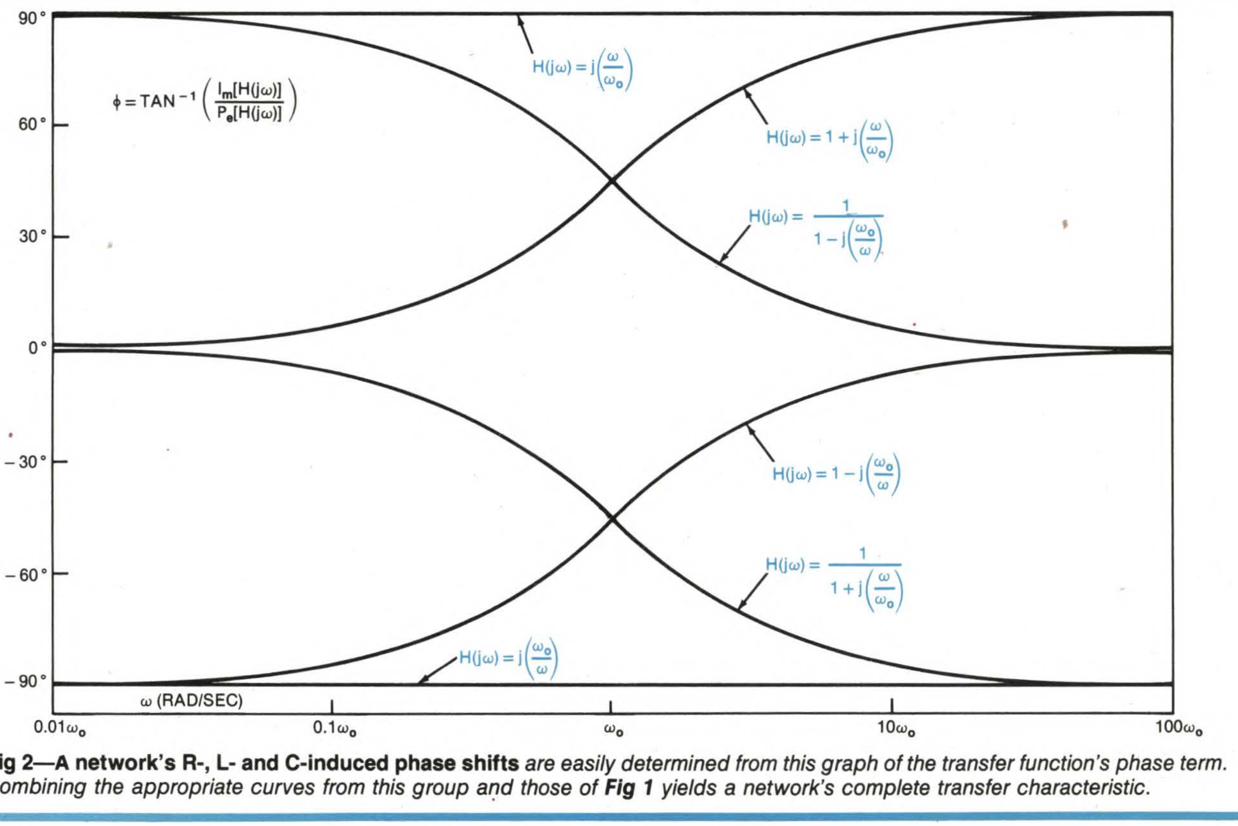
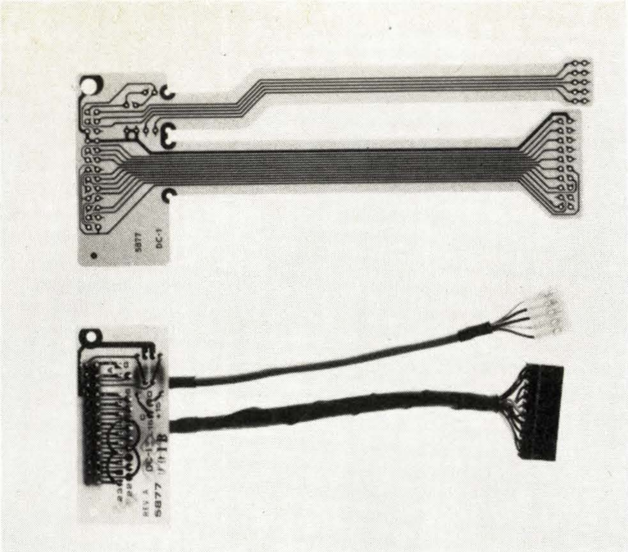


Fig 2—A network's R-, L- and C-induced phase shifts *are easily determined from this graph of the transfer function's phase term. Combining the appropriate curves from this group and those of* **Fig 1** *yields a network's complete transfer characteristic.*



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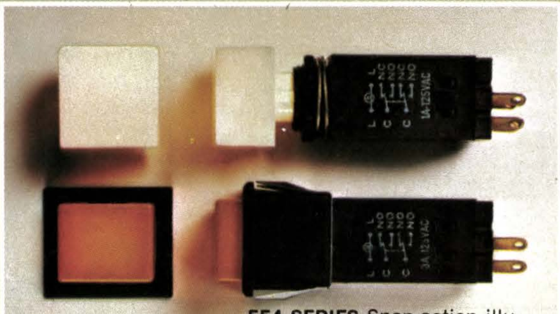

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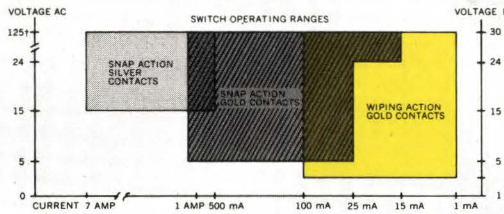

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transfer functions by combining these first-order graphs appropriately.

A graphical analysis of the circuit depicted in **Fig 3** demonstrates the use of these plots. The circuit's transfer function is:

$$H(j\omega) = \frac{V_O(j\omega)}{V_S(j\omega)} = \frac{R_2 + j\omega L}{R_1 + (1/j\omega C)}$$

$$= -(R_2/R_1)\left(\frac{1 + j\omega(L/R_2)}{1 - j(1/\omega R_1 C)}\right) \quad (1)$$

$$= -(R_2/R_1)\left(\frac{1 + j(\omega/\omega_2)}{1 - j(\omega_1/\omega)}\right)$$

where $\omega_1=1/R_1C$ and $\omega_2=R_2/L$.

To determine the magnitude plot required, evaluate

$$20\log_{10}|H(j\omega)| = 20\log_{10}(R_2/R_1) + 20\log_{10}|1 + j(\omega/\omega_2)| + 20\log_{10}|1/(1 - j(\omega_1/\omega))|. \quad (2)$$

Then, merely locate the appropriate graphs in **Fig 1** and add them. (In practice, a piecewise-linear approximation to these curves often provides quick results.)

Employing the indicated component values and solving the appropriate equations yields $\omega_1=10^5$ rad/sec and $\omega_2=10^7$ rad/sec, and the midband gain is $20\log_{10}(R_2/R_1)=40$ dB—the results shown in **Fig 4.**

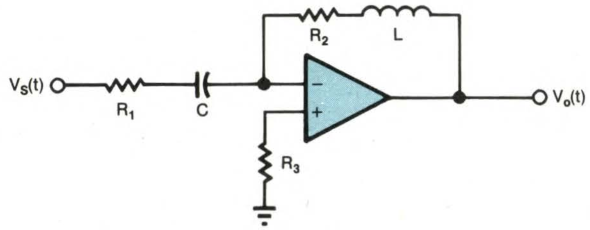

Fig 3—Analyze this simple active network *to demonstrate the utility of the phase-gain plots shown in* ***Figs 1*** *and* ***2.*** *A complete analysis would also require accounting for the op amp (assumed ideal here); its phase-gain characteristics are usually included on its data sheet.*

Obtain the phase plot similarly by adding together the appropriate graphs from **Fig 2.** Remember that you must add in a constant 180° to account for the minus sign in this example's transfer function.

Note that transfer functions such as $H(j\omega)=1-j(\omega/\omega_o)$, $1+j(\omega/\omega_o)$, $1/(1+j(\omega_o/\omega))$ and $1/(1-j(\omega/\omega_o))$ aren't plotted because they imply a negative resistance in the circuit—a sure indication of an algebraic error. **EDN**

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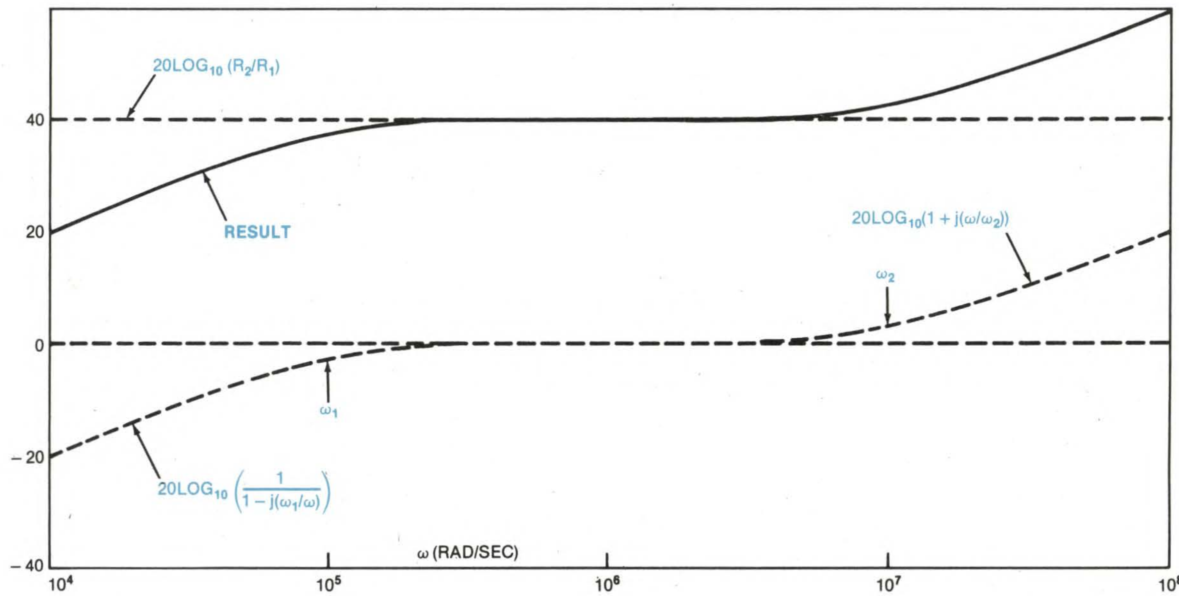

Fig 4—This graphical analysis *clearly indicates the gain characteristics of* ***Fig 3****'s circuit. Determine the circuit's phase margins similarly by using the curves shown in* ***Fig 2.***

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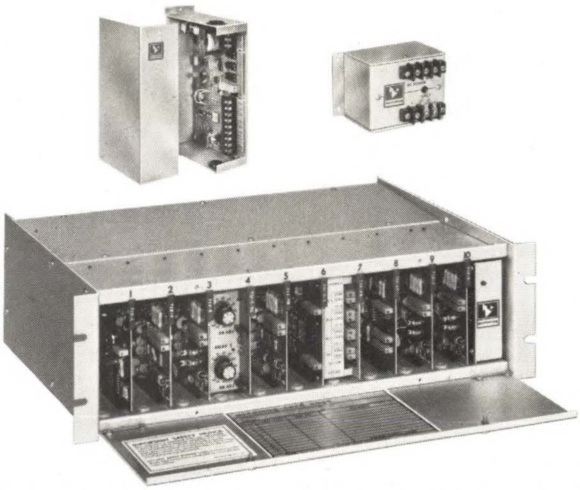

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Keyboard IC interfaces easily to 6800

Philip F Locke
Westinghouse Corp, Pittsburgh, PA

The Intel 8279 functions nicely as an interface between a keyboard or display and a microprocessor because it frees the processor from the task of scanning the keyboard and refreshing the display. However, because it was designed as an 8080 peripheral, it isn't directly applicable to systems based on other types of processors, such as the 6800. You can bridge this gap by using the 74LS TTL interface shown in the **figure.**

This design matches the devices' timing and signal-sense requirements, obeying standard 8279 software rules. Note that you must gate the derived $\overline{RD}$ and $\overline{WR}$ signals for the 8279 with the ϕ_2, TTL signal from the 6800—an action that ensures that command data latches into the 8279 on the rising edge of $\overline{WR}$ while the data and address from the 6800 are still valid. The approach also ensures that 8279 autoincrement occurs on the trailing edge of $\overline{RD}$ while $\overline{CS}$ is still LOW. Note also that you must employ VMA from the 6800 to enable the address decoding. **EDN**

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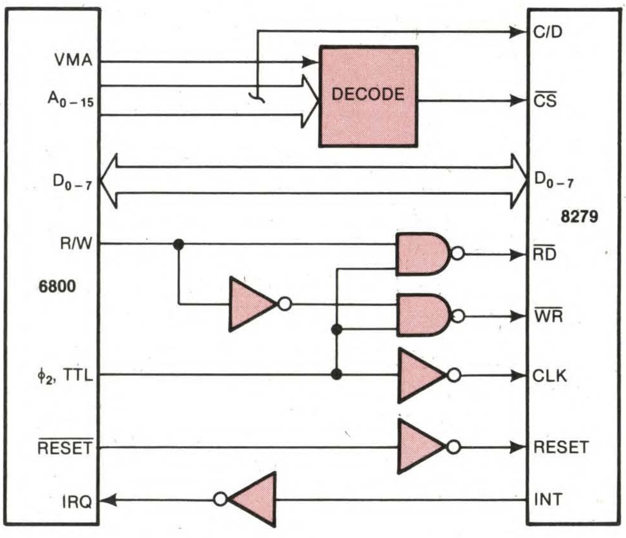

