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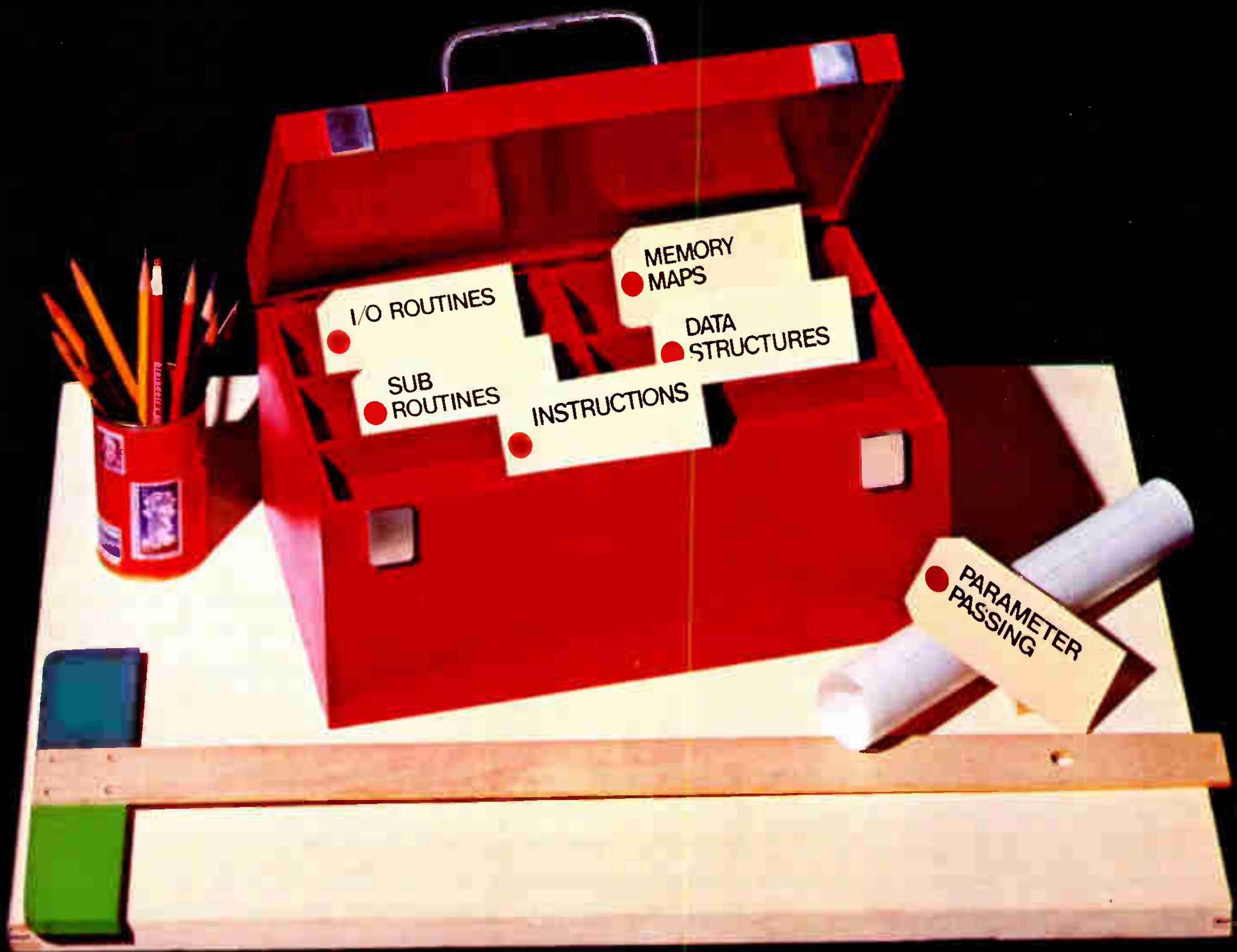

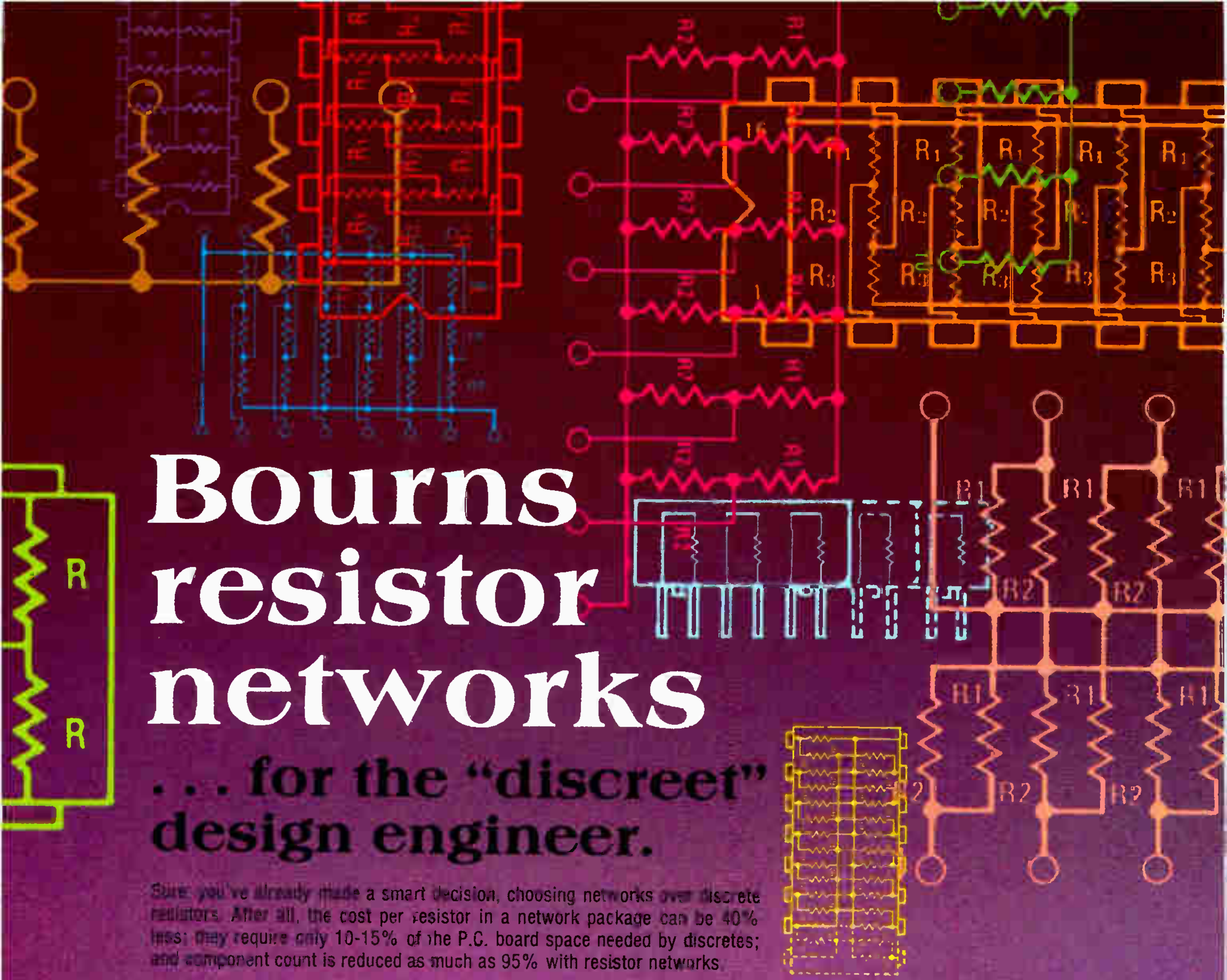

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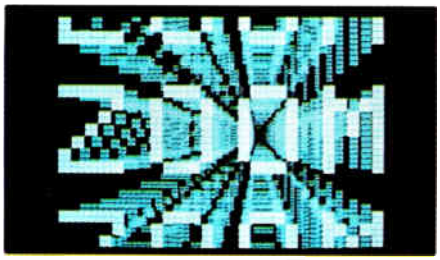
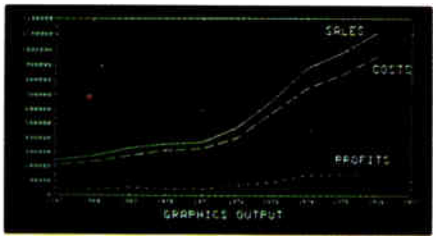
Alpha-graphics: the perfect combination.

It's the Hewlett-Packard 2648A alpha-graphics terminal. For just $5500* it will dazzle you with a



virtuoso display. You'll see zoom and pan, area shading, pattern definition, rubber band line, scientific plotting and graphics text composition. Having independent memories for graphics and alphanumerics, you can do auto-plots with or without words and figures on the screen.

And when you need a smart alphanumeric terminal for on or off-line work, stay right where you are.



How smart is smart?

Ever seen a graphics terminal scroll 200 lines of interactive dialogue? And store up to 220K bytes of data (words and pictures) on twin cartridges? And cut out repetitive routines by storing up to 80 characters on each of eight "soft keys"?

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Circle 1 on reader service card

Electronics

The International Magazine of Electronics Technology

Vol. 51, No. 2 • January 19, 1978

Highlights

Cover: Software design should be systematic, 97
The secret to software development is to see it as another form of system design. Just as with hardware, a step-by-step design approach pays off.

Cover designed by Associate Art Director Charles D. Ciatto and constructed by Bob Strimban.

Mighty fine, say pc-board users, 84
A fine-line printed-circuit process using ultra-thin copper foil is beginning to win fans. Yielding 5-to-10-mil-wide lines, the technique provides twice as much packaging density as conventional boards.

Choosing the right analog I/O board, 113
Deciding which of the many analog input and/or output boards is best for a microcomputer application is as much a matter of its architecture as its specifications. The wrong configuration can complicate system design considerably.

At last: a linear optical coupler, 121
A differential circuit technique applied to an optical coupler enables it to hit a new high in linearity and stability. This approach cancels most of the errors that are caused by the light-emitting diode.

And in the next issue . . .
A microcomputer family grows . . . dynamic RAM design can be painless . . . microcomputers take over input/output duties of minicomputers.

Electronics

Publisher's letter

In this age of the microprocessor, organizing software design has become a part of the electrical engineer's job. But for many, learning how to handle this task has not been easy. William Dalton of Western Electric, who authored the article on this subject on page 97, is actually a software expert with a lot of hardware experience and a specialist in microprocessor technology.

He knows from experience the importance of the interface between hardware and software in microprocessor applications. In fact, at present he works in tandem with an engineer whose background is hardware with lots of software experience. "I think we will see more of this type of organization," Dalton says. "It now takes engineers with software understanding and engineers with hardware understanding to make a system work."

He points out that design techniques have progressed as rapidly in software as in hardware. "We're a long way from the Fortran we learned at school," he remarks. Yet many an engineer has not taken the time to get up to speed in these new techniques. "Today you wouldn't do a software design without an assembler just as you would not do a hardware design without an oscilloscope," he points out.

Another problem, he adds, is that engineering managers have not yet realized the complexities and inherent problems of software design. He suggests that managers need to realize that software design is in many ways more inflexible than hardware design, that decisions once put into a system are as difficult to change or correct as it is to redesign a piece of hardware. "On the surface a change looks easy, but its impact on the total system will catch you every time. Putting data tolerance into software is the most complex design problem imaginable," he concludes.

With all the negative reports about what Japanese imports to the U. S.—from television sets to steel plate—have been doing to the nation's balance of trade and domestic companies, it is interesting to note that there is a bright side emerging. Like the swinging of a pendulum, an economic trend goes to an extreme, then eventually starts to swing back.

Take the Japanese yen as an example. Japan's expansive export efforts have led to trade surplus, and the yen has become so strong that it has put the dollar at a severe disadvantage in international money markets. Indeed, a dollar buys about 20% fewer yen than it did a year ago and makes the whole U. S. economy look a bit pale by comparison with Japan's.

Now the good news. With the yen commanding a premium, Japanese companies have to maintain their profits by raising the prices of their goods by that same 20% on the U. S. market. With the prices of their TV sets going up, then, some of the pressure is off the U. S. manufacturers. For details about this turnaround and about the new threats from such places as Taiwan and Korea, turn to the Probing the News article on page 80.

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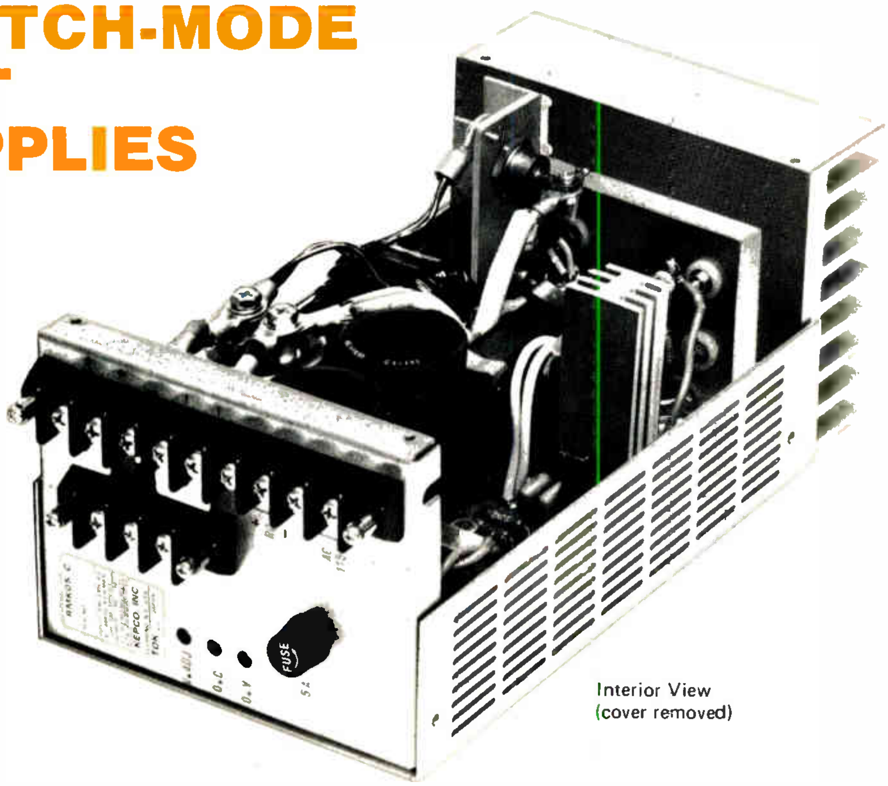
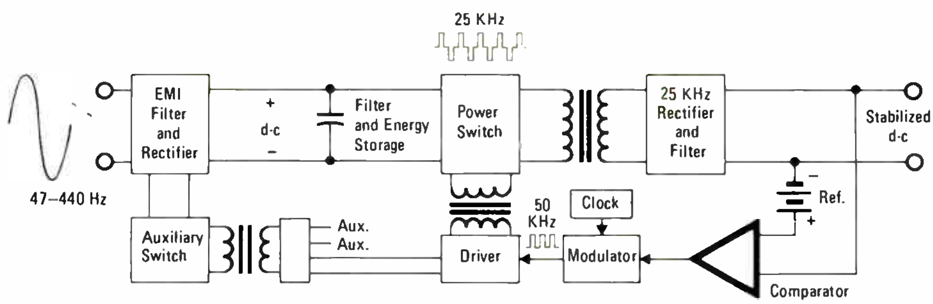


Interior View
(cover removed)

BLOCK DIAGRAM OF THE RMX SWITCH-MODE POWER SUPPLY



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Readers' comments

The U. S. grows big crystals, too

To the Editor: I read with interest the article on crystal-growing technology in Japan in the Nov. 10 issue [Electronics International, "Japanese laboratory is growing 5-in.-diameter ingots"]. Without discrediting the efforts discussed, it should be noted that much larger ingots have been produced in the U. S. in a low partial pressure of argon. Also, the vacuum pump problems have been resolved effectively for some time now.