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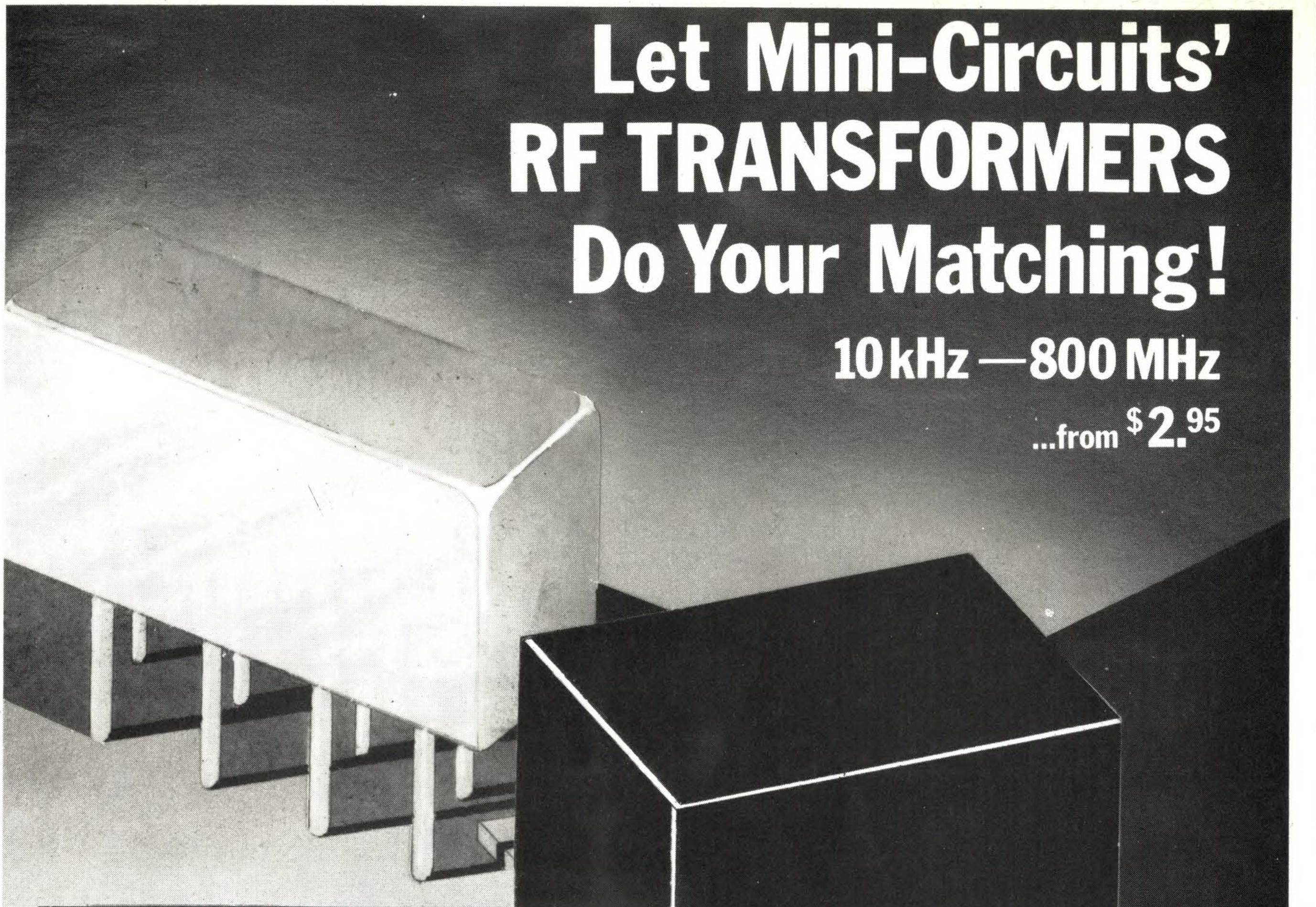

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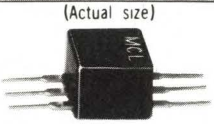

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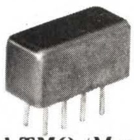

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TM09-1	9	.15-200	$6.45
● T9-1H	9	2-90	$5.45
T16-1	16	.3-120	$3.95
TM016-1	16	.3-120	$6.45
● T16-1H	16	7-85	$5.95

● Up to 100mA DC without saturation

CENTER-TAPPED DC ISOLATED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T1-1T	1	.05-200	$3.95
TM01-1T	1	.05-200	$6.45
T2-1T	2	.07-200	$4.25
TM02-1T	2	.07-200	$6.75
T2.5-6T	2.5	.01-100	$4.25
TM02.5-6T	2.5	.01-100	$6.75
T3-1T	3	.05-250	$3.95
TM03-1T	3	.05-250	$6.45
T4-1	4	.2-350	$2.95
TM04-1	4	.2-350	$4.95
● T4-1H	4	8-350	$4.95
T5-1T	5	.3-300	$4.25
TM05-1T	5	.3-300	$6.75
T13-1T	13	.3-120	$4.25
TM013-1T	13	.3-120	$6.75

UNBALANCED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T2-1	2	.025-600	$3.45
TM02-1	2	.025-600	$5.95
T3-1	3	.5-800	$4.25
TM03-1	3	.5-800	$6.95
T4-2	4	.2-600	$3.45
TM04-2	4	.2-600	$5.95
T8-1	8	.15-250	$3.45
TM08-1	3	.15-250	$5.95
T14-1	14	.2-150	$4.25
TM014-1	14	.2-150	$6.75

FOR ADDITIONAL INFORMATION, COMPLETE SPECIFICATIONS, AND PERFORMANCE CURVES, REFER TO 1979-80 MICROWAVES' PRODUCT DATA DIRECTORY pgs. 161 to 368 or 1979 EEM 2770 to 2974.

It's easy to transform impedance and reduce VSWR.

Chose from 40 models, 12.5 to 800 ohms, 10 kHz to 800 MHz, ultra- low distortion (H models) balanced, unbalanced and center-tapped . . . immediate delivery . . . at prices that can't be matched, starting at $ 2.95

World's largest manufacturer of Double-Balanced Mixers

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MINI-CIRCUITS LABORATORY

A Division of Scientific Components Corp.

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Domestic and International Telex 125460 International Telex 620156

R 42/Rev/A

For more information, Circle No 73

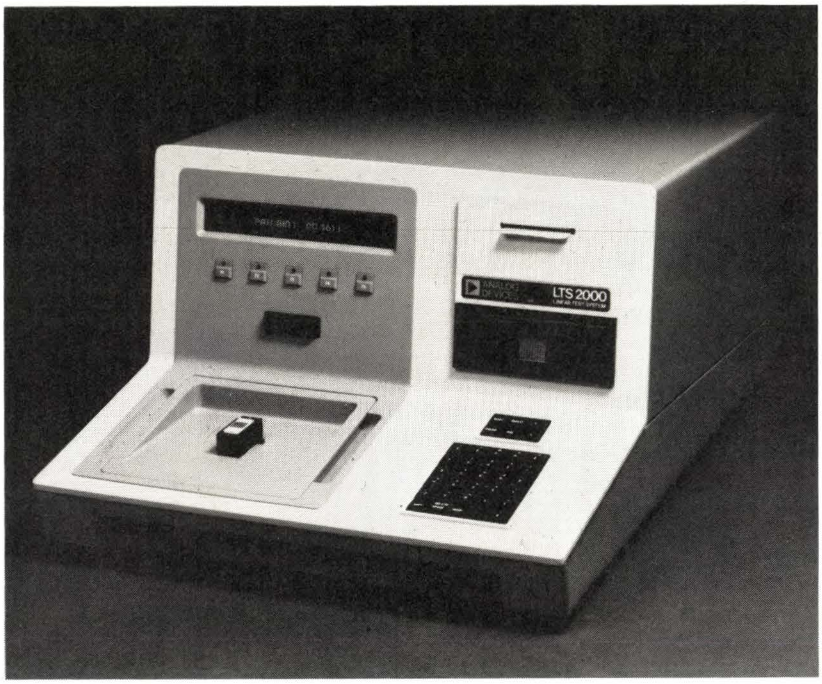
Feature Products

Compact, easy-to-use linear test system aids device selection, engineering analysis

Flexibility and operating ease highlight the Model LTS-2000 benchtop linear tester. This TM 9900-μP-based system implements software-controlled device testing and generates test reports — including statistical analyses in tabular, histogram or curve formats.

Setup requires only minutes for standard test-menu use. Specifically, response via the operator keyboard to prompting questions on the console's 40-character dot-matrix display selects tests and test order and defines test limits. Plugging in a family board for testing ADCs, DACs or op amps (additional capability is planned) and matching device pinout to tester pinout by means of a socket assembly complete the setup procedure.

The planned introduction this summer of TM 990 Power BASIC capability will permit the writing of test programs not included on the standard menu.



A dot-matrix display, *keyboard and 92k-byte floppy disc help the LTS-2000's operator test linear devices and analyze data. Plug-in function and socket-adapter modules permit ADC, DAC and op-amp testing, while an integral printer provides hard copies of test results.*

Messages aid sorting

Plugging in a device and pressing the Start Test button results in a pass/fail signal in times ranging from 1 sec for op amps to 10 sec for ADCs. If programmed in during setup, accompanying messages such as PASS BIN 3 facilitate device sorting by specified characteristics. Keyboard entries permit definition of eight bins based on tests of 32 parameters.

The unit's testing capability permits measurement of op-amp slew rate to 1000V/μsec and gain-bandwidth product to 128 MHz. It also permits testing of ADCs and DACs, including μP-compatible devices, with up to 12-bit resolution.

Simple programming

Use of the LTS-2000's data-log routine to record test results illustrates the unit's programming capabilities. Pressing the Display key causes the display to label each of five function switches located under it. Pressing the Datalog switch then initiates the routine and relabels each function switch.

Next, you press either the All switch (to record data for all devices tested) or the Fail switch (to record failed-device data only) and enter a list of tests to be logged. Similar relabeling of the function switches permits selection of the recording medium.

Individual test results or tabulated lot data, including statistical information, can be printed on the tester's integral 20-column or optional 132-column printer, displayed on an optional CRT or stored on the integral 92k-byte floppy disc.

488 interfacing

For off-line processing, you can store test results on the disc and transfer them manually to other equipment, or communicate them directly to a host computer via RS-232 or IEEE-488 ports. The planned Power BASIC compatibility will provide the IEEE port with controller capability for interfacing with IEEE-compatible instruments.

Users of automatic handling equipment can obtain an automatic-handler-interface option, which serves as a remote-mounted function module. Software rather than hardware customizing mates this module to a handler.

The tester's 65-lb console measures 19×26×12 in. The unit operates in a 10 to 30°C ambient on 100 or 250V, 50 or 60 Hz, and requires 250W.

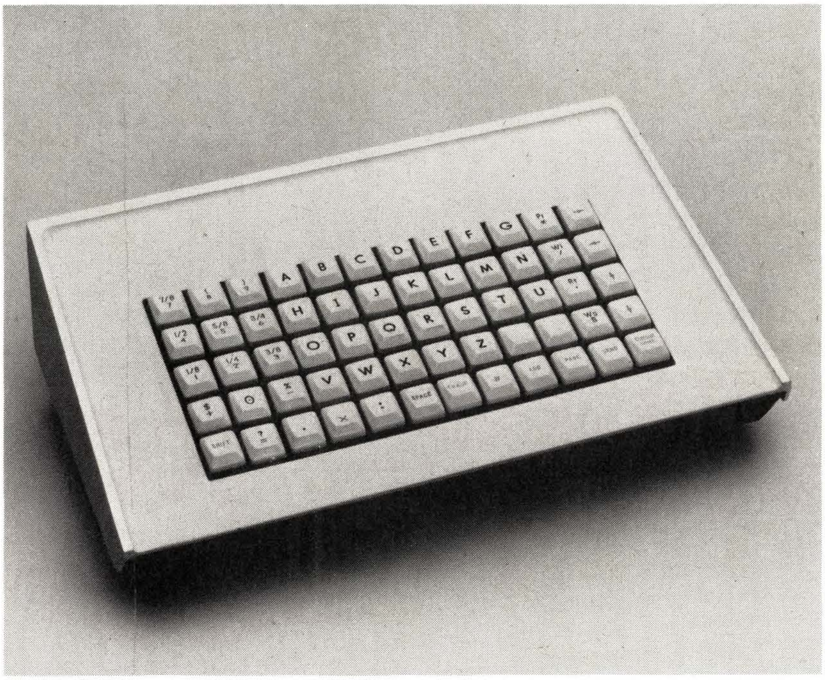
The LTS-2000 costs $25,900 with op-amp-family board installed. DAC-family board, $3000; ADC board, $4000. Delivery, 90 days ARO.

Analog Devices Inc, 360 Audubon Rd, Wakefield, MA 01880. Phone (617) 245-9550.
Circle No 450

Reliable and flexible keyboards feature optical input detection

Aimed at the high end of the keyboard market, these optical units stress reliability and durability rather than planned obsolescence. Compared with mechanical keyboards, their optical key-input detection scheme offers several advantages.

For example, units exhibit no contact bounce or wear and no arc points. And they're impervious to corrosion problems and unaffected by dust and smoke particles and static discharges.



Flexibility is the hallmark *of the optical detection scheme employed to read input data in these keyboards. Complete with μP control, buffer memory and diagnostic capability, units come with a variety of user-specified baud rates and output codes.*

Built-in diagnostics

The keyboards include μP control, a 15-character FIFO buffer memory and integral diagnostics. The latter provide a display of system-component status on a CRT to pinpoint any problem area, thereby reducing troubleshooting time and cost.

Other features include infinite-key rollover, serial or parallel RS-232 outputs and short-circuit protection. Units function over 0 to 50°C and exhibit an MTBF of more than 100 million keystrokes.

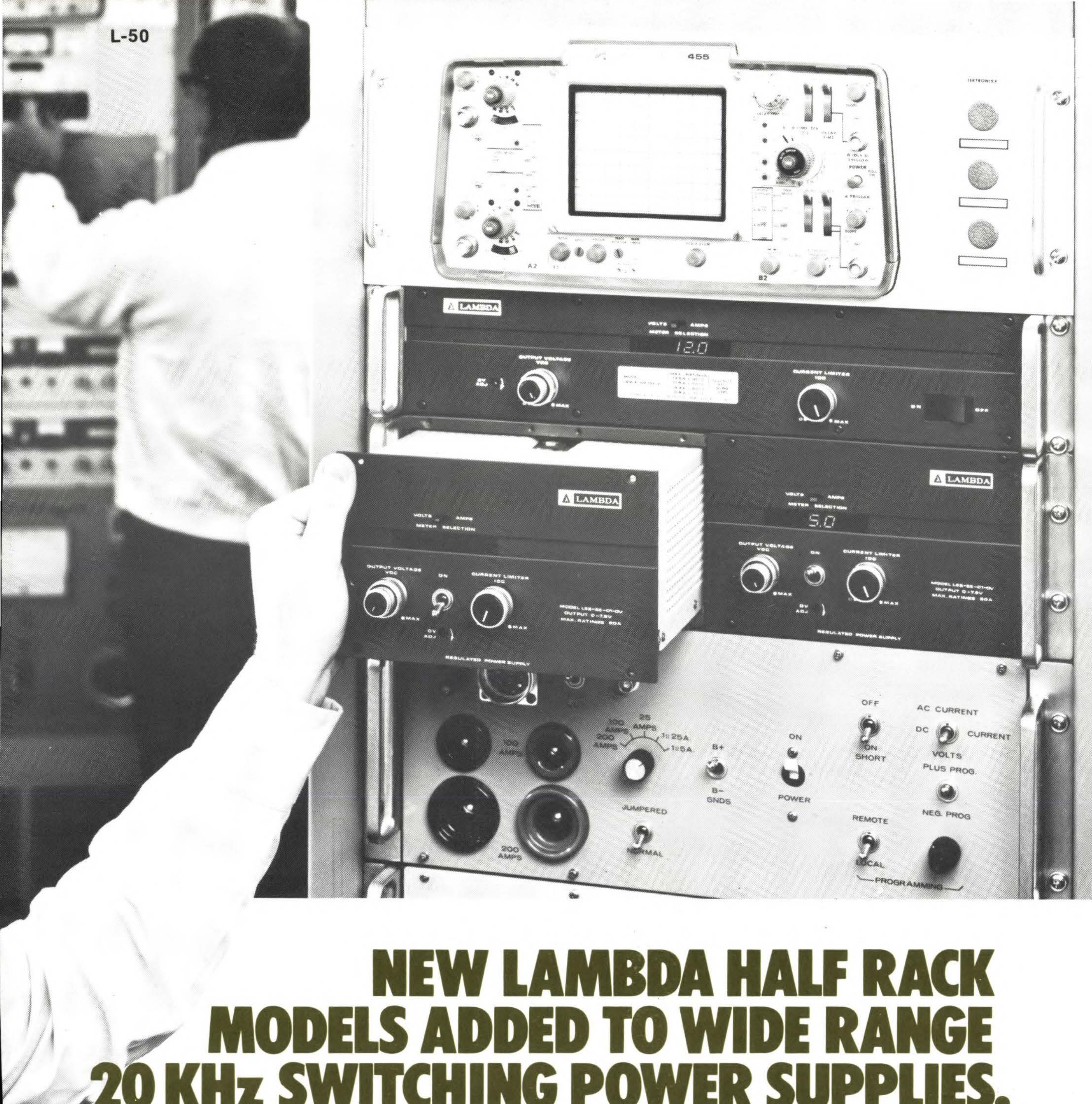
Lowered driver needs

The keyboards' light sources and detectors exhibit a novel matrix arrangement that greatly reduces driver and amplifier electronic requirements (on average, an n-key design requires n/3 sources and n/3 detectors). Besides increasing reliability, this arrangement improves flexibility and makes configuring a keyboard to suit most user applications easy.

The keyboard comes with or without tactile feel or with a switch that permits user choice of this feature. Field-service personnel can readily upgrade a unit by replacing keytops (or even the μP if necessary) to produce different functions, without making any solder connections.

The manufacturer produces the keyboard to customer specifications, including desired baud rate, type of encoding (ASCII is standard) and case styles. Approximately $0.71 per key (10,000), depending on layout and options desired.

Topper Manufacturing, 1515 Crenshaw Blvd, Suite F, Torrance, CA 90503. Phone (213) 533-6866. **Circle No 451**



NEW LAMBDA HALF RACK MODELS ADDED TO WIDE RANGE 20 KHz SWITCHING POWER SUPPLIES.

LES-EE Series for laboratory, systems and test equipment.
Up to 0-60V, up to 0-60A from $1000.

5 YEAR GUARANTEED

λ LAMBDA ELECTRONICS

LE SERIES 20 KHz WIDE RANGE SWITCHING POWER SUPPLIES

OUTPUT RATINGS FOR LES-F SERIES

MODEL	MAX CURRENT AMPS AT AMBIENT OF 40°C	50°C	60°C	71°C	DIMENSIONS	PRICE
0-7.5 VOLTS						
LES-EE-01-OV	60	52	41	30	$5\frac{3}{16} \times 8\frac{3}{8} \times 16$	**$1100**
LES-F-01-OV	100	83	66	47.5	$3\frac{15}{32} \times 19 \times 16\frac{1}{2}$	**1350**
0-18 VOLTS						
LES-EE-02-OV	29	25	20	14	$5\frac{3}{16} \times 8\frac{3}{8} \times 16$	**1000**
LES-F-02-OV	47.5	41	32.5	23.5	$3\frac{15}{32} \times 19 \times 16\frac{1}{2}$	**1200**
0-36 VOLTS						
LES-EE-03-OV	14.5	12.5	10	7	$5\frac{3}{16} \times 8\frac{3}{8} \times 16$	**1000**
LES-F-03-OV	24	20.4	16.5	12	$3\frac{15}{32} \times 19 \times 16\frac{1}{2}$	**1200**
0-60 VOLTS						
LES-EE-04-OV	9	7.7	6.2	4.5	$5\frac{3}{16} \times 8\frac{3}{8} \times 16$	**1100**
LES-F-04-OV	15	12.8	10.3	7.5	$3\frac{15}{32} \times 19 \times 16\frac{1}{2}$	**1350**

Note: Maximum output current applies over entire output voltage range.

OUTSTANDING FEATURES

Designed to meet military environment MIL-STD-810C

Digital Meter Readout

Convection cooled, no fans or blowers

Constant voltage/constant current

Overvoltage protection—built in on all models

Guaranteed 5 years

SPECIFICATIONS OF LE SERIES

Dc output and rating
Refer to the table.

Regulated voltage
regulation line ....0.02% + 2 mv for line variations from 105 to 132 vac (or 187 to 242 vac on 'V' options, 205 to 265 vac on 'VI' options).
regulation load ....0.02% + 2 mv (LE-01, 02) 0.02% + 4 mv (LE-03, 04) for load variations from 0 to full load.
remote programming resistance ....200 Ω/volt nominal
remote programming voltage ..volt/volt
ripple and noise ....10 mv-rms; 50 mv pp for LE-01 15 mv-rms; 100 mv pp for LE-02,03,04
temperature coefficient ....(0.02% + 50 μv)/°C

Constant current
(current regulated line and load) automatic crossover.
voltage range ....As shown in table.
current range ....5% to full load current.
regulation, line ....0.5% + 50 mA (LES-01, 02) 0.5% + 20 mA (LES-03, 04) for input variations from 105 to 132 vac (or 187 to 242 vac on 'V' opts, 205 to 265 vac on 'VI' opts).
regulation, load ....0.5% of Io_{max} for load changes from 5% to rated DC voltage.

AC input
line ....105-132 vac (47-63 Hz) standard input (derate output current by 5% at 50 Hz)
power ....750 watts max (LES-EE) 1250 watts max (LES-F) at 0.6 pF at maximum output voltage, nominal line.
efficiency ....Minimum 60% at maximum output voltage.
soft start circuit ....Limits inrush current at turn on to 200% of full load peak current.
input current ....15A rms max (LES-EE) 25A rms max (LES-F)

Ambient operating temperature
Continuous duty from 0° C to 71°C with appropriate deratings (40°C to 71°C—see table).

Storage temperature range
−55°C to +85°C

Overload protection
Thermal
By self resetting thermostat
Electrical
External overload protection—adjustable, automatic, electronic current limiting circuit limits output current to preset value. Current limiting settabiliy to 105% of rated current via front panel adjust.

Overvoltage protection
Built in, adustable overvoltage protection standard on all sets. When preset voltage is exceeded, the overvoltage protector crowbars the output and removes the inverter drive. See table for OV range on each unit.

OVERVOLTAGE PROTECTION ADJUSTABLE RANGES—LE SERIES

V_{OUT}	ADJUSTABLE OVERVOLTAGE PROTECTOR RANGE V_{OV}(min)	V_{OV}(max)
0 TO 7.5VDC	3V	10V
0 TO 18VDC	6V	24V
0 TO 36VDC	9V	47V
0 TO 60VDC	12V	70V

EMI
Conducted EMI conforms to MIL-I-6181D.

Cooling
Convection cooled—no fans or blowers.

Input and output connections
Heavy duty barrier strip and output studs on rear of chassis.

Meters
Digital panel meter standard on all sets monitors output voltage/current by means of a volt/amp selector switch.

Controls
DC output controls
coarse and fine voltage adjust and single current adjust on front panel.
Overvoltage protection
overvoltage trip point set by screwdriver adjust on front panel.
Power
on-off-switch on front panel.

Remote sensing
Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation.

Fungus proofing
All units are rendered fungi inert.

Options
AC input

Add Suffix	For Operation at:	Price Qty. 1-14	Price Mixed Models Qty. 15 and up	Price Single Model Qty. 15 and up
-V	187-242 VAC (47-63 Hz) (derate current 10%)	12%	12%	10%
-VI	205-265 VAC (47-63 Hz)	12%	12%	10%

Accessories
Rack Adapters LRA-1, LRA-2 (LES-EE)
Chassis slides KHT-34-012 (LES-F, LRA-1)

Physical Data

Series	Weight Lbs, net	Lbs, ship	Size
LES-EE	27	33	5³⁄₁₆ x 8⅜ x 16
LES -F	40	50	3¹⁵⁄₃₂ x 19 x 16½"

Guaranteed for 5 years
5 year guarantee includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 5 years.

Digital signal-processing IC features 250-nsec decode time

The world of single-chip signal processors has expanded by 50% with the introduction of the μPD7720. Occupying just 0.044 in.² of silicon, this device employs approximately 40,000 transistors to realize the hardware functions depicted in the **figure.**

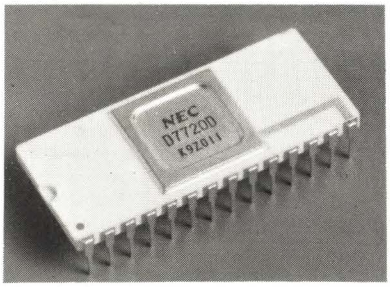
Although designed primarily for voiceband (to 4 kHz) signal processing, the all-digital device features high-speed and flexible I/O and programming capabilities that encourage its use in FFT and voice-recognition or -synthesis applications.

Pipeline speeds decode

Hardware/software pipelining yields the part's 250-nsec instruction-decode time—making it possible to process a 64-point complex FFT in 1.6 msec or a single second-order digital-filter section in 2.25 μsec. Thus, 4-kHz analog signals can be processed by as many as 55 second-order filters in about 125 μsec—an 8-kHz sampling rate.

Perhaps the most impressive part of the chip, though, is its multiplier—a 16×16-bit configuration based upon Booth's algorithm. Use of this technique nearly halves the multiplier's carry-propagation time and the number of full adders that would be required by an array-type device.

Additionally, separate data paths connect the data ROM and RAM to the multiplier registers so that the multiplier and multiplicand can transfer directly and simultaneously.



Nearly 40,000 transistors would be required *to equal the μPD7720's signal-processing capability. Requiring a single 5V supply and 8-MHz clock, this IC can match the performance of 55 second-order digital filters.*

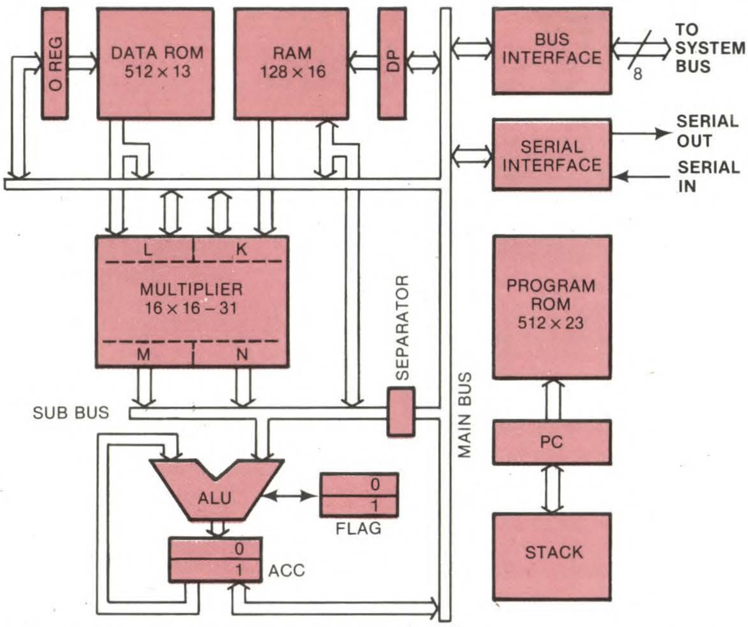
Concurrent transfers

A separator divides the chip's internal main and sub buses; the sub bus connects directly to the ALU. This architecture permits multiplier (or RAM)-to-accumulator data transfers to occur concurrently with main-bus system I/O.

Configured as is, the μPD7720 can serve in stand-alone or multiprocessor data-acquisition applications. It incorporates three separate memories: a 512×13-bit data ROM for equation-coefficient storage, a 512×23-bit program ROM and the 128×16-bit data RAM.

Housed in a 28-pin DIP, the part requires a single 5V supply and dissipates 900 mW typ. 8080-bus compatible, it operates at an 8-MHz clock rate. Sample quantities from $300. Delivery, first qtr 1981.

NEC Microcomputers Inc, 173 Worcester St, Wellesley, MA 02181. Phone (617) 237-1910. **Circle No 452**

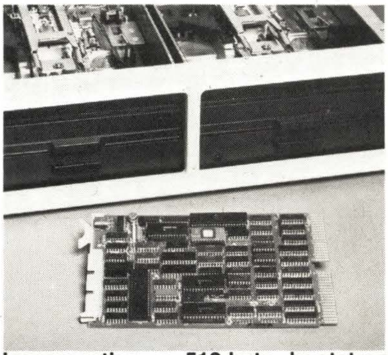


Software/hardware pipelining techniques *reduce the μPD7720's instruction-cycle time to 250 nsec. Separation of the main and sub buses permits concurrent data transfers between the outside world and internal memory or ALU functions.*

Floppy-disc controller furnishes diagnostics, bootstrap

Sporting built-in Z80 μP control and three 2×4k PLAs containing user-selectable diagnostic microcode, the Flex-02 floppy-disc controller is fully compatible with all Digital Equipment Corp floppy-disc conventions. It meets all electrical and physical specifications for the Q Bus, including definition of registers, signal leading, power consumption and I/O characteristics.