In terms of ingot size, giant 8-inch-diameter crystals have been reported by Hamco [Rochester, N. Y.], and 6-in.-diameter ingots are produced routinely.

Vacuum pumps required to produce low clean-up pressure but also capable of sustained operation at elevated pressures in the presence of contaminants have been in successful operation for years. These pumps, with the necessary adaptive modifications and auxiliary equipment, are available from Kinney Vacuum Co.

I am certain domestic producers would be happy to sell their advanced equipment to Japan if they could break the tariff barriers.

Z. C. Dobrowolski
Kinney Vacuum Co.
Boston, Mass.

It's a wide, wide world

To the Editor: In your Oct. 27 editorial [p. 24], the issue of proper industrial or academic placement of engineers is once again addressed with the same old misconceptions and the same old conclusions.

Engineering studies at college are far different from actual engineering, a statement to which countless entrants into the field would attest. A college background enables an individual to become an engineer, but he can do other things: sales, small business administration, entrepreneurship—any thing that beckons any liberal arts major.

The learning process at institutions is not exercised solely in direct preparation for a career. Ask any English major.

Stacy V. Holmes
Arlington, Va.

New RCA kit makes it easy . . .

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Here's a microprocessor kit that lets you prove how cost-effective the all-CMOS RCA 1800 system can be.

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To get your kit or more information, contact your local RCA Solid State distributor. Or contact RCA Solid State headquarters in Somerville, NJ; Sunbury-on-Thames, Middlesex, England; Quickborn 2085, W. Germany; Ste.-Anne-de-Bellevue, Quebec, Canada; Sao Paulo, Brazil; Tokyo, Japan.

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Circle 7 on reader service card

News update

■ With Intel Corp.'s 8080A central processing unit becoming the first microprocessor chip and first large-scale integrated part to win approval as a military standard device [*Electronics*, Jan. 5, p. 48], the big push is on to provide military specifications for many other microprocessors, support chips, and memories. The intensive effort is part of a continuing program run by Rome Air Development Center, the U. S. Air Force's semiconductor watchdog, and aimed at ensuring the reliability of microprocessors and other LSI devices expected to find wide use in military systems over the next 10 years [*Electronics*, Oct. 14, 1976, p. 8].

"We will be spending about $1 million during fiscal 1978 for electrical characterization of these parts," says Jerry Hilow, an engineer in RADC's Reliability branch. The next LSI addition to the qualified product list of MIL-specified devices is Motorola Inc.'s 6800 CPU, "expected to be qualified next month," he adds. The same MIL-M-38510 electrical characterization specification developed for the 8080 and 6800, Hilow notes, "is now being generated for the 2901, 9900, and 1802" CPU chips from Advanced Micro Devices Inc., Texas Instruments Inc., and RCA Corp., respectively. If all goes as planned, he adds, the 2901 will be qualified in December and both the 9900 and 1802 will follow a month later.

Support next. Once the specifications for the basic CPU chips are generated, says Hilow, "we will go all out to complete the job by picking up the popular support chips and generating specs for them." RADC already has rough specs for support chips in the 8080, 6800, and 2900 families and, he adds, will soon award a two-year contract worth several hundred thousand dollars to develop electrical characterization specifications for support chips in the 1802 and 9900 series, as well as for newer 8-bit CPU chips such as Intel's 8085 and Zilog Corp.'s Z80. Another two-year award, of comparable value, will ask for like specifications for some of the new single-chip microcomputers. **Bruce LeBoss**

The world's only precision low-power op amps: PMI's OP-08 and OP-12.

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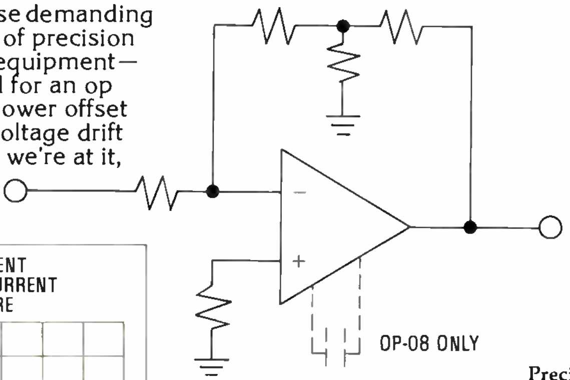

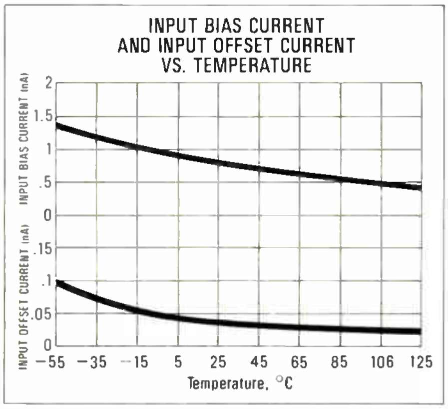

PMI's new OP-08's and OP-12's are the **only** precision, low-power, low-input-current op amps on the market. They are pin-for-pin replacements for 108A's and 308A's in all applications to give you even better performance. Here are the key specs:

Offset voltage of the OP-08 and OP-12 is three times lower than the LM108A. Voltage drift is two times lower. CMRR and PSRR are at precision levels.

And for battery and solar-powered systems, **the OP-08 and its internally-compensated twin, the OP-12,** each drive a 2kohm load—**five times** the output current capability of the 108A and 308A.

How did we come up with the OP-08 and OP-12?

How did we do it? By being fussier. By using our proprietary ion-implantation and zener-zap trimming processes. By careful design: completely balanced input stage and second stage, and proprietary output design to drive a 2Kohm load. By careful fabrication. And by QA like nobody else in the industry.

When you have to go quality and performance all the way, it's good to know that PMI's OP-08 and OP-12 are available—on your distributor's shelf—right now.

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If you'd like to get your hands on an OP-08 or an OP-12, just write us (on your company's letterhead) and we'll send a sample and a data sheet. Be glad to, in fact. After all, when you make the only chip of its kind, it pays to advertise.

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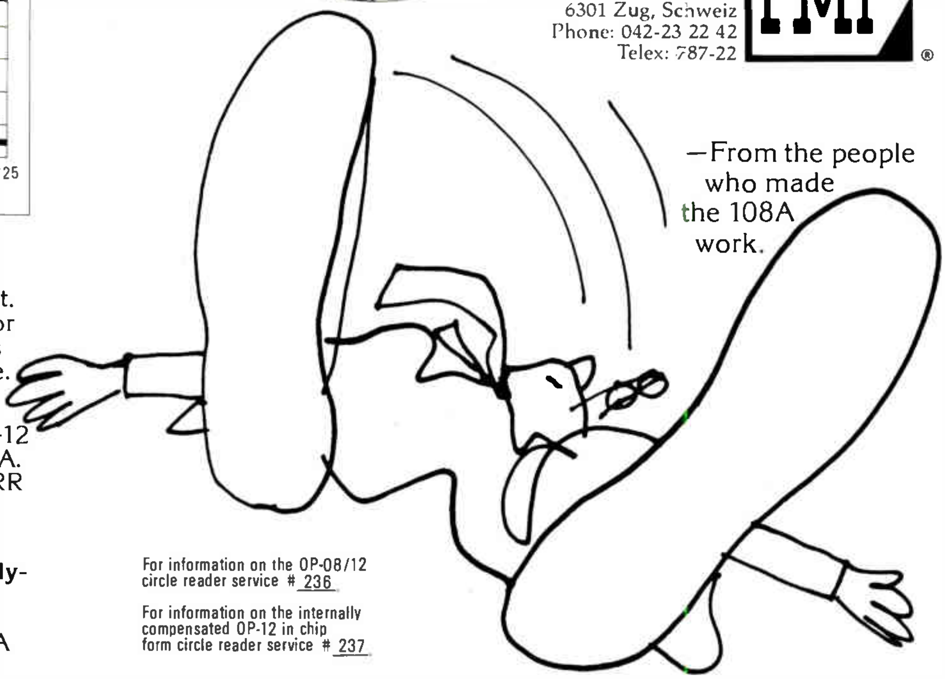


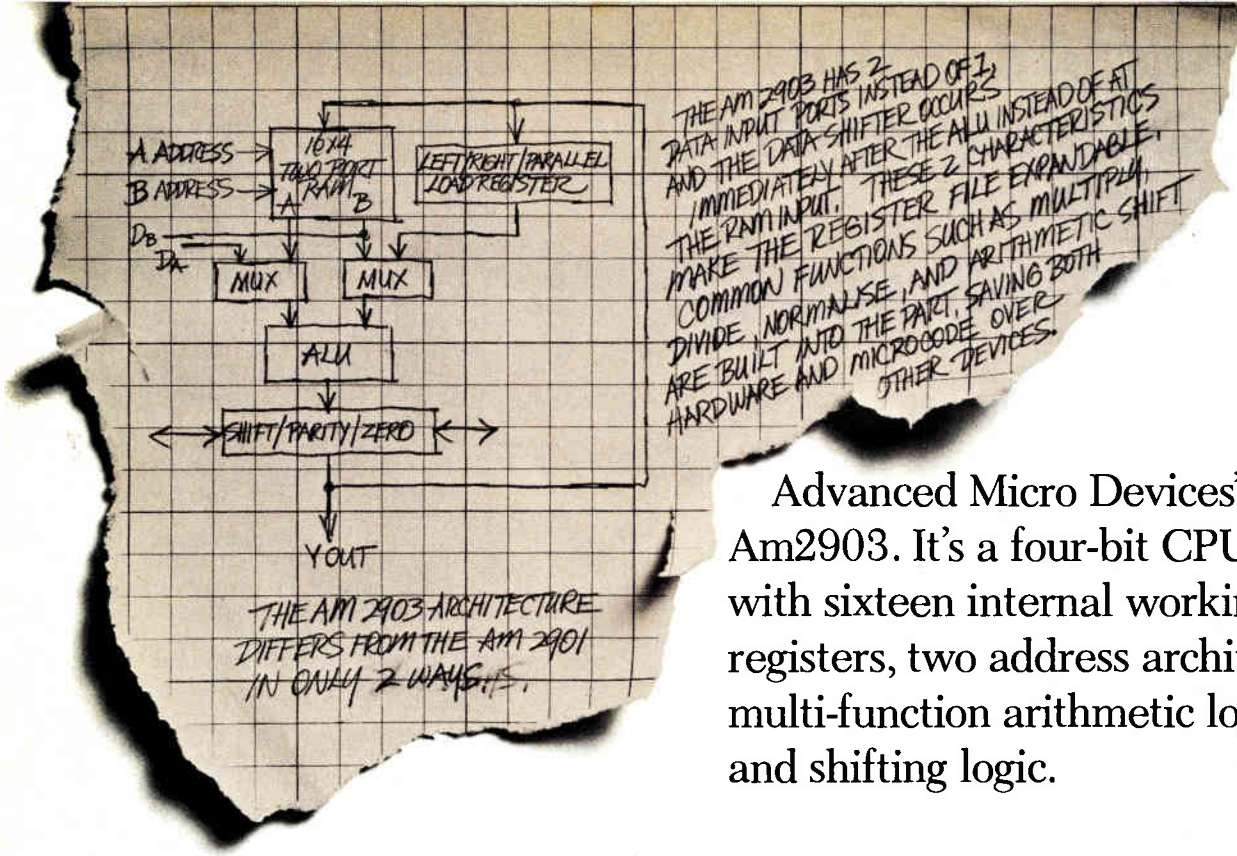
—From the people who made the 108A work.

For information on the OP-08/12 circle reader service # 236

For information on the internally compensated OP-12 in chip form circle reader service # 237

Electrical Characteristics $V_S = \pm 15V$	OP-08A/OP-12A OP-08E/OP-12E			OP-08B/OP-12B OP-08F/OP-12F			OP-08C/OP-12C OP-08G/OP-12G			
Parameter	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Min**	**Typ**	**Max**	**Units**
Input Offset Voltage	–	0.07	0.15	–	0.18	0.30	–	0.25	1.0	mV
Offset Voltage Drift	–	0.5	2.5	–	1.0	3.5	–	1.5	10	μV/°C
Input Offset Current	–	0.05	0.20	–	0.05	0.20*	–	0.08	0.50	nA
Input Bias Current	–	0.80	2.0	–	0.80	2.0*	–	1.0	5.0	nA
Output Voltage Swing $R_L = 2K$	±10	±12	–	±10	±12	–	±10	±12	–	V
Common Mode Rejection Ratio	104	120	–	104*	120	–	84	116	–	dB
Power Supply Rejection Ratio	104	120	–	104*	120	–	84	116	–	dB
Power Consumption	–	9	18	–	9	18	–	12	24	mW

*For OP-08B/08-12B



Advanced Micro Devices' new Am2903. It's a four-bit CPU slice with sixteen internal working registers, two address architecture, multi-function arithmetic logic unit and shifting logic.

AND NOW, THE SUPERSLICE.™

And if that's not enough, hang on.

The Am2903's register file is expandable. If sixteen registers aren't enough, add as many working registers as you want and still retain the two-address architecture.

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R6500 is designed for greater memory and I/O efficiency.

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R6500 memory-managed I/O eliminates performance bottlenecks associated with the separate I/O buses, I/O commands and register overhead required by other microprocessors.

A broad selection of memory, I/O and combination memory-I/O-timer circuits are available. And Rockwell is presently delivering the industry's first fully static 32K ROM—the R2332—and the industry's fastest 32K ROM—the R2332-3.

SYSTEM 65 gets you started for less.

SYSTEM 65 Microcomputer Development System is efficient and easy-to-use and is equipped with dual mini-floppies. It's priced at only $4800.