Because the controller meets these conventions, it also provides media compatibility with the DEC RX02 and 01 drives, which employ industry-standard IBM 3740-formatted diskettes. The controller thus allows diskette interchangeability on similar systems.



Incorporating a 512-byte bootstrap and user-selectable diagnostics, *the Flex-02 floppy-disc controller plugs directly into an LSI-11 Q Bus.*

The controller board plugs directly into an LSI-11 and features DMA interrupt logic, an 8-MHz oscillator for the Z80 and phase-locked loops for FM and MFM recording. Additionally, an on-board 512-byte bootstrap ensures disc loading while reducing space requirements and costs in LSI-11 systems. According to the controller's manufacturer, the device operates under the RT-11 system at an approximate gain in transfer speed of 20% over DEC's RX02.

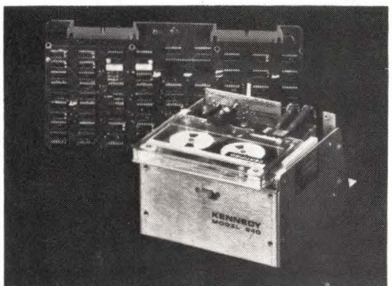
Part of the board's microcode diagnostics handle power-up, self-test and system-problem user-advisory functions. The controller can read or write both single- and double-density media. $700 (100).

Advanced Electronics Design Inc, Box 61779, Sunnyvale, CA 94088. Phone (408) 733-3555. **Circle No 453**

Intelligent cartridge-tape formatter reduces backup drive's overhead

The Model 650 μP-based formatter, compatible with its manufacturer's Model 640 8-in. rigid-disc-backup cartridge-tape transport, implements an advanced data-recovery system employing sophisticated group-coded-recording (GCR) techniques to reduce host-computer overhead while improving data integrity. It also simplifies peripheral-controller design because the disc-drive and tape-backup controllers both utilize the same bus and signal conventions.

The formatter operates as an integral part of the Model 640 6400-bpi, 4-track serpentine cartridge drive, which provides



Designed for use with its manufacturer's backup cartridge-tape drive, *Model 650 formatter permits selective address and search operations for specific records on any track, thereby reducing access time. It employs DIP switches to activate μP-controlled diagnostic routines, thereby cutting repair time.*

a 17.3M-byte unformatted storage capacity. And because the manufacturer anticipates that Models 650 and 640 will serve to back up 8-in. rigid discs, provisions are included to allow a single DMA controller to handle both disc and tape subsystems. Such transactions occur via a bus structure consisting of 8-bit bidirectional control and data lines with full handshaking between the host system and disc subsystem.

Major formatter components include an 8-bit MOS μP and 2-speed bipolar microsequencers. The μP handles communications with the host, provides transport control, initiates read/write sequences and monitors the timing structure of commands in progress.

The unit also contains special routines that sense broken tape or the loss of tape on the reels. The high-speed micro-sequencers provide write encoding, read synchronization and GCR decoding. The formatter also employs diagnostic and signature-analysis software to assist in fault isolation.

Data integrity paramount

The formatter utilizes GCR encoding rather than conventional modified frequency modulation (MFM) to provide recovery margins of ±0.5 cell—a vast improvement over the ±0.25-cell margin characteristic of MFM.

For further data integrity, Model 650 writes a hardware-implemented 16-bit cyclic-redundancy-check (CRC) character on the tape at the end of each record. During read operations, the formatter calculates the CRC character and compares it with the recorded check character. In addition, the unit's write and differential read chain provide higher signal-to-noise ratios with improved fidelity over ambient noise compared with earlier models, while minimizing pulse crowding and peak shift.

The Model 640 cartridge transport employs 4-track read-after-write heads and performs selective erase operations—permitting nearly continuous data writing and recovery without pausing for rewinding. The formatter supports this capability by allowing selective address and search operations for specific records to reduce access times.

The transport transfers data at 192k bps. Read/write tape speed is 30 ips, while rewind occurs at 90 ips. Start/stop time equals 25 msec at 30 ips and 75 msec at 90 ips.

The formatter measures 6×11×0.5 in. and requires a 5V power supply. $400, with OEM quantity discounts available.

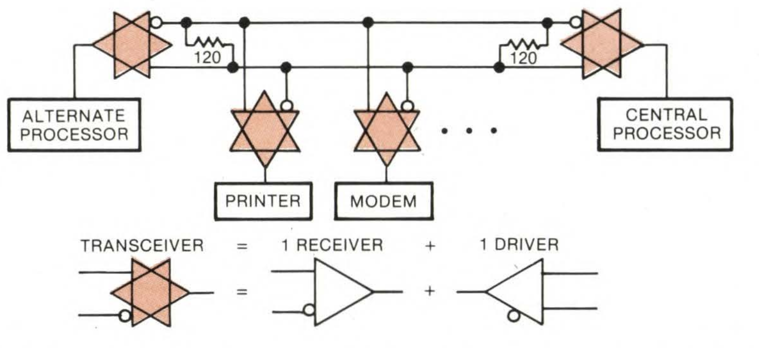
Kennedy Co, 1600 S Shamrock Ave, Monrovia, CA 91016. Phone (213) 357-8831.

Circle No 454

Quad differential line circuits provide party-lining capabilities

Offering the ability to implement party-line systems, the 75174/75172 quad differential line drivers and 75175/75173 receivers meet the RS-422 EIA standard; they're optimized for multipoint data-bus transmission at data rates up to 10M bytes/sec over distances up to 4000 ft.

The receivers feature ±200-mV input sensitivities over a common-mode range of +12 to −12V in addition to hysteresis for increased noise immunity. The drivers feature protection from line-fault conditions and line contention among multiple units—capabilities achieved by means of both positive and negative current limiting as well as through thermal shutdown.



Up to 32 devices can share a common bus *in a party-line configuration utilizing Texas Instruments' 75174/75172 line drivers and 75175/75173 line receivers. This diagram shows a typical transceiver arrangement with 120Ω resistors at each end of the line to establish balanced operation.*

Operating from a single 7V supply (V_{CC}), up to 32 devices can share a common balanced line in a party-line arrangement. Additionally, the drivers are pin compatible with the Am26LS31 and MC3486, while the receivers are compatible with the 26LS32 and 3487.

The transceivers operate over a 0 to 70°C range with a 5.5V input voltage and total power dissipation ranging from 1150 to 1375 mW, depending on packaging. $3.02 (100) for the drivers; $2.23 (100) for the receivers.

Texas Instruments Inc, Box 5012, Dallas, TX 75222. Phone (214) 238-4783. **Circle No 455**

New Products

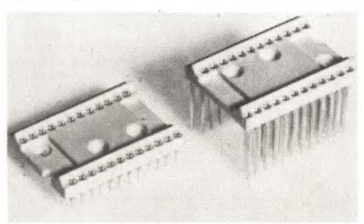
COMPONENTS & PACKAGING

ASCII KEYBOARDS. Models VP-601, with a 58-key typewriter format, and VP-611, with the same format plus a 16-key numeric keypad for fast data entry, feature fully encoded 128-character ASCII alphanumerics and utilize flexible-membrane key switches.

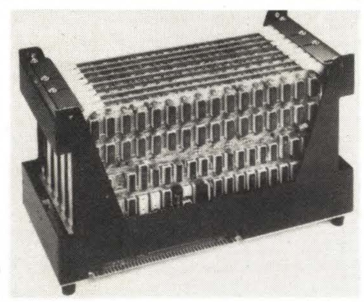
Contact life is rated at >5 million cycles per key. A finger-positioning overlay, combined with positive key-press action, provides good operator feel, and an on-board tone generator furnishes aural keypress feedback. The unitized keyboard surface is impervious to liquids or dust particles.

The keyboards operate from a single 5V dc supply and include an LED power-on indicator; their buffered 7-bit ASCII output is TTL compatible. Other features include two user-definable keys (switch closures), 2-key-rollover circuitry, even parity bit and buffered KD (keydown) and $\overline{KD}$, Strobe and Strobe handshake signals. $80. **RCA/Electro-Optics and Devices,** Rte 202, Somerville, NJ 08876. Phone (201) 685-6423. **Circle No 178**

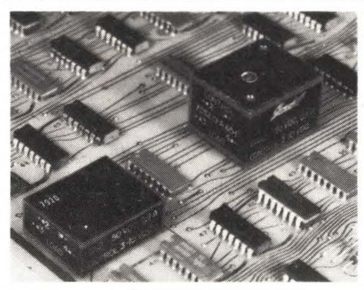
PIGTAILED LED. IRE-160FC uses DuPont PFX-S120 fiber-optic cable, provides a 790-nm peak wavelength of emission and typically yields 200-μW optical power into the fiber core at 100-mA dc drive. The fiber is plastic-clad silica with an NA of 0.27; the core measures 200 μm with an outside diameter of 600 μm. A typical rise and fall time of 10 nsec permits digital data rates up to 40M bps. $325. **Laser Diode Laboratories Inc,** 1130 Somerset St, New Brunswick, NJ 08901. Phone (201) 249-7000. **Circle No 179**



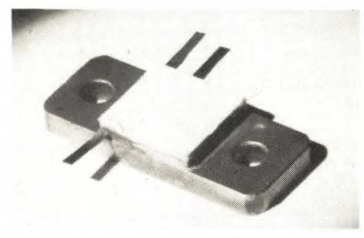
QUAD-IN-LINE SOCKET. Accepting the Motorola QUIL family of bipolar LSI chips and other similar devices, the 48-position Series 860 header is molded of Valox 420-SEO glass-reinforced polyester (UL 94V-0 listed) and comes with 0.025-in. square wire-wrapping posts or dip-solder terminals for pc-board applications. The unit is supplied with screw-machined sockets consisting of brass sleeves, either gold-over-nickel or electro-tin-over-nickel plated, and 4-tine beryllium spring clips, 25-μin. gold plated over 50 to 100 μin. of nickel. $3.50 to $5.50 (small qty). **Garry Manufacturing Co,** 1010 Jersey Ave, New Brunswick, NJ 08902. Phone (201) 545-2424. **Circle No 180**



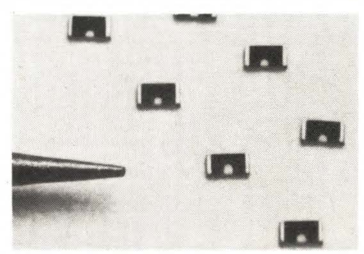
CARD CAGE. A 9-slot unit for Intel's iSBC-80 Multibus, SBC 609 fits in the same space and has the same mounting configuration as two 4-slot card cages. It maintains the standard 0.6-in. card center-to-center spacing and provides an extra ninth card slot. Additionally, one card slot can accept a 2-level wire-wrapping card. Features include smooth nylon card guides for easy card insertion, an expansion connection and mounting holes for a reset switch and a -5V regulator. $410. Delivery, stock to 6 wks ARO. **Electronic Solutions Inc,** 5780 Chesapeake Ct, San Diego, CA 92123. Phone (714) 292-0242. **Circle No 181**



DC/DC RELAYS. Switching a dc load with a dc input, these solid-state units operate over a load range of 3 to 50V dc. Two package sizes with load-current maximums of 400 mA and 2A are available. The inputs are logic compatible and sensitive to 3 to 24V dc with low drive currents; the devices have DIP-compatible terminations. Optical isolation protects the driving logic circuitry; a clamped output furnishes transient protection for the pc-mountable relay. $7.50 to $9 (100). **Grayhill Inc,** 561 Hillgrove Ave, La Grange, IL 60525. Phone (312) 354-1040. **Circle No 182**



POWER ATTENUATOR. The PAA-100 dissipates 100W at a heat-sink temperature of 100°C. Frequency is dc to 750 MHz with a maximum VSWR of 1.25, and attenuation values of 1 through 20 dB ±0.5 dB are available. The resistor substrate is beryllium-oxide ceramic with a 96% alumina ceramic cover; the tabs are beryllium copper. $30 (100). Delivery, stock to 8 wks ARO. **KDI Pyrofilm Corp,** 60 S Jefferson Rd, Whippany, NJ 07981. Phone (201) 887-8100. **Circle No 183**



CHIP RESISTOR. A thick-film unit that can be attached directly to either side of a pc board and flow soldered along with other components, MCR-18 measures 0.125×0.062×0.023 in., comes in ±2, ±5 and ±10% tolerances and is multirated from 1/16 to 1/2W. Values range from 2.2Ω to 10 MΩ, and power rating is based on continuous full-load operation at an ambient temperature of 70°C. Other specs include maximum working voltage of 200V, maximum overload voltage of 400V and a −40 to +125°C temperature range. $50 (1k) in magazines or in tape/reel form. Delivery, 12 wks ARO. **R-Ohm Corp,** Box 19515, Irvine, CA 92713. Phone (714) 546-7750. **Circle No 184**

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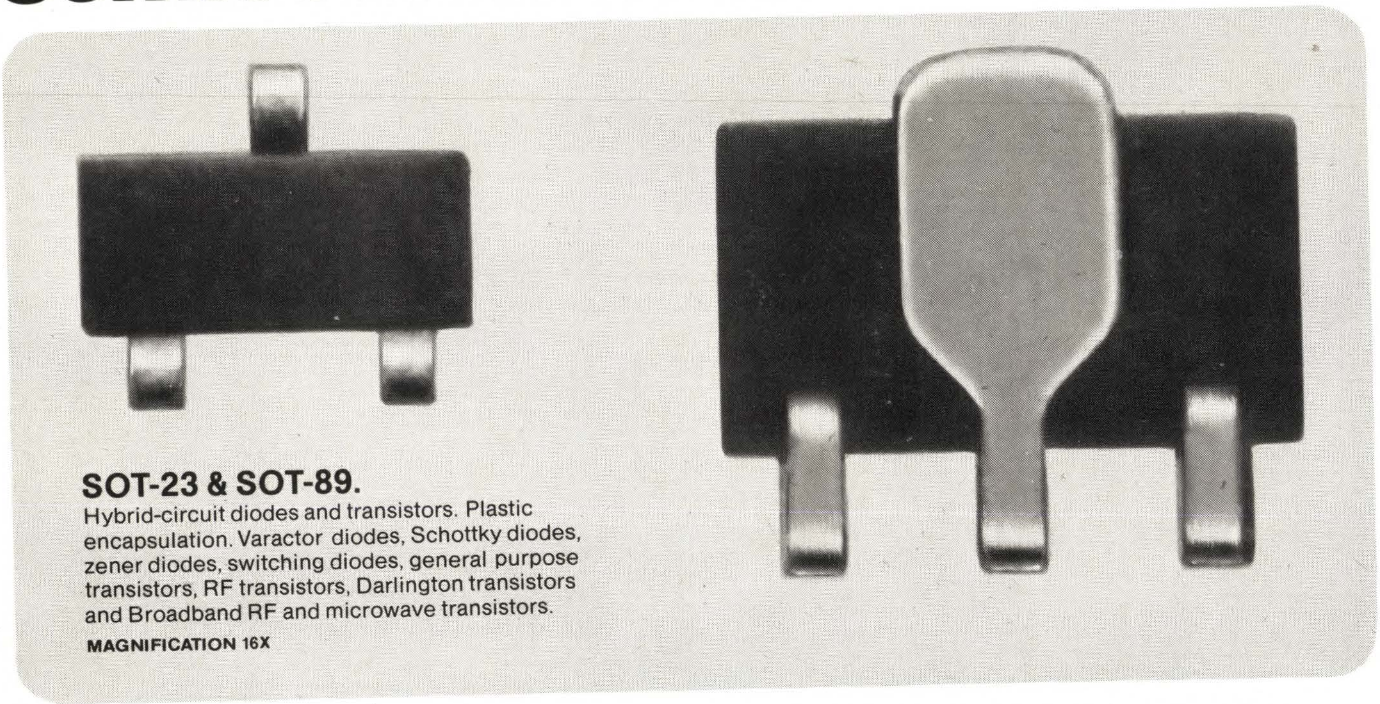

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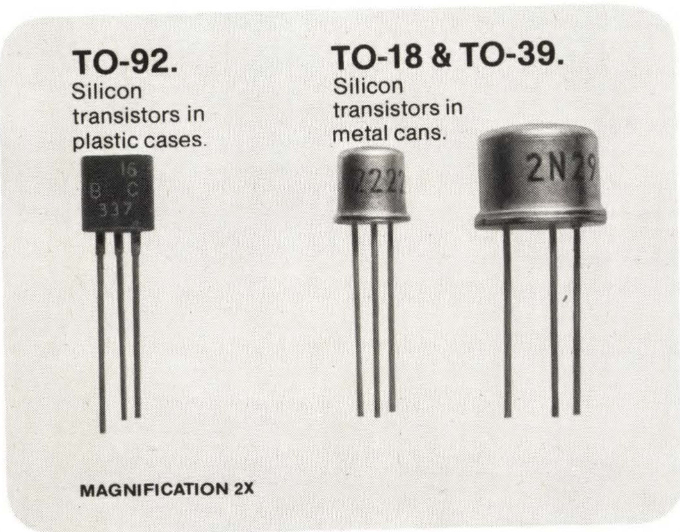

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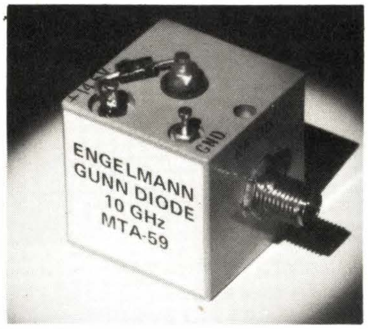
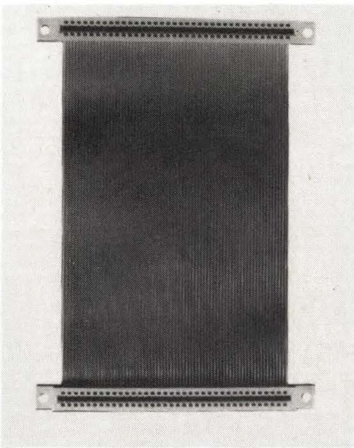
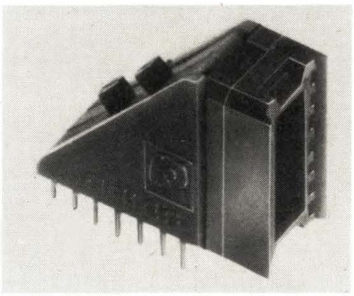
New Products



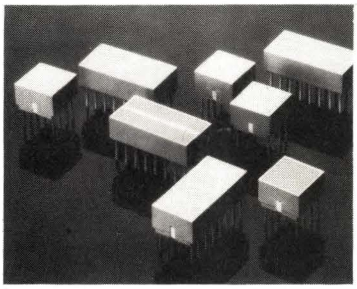
GUNN-DIODE OSCILLATOR. Providing 10 to 100 mW of adjustable RF output power at 10 GHz, Model MT-A59 has level-set tuning with screwdriver frequency adjustment over a 5% range. Features include frequency stability of 0.25 to 1% (depending upon the output-power-level setting) over the temperature range of −30 to +85°C, an internal power-supply regulator that accepts input voltages from 12 to 28V dc, and overvoltage and reverse-voltage protection. Spurious responses and harmonics spec at −60 and −20 dBc, respectively. $275. Delivery, 45 days ARO. **Engelmann Microwave Co,** Skyline Dr, Montville, NJ 07045. Phone (201) 334-5700.
Circle No 185



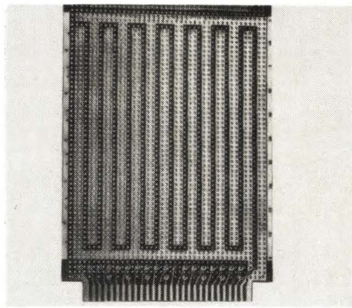
CABLE ASSEMBLIES. Suiting panel-to-panel or backplane-to-backplane interconnection applications, these IDC units mate with straight and right-angle cable-connector families as well as with pc-board edge fingers. For insulation-displacement connectors, the assemblies come with 26, 36, 40, 50 or 72 conductors (single and double ended). $23 (10) for a double-ended, 72-conductor 1-ft-long unit. **Mupac Corp,** 646 Summer St, Brockton, MA 02402. Phone (617) 588-6110. **Circle No 186**



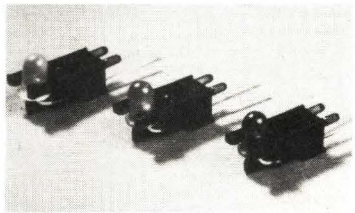
DISPLAY-DEVICE SOCKET. 14-pin display devices can be mounted vertically on the Vertisocket. Its tin-plated pins are on 0.1-in. centers with rows on 0.3-in. centers, and its socket contacts are 1-piece bifurcated construction to accept both round and flat leads. Features include rail entry guide, posts on socket body that snap into a bar (thus allowing multiple displays to be installed as a single unit) and pins protected within the enclosed section of the glass-filled thermoplastic body. $0.96 to $1.99. **Aries Electronics Inc,** Box 130, Frenchtown, NJ 08825. Phone (201) 996-6841. **Circle No 187**



LIGHT-BAR MODULES. These LED devices come in six different package types, including 8.89-mm-square and 8.89×19.05-mm continuous-rectangular surface areas. HLMP-26XX Series modules are high-efficiency red, HLMP-27XX Series units are yellow and HLMP-28XX Series devices are green. Typical luminous sterance equals 160 cd/m^2 at 20 mA dc average, and the units' radiation pattern is approximately Lambertian. Individual LEDs can be connected in parallel, series or parallel/series. Dual-in-line packages are on 2.54-mm centers with 7.62-mm rows, can be flush-mounted or used with a socket and are X-Y stackable and IC compatible. $1.75 for 8.89-mm-square units; $2.56 for 8.89×19.05-mm devices (1k). **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 856-1501. **Circle No 188**

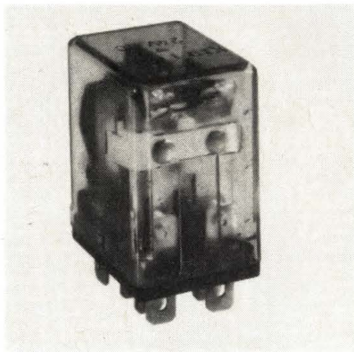


DEVELOPMENT BOARDS. Size and plug compatible with Pro-Log 7801, 2, 3 and Mostek MD-SBC-1 or other μC systems using the STD Bus, 4610 Series boards permit interface design and system expansion using wrapped-wire or soldered interconnections. The 4.5-in.-wide, 6.5-in.-high and 0.062-in.-thick units have 0.042-in.-diameter holes on a 0.1-in. grid; 56 card-edge contacts (28 each side) on 0.125-in. centers supply STD Bus input/output. Model 4610 suits soldered interconnections; Model 4610-2, wrapped wiring. The boards are manufactured from FR4 epoxy/glass composite material with 2-oz copper cladding. $18.95 for Model 4610 or 4610-2. **Vector Electronic Co Inc,** 12460 Gladstone Ave, Sylmar, CA 91342. Phone (213) 365-9661.
Circle No 189

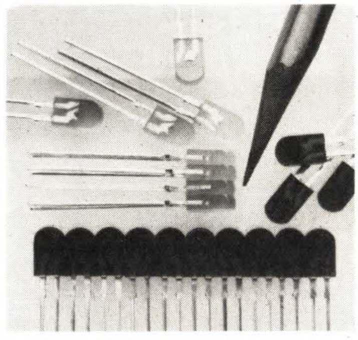


LED INDICATORS. Series 5320/5321 Super-Brite subminiature units' LEDs are positioned at right angles to the base mounting pins of the assembly; the pins press into holes in a pc board to provide precise LED location. The mounting base includes a board stand-off to prevent flux entrapment and permit easy cleaning, and the high-intensity-light-output LEDs come in red, green or yellow. Typical forward voltages spec at about 2V at 20 mA, and luminous intensity at this current is typically 4 to 5 mcd. The black nylon housing positions the LED 0.35 in. above the pc board for Series 5320 units and 0.45 in. above for Series 5321. $0.43 (1k). **Industrial Devices Inc,** 7 Hudson Ave, Edgewater, NJ 07020. Phone (201) 224-4700. **Circle No 190**

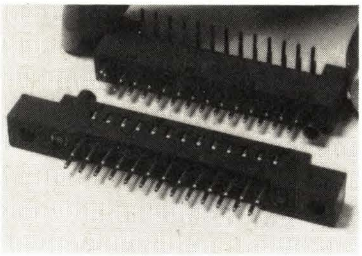
New Products



10A RELAYS. K10 Series units are UL recognized and offer silver or silver-cadmium-oxide contacts rated 10A at 30V dc resistive or 277V ac in configurations up to dpdt. Contact life exceeds 100,000 operations at rated load. Continuous-duty ac coils are available up to 125V, 50/60 Hz, while dc coils come with up to 120V ratings. AC models pick up at 85% of nominal voltage at 25°C; dc models, at 75%. The slightly larger than 1-in.^{3} units have 0.187-in. quick-connect/solder terminals and come as socket-mount relays or with a mounting bracket plate with stud. $2.76 (500). **Potter & Brumfield,** 200 Richland Creek Dr, Princeton, IN 47671. Phone (812) 386-1000. **Circle No 191**



RECTANGULAR LEDs. These narrow, 0.1-in.-wide, 0.2-in.-high rectangular red, green and yellow LED lamps serve as status indicators and can be stacked in a line (10 per inch) to create an illuminated bar-graph effect. The lamps emit a narrow rectangular wedge of light with luminous intensity (20-mA current) of 2 mcd typ; maximum power dissipation at 25°C equals 200 mW for red lamps and 160 mW for green and yellow. $0.33 for RL-10 (red); $0.39 for GL-11 (green) or YL-12 (yellow) (1k). **Litronix Inc,** 19000 Homestead Rd, Cupertino, CA 95014. Phone (408) 257-7910. **Circle No 192**

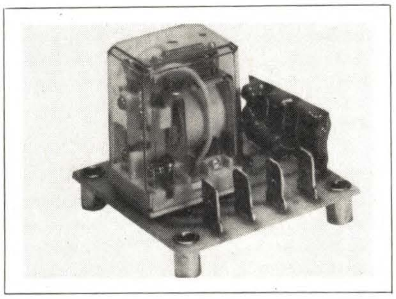


PC CONNECTOR. For use with either multilayer pc boards or flexible printed wiring, this connector meets MIL-C-55302, includes repairable socket contacts replaceable from the connector-engaging face and comes with 10 through 70 contact positions and a variety of contact terminal types and coupling styles. Low connector mating force results from the use of stamped socket contacts; good contact reliability is provided by beryllium-copper contacts. Basic configurations include right-angle plug with pin contacts (with and without flange) and receptacle with socket contacts (also with and without flange). Termination provides solder tails for pc boards, DIPs and flexible circuitry. Approximately $0.38 per mated line (OEM qty). Delivery, 6 to 8 wks ARO. **Hughes Connecting Devices,** 17150 Von Karman Ave, Irvine, CA 92714. Phone (714) 549-5701. **Circle No 193**

3½-DIGIT DPM. 115 or 230V ac powered (pin selectable), Model DM-3100B sports differential inputs and ratiometric measurement capability. Measuring 3×2.15×1.76 in., the CMOS unit provides a bright-red, self-illuminated LED display with 0.56-in.-high numerals. Specs include CMR of 80 dB (common-mode voltage between −4 and +4.5V dc, referenced to meter power ground), input bias current of 5 pA typ and 50 pA max, input voltage of ±1.999V dc (nominal), input impedance of 1000 MΩ (typ), meter accuracy to ±0.1% of displayed reading (±1 count) and TC of ±50 ppm/°C typ. Other features include user-selectable decimal point, adjustable sampling rate and autopolarity. $70. Delivery, 6 to 8 wks ARO. **Datel-Intersil,** 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 339-9341. **Circle No 194**