ROM-resident SYSTEM 65 firmware features a two-pass assembler, text editor and symbolic debug/monitor package. Current loop, RS-232C, printer and scope sync ports are also provided. The optional USER 65 (User System EvaluatoR) module extends the power of SYSTEM 65 for in-circuit emulation.

Other design support includes KIM-1, TIM, timesharing cross-assembler, complete documentation and extensive applications engineering.

Industry researchers say the multiple-sourced 6500 outshipped the Z-80, 6800 and 8085 during the last quarter of 1977. Benchmark it!

For more information, contact your nearest Rockwell distributor or Rockwell International GmbH, Microelectronic Device Division, Fraunhoferstrasse 11, D-8033 Munchen-Martinsried, Germany. Phone: (089) 859-9575. Or Rockwell International Overseas Corp., Ichiban-cho Central Building, 22-1 Ichiban-cho, Chiyoda-ku, Tokyo 102, Japan. Phone: 265-8808.

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Matsushita Electric Trading Company
71 Kawaramachi 5-chome
Higash.-ku, Osaka 541
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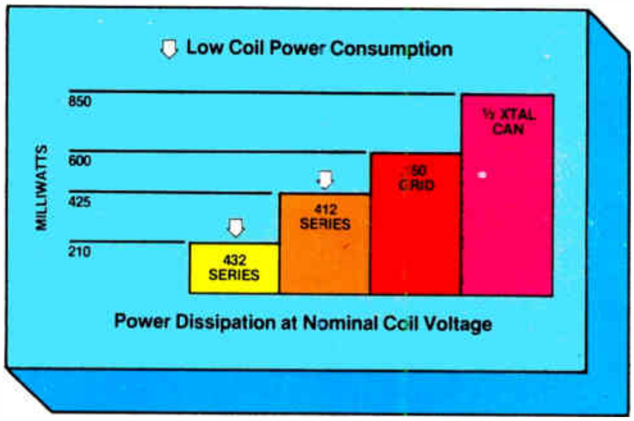
Osaka (06) 204-5563
Telex: J63380

Circle 12 on reader service card

TO-5 RELAY UPDATE:

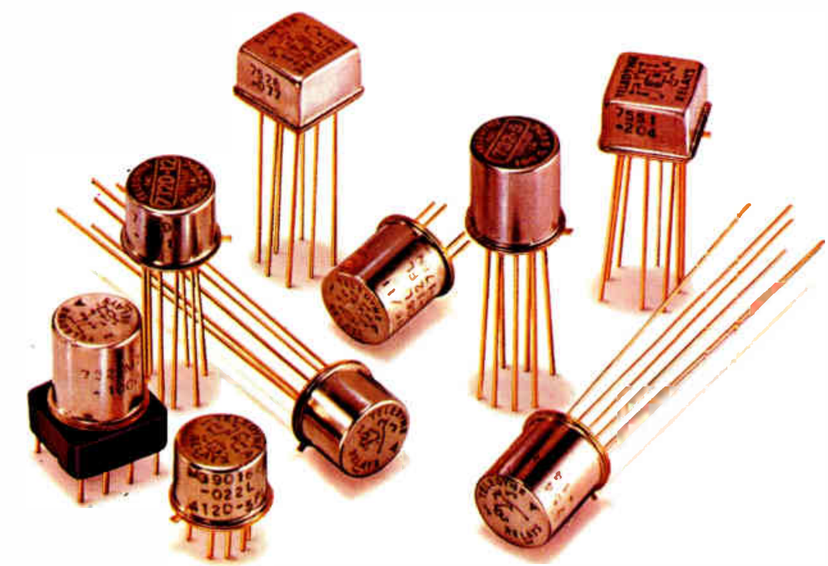
Solve your energy crisis with TO-5 relays



Subminiaturization and pc board compatibility — two obvious advantages of Teledyne TO-5 relays. But there's another outstanding advantage: low coil power consumption. This feature is best illustrated in the above graph which shows our TO-5 relay power savings compared to other miniature relays. The Teledyne 412 Series dissipates about 30% less power than the .150″ grid relay, and 50% less than the ½ crystal can. Our sensitive 432 Series is 65% less than the .150″ grid. And 75% less than the ½ crystal can.

This means you can save over 6 watts in a typical system using, let's say, ten TO-5 relays. In the end, you gain significant advantages in terms of thermal and power supply considerations that can help prevent an "energy crisis" in your system.

Our complete line of TO-5 relays includes military and commercial/industrial types, with virtually all military versions qualified to established reliability MIL specs. For complete data, contact Teledyne Relays — the people who pioneered the TO-5 relay.



- **Hybrid "T" Series**
  SPDT & DPDT types with internal transistor driver and suppression diode
- **"D" and "DD" Series**
  Military and commercial/industrial versions with internal suppression and steering diodes
- **Maglatch Series**
  SPDT, DPDT, and 4PST magnetic latching types
- **Centigrid® Series**
  World's smallest relay — only .225″ (5.72mm) high x .370″ (9.40mm) square
- **Hi-Rel Series**
  Screened versions for space flight applications (NASA qualified)
- **High Environment Series**
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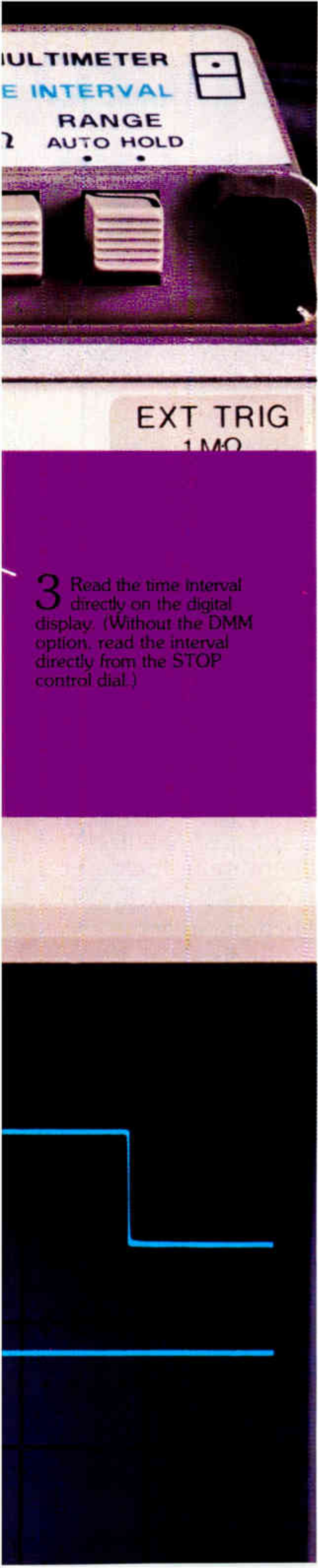


For improved Δ-time measurements, plus autoranging AC/DC volts, amps and ohms ...

HP's the Answer.

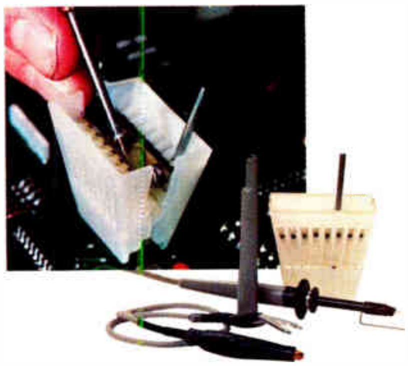
Now you can choose from two new scopes with improved Δ-time capability: The 200 MHz **1715A** priced at $3100* or the 275 MHz **1725A** for $3450*. Both offer an optional built-in DMM for direct Δ-time readout, plus autoranging AC/DC volts, amps, and ohms.

Δ-time measurements are now faster with the 1715A and 1725A. They're more accurate because scope and operator errors are significantly reduced. Plus you have switch selection of channel A or B as the starting point for Δ-time measurements, often eliminating the need to move probes and simplifying trace overlap for zeroing. But you can still select conventional delayed sweep with the flip of a switch, for brighter low-rep-rate traces and convenient trace expansion.

The optional autoranging 3½ digit DMM is priced at $325* factory installed. Or, for easy field installation, there's a kit priced at $375*. Another option, HP's "Gold Button" for $150*, gives you pushbutton selection of either time domain or data domain when the 1715A or 1725A is used with HP's 1607A Logic State Analyzer.

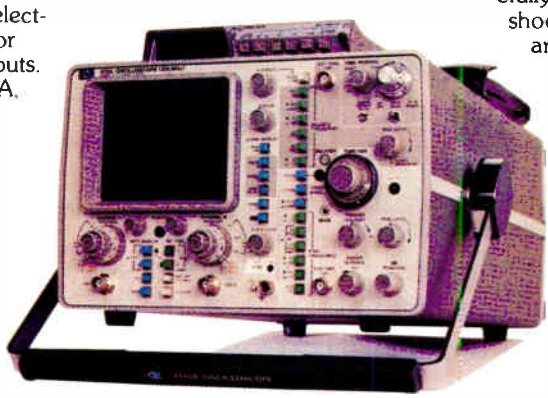
Like all new high-frequency HP scopes, the 1715A and 1725A have switch selectable 50 ohm or 1 Megohm inputs. And the 1725A, with 275 MHz bandwidth, is the fastest 1 Megohm-input scope available. That reduces the need for active probes when working with fast logic near maximum fan-out.

The story with both of these scopes is user convenience—from front-panel controls to the minimum of adjustments for servicing. Your local HP field engineer can give you all the details.



And here's something NEW for scopes. HP's **Easy-IC Probes.** A new idea for probing high-density IC circuits that eliminates shorting hazards, simplifies probe connection to DIPs and generally speeds IC trouble-shooting. The probes are standard equipment with these two scopes.

*Domestic U.S.A. price only.



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Circle 19 on reader service card

Intel delivers the micro components designers

There's no more efficient way to solve your interface and control requirements for microcomputer-based systems than our peripheral components.

They're single-chip solutions to even the most complicated operations, integrating up to 22,000 transistors per chip to replace circuit boards full of discrete logic with a single component. Result: you cut parts cost, reduce package count and board space, and simplify both development and operating software.

"I can accomplish almost any I/O function with one chip using Intel's versatile peripheral interfaces and dedicated device controllers."

We've designed each of these peripheral chips to be an intelligent, programmable component in your system and to perform most functions with minimal cpu supervision. The resulting decrease in cpu overhead provides your system with higher performance and increased throughput.

The dedicated function components below are available now, with more on the way. Here's a brief description of their versatility.

8271 Programmable Floppy Disk Controller. Provides full control of up to four standard or minifloppy drives. (Available early 1978.)

8273 SDLC/HDLC Protocol Controller. For SDLC and HDLC communications.

8275 Programmable CRT Controller. Provides fully buffered interface and control of almost any raster scan CRT display.

8278/8279 Programmable Keyboard/Display Interfaces. Keyboard/sensor array input scan, and output scan for LED, incandescent and other displays. 128-key or 64-key input.

8251A Programmable Communications Interface. Industry standard USART for synchronous or asynchronous serial data transmission, including bisync.

8253 Programmable Interval Timer. Contains three independent 16-bit counters, programmable modes from dc to 2MHz.

8255A Programmable Peripheral Interface. General purpose I/O interface with 24 individually programmable I/O pins.

8257 Programmable DMA Controller. Provides four-channel, high speed direct memory access independent of CPU.

8259 Programmable Interrupt Controller. Handles eight levels of vectored priority interrupt. Expandable to 64 levels.

computer peripheral are talking about.

UPI-41™ is Intel's Universal Peripheral Interface, bringing distributed intelligence to microcomputer systems for the first time.

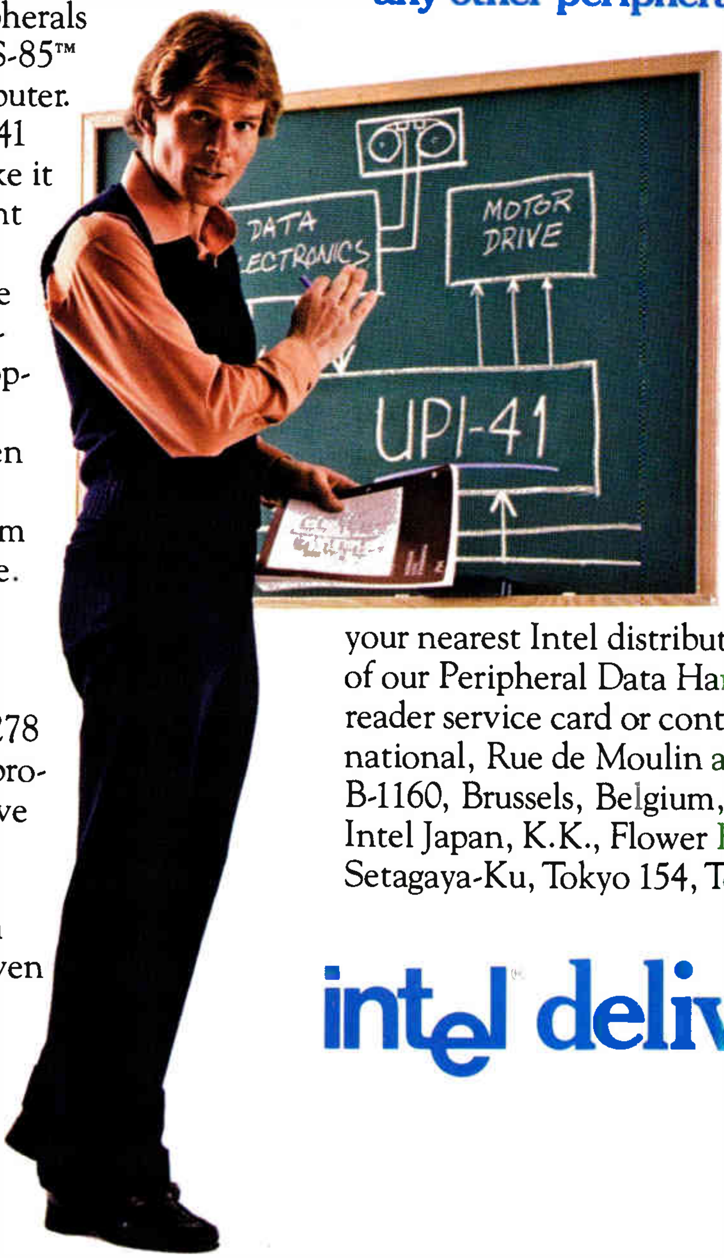
Actually a highly integrated, user-programmable microcomputer, UPI-41 is a new solution that obsoletes custom LSI and specialized discrete designs for interfacing most low and medium speed peripherals with an MCS-80,™ MCS-85™ or MCS-48™ microcomputer.