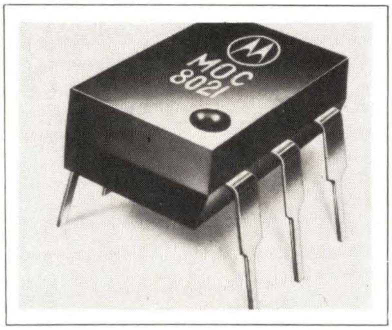
ELECTROLYTIC CAPACITORS. Claimed to provide tantalum-like performance but at significantly lower cost, Series PDA-L units exhibit maximum leakage of 0.002 CV or 0.4 μA (whichever is greater) over the operating temperature range of −40 to +85°C. Capacitance range spans 0.1 to 220 μF, capacitance tolerance equals ±20% (with ±10% also available), and voltages offered range from 6.3 to 50V. From $0.078. Delivery, stock to 10 wks ARO. **International Components Corp,** 105 Maxess Rd, Melville, NY 11747. Phone (516) 293-1500. **Circle No 195**

New Products



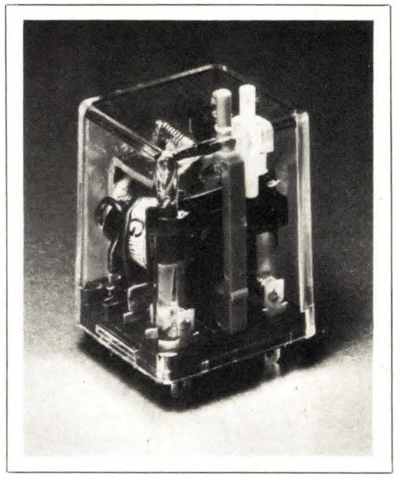
TIME-DELAY RELAY. Opdelay timer is a compact fixed-, adjustable- or remotely-adjustable-delay device featuring ease of mounting and fast replacement. Using a hybrid solid-state timing module that spans the timing range of 0.1 to 300 sec in 10-to-1 increments, the open pc-board unit drives a miniature relay with two Form C 10A (resistive) contacts. Repeat accuracy is ±3% (at nominal voltage and temperature after third and succeeding cycles), and all interconnections are accomplished through quick-disconnect terminals. Polarity and transient protection come standard. <$10 (OEM qty) for ON-delay unit. **Instrumentation & Control Systems Inc,** 520 Interstate Rd, Addison, IL 60101. Phone (312) 543-6200. **Circle No 196**

FILTER CHOKES. For use with switching power supplies or as typical line filters, Model IHV units come in two lead styles, both designed for pc mounting. Eight standard inductance/current values are available, ranging from 500 μH at 15A to 24 μH at 60A. All devices are epoxy coated and use straightforward construction techniques for economy. $11 (100) for a typical (50 μH at 50A) unit. **Dale Electronics Inc,** Box 609, Columbus, NB 68601. Phone (605) 665-9301. **Circle No 197**



OPTOISOLATOR. The high-gain MOC8021 optical coupler/isolator has a current-transfer ratio of 1000% and an isolation-voltage rating of 7500V ac pk (an -8020 version provides a current-transfer ratio of 500%). The unit derives its high gain from the Darlington amplifier employed in its monolithic structure; a GaAs LED, optically coupled to the Darlington, achieves the high degree of isolation. Because the device lacks a pin connection to the base of the Darlington, pickup of stray radiation is significantly reduced. The UL-recognized unit comes in a 6-pin plastic DIP. MOC8021, $1.25; MOC8020, $1.20 (100). **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-4306. **Circle No 198**

ALPHANUMERIC KEYBOARDS. Fas-type units feature a patented membrane-switch technology that provides 50 million operations per key and contact bounce typically <2 msec. Said to be characterized by intrinsically low EMI emissions, the modular units operate with a consistent force of 3 to 5 oz per key and 5 to 7 oz per space bar over a 0.15-in. travel. Available in a variety of stock and custom models, the keyboards provide flex-tail terminations (other terminations available). Backer-board options include phenolic, metal and PCB. From $30 (OEM qty). **Chomerics Inc,** 77 Dragon Ct, Woburn, MA 01888. Phone (617) 935-4850. **Circle No 199**

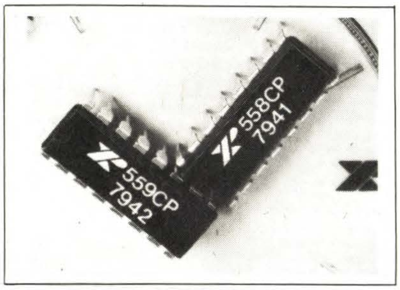


RELAYS. These enclosed square-base devices feature a push-to-test operator/manual-reset button combination on general-purpose 5A/10A low-level 30 Series units, dc current-sensitive 31 Series models and on compact fixed- or adjustable-time-delay 39 Series versions. Plug-in solder/quick-connect or pc-board terminals are supplied, and mechanical life expectancy for the units exceeds 20 million operations (no load) and a minimum of 100,000 operations at full rated load. $8.85 to $31.25. **Eagle Signal Industrial Controls,** 736 Federal St, Davenport, IA 52803. Phone (319) 326-8147. **Circle No 201**

S/D OR R/D CONVERTERS. Model 1663 units furnish transformer-isolated signal and reference inputs and have separate analog and logic grounds to minimize potential ground-loop problems. The 400- or 50/60-Hz devices feature 18-bit (±30 arc-sec) resolution, ±0.5 arc-minute accuracy, 0 to 360°/sec tracking rate, 1000°/sec^2 acceleration, 750-msec step response (180° step) and a 0 to 70 or −55 to +105°C temperature range. $1700. Delivery, 8 wks ARO. **Transmagnetics Inc,** 210 Adams Blvd, Farmingdale, NY 11735. Phone (516) 293-3100. **Circle No 202**

BUSING SYSTEM. Providing a solderless, press-fit, highly conductive method of linearly tying together wire-wrapping posts, the Series BP device uses a cantilever-contact interface system and a tri-point grip that activates and exerts a continuous force on the posts. An electrical-grade Mylar film is bonded to the bus bar's external surfaces so that adjacent rows of contacts can be bused without the use of separating strips or added insulators. The unit comes in a variety of pitches and for various sizes of posts; lengths to 18 in. can be supplied from stock. **Buss-Tronics,** 261 Saint Mihiel Dr, Riverside, NJ 08075. Phone (609) 871-7711. **Circle No 203**

ICs & SEMI-CONDUCTORS



QUAD TIMER CIRCUITS. XR-558 and -559 are direct pin-for-pin replacements for the NE-558/NE-559 family of quad timers.

Both monolithic chips contain four separate timer sections, each of which produces independent time delays ranging from microseconds to several minutes, depending on the external RC-network settings.

Each timer section has separate output, timing and trigger controls; all sections share a reset control. Because both XR-558 and -559 are edge-triggered devices, the timers can be cascaded to other sections without using coupling capacitors.

The XR-558 furnishes open-collector outputs, each of which can sink up to 100 mA of load current; the -559 has emitter-follower outputs that can source up to 100 mA each. The outputs, normally LOW, go HIGH during the timing interval.

Both chips come in 16-pin plastic or ceramic DIPs and operate over either a military (−55 to +125°C) or industrial (0 to 75°C) temperature range. XR-558CP or -559CP (industrial version, plastic package), $1.42 (100). **Exar Integrated Systems Inc,** Box 62229, Sunnyvale, CA 94088. Phone (408) 732-7970.

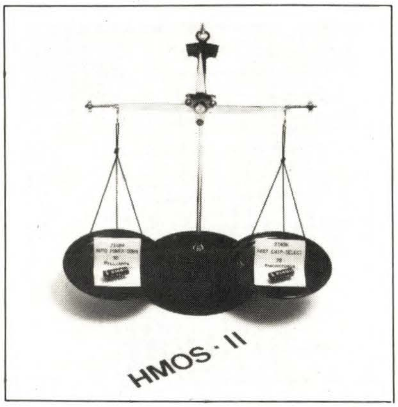
Circle No 211

BIPOLAR TRANSISTOR. An npn silicon device, HXTR-4101 provides predictable and consistent results in fixed-frequency oscillator applications. Oscillator output power in a fixed-tuned oscillator is guaranteed at 19.0 dBm min and typically equals >20 dBm at 4.3 GHz. For higher frequency applications, output specs at 17 dBm (typ) at 6 GHz and 12 dBm at 8 GHz. Recommended maximum continuous operating conditions include V_{CBO} of 25V, V_{CEO} of 16V, I_C of 35 mA and P_T of 450 mW. The unit comes in a rugged metal/ceramic hermetic package and is capable of meeting MIL-S-19500 and MIL-STD-750/833. $28.50 (100). **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 856-1501.

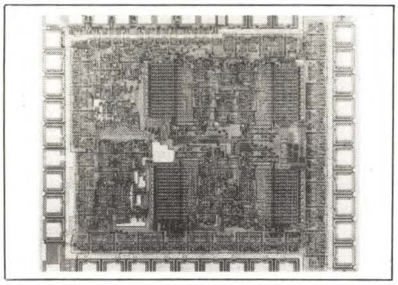
Circle No 212

STATIC RAMs. Models 2148H and 2149H high-speed HMOS-II units feature 1024-words×4-bit organization, require 180 mA (max) operating current, are fully TTL compatible and require only one 5V±10% power supply. The 55-nsec-access-time 2148H has a power-down feature, initiated by chip select, that automatically places the device into a low-power standby mode requiring 30 mA per chip. The non-power-down 45- or 55-nsec-access-time 2149H provides faster chip-select access times, to 20 nsec. Both 18-pin hermetic Cerdip

New Products



devices are pin compatible with the 2148 and 2114A and have common data input and output pins and 3-state outputs. 2148H-3 or 2149H-3 (55-nsec versions), $40.80 (100). **Intel Corp,** 3065 Bowers Ave, Santa Clara, CA 95051. Phone (408) 987-8080. **Circle No 213**



VAC-FLUO DRIVER. A single-chip interface decoder/driver between digital logic or µPs and nonmultiplexed 7-segment vacuum-fluorescent displays, the monolithic CMOS ICM7235 comes with multiplexed BCD input or a high-speed processor interface. It is also available in hex (0-9, A-F) or Code B (0-9, dash, E, H, L, P) output versions. The unit provides 28 high-voltage open-drain p-channel transistor outputs organized as four 7-segment digits, thus permitting the elimination of up to six TTL or CMOS ICs required with conventional VF display-driver circuits. Inputs provide display blanking and protection against static discharge and all versions feature brightness control. $3.75 (100) in plastic 40-pin DIP. **Intersil Inc,** 10710 N Tantau Ave, Cupertino, CA 95014. Phone (408) 996-5100. **Circle No 214**

HOCKEY-PUCK DIODES. For ac or dc motor-control, air-conditioning-system, machine-tool and UPS-system applications, D1400 and -800 Series devices have 1-cycle nonrepetitive-surge-current ratings of 34,000A and voltage ranges of

2000 to 3200V. Model D1400 is rated at 3500A rms and 2250A avg at $T_C=45°C$, while D1800 specs at 4000A rms and 1800A avg at $T_C=100°C$. Thermal resistance equals <0.0212 and 0.016°C/W, respectively. $225. **AEG-Telefunken Corp,** Box 3800, Somerville, NJ 08876. Phone (201) 722-9800. **Circle No 215**

4k STATIC RAMS. MSM5104-2/3 and MSM5115-2/3 CMOS devices are organized as 4096 words×1 bit and 1024 words×4 bits, respectively. Standby power is <200 mW, and operating power equals <33 mW per MHz. Maximum access time specs at 200 nsec in -2 versions and 300 nsec in -3 versions. Both units operate from one 4 to 6V power supply and sport on-chip address/data registers. The MSM5104 is pin compatible with the Mostek 4104 and interchangeable with the Harris 6504; the MSM5115 is similarily pin compatible and interchangeable with the Intel 2114 and the Harris 6514. $20.70 for -2 version of MSM5104 or -5115 in 18-pin ceramic or plastic; $19.20 for -3 versions (100). **OKI Semiconductor,** 1333 Lawrence Expressway, Santa Clara, CA 95051. Phone (408) 984-4840. **Circle No 216**

500V DARLINGTONS. These fast-switching, high-power devices are rated at 15A (Series 6000) and 20A (Series 6060), have a 500V sustaining operating range and come in TO-3 packages employing a gold-silicon die eutectically bonded to a molybdenum pedestal. An internal diode provides rapid device turn-off. Specs include total power dissipation of 125W at 25°C T_c, thermal resistance of 1°C/W (junction to case), rise time of 0.4 µsec, fall time of 1 µsec and storage time of 2.5 µsec. The units suit switching-power-supply, regulator, inverter and PWM applications. From $4.75 (1k) for 20A, 300V PTC 6060. **Power Transistor Co,** 800 W Carson St, Torrance, CA 90502. Phone (213) 320-1190. **Circle No 217**

Total sealing

Each Grayhill SPST Rocker DIP Switch is now potted as part of the assembly process, to provide a more professional and economical bottom seal, with maximum seal integrity. Flux entry during wave soldering is totally prevented; contamination is eliminated; reliability is enhanced; and prices are unchanged . . . there is no cost premium for this important new feature. Grayhill also offers 3 topside sealing options, for raised or recessed rockers—a tape seal, applied at Grayhill; cards of tape seals, for your application; or re-usable protective covers. Whichever you choose, you get complete freedom during PC Board cleaning.

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All Grayhill DIP Switches incorporate our exclusive spring-loaded, sliding ball contact system. This highly reliable contact system provides positive wiping action, immunity to normal shock and vibration, and exceptional 50,000 cycle life.

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Grayhill Sealed Base Rocker DIP Switches are available SPST, from 2 to 10 rockers, with raised or recessed rockers. Grayhill also provides the Piano DIP™ SPST side-actuated DIP Switch, sealed; the Toggle-DIP (SPDT or DPDT) for front panels, plus SPDT or DPDT back panel programming DIP Switches.

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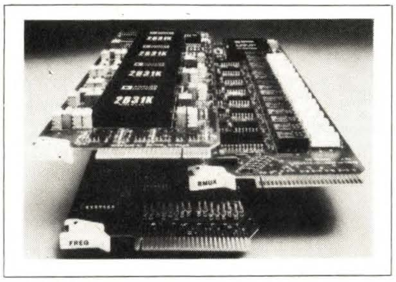
New Products

COMPUTER-SYSTEM SUBASSEMBLIES

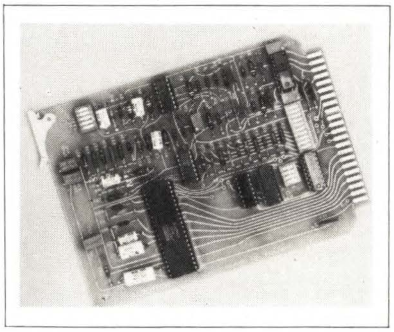


INTERFACE CARDS. The AIM04 16-channel flying-capacitor multiplexer board with programmable gain amplifier, the AIM05 4-channel strain-gauge board and the FIN01 and -02 8- and 16-channel frequency-counter cards suit the manufacturer's Macsym 2 and Macsym 20 measurement and control systems.