Intel delivers UPI-41 in two versions that make it easy for you to implement your own designs. The 8741 includes an erasable and reprogrammable 1K-byte EPROM, for development, testing and low volume production. Then the 8041, with masked ROM, provides maximum economy in high volume.

We've taken the UPI-41 concept a step further with the 8278, described at left. The 8278 is the first of several preprogrammed 8041's that we've adapted to specialized applications.

Because UPI-41 is a microcomputer, we've given it the same high level of support we give all our microcomputers. UPI-41 is supported by our Prompt™ 48 Design Aid, the Intellec® microcomputer development system with resident UPI-41/MCS-48 Macro Assembler. Plus applications assistance worldwide, full documentation, training classes, design seminars and a rapidly expanding users' software library.

"And, for my special I/O requirements, Intel's UPI-41 Universal Peripheral Interface is user programmable to control nearly any other peripheral device."



Intel's peripheral components, and the MCS-80, -85 and -48 microcomputers they support, are available through your nearest Intel distributor. For your copy of our Peripheral Data Handbook use the reader service card or contact: Intel International, Rue de Moulin a Pápier, 51-Boite 1, B-1160, Brussels, Belgium, Telex 24814; or Intel Japan, K.K., Flower Hill-Shinmachi, Setagaya-Ku, Tokyo 154, Telex 781-28426.

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Circle 21 for more information

Editorial

Massachusetts, technology, and history

It is an economic story that has happened before and will happen again. Yet it is hard to accept the fact that Massachusetts, one of the prime spawning grounds for today's vital electronics technology, is now being called a "hostile environment" for innovative, high-technology companies.

High taxes and a shortage of trained, skilled workers are making corporate life very difficult for the scores of companies that, in self-defense, have banded together into the Massachusetts High Technology Council. The goal of the new group is a basic revamping of the economic climate of Massachusetts—turning around state policies that impede business expansion, convincing legislators of the long-term folly of some laws that treat short-term problems, and working in a host of other areas from education to recruitment.

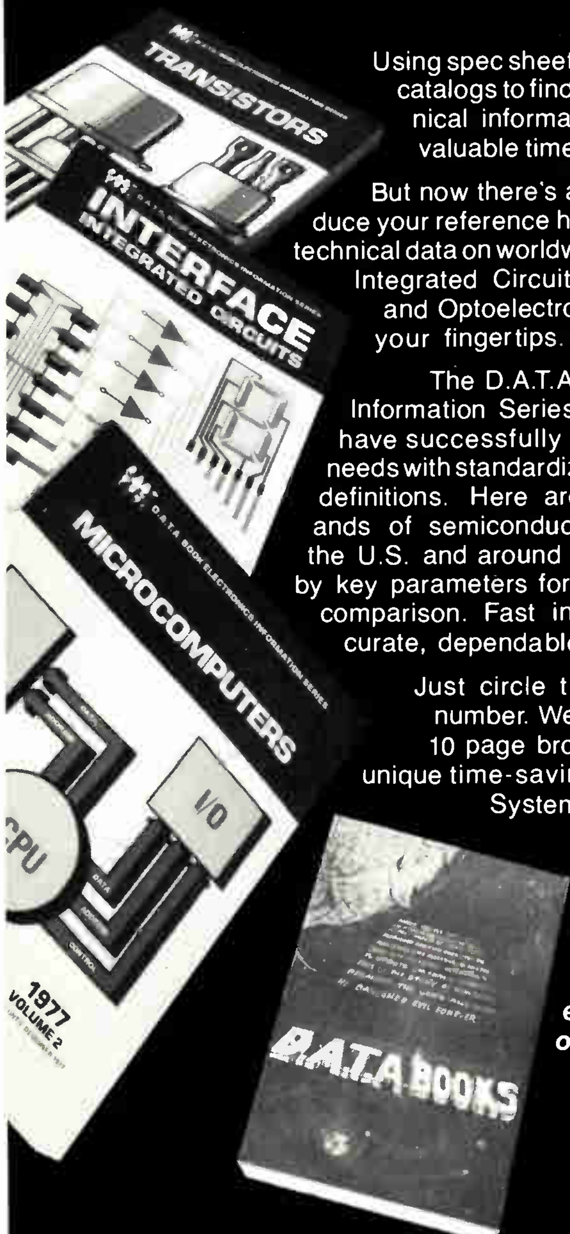
The kind of problems that are facing electronics companies in Massachusetts are by no means limited to that state. For example, although it has an annual per-capita tax bite that comes to some 22% higher than the national average, New York and California, two other important states for the electronics industries, outpace the Bay State in tax levies.

History has a lesson here. Over the centuries, various emerging technologies have given rise to vital industries and enriched the communities in which they grew—nearly always at the expense of older technologies and their communities. Massachusetts, with the rest of New England, grew strong on water power and the resultant textile, shoe, and related industries. But times changed, and other parts of the nation—even the world—proved to be more economically receptive to those industries.

That sort of repetition of history—and fairly recent history, at that—is what the High Technology Council wants to avoid while there is still time. The electronics industries are energetic, and some segments can truly be called dynamic. Thus, they can surmount economic obstacles that would hobble other, older industries. Yet no corporate executive wants to do that for long.

While many electronics centers have sprung up around institutions of advanced research, such as universities, there are few geographical limits on where the plants can be located. Thus, unless Massachusetts, New York, and California start taking a realistic look at what is causing the "hostile environment," the stage is set for another large-scale migration of industry.

It is to be hoped that the High Technology Council and similar groups in the other states will be heeded.



Meetings

CLEOS—**Conference on Laser and Electro-Optical Systems,** IEEE and OSA, Town and Country Hotel, San Diego, Feb. 7–9.

Wincon—Aerospace and Electronic Systems Winter Convention, IEEE, Los Angeles, Feb. 13–15.

International Solid State Circuits Conference, IEEE, San Francisco Hilton, San Francisco, Feb. 15–17.

Computer Science Conference, ACM, Detroit Plaza Hotel, Detroit, Feb. 21–23.

Fifth Energy Technology Conference and Exposition, U. S. Energy Research and Development Administration, Sheraton Park Hotel, Washington, D. C., Feb. 27–March 1.

Nepcon West and Semiconductor Hybrid Microelectronic Symposium and Exhibits, Industrial and Scientific Conference Management Inc. Anaheim Conference Center, Calif., Feb. 28–March 2.

Compcon Spring, IEEE, Jack Tar Hotel, San Francisco, Feb. 28–March 2.

IEA **78—12th Instruments, Electronics, and Automation Exhibition,** Industrial & Trade Fairs Ltd. (Solihull, West Midlands), National Exhibition Center, Birmingham, England, March 13–17.

Industrial Applications of Microprocessors, IEEE, Sheraton Hotel, Philadelphia, March 21–23.

International Conference on Physics of SiO_2 and Its Interfaces, American Physical Society, IBM, ONR, and ARPA, IBM Thomas J. Watson Research Center, Yorktown Heights, N. Y., March 22–24.

28th Vehicular Technology Conference, IEEE, Regency Hotel, Denver, Colo., March 22–24.

Computer Architecture Symposium, IEEE, Rickey's Hyatt House, Palo Alto, Calif., April 3–5.

Interactive VAX-11/780: A new computer system with exceptional performance...

VAX-11/780™ is a new, virtual memory, multi-user, multi-language, multiprogramming, interactive computer system with extensive batch and real time response capabilities.

It is the product of many man-years of effort layered on top of more experience and more success with interactive computers than that of any other company in the world.

Digital believes the VAX-11/780 is a landmark computer system. It believes the VAX-11/780 is the beginning – of new definitions, new standards, new expectations.

Take performance. Throughput. Quantity and quality of useful work.

VAX-11/780 will take essentially *any* size program. It has a 32-bit word length, 2 million bytes of physical memory, and more than 4 *billion* bytes of virtual addressing space.

It will operate on that program quickly. Its big cache memory yields an effective cycle time of 290 nanoseconds. With its optional floating point accelerator, it performs double precision floating point 64-bit addition in 1.4 microseconds.

It will move the data with exceptional speed. Its synchronous backplane interconnect, which is its main control and data path, has a bandwidth of 13.3 megabytes per second. And it checks for parity and errors on each 200 nanosecond cycle for data integrity.

And it even makes the programming efficient. Its new, powerful instruction set is a model of efficient code generation. A FORTRAN DO loop, for example, is one instruction. Calls to subroutines, and returns to the main programs combine up to 15 operations into just one instruction. And for time-critical applications, one instruction will store and another will restore the contents of all general-purpose registers simultaneously.

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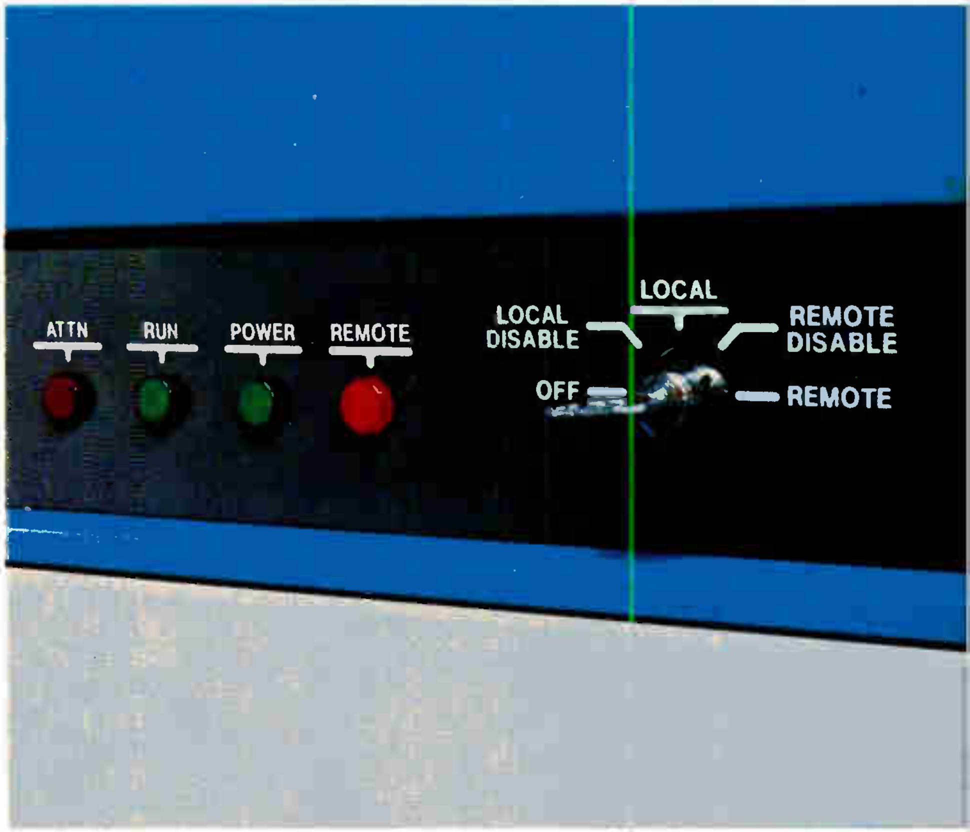
VAX11 780

..unmatched reliability, availability, maintainability...



By design, the interactive VAX-11/780 is the most reliable, available, and maintainable computer system of its general class that has ever been built. It is another standard against which others must be measured.

Reliability, availability, and maintainability features are found in the hardware architecture, the software architecture, the individual component and board designs, and in the cabinetry – all supported by new and improved diagnostic aids.

Objective: keep the system running. If it fails, find the fault quickly, fix it, get the machine up and running again. Protect that data.

Four hierarchical access modes protect the system information. A diagnostic console contains an LSI-11 microcomputer. Automatic consistency and error checking detect abnormal instruction uses or illegal arithmetic conditions. Integral fault detection and maintenance features detect errors on memory, on disks, keep a history of recent bus activity, detect hung machine conditions, and allow automatic restart recovery.

Parity checking for the integrity of the data is performed on the synchronous backplane interconnect, the MASSBUS and UNIBUS adaptors, memory cache, address translation buffer, microcode, and writable diagnostic control store. There are fault tolerance features. There are remote diagnosis capabilities. There are system verification test packages. There are functional and fault isolation diagnostics.

There are operating system consistency checks, redundant recording of critical information, uniform exception handling, on-line error logging, unattended automatic restart capabilities.

There are power loss, temperature and air flow sensors, cabling located away from the modules, a modular power supply with malfunction indicators...

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VAX11
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Major Features of the VAX-11/780 system

CPU 32-bit word length • Can directly address 4 billion bytes of virtual memory • User program can be up to 32 million bytes • Powerful instruction set includes integral floating point and context switching instructions • Instruction set supports 9 fundamental addressing modes with single instructions simulating entire high level language constructs • 8K byte write-through memory cache results in effective 290 nsec memory access time • Supports state-of-the-art paging memory management with 4 hierarchical protection modes each with read-write access control • 16 32-bit general-purpose registers • 32 interrupt priority levels, 16 for hardware and 16 for software • 2 standard clocks, programmable real-time and time-of-year with battery backup for automatic system restart operations • 12K bytes of writable diagnostic control store.

The Console Subsystem Intelligent microcomputer LSI-11 with 16K bytes of read-write memory and 8K bytes of ROM, floppy disk, and terminal • Optional port for remote diagnostics • Fast diagnosis, both remote and local, simplified bootstrapping, improved distribution of software updates.

Main Memory Subsystem ECC MOS memory built using 4K MOS RAM chips • Memory controller includes request buffer, increasing system throughput, eliminating most need for interleaving • Minimum memory configuration 128K bytes – maximum up to 1 million bytes per controller, two controllers allowed per system, for total of 2 million bytes physical memory.

Input/Output Subsystems Synchronous Backplane Interconnect (SBI) is main control and data transfer path. SBI capable of aggregate throughput rate of 13.3 million bytes per second • Error and parity checking every cycle for data integrity • SBI protocol uses 30 bits for address, allows both 32-bit plus parity and 64-bit plus parity data transfers • UNIBUS connected to SBI permits interfacing of general-purpose peripherals and user devices • Buffered UNIBUS adapter pathway between UNIBUS and SBI has throughput of 1.5 million bytes per second • MASSBUS connects to SBI via buffered adapter, permits interfacing high performance mass storage peripherals with parity checking • MASSBUS adapter throughput rate is 2 million bytes per second • Four MASSBUS adapters permitted per system.