The AIM04 uses reed relays to make differential measurements in the presence of common-mode voltages up to 250V rms. Its 16 differential channels can be sampled at a 130-sample/sec rate and provide ±0.01% linearity. Software-programmable gains of 1, 16 or 256 permit use with low-level to ±10V signals.

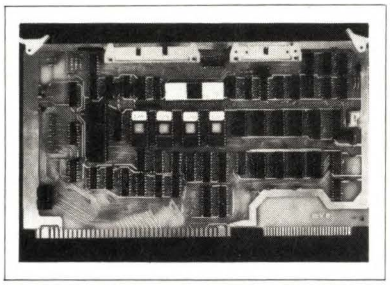
Providing bridge-completion and calibration resistors, excitation supply and DIP-switch-selectable gains of 1 or 128 for each channel, AIM05 also allows DIP-switch selection of 5 or 10V excitation voltages.

FIN01 and -02 measure frequencies from 1.6 Hz to 1 MHz with 0.1% resolution and feature Schmitt-trigger circuitry with four user-selectable hysteresis levels. AIM04, $800; AIM05, $700; FIN01, $450; FIN02, $650. **Analog Devices Inc,** Box 280, Norwood, MA 02062. Phone (617) 329-4700.
Circle No 166



SIGNAL CONDITIONER / ADC. P/N 50048 provides a direct multichannel signal-card interface between a plug-in strain-gauge transducer and a μC. Ratiometric operation minimizes transducer excitation-supply stability requirements; convert and 3-state output-to-bus commands are both addressable. Other features include 0.025% resolution of 2 mV/V transducer signals and ±5V dc operation. $425. **Acrotech,** 1160 E Ash Ave, Fullerton, CA 92631. Phone (714) 879-8470. **Circle No 167**

PRINTER INTERFACES. These PDP-11 (Model 1024) and LSI-11 (Model 1025) bus-compatible interfaces for the Xerox 6500 color graphics printer enable the color copier and DEC computer to replace older color-reproduction technologies, such as multipen plotters and electrostatic printers. The dual-width interface boards allow the computers to generate full-color 13.75×6.4-in. (max) images with 100-points/in. resolution. $4500 for either model. Delivery, 60 days ARO. **Metacomp Inc,** 7290 Engineer Rd, Suite F, San Diego, CA 92111. Phone (714) 278-0635. **Circle No 168**



FLOPPY-DISC CONTROLLER. Providing all control functions required for formatting, sector read/write, drive select and head positioning for one to eight Shugart-compatible single- or double-density drives, Multibus-compatible FDC 100 M also reads and writes IBM-compatible diskettes. Utilizing LSI devices and an 8085 μP, the controller can easily be programmed for customizing and changing its primary functions. Features include IBM 3740 or System/34-compatible format, variable sector length, 4k RAM buffering, 8k of PROM and eight bidirectional data lines. From $935. **PRT Inc,** 504 Vandell Way, Campbell, CA 95008. Phone (408) 378-5610. **Circle No 169**

15-BIT DAC. M-DAC-15 is a 4-quadrant multiplying unit that provides 10-μsec analog settling time and 5-μsec digital settling time to 0.01%. Feedthrough capacitance is 5 pF typ, and dc accuracy equals ±0.0031% of full scale. $393 (10) for the 2.625×3.125×0.42-in. 5-oz unit. **Intech,** 282 Brokaw Rd, Santa Clara, CA 95050. Phone (408) 244-0500.
Circle No 170

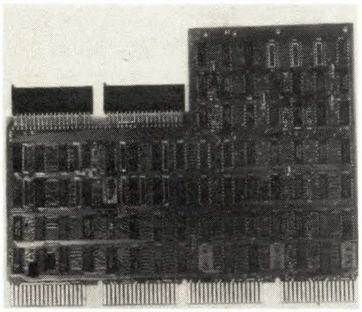
COMPUTERS & PERIPHERALS

MATRIX PRINTER. A lower speed (and less expensive) version of the manufacturer's Model M-200, Model M-120 uses a 7-wire head to print a 7×7 half-dot-matrix font in standard or expanded characters. Features include 180-cps bidirectional logic-seeking operation, throughput rates ranging from 75 lpm for full 132-character lines to 200 lpm for 40-character lines (average throughput is 120 lpm) and built-in self-test feature. An optional LED diagnostic display shows the cycle the printer is in when it goes off line, allowing operator-correctable conditions to be handled without a service call. 8080-μP controlled, the unit handles proportional spacing when operating with user-developed software. From $1350 (OEM qty). **Dataproducts Corp,** 6200 Canoga Ave, Woodland Hills, CA 91365. Phone (213) 887-8451. **Circle No 171**

S-100 SPEECH CODEC. The Articulator S-100 circuit card and software package enable users to encode, store and play back spoken words and messages. Selectable data rates of 1k to 2k bytes/sec tailor memory consumption to the speech quality required by an application. Audio input can come from an inexpensive dynamic microphone; audio output is a standard 1V rms, and the board operates in status or interrupt mode. $289. **Quintrex Inc,** 9185 Bond, Overland Park, KS 66214. Phone (913) 888-3353. **Circle No 172**

LONG-LIFE RIBBON. Serving the company's 700 Series of impact dot-matrix printers, 7-Meg cassette prints 7 to 10 million characters before it requires replacement. Enclosed in a plastic cover, the unit provides a small opening where the printer head hits the ribbon and can be snapped over the head in a few seconds. Approximately $18. **Centronics Data Computer Corp,** Hudson, NH 03051. Phone (603) 883-0111. **Circle No 173**

New Products



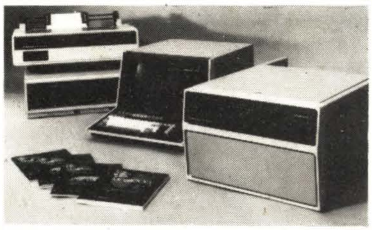
BUS CONVERTER. Qniverter dual-purpose unit permits a PDP-11 Unibus system to access LSI-11-compatible controllers and memories; it also allows LSI-11, LSI-11/2, LSI-11/23, PDP-11/03 or PDP-11/23 systems to access Unibus-compatible controllers and memories. Supporting many features of the LSI-11/23, including 4-level interrupt structure, memory parity and full 256k-byte addressing, the board installs into a quad slot of the LSI-11 backplane and is software transparent to the host computer. From $750. **Able Computer,** 1751 Langley Ave, Irvine, CA. 92664 Phone (714) 979-7030. **Circle No 174**

DOS DEVELOPMENT SYSTEM. The CDP18S007 CDOS development system operates at a 2.5-MHz clock rate, 25% faster than its CDP18S005 predecessor. The unit provides 28k bytes of user-accessible RAM and a dual-drive floppy-disc system; additional available software includes an editor and a Level II macroassembler. Because the system references files by name rather than by track number, rapid access to them is provided without concern about file size or disc space allocations. Binary files can also be loaded. $9500. **RCA Solid State Div,** Box 3200, Somerville, NJ 08876. Phone (201) 685-6423. **Circle No 175**

SOFTWARE DEBUGGER. APPLEBUG is a programming aid that assists in developing, debugging and testing machine-language code on Apple II computers. Operating as a stand-alone debug package or in conjunction with the company's 6-character label editor assembler, the package furnishes three operational modes: Step mode single-steps through a program and displays executed instructions, Trace mode monitors program exeuction and Run mode runs a program with no instructions or registers displayed. $29.95 on diskette. **Microproducts,** 2107 Artesia Blvd, Redondo Beach, CA 90278. Phone (213) 374-1673. **Circle No 176**

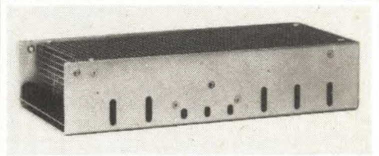
SPOOLING SOFTWARE. Requiring a 2-disc 32k- or 48k-byte system to support its 3k assembler program, LPSPOOL line-printer spooling facility for the TRS-80 Model I permits concurrent printing in the foreground while normal TRSDOS operation continues in the background; a multitasking monitor allows switching between foreground and background processes. The despooler accesses spool files through a queue generated by a utility program or automatically by the spooler. Separate spool and despool queues are maintained by the system. $39.95 for 32k or 48k versions on diskette, queue maintenance utility, demonstration program and users manual. **Automated Resource Management Inc,** Box 4353, Irvine, CA 92716. Phone (714) 963-2975. **Circle No 177**

INSTRUMENTATION & POWER SOURCES



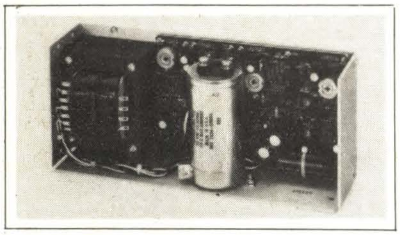
µC DEVELOPMENT SYSTEM. For the design of µCs based on the MC68000, Exormacs supports the MC68000's 16-bit capability and anticipates the requirements of next-generation 32-bit machines. The system comprises a µC chassis, an intelligent CRT terminal, a 132-column printer and a 1M-byte dual-floppy-disc mechanism. An advanced operating system, symbolic Debug assembler/editor and PASCAL compiler constitute the software complement.

Exormacs follows the M6800 Exerciser building-block design. The basic chassis houses a switching power supply, cooling fans and front-panel controls. An internal card cage accommodates up to 15 modules, four of which are included in the basic system. The remaining slots offer expansion potential through the use of separately available and compatible Versabus modules. Resident modules include the MPU (containing the MC68000 MPU chip), the Debug, the intelligent-floppy-disc-controller and the dynamic memory modules. $28,775. Delivery, 6 to 9 months ARO. **Motorola Semiconductor Products Inc,** Box 20912, Phoenix AZ 85036. Phone (602) 962-3127. **Circle No 204**



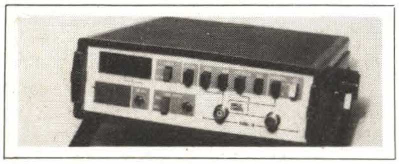
175W SWITCHERS. 63 open- and closed-frame models make up the SQ175 Series, which offers nominal efficiencies of 70%. Each model's main output provides 5V at 20A while three regulated auxiliary outputs deliver 5 to 28V with current ratings to 5A. Features include 117 to 234V ac input, 20-msec line-loss holdup, input surge current limiting and differential and common-mode EMI suppression. Line and load regulation spec at 0.1%. Ripple and noise is 50 mV p-p for outputs <15V and 100 mV p-p for outputs >15V. $329 in sample quantities. Delivery, 10 to 12 wks ARO. **Deltron Inc,** Wissahickon Ave, North Wales, PA 19454. Phone (215) 699-9261. **Circle No 205**

DIGITAL IR RADIOMETER. By measuring heat loss directly in Btu/ft²-hr, ThermoFlow senses insulation defects in pipes, vessels, furnace walls and high-voltage electrical connectors. Pointing the unit at surveyed equipment thus provides immediate, quantitative information for energy surveys. Features include digital display, internal calibration, no moving parts and sensitivity and stability to within 0.1°F. $950. **Linear Laboratories,** 475 S San Antonio Rd, Los Altos, CA 94022. Phone (415) 941-4996. **Circle No 206**



DISC POWER SUPPLY. Model CP384 provides multiple dc outputs for Winchester technology fixed-disc memory systems. The unit can power most currently available Winchesters, including Shugart SA1000 and SA4000 Series, Century Marksman and Micropolis Microdisk 1200 Series drives as well as required controller circuitry. The unit supplies +5V at 9A, +24V at 4.5A pk and −12V at 0.8A and offers protection against short circuits and overloads. $120. **Power-One Inc,** Power One Dr, Camarillo, CA 93010. Phone (805) 484-2806. **Circle No 207**

BREAKOUT PANEL. Designed to monitor and break out a Bell 303 type current interface between a modem and a terminal, Model 70 allows access to all 14 signal conductors specified for the Bell 303 high-speed coaxial connector. Current conductors are monitored by series current sensors driving LED indicators; the two RS-232 signals are monitored by high-impedance voltage-sensing circuits with LED indicators. The battery-powered hand-held unit features 14 switches, permitting interface signals to be interrupted for testing and monitoring. $1265. **International Data Sciences Inc,** 7 Wellington Rd, Lincoln, RI 02865. Phone (401) 333-6200. **Circle No 208**



FIBER-OPTICS METER. The portable Model UDT-S550 power unit measures fiber-cable transmission parameters, connector/splice loss, light-source intensity, cable or fiber outputs and receiver efficiency. The dual-head optical instrument offers a measurement range of 250 to 2000 nm. Features include direct readout in dBmW or dBμW, absolute or ratio measurements, autoranging, selectable resolution of 0.1 or 0.01 dB and analog and digital outputs. A Cal Adjust feature permits direct readouts at wavelengths other than the factory-calibrated standard. $650. **United Detector Technology,** 3939 Landmark St, Culver City, CA 90230. Phone (213) 204-2250. **Circle No 209**

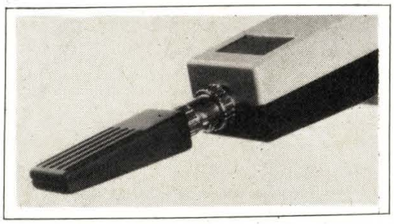
HEAT-FLOW PROBES. Measurement of heat flux (in Btu/ft²-hr) with Models HFP-10 and -20 aids thermal-conductivity studies of insulation and other materials. A 4-position range switch allows heat-flux measurements from 1 to 2000 Btu/ft²-hr (HFP-20) and 0.5 to 1000 Btu/ft²-hr (HFP-10). Self-contained portable heat-flow probes facilitate operation. HFP-20, $365; HFP-10, $420. Delivery, stock to 6 wks ARO. **Concept Engineering,** 43 Ragged Rock Rd, Old Saybrook, CT 06475. Phone (203) 388-5566. **Circle No 210**