Software System Designed for many applications including scientific, time-critical, computational, data processing, batch, general-purpose timesharing • Process-oriented paging for execution of programs larger than physical memory, transparently to the programmer • Memory management facilities controlled by user – can lock pages into working set, never to be paged out, or lock into physical memory, never to be swapped out • Sharing and protection at page level (512 bytes) • Four hierarchical access modes • Interprocess communication through files, shared address space, or mailboxes • System management facilities • DIGITAL command language and MCR command language provided • File and record management facility includes sequential and relative file organization, sequential and random record access • Supports Files-11 on disk structure level 2 • Program development capability includes an editor, language processors, symbolic debugger • Support provided for FORTRAN IV-PLUS/VAX and MACRO/VAX in native 32-bit mode, COBOL-11 (V3) and BASIC-PLUS-2 (V1) in compatibility mode • Scheduler is priority-ordered, round-robin/time-slicing, event driven • 32 levels of software process priority for fast scheduling • Networking capabilities are supported through DECnet for process-to-process, file access and transfer, and down-line loading • Batch facilities include job control, multi-stream, spooled input and output, operator control, conditional command branching and accounting • Command procedures are supported by command languages.

PDP-11 Compatibility Provides system-wide compatibility supporting execution of the PDP-11 instruction set (with exception of privileged and floating point instructions) in compatibility mode • Applications Migration Executive allows RSX-11M/S non-privileged tasks to run with minimal or no modification • Host Development Package allows creation and testing of RSX-11M tasks • Same data format • Same source-level programs • High level languages • Files-11 on disk structure, level 1 • RMS file access methods including ISAM • DIGITAL Command Language and the RSX-11 MCR command language.

Reliability, Availability, Maintainability Remote diagnostics by means of integrated diagnostic console permits diagnostics, examination of memory locations from remote terminal • Automatic on-line error logging • Automatic restart capabilities after power failure or fatal software error • Users continue to use system with failed hardware components • Consistency and error checking detects abnormal instruction uses or illegal arithmetic conditions • Improved packaging and cabinetry increase hardware reliability and ease of maintenance • On-line diagnostics available and run under operating system.

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VAX11 780

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Electronics newsletter

Data General to unveil powerful system

What's believed to be the most powerful computer system yet offered by Data General Corp. will be announced next week. Although officials of the Westboro, Mass.-based minicomputer maker are not talking in advance, the machine is believed to be called the Eclipse 600 **and to be competitive with medium-scale mainframes for up to 64 users.** The machine will probably be announced with 1 megabyte of main memory implemented in either MOS 4,096-bit random-access memories or core, whichever is desired. But a novel approach to input/output techniques is what will give the new Eclipse entry its high throughput for large numbers of users in batch and real-time programs. Part of the I/O approach is incorporation of a multiplexer link between main memory and fast peripherals that allows data transfer at up to 10 megabytes per second.

Another ingredient in the I/O scheme is a data channel that handles communications between medium-speed peripherals, such as magnetic tape and cartridges, and also functions as the interface between the main processor and a front-end processor that relieves the main unit of the task of buffering slow-speed peripherals. The main processor's instruction set includes 16-bit single-word and 32-bit double-word instructions.

First color CCD TV camera shown by RCA

Engineering models of the first color video camera to use charge-coupled devices were to be shown by RCA Corp. at the 39th National Audio-Visual Convention and Exhibit in Houston, Jan. 14 – 17. The camera, aimed at the audiovisual market, **offers four major improvements over vidicon models,** says RCA. First, it does not suffer from lag and image burn; second, it weighs only 3.6 pounds; third, it is completely solid-state and reliable; and fourth, it is low-powered.

Hard disks to appear as floppy replacements

This year will see the birth of a new computer peripheral—a disk-drive memory subsystem with a nonremovable hard platter. About the size of a standard floppy disk—8 inches—**it stores from 10 to 100 megabytes,** compared with about 1 megabyte for the floppies. At work on such a drive, which will occupy no more space than a floppy and cost under $2,000, versus about $700 for a floppy, are Shugart Associates Inc., IBM Corp., and at least two small firms. Although the approaches of the various manufacturers differ—some will use thin-film heads and media, while others will stick to standard Winchester technology—all have confidence in the success of the drive, since they believe it will replace the many less-reliable floppies backing up minicomputer systems for less per bit.

Laser trimmer for thick films to up throughput

A new $100,000 laser trimming system for thick-film hybrids expected to be unveiled next month by Teradyne Inc. is designed to boost the already substantial throughput of its predecessor, the W311. The Boston-based manufacturer of semiconductor and circuit-board testing and manufacturing equipment had the updated unit operating unidentified and without fanfare at last October's Baltimore meeting of the International Society of Hybrid Microelectronics. In those tests, which simulated a production environment, the system trimmed more than 400,000 resistors and networks in less than 10 hours, Teradyne officials say. **That represents about $1,500 in revenue for a thick-film hybrid supplier,** the officials add.

Electronics newsletter

Data General to bring PL/1 to minicomputers

Under test for the last nine months at the University of California anthropological lab, a PL/1 compiler will be unveiled soon by Data General Corp. for the Westboro, Mass., firm's Eclipse minicomputers. The sophisticated high-level language, developed by IBM Corp., **combines some of the better features of Fortran and Cobol.** PL/1 has found its home mostly in batch-oriented mainframes, though IBM offers it for the Series/1. Now, Data General has optimized PL/1 for the mini, and it expects both of its major competitors—Digital Equipment Corp. and Hewlett-Packard Co.—to soon follow suit.

RCA to discuss flat-panel display at SID session

A 30-by-40-inch color TV flat-panel display about 2 inches thick is under development at RCA's David Sarnoff Research Center, Princeton, N. J. **The display uses internal electron multipliers to create free electrons, which are accelerated to strike the phosphor screen.** The display will be the subject of a full session at the upcoming Society for Information Display Conference in San Francisco, April 18–20.

2 European firms in deals with U. S. companies

Transatlantic electronics cooperation is getting another boost with a marketing agreement between the French firm Adret Electronique and the Comstron-Seg Corp. of Freeport, N. Y., and with the purchase of Interdesign Inc., Sunnyvale, Calif., by Ferranti Ltd. of Great Britain. Adret, a small instrument maker specializing in top-of-the-market frequency synthesizers, is teaming with Comstron to find a sizeable niche in the U. S. market. Comstron will distribute Adret's line of generator synthesizers and could start making them if sales warrant. They expect $500,000 in synthesizer sales this year, 50% more than Adret managed on its own in 1977. With the Ferranti-Interdesign tieup set [*Electronics,* Jan. 5. p 62], **the British firm will market its new subsidiary's Monochip in Europe,** and its uncommitted-logic-array chips will be designed and its wafers masked in Sunnyvale. Interdesign founder Hans Camenzind is staying on as part-time consultant, while Robert W. Townley moves up to president and Alan Shepherd, formerly Ferranti's general manager for components, takes over the job of chairman.

Fast fax machines due from Burroughs

Graphic Sciences Inc., a subsidiary of Burroughs Corp., will announce soon two facsimile machines and a network communications protocol it calls Dexnet. The machines, according to International Resource Development Inc., a market-research firm, will transmit a page in less than a minute, joining such machines now supplied by Rapidfax, Dacom, and 3M. According to the New Canaan, Conn., research firm, the two new machines will be competitive with other U. S. machines. **However, even cheaper machines from Japanese manufacturers** including NEC, Panafax, and Hitachi, are expected to bow later this year.

Addenda

Sony Corp. hopes to open its **video technology center in the San Francisco Bay Area by year's end.** The center will specialize in nonconsumer applications of video cassette recorders. . . . Leeds & Northrup Co. of North Wales, Pa., **has acquired Hy-Cal Engineering of Santa Fe Springs, Calif.,** a $2.5 million producer of temperature-measuring instruments.

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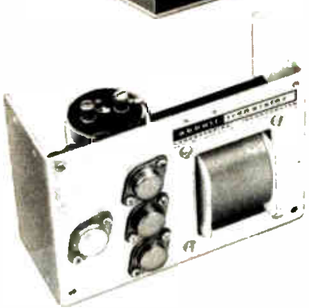
It all paid off. Just look at Abbott today.

Militarized Power Supplies — Our early bread-and-butter line has grown to over 1500 versions. Some we stock. Yet we're equipped to provide fast delivery on any number of high efficiency, hermetically sealed, single or dual output power supplies and switcher modules. That includes our popular 60 and 400Hz and DC versions with outputs from 3VDC to 740VDC, 1 to 250 Watts. And prices go as low as $174 for 2-4 units.

For Catalog Circle Card Number 100



Industrial Power Supplies — Ours isn't a big line yet — only 279 models. But you won't find a better quality of OEM power modules anywhere. (It's just our hi-rel way of thinking.) We provide covered/open frame, AC to DC single, dual and triple output versions, with outputs of 5 to 36VDC, 0.5 to 320 Watts. Plus DC to AC converters with 50 to 60Hz outputs. Competitively priced? You bet. As low as $35 for up to 24 units.

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Transformers — For the do-it-yourself power supply designer who wants our kind of quality for his own military, industrial and pcb application. If you're one of them, we offer over 800 standard transformers, with instructions on how to specify for your custom units. Included are 60 and 400Hz, single phase input versions. Prices start as low as $5.10 for up to 9 pieces.

For Catalog Circle Card Number 102

See Power Supply Section 4000, and Transformer Section 5600, Vol. 2, of your EEM catalog; or Power Supply Section 4500, and Transformer Section 0400, Vol. 2, of your GOLD BOOK for complete information on Abbott products.

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A ROM so big (65K) it can hold complete high level language interpreters.

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CDC to cash in on peripheral needs of IBM minicomputer

Range of units for Series/1 coming next June will be aimed at big end users; sales could reach $250 million

Long the leading independent supplier of computer peripherals, Control Data Corp. has found a back door to the market in end-user minicomputer peripherals. It plans to offer a whole array of them for IBM Corp.'s Series/1. CDC figures that its breadth of products and services gives it an edge on its competitors, and it is spending several million dollars to insure that its designs underscore that advantage.

IBM opened the door for sales of the end-user miniperipherals when it announced its new minicomputer in November 1976. With it came the message that the Series/1 could accept a large variety of attachments and that interface details would be readily available to potential suppliers. For the first time, IBM was inviting independent firms to engage in hardware and software development for the machine. The new stance for the computer giant, which has always protected its products by trying to sell them in complete systems, is apparently key in a plan to boost its minicomputer market share from the present 4% to 15% by 1980, according to industry sources. The firm counts on the availability of peripherals from a maker like CDC to promote sales of its minicomputer.

"IBM may be playing in the same ballpark, but it's playing the game in a different way," says Phillip W. Arneson, vice president of CDC's Miniperipheral Systems and Terminals division, a group set up in Roseville, Minn., a suburb of Minneapolis (see p. 14), to respond to the IBM lure. His new division will go after big sophisticated users—banks, utilities, retailers, and insurance and manufacturing companies—because "they usually have internal hardware and software capabilities and have been buying peripherals and miniperipherals from independent suppliers." Large companies like these own the bulk of the 3,000-plus Series/1s installed in the U.S. in 1977, says Lee Walther, a Cupertino, Calif., market consultant. He expects this year's shipments to exceed 5,000 in the U.S. and 3,000 more worldwide.

CDC will show in June at the National Computer Conference in Anaheim, Calif., what it claims will be the broadest line of high-performance peripherals for the IBM minicomputer. "We don't think anyone is positioned as well as we are," says Arneson, pointing to CDC's existing miniperipherals, which are now sold only to manufacturers of original equipment.

The opportunity to capitalize on the Series/1 probably knocks loudest on CDC's door. No other company has the financial resources, service network, and the broad product line, which includes printers, terminals, and disk and tape drives. But it is not going to be an easy sell—Control Data will have to persuade IBM users to split up their buys. Says

Custom I²L key to CDC challenge

To get ready for the Series/1 market, CDC has spent over $1 million since last August on choosing a half-dozen or so miniperipherals from its OEM catalog and reconfiguring them, largely with new controllers for IBM end users. "And it will probably take several million dollars more," remarks Gordon R. Brown, senior vice president for marketing and planning for CDC's peripheral products organization. The money has gone primarily to develop microcircuits for the controllers necessary to interface the existing peripherals to IBM's mini. The firm decided to implement its controllers with large-scale integrated circuits, which will be able to fit onto a single card that can be slipped into the card cage provided by IBM, rather than requiring the stand-alone controllers that other Series/1 peripherals suppliers have usually been working with.

Each card consists of a Z80A microprocessor and four integrated-injection-logic chips that handle data and address buses, along with a handful of off-the-shelf circuits that dedicate the card to the peripheral being driven. The I²L chips will be built by CDC's Microcircuits division, a Minneapolis facility that produces about a million parts each month, although the firm is also searching out an alternate source. Controllers are in design now for a conventional keyboard display terminal, a floppy disk, 10- and 20-megabyte fixed-head disks, 80- and 150-megabyte storage modules, and 70-, 720-, and 1,130-line-per-minute matrix and band printers—the products that will be introduced in June.

consultant Walther: "CDC will now have to get in bed with systems houses, software houses, and contract-programmers—and that's expensive marketing."

The cornerstone of CDC's strategy is to sell the user a complete peripheral array—with maintenance—which it hopes will lock out other independent suppliers. "We think that most customers will want a complete product line with a single maintenance contract" that could include the mini, says Arneson. That is critical in the distributed-processing environment at which the Series/1 is aimed, where equipment is scattered over a wide distance.

Will it build a processor to emulate the Series/1? CDC says no. "Why should we go into a major design effort to build a minicomputer to compete with IBM when IBM has invited us to participate in the major part of the system?" asks Larry Eaton, marketing manager for the new peripherals. Nor does Control Data plan to start selling mini-peripherals to non-IBM end users. "It would disrupt our OEM business," Arneson says.

CDC is clearly joining IBM in its fight against the dominant minicomputer firms like Digital Equipment Corp., Data General Corp., and Hewlett-Packard Co. At stake is a market that the industry figures will be massive. Estimates generated by independent research firms suggest that 50,000 to 100,000 Series/1 systems will be shipped in 1982. And CDC thinks its share of Series/1 business, with system prices averaging $55,000, will be sizeable. "We expect it to be as large as our OEM business in about five years," asserts CDC's Gordon R. Browne, senior vice president. The firm's OEM revenues are estimated to be over $250 million annually. □

Litigation

Intel sues U.S. Copyright Office over registering microprocessor chips

The cost of developing complex new devices has become so high that Intel Corp. is launching a legal war to protect its products from piracy. Intel fired its first shot on Dec. 21 in San Francisco's Federal District Court, when it filed suit to force the U. S. Copyright Office to grant it a registered copyright for its 8755 eraseable programmable read-only memory.

By getting such copyright protection, Intel seeks as much legal muscle as possible to prevent unauthorized second sourcing, or "the photographic ripoff," as it calls it, and to force competitors to take the time to develop their own competing devices. The goal is to protect Intel's market lead in certain new products, says Roger S. Borovoy, the company's general counsel and secretary, at company headquarters in Santa Clara, Calif.

Warning to industry. He also fires a warning shot across industry's bow. "The first unauthorized copy of Intel's current generation of products will be the next subject of Intel's lawsuit," he says. This means everything after the 8080 microprocessor, including the newer microprocessors and major supporting peripheral chips.

"The reason we are doing this is that the cost of developing new circuits is skyrocketing," Borovoy says, noting that Intel spent $28 million on research and development for the fiscal year just ended, up from $21 million a year ago. Obviously, if a competitor can copy a part instead of developing its own version, it can get into the market sooner and spend a lot less to boot.

Borovoy concedes that, except for one instance, Intel designs have not been pirated yet. However, "we're concerned that the equation will shift so that it will become advantageous for competitors to copy our designs rather than lay out their own," he says. He knows of a Japanese company that can take a chip and return a full set of masks within 30 days for a mere $20,000 to $30,000.

What Intel is attacking with its suit is the Copyright Office's long-held position that chips themselves cannot be copyrighted. Intel wants not only a copyright but a registered copyright, which it feels will give it greater legal protection. To force this issue, Intel submitted a set of Mylar masks representing engineering drawings as an "unpublished work," which the Copyright Office accepted for registration. When Intel later deposited two 8755 chips as the "published work," the Copyright Office refused to accept them. Intel is suing to have the chips themselves copyrighted as published works.

Chipping away. If Intel wins, then "it chips away at the Copyright Office's position," Borovoy says. But he adds that Intel has another shot waiting to be fired. It also sent two 2716 eraseable programmable read-only memory chips to the Copyright Office for a registered copyright without first submitting engineering drawings. As expected, the office refused to accept them, too, Borovoy says. He says he will wait with the 2716 issue until he sees what happens with two allied cases in other fields or "an infringer [or unauthorized copier] turns up." Borovoy expects his case in Federal District Court to go on for at least a year.

So far, the only chips that can be copyrighted are read-only memories containing computer programs, Borovoy says. These are treated like magnetic tape or disks, provided that the computer printout is submitted, too. Overall, Intel's plan is to get registered copyright protection under both the old law and the new Copyright Act of 1976, which went into effect on Jan. 1, for the appropriate products. Borovoy, a Harvard Law School graduate, is well armed to lead the effort. Before joining Intel, he was with Fairchild Camera and Instrument Corp., where he directed Fairchild's acquisition of patents for its planar process.

At Intel, he hopes the company's strong declaration of its intent to sue infringers will be sufficient to scare them off. "We have a war chest budgeted to fight this all the way to the Supreme Court, he says. "All we need is a defendant." □

Photovoltaics

60-kW station largest so far

Slated to be operating in southern California by the end of this year, a proposed solar photovoltaic power-generating station looks to break new ground for this kind of energy. At 60 kilowatts, it will be the largest station of its kind, with some 190,000 solar cells mounted in stationary panels covering half an acre.

In addition, to get maximum power at all levels of sunlight, its circuitry will closely match the impedances of the solar array and the subsystem that converts the direct current into alternating current, thus boosting output 25%. Also, any excess power generated will be fed into public utility lines.

Perhaps of even more interest is the little-known company that designed the system. Delta Electronic Control Corp. of Irvine, Calif., an eight-year-old firm with 65 employees and $2.5 million annual sales, won the award from the Army's Mobility Equipment Research and Development Command against much larger competitors—Xerox Corp.'s Electro-Optical Systems division and Motorola Inc.'s Government Electronics division.

Circuit similarity. The Army will not say why it chose Delta over heavyweight opposition, other than "they're the best qualified." But Delta president Charles W. Jobbins thinks he knows the main reason. "It's the similarity of the solar station's circuitry to that of power inverters in our line of uninterruptible power systems," he says. Delta makes such units for computer, medical, and military installations. Ranging from 1 to 400 kw, the systems supply "clean power" (without line noise and variations caused by ac sources) and can switch to internal batteries when necessary.

"Peak power tracking" is what the photovoltaic industry calls matching a solar array to its load on spacecraft. But Jobbins notes his arrays do not actually move with the sun. "Rather, it refers in our case to tracking peak power available by matching impedances," he says. The change from hazy to bright sunlight, for instance, can cause impedances of the solar array and the load to vary by from 5 to 30 milliohms. "Our power supplies typically invert widely varying inputs in the same kind of problem," he adds.

Another important aspect of the Delta station is its ability to convert dc output of the solar array into ac for utility lines. Here, Delta has spent its own funds in work with Southern California Edison to iron out problems—reportedly, those of introducing excessive interference into utility lines. "This is a key point for the Army, and we had to demonstrate we can do it," says Jobbins.

JPL cells. Delta will start putting the station array and interface together as soon as it starts receiving solar-cell modules, which are among those purchased over the last year by the Jet Propulsion Laboratory for the Department of Energy. The 60-kw array will be assembled and installed first at Delta's 11-acre Irvine site for a two-month shakedown test, scheduled for midsummer. Ultimate destination of the array is Mount Laguna Air Force Station, east of San Diego, where it is to provide about 10% of the 750-kw total power requirement for the radar installation.

The initial fixed-price, negotiated contract with Delta is for $285,600. The total value, including Government-furnished materials, is about $1.5 million, according to the company, and options could increase it further. The station's real significance is seen in its commercial potential, however, through establishing guidelines for such equipment. Delta's intentions, in fact, are "to quickly go very heavily into smaller systems" for commercial customers. □

The military's solar arrays

The 60-kilowatt solar station being built for the Air Force is the sixth and largest project in the Department of Defense's two-year program for military applications of photovoltaic systems. Even so, it is still too early to say whether the program has reached its goal: "to promote an awareness of the technology throughout DOD and the services," according to Donald Faehn, project manager at the Army's Mobility Equipment Research and Development Command, Fort Belvoir, Va.

One reason: photovoltaic options are not yet available to DOD users because of their high cost, he says. But in the meantime, the effort is giving the DOD pertinent experience so that when costs do come down, the services can start ordering with some idea of photovoltaic capabilities.

Earlier projects are: 35- and 74-(peak)-watt radio relay stations, including battery charging; a 150-W charger for nickel-cadmium batteries; a 12-kW generator for a remote radar at the Naval Weapons Center, China Lake, Calif.; a 10.8-kW array for a water purification plant at Fort Belvoir, Va.; and a 2.4-kW telephone-communications power system.

Satellites

Japanese satellite goes live in March

Japan will join the club of communications satellite operators in March when it begins using its new CS spacecraft for telephone and color television coverage of the home islands. By then, according to the timetable, Japan's National Space Development Agency will have com-

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After the Z8, comes the Z8000

Later this year, after the Z8 bows, Zilog plans to introduce its powerful big brother, a full 16-bit microprocessor called the Z8000. Sharing many of the Z8's features, it will offer the speed of a PDP-11/45 coupled with some modern architectural capabilities usually found in 32-bit minicomputers, such as the ability to manipulate data words up to 32 bits long.

The Z8000 also will directly address an impressive 8 megabytes of memory, which can be enhanced with a separate memory management chip to provide relocation and memory protection. Because it is bus-compatible with the Z8, it can use a version of that microprocessor as a general-purpose peripheral controller. Like the Z8 and Z80, the Z8000 will be made with Zilog's standard n-channel metal-oxide-semiconductor process.

The firm aims for easy and efficient programming by designing the Z8000 with architecture and a large instruction repertoire of 418 instruction combinations, including 16-bit multiply and divide and powerful string manipulation instructions. In comparison, the Z80 has 158 instruction combinations and the Z8 has 130. All of the Z8000's 16 general-purpose 16-bit registers can be accumulators, and 15 of them can be used as index registers. Zilog also boasts advanced features to support interrupts, traps, and large multiprogramming applications.

the act in the single-chip category with its Z8, an 8-bit microcomputer.

It is the combination of features the Z8 is being designed with that will make it so tough for competitors like Fairchild's F8, Intel's 8048, Mostek's 3870, and Texas Instruments' 9940 in high-performance applications. That includes telephone handsets, consumer computers and high-powered games, and peripheral controllers in communications. Samples will be available in the summer.

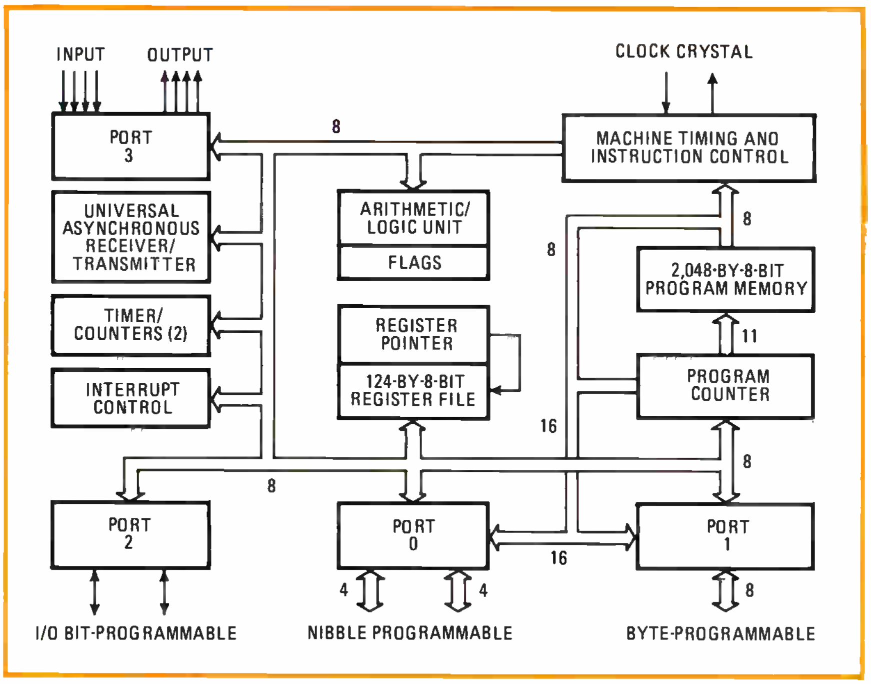
Among the performance-boosting features of the Z8 is its internal 4-megahertz clock that makes the chip as fast as the Z80 itself and faster than other single-chip microcomputers. It can execute many instructions in as short a time as 1.5 microseconds (with 2.5 μs average) and has more computational power and memory address capability than the rest of the field. Moreover, it can execute a large, 96-instruction repetory subset of the powerful Z80 instructions.

Lots of registers. To do it, Zilog designers are packing 144 registers and four 8-bit input/output ports on a chip. It also has 2,048 bytes of read-only memory and 128 bytes of random-access memory. That is as much ROM and more RAM as the best of the competition.

Another feature likely to interest communications systems designers in particular is the on-chip universal asynchronous receiver/transmitter, which comes in a standard format without external interface, according to James H. Gibbons, product manager for development systems and components. Gibbons stresses the "pin economy" of having the two in one 40-pin package. No other single-chip microcomputer has the receiver/transmitter capability, which means either they run the risk of bogging down the central processing unit, trying to make it act like a UART, or they tie up input/output lines connecting the processor to an external UART. Gibbons also points to a dual timer-counter feature, useful for such applications as automotive controls.

Other features include four handshake input/output ports that can be programmed to function in bits or groups of bits. This makes I/O management extremely flexible. The Z8's port 0, for example, is programmable into two groups of 4 bits, explains Peter Alfke, the new-product marketing and applications manager. This is useful where only half a port is needed to drive a seven-segment display.

Gibbons even expects the Z8 will compete in some applications with multichip systems like Intel's 8080 and Zilog's own Z80. This is because it can add externally another 62 kilobytes each of data and memory address storage to its onboard memory store. Also, the Z8's pipelining overlaps fetching of a new instruc-



Chip to come. Bit, nibble, and byte programmability of the 8-bit input/output ports adds a lot of flexibility to Zilog's upcoming Z8 one-chip microcomputer. Also included as part of the chip is a universal asynchronous receiver/transmitter.

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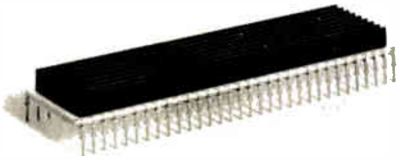

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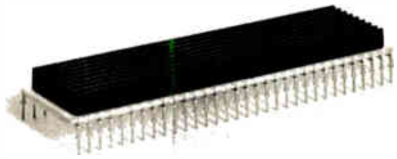

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Circle 44 on reader service card

tion and execution of the old one, so there is only one machine cycle per instruction byte.

Rather than competing directly with the Z80, Gibbons feels that the Z8 is more likely to fit in areas where the Z80 cannot be used because of its larger physical size or power consumption. But is there a risk in announcing now performance specifications for a part that will not be available for so many months? No, according to Zilog, because the Z8 is being built with the same n-channel metal-oxide-semiconductor process employing silicon gates and ion implantation that is standard for the Z80. □

Personal computers

Personal-computer makers clash over best route to the home

With the market for home computers barely off the ground, the makers of the hardware cannot agree over how to interest consumers. The lines were clearly drawn at the Consumer Electronics Show in Las Vegas early this month where the first truly home—as opposed to hobby—computers were being demonstrated. Essentially the disagreement among the hardware companies springs from the fact that nobody yet has a good enough insight into what will attract the mass consumer market to computers.

The disagreements involve:

- Point of entry. Games makers like Bally Manufacturing Corp. and Coleco Industries Inc. are betting on selling their home computers, due out into the market late this year, through the consumer interest in games. But Apple Computer Inc., Commodore Business Machines, APF Electronics Inc., and Compucolor Corp. are banking on personal computers that handle data and have only incidental game capabilities.
- Hardware configuration. Umtech Inc.'s new VideoBrain home computer [*Electronics*, Jan. 5, p. 60] uses the television receiver for display with the help of two custom-designed chips that sharpen color fidelity on the TV tube. Companies already involved in the hobby computer market sharply disagree with using the TV receiver, instead including a dedicated display with their hardware. Consumers will not want to tie up a TV set with a computer, they say, and the dedicated display not only yields higher resolution but in addition does not need approval from the Federal Communications Commission.
- Software design. The biggest controversy, however, has come up over software. Basically, the issue is whether the consumer will want fixed program packages or, instead, enough of an understanding of programming to do his or her own software. A related issue is whether buyers should be counted on to handle Basic as the standard programming language or should be given an easier-to-use, English-based language.

Sophisticated users. Competitors agree that the personal-computer market consists now only of relatively sophisticated consumers who already understand how a computer would be of use. The mass market has yet to be tapped. According to Robert Wickham, president of market research firm Vantage Research Inc., there are presently only about 2 million people likely to be able to use a machine constructively.

The question is how to push beyond this group. To David Chung, vice president of Umtech, the solution is to eliminate the need to program—nobody likes the work, he believes—and employ one of the consumer's most common instruments, the TV set. "The home computer will sell, not because it's a nice piece of engineering, but because the consumer can see a use for it and want to use it," Chung comments. VideoBrain has 12 fixed programs available now, and it expects to have close to 50 available by year's end.