New Products

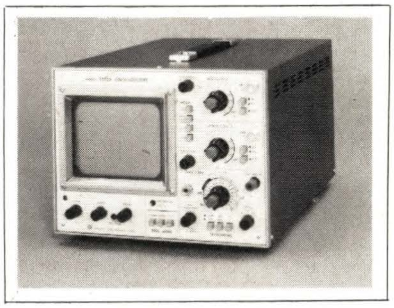
WHEATSTONE BRIDGE. Model 140.-100's Wheatstone and Kohlrausch modes provide solid and liquid resistance measurements. Designed for constant sensitivity on all ranges, the instrument employs the slide-wire-bridge principle and features a 200-mm potentiometer dial and a taut-band suspension galvanometer. A logarithmic amplifier protects the galvanometer from overload and provides maximum sensitivity near zero. The Wheatstone bridge's test range extends from 0.05Ω to 10.5 MΩ; the Kohlrausch bridge's, from 0.05Ω to 1.05 MΩ. Sensitivity equals 1 mm for 1% of measured resistance with an accuracy of 1% of reading ±3 mΩ from 0.1Ω to 10 MΩ. $405. **AEMC Corp,** 729 Boylston St, Boston, MA 02116. Phone (617) 266-8506. **Circle No 224**

HYSTERESIGRAPH. Capable of plotting the hysteresis curve of hard or soft magnetic materials at the touch of a button, Model 5200 consists of a programmable dc power supply, a digitally controlled programmer, a field meter and an electronic integrating fluxmeter. The power supply can drive loads such as toroids, Epstein frames and electromagnets. The recorder pen's horizontal motion can be reversed at will to facilitate drawing minor loops or recoil slopes. $11,500. Delivery, 6 to 8 wks ARO. **LDJ Electronics Inc,** 1064 Naughton, Troy, MI 48084. Phone (313) 689-3623. **Circle No 225**

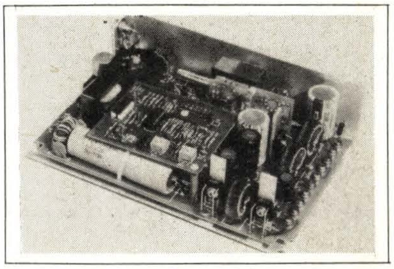
RECORDER/REPRODUCER. The Store 7DS offers direct or FM operation on an individual-channel basis (to seven channels) by insertion of the proper plug-in module. FM operation can be either intermediate or wideband Group I. The unit features tape-speed accuracy of ±0.2% over the operating range of 0 to 50°C through the use of servo-controlled reel motors, and single-switch selection of seven operating speeds from 15/16 to 60 ips. $11,245 for basic unit; $465 for each plug-in module. **Racal Recorders Inc,** 5 Research Pl, Rockville, MD 20850. Phone (301) 948-3085. **Circle No 226**



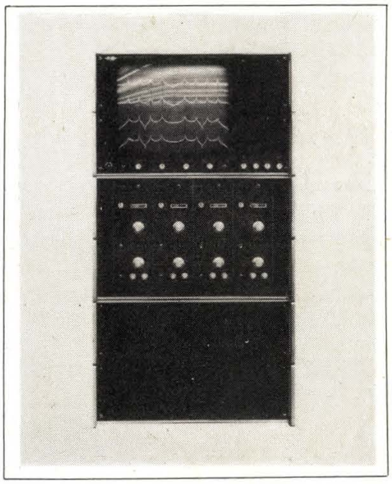
HUMIDITY/TEMP METER. The direct-reading, hand-held Model KM5001 reads relative humidity to within ±2% and temperature to within ±0.5°C. The unit weighs less than 9 oz including its internal NiCd batteries and features switch-selectable relative-humidity measurements from 0 to 100% with 0.1% resolution or temperature measurements from −9.9 to +95°C with 0.1°C resolution. The device requires no interpolation, charts or water reservoirs. **Electric Tachometer Corp,** 6749 Upland St, Philadelphia, PA 19142. Phone (215) 726-7723. **Circle No 227**



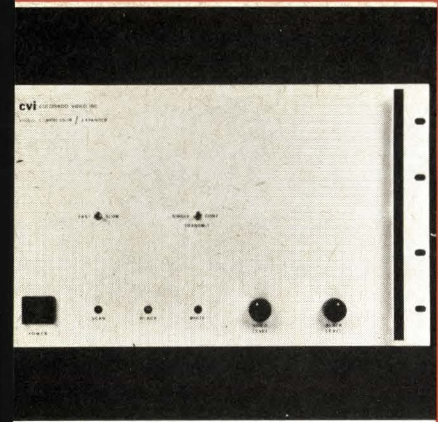
PORTABLE SCOPE. A list price claimed 20% less than that of comparable equipment highlights the 15-MHz, dual-channel Model 5512A. It features sensitivity of 5 mV/div to 10V/div in 11 steps with Channel 1, Channel 2, chop and alternate modes. Normal, auto and TV triggering modes operate from internal or external sources. Horizontal sweep times range from 0.5 μsec/div to 0.5 sec/div in 19 steps. The scope offers a 1-MHz bandwidth in the X-Y mode and a Z-axis (intensity modulation) input level of more than ±3V p-p to 5 MHz. $795. **Kikusui International Corp,** 17721 S Central Ave, Carson, CA 90746. Phone (213) 638-6107. **Circle No 228**

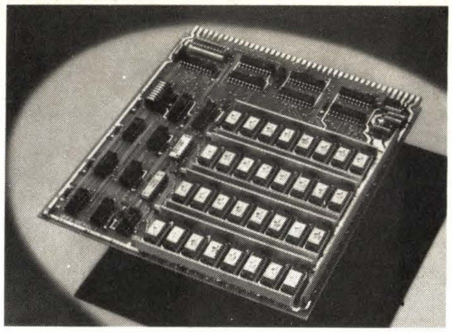


200W SWITCHER. Featuring a monolithic chip for improved MTBF, Model ESM-200 sports a 2-yr warranty. The standard unit has one 5V and two 12 or 15V regulated outputs (0.2% line, ±0.2% load), plus semiregulated 5V and 24V (±5%) outputs. Special units can provide 5 to 28V for each regulated output and 5 to 50V for the two semiregulated ones. Noise and ripple is 50 mV p-p on the regulated, 150 mV p-p on the semiregulated outputs. The 2.75×6.19×9.22-in. unit operates on 85 to 132V or 170 to 264V (47 to 63 Hz). $319. **Power/Mate Corp,** 514 S River St, Hackensack, NJ 07601. Phone (201) 440-3100. **Circle No 229**



FFT SYSTEM. Simultaneous processing and display of four channels enhances analysis of 0.01-Hz to 100-kHz signals with Model 5004-4. Features include a real-time analysis rate of 16.7 kHz, 65-dB dynamic range, selectable resolution from 0.01 to 125 Hz and digital zoom translation. Each channel allows independent control and averaging on a linear, exponential or peak basis. The 12-in.-diagonal CRT screen displays real-time or averaged data. A cursor provides frequency and amplitude readings of any selected spectrum point. $48,500. **Spectral Dynamics,** Box 671, San Diego, CA 92112. Phone (714) 268-7200. **Circle No 230**





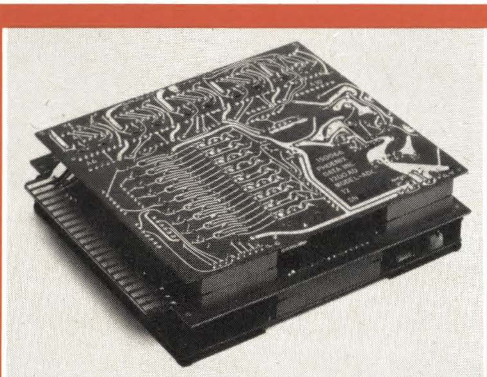
Literature

Testing and servicing μP-based systems

The "Guide to Testing Microprocessor Based Systems And Boards" describes the use of in-circuit-emulation, signature-analysis and time-domain-analysis techniques for testing and diagnosing. Sections of the 19-pg brochure cover problems caused by the μP, traditional approaches to testing, in-circuit emulation as a test stimulus, RAM- and ROM-module testing and the synergy of testing made easy with in-circuit emulation and signature analysis. The treatment ends with an application of the techniques and a glossary of terms. **Millennium Systems,** 19050 Pruneridge Ave, Cupertino, CA 95014. **Circle No 218**

Designer's guide to data conversion

A 32-pg handbook outlines procedures for determining parameter tradeoffs relative to resolution, accuracy, linearity, offset and temperature coefficient and tells how these parameters affect high-resolution, high-speed A/D and D/A signal translation. It discusses theory and practice and includes selection guides for A/D and D/A converters, sample/hold circuits and ancilliary devices. Other sections detail power supplies and A/D-subsystem modules. **Analogic Corp,** Audubon Rd, Wakefield, MA 01880. **Circle No 219**



Literature

Power-supply selection guide

A full-line catalog contains information on power supplies providing outputs from 1 to 200V and up to 60A. It describes miniaturized power modules (in both pc-board and chassis-mounting versions), in addition to plug-in, premium-performance, general-purpose, narrow-profile, programmable and unregulated supplies. For applications where highest reliability is expected, the 52-pg brochure details a redundant-output power system. A selection guide pictures all items, lists electrical and mechanical specs and furnishes outline drawings for all models. **Acopian Corp,** Easton, PA 18042. **Circle No 221**

Test chamber for precise temp control

Bulletin #101N describes the TH Jr temperature and humidity environmental test chamber. This 2-pg leaflet outlines the unit's engineering and construction features, and provides complete data on performance and optional accessories. **Tenney Engineering Inc,** 1090 Springfield Rd, Union, NJ 07083.

Circle No 222

Replacement of defective capacitors

"Servicing And Replacing AC Motor Starting And Running Capacitors" gives a complete analysis of failure modes, capacitor design and reliability and test procedures. The 12 pages are illustrated with photos, wiring diagrams, line drawings and tables. Along with application information, the booklet includes a guide for replacing capacitors with unknown ratings. **Cornell-Dubilier Electric Co,** 150 Ave L, Newark, NJ 07101. **Circle No 223**

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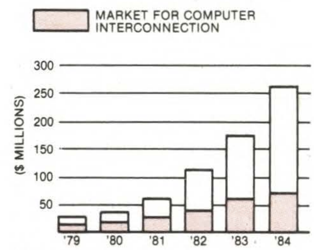
Looking Ahead: Trends and Forecasts

Fiber-optics use grows in computer interconnect

Although the military and telephone industries are today the largest single users of fiber optics in the US, the interconnection of computers, peripherals and sensors will constitute the lion's share of tomorrow's market, predicts Kessler Marketing Intelligence, Newport, RI. Thus, while the total US fiber-optics market will rise from last year's $30 million mark to over $250 million by 1984, computer-interconnection fiber-optic applications will expand from 1979's $13 million level to reach nearly $80 million over the forecast period.

COMPUTER-INTERCONNECT SHARE OF US FIBER-OPTICS MARKET



SOURCE: KESSLER MARKETING INTELLIGENCE

Military applications dominated last year's fiber-optic computer-interconnection market with a $3.6 million share; end users (utilities, transportation and chemical industries, financial systems, earth stations and experimenters) purchased $3.2 million worth of systems. Over the next 5 yrs, however, end users' market share will decline, with the slack taken up by OEM markets (computers, process control and office automation)—a $2.6 million share in 1979.

Growing data-transfer needs and the demand for greater bandwidth-vs-distance capability and improved error rates—areas in which fiber-optic systems excel compared with coaxial and other cables—will help drive the market.

In a related area, the market for fiber-optic connectors will grow tenfold in the 1980s, reaching more than $30 million by the end of the decade, forecasts International Resource Development Inc, Norwalk, CT. Annual growth rates in the early '80s will average more than 30%.

Semi memories: Sales to double by '85

Worldwide shipments of solid-state memory devices by US semiconductor firms will increase from last year's $1.4 billion level to $1.7 billion this year and then more than double to $3.7 billion by 1985, according to Frost & Sullivan Inc, New York City.

Prices per memory bit will continue to decline. MOS dynamic RAMs' price per bit, for example, will drop from 1979's 42-millicent figure to 30 millicents this year and 6 millicents by 1985. At that time, 1k devices are expected to completely disappear; 4k units will wane; 16k RAMs, peak.

SOLID-STATE MEMORY DEVICES
ANNUAL REVENUE GROWTH RATES 1979-1985 (%)

STATIC RAM	
BIPOLAR ECL	19
TTL	6
MOS HIGH SPEED	27
STANDARD SPEED	16
DYNAMIC RAM	16
BIPOLAR PROM	16
BIPOLAR ROM	9
MOS EPROM	18
MOS ROM	18
SERIAL	
CCD	6
BUBBLE	50

SOURCE: FROST & SULLIVAN INC

Other projected trends include a growing market for high-density PROMs and E-PROMs and small or negligible market growth for CCD devices, making the latter's long-term viability doubtful.

14.7% growth seen for electronic detection

The market for electronic monitoring and detection equipment will grow faster than the security-systems market as a whole, expanding at a 14.7% annual rate through 1990. This equipment will often replace higher cost guard services, forecasts Predicasts Inc, Cleveland, OH.

Electronic access control—a deterrent to computer crime, which costs US businesses as much as $40 billion a year—will grow 17% annually, faster than any other security product. And tight control required by facilities such as nuclear power plants will generate additional demand for this type of system.

A proliferation of high-quality, low-cost intrusion and fire-alarm devices from a growing number of manufacturers will propel the fast-growing single-family home-alarm market from 1978's $260 million to $1.5 billion by 1990.

PURCHASED ELECTRONIC SECURITY EQUIPMENT
($ MILLIONS)

	1978	1990	% ANNUAL GROWTH
DETERRENT EQUIPMENT			
ELECTRONIC ACCESS CONTROL	90	600	17.1
SECURITY LIGHTING	285	750	8.4
MONITORING & DETECTION EQUIPMENT	890	4600	14.7
ELECTRONIC ALARM SYSTEMS	260	1450	15.4
MONITORING & SURVEILLANCE EQUIPMENT	530	2800	14.9
CCTV	100	350	11.0

Material for this page developed from *Electronic Business* magazine and other sources by Jesse Victor, Assistant/New Products Editor, and Joan Morrow, Production Editor.