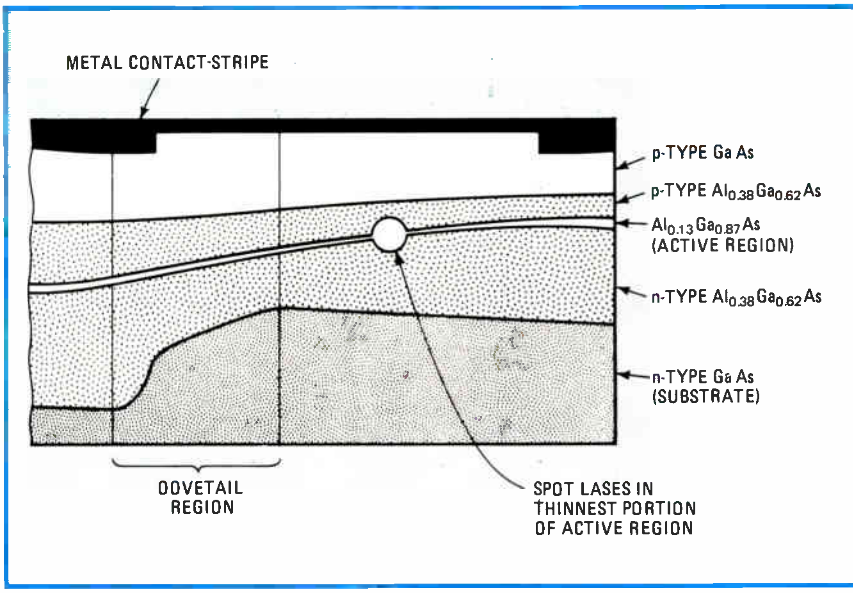
Individual needs. "The consumer must be able to program for individual, customized needs, not follow a set plan," counters Apple vice president Michael Markkula. "If a consumer is going to use a computer to handle a check book, he's going to do it his own way, not the way an Apple programmer decides." Adds Charles Peddle, director of Commodore's Systems division, "Part of the motivation in getting a home computer is interest in learning more about computers. This means learning to program."

However, Sy Lipper, president of APF Electronics, contends that Apple and Commodore are on the wrong track in their commitment to Basic as the programming language. "When calculators were introduced, there was a thing called Polish notation that only an engineer could use and understand. Calculators did not go anywhere in the mass market until algebraic input was possible. Then the consumer could use the calculator comfortably. English is the most common language, and that's why we have a software language that the consumer in the mass market will understand. Input is made the way people write. Interaction with the computer is plain English." APF's new Pecos One personal computer employs the JOSS language that was developed by Rand Corp. □

Lasers

Laser diode hits one and the same spot

For some people, the spot of light produced by a semiconductor laser diode is just not stable enough for fiber-optic systems used in communications, imaging, and printing. "Maintaining a round spot that doesn't vary in size or position is essential to couple power efficiently into low-loss optical fibers," says Eric Lean, manager of optical solid-



Bright and stable. Cross section of laser diode developed by IBM researchers indicates where the stable output is produced—at a constriction of the semiconductor layers.

state technology at IBM Corp.'s Thomas J. Watson Research Center in Yorktown Heights, N. Y.

Lean's group has therefore developed a gallium-aluminum-arsenide laser diode that produces a round spot, 2 micrometers in diameter, that remains stable in size and position up to power levels where the diode itself may fail catastrophically. It is also compatible with relatively simple systems using spherical lenses. Most semiconductor lasers have elliptical spots that require focusing by cylindrical lenses to produce the desired roundness. This wastes power and adds complexity.

The new device is a double heterostructure diode grown by a one-step liquid-phase epitaxy over a dovetail-shaped channel etched in the gallium-arsenide substrate. But its active or lasing region, instead of being the same thickness throughout, is constricted in the middle. This constriction occurs in the diode's active region, shown in the diagram, giving it a divergent-lens-like cross section: thinner in the middle than at both ends. The thinnest portion of the active region has the highest gain, and it is at this spot that the diode will lase when current is applied to it through the contact stripe.

What's more, the diode oscillates in a fundamental spatial mode, which cuts into noise caused by mode jumping in diodes with conventional structures. The next job is to design a package that dissipates heat efficiently. □

Military

Alaska to get new surveillance radars

The Air Force is going to update its 1950s-vintage Alaskan Air Command surveillance radar system between now and 1984 in a program called Seek Igloo. Requests for proposals for design validation will shortly go to industry from the office of Lt. Col. Raymond McMillan, program director of the Seek Igloo minimal-attendance radar program at the Air Force Electronic Systems division, Hanscom Air Force Base, Bedford, Mass.

As is the case with so many of the command, control, and communications systems administered by the division, 20-year life-cycle costs will be hammered home to potential bidders, the list of which includes "just about every major radar manufacturer in the U. S.," says McMillan. In addition to a single three-

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IBM Corp. next month will begin delivering a new desktop small-business computer system, the 5110, offering a range of storage capacities. Model 1 has up to 204,000 bytes per tape cartridge or 1.2 million bytes on a diskette. Model 2, with a diskette store only, has an on-line capacity of 4.8 million bytes. Prices range from $9,875 for a basic model 1 to $32,925 for a model 2 that includes 65 kilobytes of main storage and two programming languages, APL and Basic.

Hy-Gain files bankruptcy, idles 500 indefinitely
Citizen's band radio manufacturer Hy-Gain Electronics Corp. of Lincoln, Neb., has filed Chapter XI limited bankruptcy proceedings in U. S. District Court and laid off 500 production workers in Lincoln and at its facilities in Puerto Rico. In fiscal 1977, Hy-Gain lost more than $24.5 million on sales of $50.3 million, compared with a year-earlier profit of $17.3 million on sales of $96.9 million. Hy-Gain president Andrew A. Andros cites oversupply caused by "continual excess of CB imports from the Far East."

dimensional radar that combines search, height-finding, and Federal Aviation Administration beacon functions usable for Identification Friend or Foe at the 13 sites in the network, they will also have to propose radar systems that will work without operators. This means the units must incorporate automatic clutter processing, so that operators are not required to pick out the true target returns from echoes.

Finally, the radars will have to provide automatic fault isolation down to the level of a line-replaceable unit. "They'll have to detect 98% of the total faults," McMillan says, "and isolate 95% of them down to three LRUs or less."

McMillan says he knows of no present radar that combines all these features—the three-dimensionality, automatic clutter processing, minimal need for an operator, and stringent fault isolation—but he is quick to add that, taken individually, these requirements do not push the state of the art. The E-3A (Awacs) aircraft has similar fault isolation, and automatic clutter processors exist. Several FAA radars could meet the search (detection) requirements, but they are mostly two-dimensional systems that depend on a cooperative transponder for altitude data.

Manpower cut. The push for automaticity stems from an Air Force objective to cut the number of support personnel from the 1,100 needed today to a scant 85. This will save the service $500 million over 20 years, McMillan says.

All 13 Alaskan Air Command sites are now equipped with AN/FPS-93 L-band search radars built by Bendix Corp., and most of them have General Electric Co.'s AN/FPS-6/90 S-band height finders. The Seek Igloo radars will replace them, with 9 on the west coast of Alaska facing the Soviet Union, and 4 in the interior. All the radars will have a range of approximately 200 nautical miles and detect targets as high as 100,000 feet.

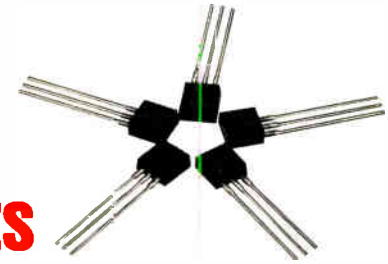
Design leeway. The request for proposals will not specify a frequency band. McMillan stresses that he wants to set forth functional requirements and let bidders propose a system that will satisfy them.

When installed, the Seek Igloo radars will digitize the received signals, eliminate the clutter, and transmit data, including target range, azimuth, beacon, and altitude, to a central station by radio. That station will be at Elmendorf Air Force Base near Anchorage, the Alaskan region operations control center in the Air Force's Joint Surveillance System.

The six-month design-validation phase precedes selection of a single contractor to carry out full-scale development. □

There's a better way to measure or monitor mechanical motion—

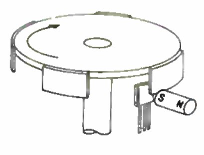
magnetically-activated 'Hall effect' integrated circuits



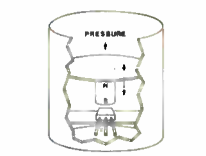
- Convert mechanical motion to electronic signals by sensing changing magnetic fields.
- Excellent for position sensing, thickness determination, weight measurement, speed control, pressure monitoring.
- Provide contactless switching—no contacts to wear, no contact welding.
- Highly reliable under adverse environmental conditions.
- None of the contamination problems suffered by mechanical or photo-electric switches.
- No moving parts to cause spurious signals often associated with conventional switches.
- Economical transistor-style package.
- Ideal interface between mechanical motion and electronic controls, counters, etc.

TYPE UGN-3020T DIGITAL SENSORS

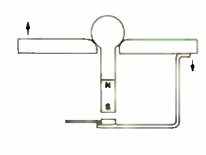
TYPICAL APPLICATIONS



VANE INTERRUPTER
(ignition switch, etc.)



LIMIT SWITCH
(pressure monitor, etc.)

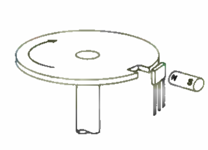


ANGLE SENSING
(tilt switch, etc.)

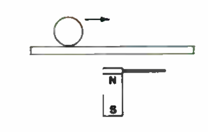
- Designed for use with readily-available samarium cobalt or sintered alnico VIII permanent magnets.
- Operate at any voltage from 4.5 to 24 VDC.
- Constant amplitude output, independent of frequency up to at least 100 kHz.
- Higher sensitivity, wider operating temperature range, smaller physical size, more economical than any other device of its type.

TYPE UGN-3501T LINEAR SENSORS

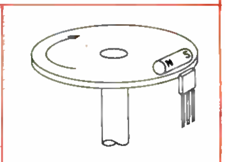
TYPICAL APPLICATIONS



CHANGE IN FLUX PATH
(notch sensor, etc.)



FERROUS METAL SENSOR
(pinball detector, etc.)



ANGLE OF ROTATION
(antenna position, etc.)

- Voltage output of these devices is proportional to magnetic field intensity.
- Will operate if slightest change in flux path is made.
- Operate at any voltage from 8 to 12 VDC.
- Hall cell and linear differential amplifier integrated in one monolithic device to simplify problems relating to handling of millivolt analog signals.
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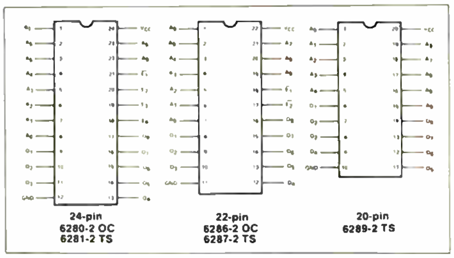

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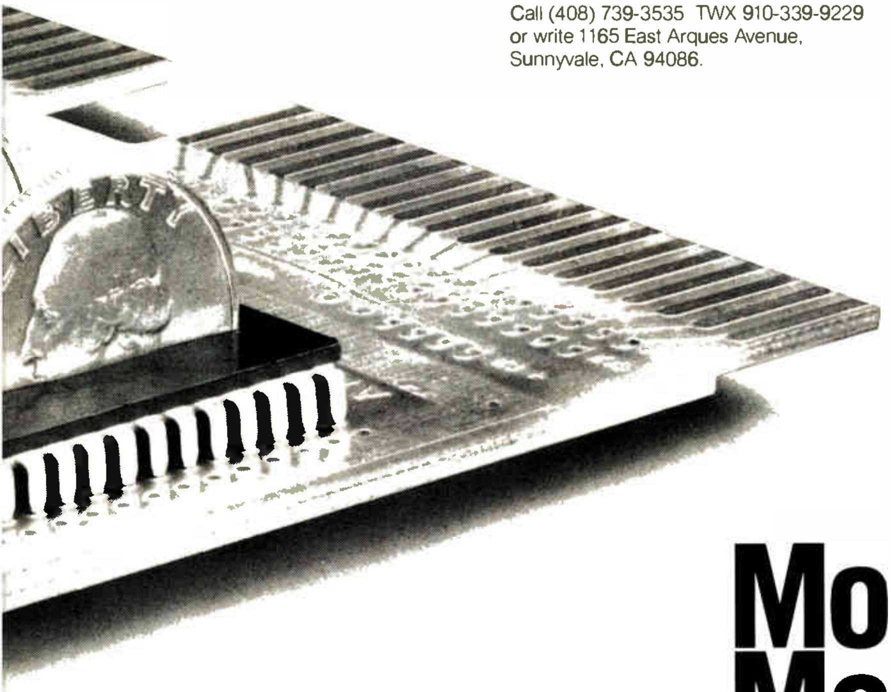

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F6852	SSDA, COMMUNICATIONS	F6854	AUTOMATIC DATA LINK CONTROLLER
F6840	PROGRAMMABLE TIMER		
Memory			
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F68316/317	2K x 8 ROM	F4027	4K, DYNAMIC RAM
F6810	128 x 8 RAM STATIC	F16K	16K, DYNAMIC RAM
F2102	1K x 1 RAM STATIC		
Interfaces			
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Coming Soon			
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House hearings set on British MLS charges

A House subcommittee will begin hearings Jan. 31 on British charges that the Federal Aviation Administration deliberately misled the International Civil Aviation Organization in order to get the ICAO to adopt a new U. S. microwave landing system instead of a competing UK system. The FAA rejects the British charges that it "totally misled" the ICAO by using "contrived" data on the time-reference scanning beam microwave landing system. **The TRSB/MLS has been proposed by the U. S. and Australia to the ICAO, which will decide at a Montreal meeting in April on adoption** of a new worldwide standard all-weather approach and landing guidance system. Rep. John Burton (D., Calif.) said his transportation subcommittee of the Government Operations Committee has scheduled hearings because "it is vital to explore this controversy now to clear the air, if you will, because American integrity is at stake."

Color TV imports rise despite cut in Japanese share . . .

America's color television imports rose 1.4% to a record 1.97 million units in the first nine months of last year, even though shipments from Japan declined as a result of its agreement with the U. S. to limit exports as of last July. **U. S. importers more than offset that 5.7% dip by shifting to supply sources in Korea, Taiwan, and Singapore.** But Japan remained the predominant foreign supplier, shipping 1.65 million sets through September, according to the Department of Commerce. The new figures show that total consumer imports reached $2.84 billion, 13.4% above 1976's record $2.51 billion for its first three quarters.

. . . as video, audio tape units show big gains

Video cassette recorder imports—almost exclusively from Japan—soared 104% to nearly $89 million in 1977's first three quarters, the largest percentage increase of any electronics product. Shipments of audio tape recorders, the largest import product category, **rose to a value of nearly $785 million, an increase of almost two thirds from the 1976 level.** Transceiver imports, primarily citizens' band radios, dropped sharply in the period—28.5% by value to $475 million and 10% by unit count to a total of 14 million.

JEDEC wants to speed standardization via teleconferencing

The Joint Electron Device Engineering Council wants the National Science Foundation to fund an 18-month experiment to use computer conferencing as a means of compressing the months-long process required to develop standards for microcomputers and large-scale integrated products, particularly microprocessors. A joint effort of the Electronic Industries Association and the National Electrical Manufacturers Association, **JEDEC wants to use the NSF-sponsored Electronic Information Exchange System with teleprinter display terminals to speed up meetings and data exchange** between members of the standards committee. John F. Hessman, a council staff member, says limited observation and participation in sessions would be accorded to such other interested groups as computer scientists, professional societies, trade associations, the U. S. military, and the trade press.

Baruch's plan for cooperative technology

The Commerce Department is moving to establish two new national centers this year at the National Bureau of Standards. If blessed by Congress in the forthcoming annual budget rites, they will be known as the Center for Industrial and Commercial Technology and the Center for International Technology. They are projects of Jordan Baruch, assistant secretary for science and technology, who is gaining a reputation as a bureaucratic mover and shaker at the department. If they work, they should help the bureau shed its good-for-nothing-but-statistics image.

The CICT proposes to help American industry upgrade its competitiveness in world markets by identifying technological problems and opportunities and then managing responsive collaborative projects. The international technology center's goal is to strengthen the U. S. position in foreign trade by promoting the economic and social well-being of less developed countries so they can become better U. S. trading partners.

Not another MITI

Those companies uncertain about the Commerce department's goal and suspicious of more Government interference in the private sector say the centers are reminiscent of Japan's powerful Ministry of International Trade and Industry. But the program's proposers are quick to reject that.

The first principle of the CICT will be that industry must want Government assistance in dealing with a problem of opportunity and ask for it. Industry must also take the first steps to define the problem and the approach to a solution. Unlike MITI, says one official, "this is not the case of the Government telling you that you need to solve your problems."

Indeed, the placement of the new centers within the NBS is considered a plus by those in the Department of Commerce who are pushing the concept. Since its creation by Congress more than 75 years ago, the standards bureau has functioned successfully with virtually no regulatory or enforcement powers. It is perceived by industry as a body with high credibility, objectivity, and freedom from biases.

A principal goal of the Center for Industrial and Commercial Technology will be to work with industries so they may become more efficient producers through refining what NBS calls infratechnologies—the basic knowledge and techniques and equipment that are commonly used for product design, procurement, and evaluation of manufacturing materials, controlling manufacturing processes, and product testing.

Semiconductor success

NBS has already demonstrated that such goals are achievable under its small but vigorous semiconductor technology programs used to resolve product measurement problems. Already it has come up with improvements in resistivity measurements, new wire-bonding procedures and controls, and better tests for thermal resistance, hot spots, and forward-biased breakdown that it says are quick, economical and nondestructive. The bureau has also developed new theory and procedures that improve both accuracy and precision in measurements of photomask line widths.

Baruch clearly believes NBS can make similar contributions to other segments of electronics and other high technologies. The department believes that industry typically underinvests in the development of infratechnologies. Moreover, it is not a field of interest in universities, which are searching for new breakthroughs and customarily subordinate their efforts to improve on old ones. Thus does the department justify the need for a new collaborative effort between industry and Government.

Call for support

But Jordan Baruch and Howard Sorrows of NBS, director designate for the National Centers for Cooperative Technology, still have a way to go before their concept becomes reality. Both want recommendations and questions from every quarter—industry, trade associations, industrial research institutes, and universities—about the operation of centers, particularly in this formative period, so they can function most effectively.

It is an opportunity that companies and their trade associations—distressed with past Federal inability to help them compete more effectively in the global marketplace—cannot afford to let pass. Effectively structured, the new Commerce Department program is one that might work and work well. But that will never happen without industry support from the outset.

Ray Connolly

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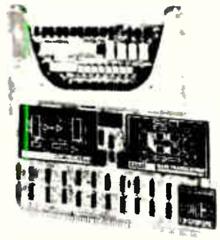

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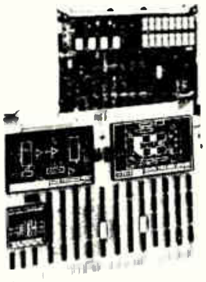

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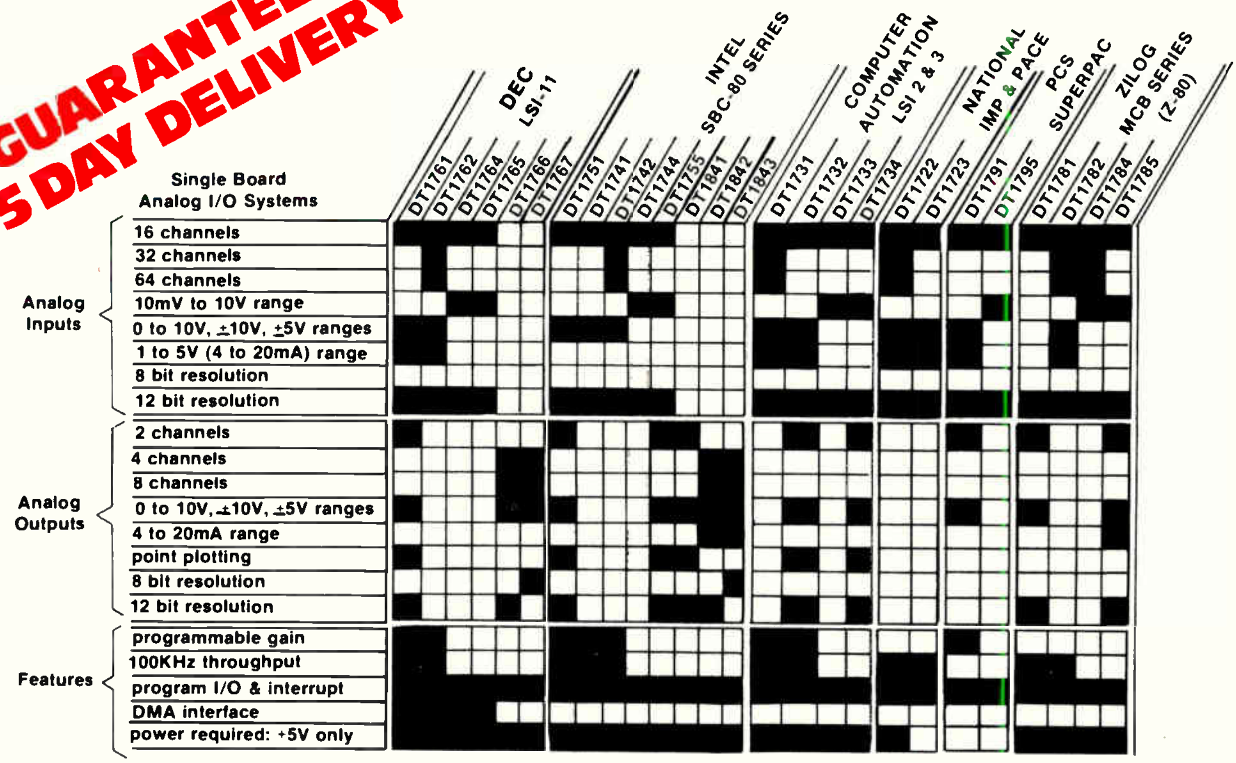

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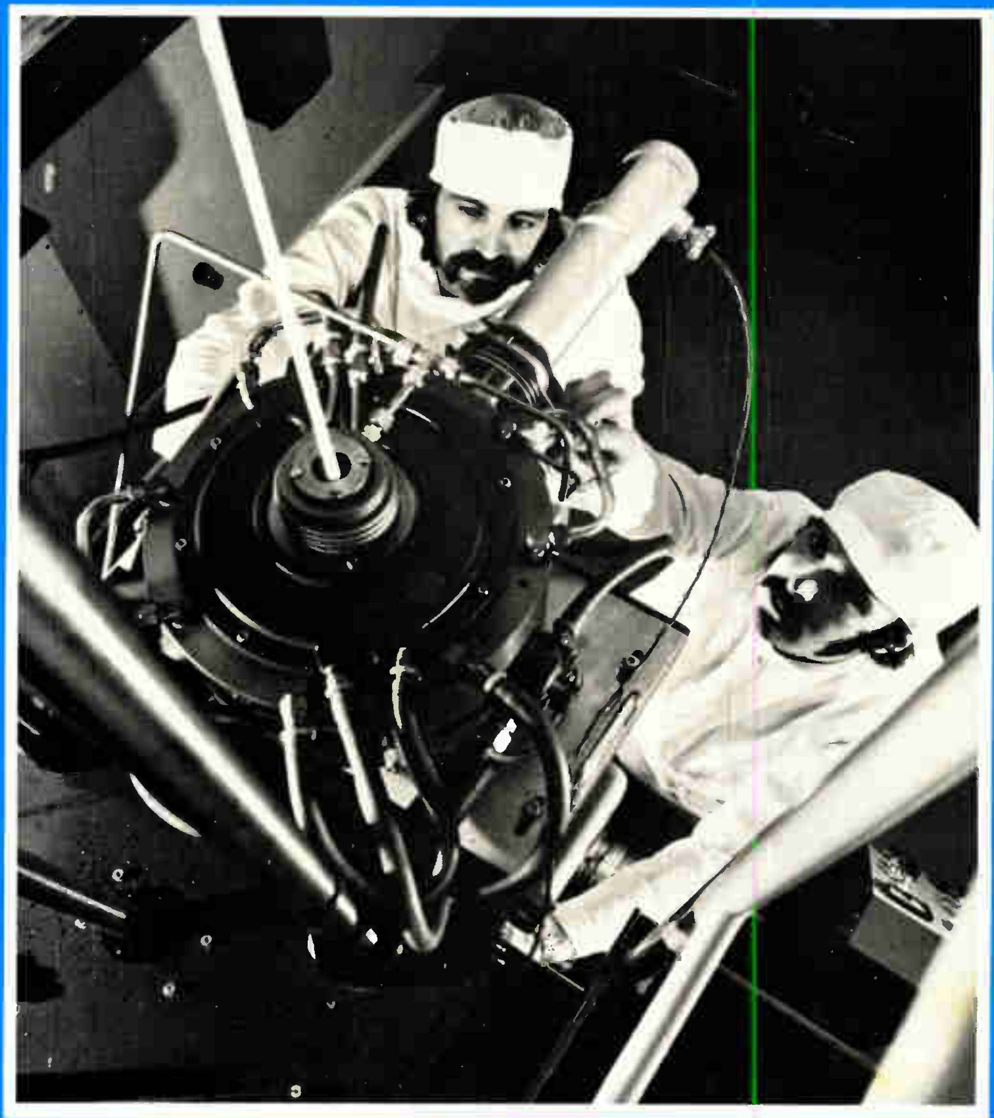
Electronics International®

Associative parallel processor on a chip due: page 7E



Optical-fiber production at STC and other British firms will grow, as the nation's electronics industries look for a good year: page 77

RCA first in CMOS.

First in CMOS microprocessors.

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Cost-effective COSMAC architecture. Since our CDP1802 CPU accepts compact 1-byte instructions, you need less memory. Registers store data with 1-byte access. And they act as pointers, so individual instructions don't need addresses.

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The RCA 1800 Microprocessor Family

CDP 1802	COSMAC CPU
CDP 1821S	1024x1 High-speed RAM
CDP 1822	256x4 Low-cost RAM
CDP 5101	256x4 Industry-standard RAM
CDP 1822S	256x4 High-speed RAM
CDP 1824	32x8 RAM
CDP 1831, 2	512x8 ROM (with or without latch)
CDP 1833, 4	1024x8 ROM (with or without latch)
CDP 1852	Byte I/O
CDP 1853	I/O decoder
CDP 1854	UART
CDP 1856, 7	Bus buffer/separators
CDP 1858, 9	Address latch/decoders
CDP 1861	TV interface
	Coming in 1978
CDP 1823S	128x8 High-speed RAM
CDP 1851	Programmable I/O
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And these major parts: 4K RAM, 4K EPROM, 1-chip COSMAC microcomputers—all in CMOS.

When you say CMOS, say RCA first.

RCA

UK firm readies speech-interpolation gear for satellite tests

Digital speech-interpolation equipment, which can double a communications satellite's traffic capacity by seizing and relocating channels during conversational pauses, will be installed at the UK satellite ground station at Goonhilly in time for April trials of the international time-division multiple-access satellite communications system [*Electronics*, Jan. 5, p. 47]. **The 120-megabit-per-second equipment uses an array of five Texas Instruments 9900 16-bit microprocessors to monitor satellite channels and incoming ground lines and allocate speech signals to unassigned satellite channels.** Two processors assign satellite transmit and receive channels, and the others are in the operator console, the communications signaling system, and the communications signaling channel. Cambridge Consultants Ltd. of Bar Hill, Cambridge, is developing the gear under a $216,000 British Post Office contract.

Matsushita to offer bipolar chip for VIR color control

An IC that uses the incoming vertical-interval-reference signal to control color saturation accurately will soon appear in Japanese television sets. The Matsushita Electronics Co. device will be in Panasonic sets from parent Matsushita and Quasar sets from its U. S. subsidiary and will be sold to other manufacturers. **The 3.2-by-2.9-mm bipolar chips has 481 elements arranged in both linear and digital circuits. It requires only about 60 peripheral parts and needs no assembly-line adjustments.** The first-generation VIR color-control circuit developed and used by GE in the U. S. has about 180 parts, including five ICs and 30 transistors, and needs production adjustments. Shipments of samples are beginning, with Japanese quantity prices slated to be between $2.50 and $2.90.

West Germany hikes electronics role in U. S. by 20%

For West Germany's electrical and electronics industries, the U. S. market turned out to be the most attractive for investments last year. By mid-1977, the industry's total outlays in the U. S. had jumped to nearly $330 million, up from $250 million 12 months before. **This 32% increase compares with a rise of about 11% for total foreign investments by the country's electrical/electronics sector.** Among the prime reasons for the American market's attractiveness, says the Frankfurt-based Electrotechnical Industry Association, are the higher value the Deutschemark has attained against the dollar in recent years, the somewhat lower wages in the U. S., and that country's economic and political stability.

ICL is readying data processor with associative memory

Coming up from England's International Computers Ltd.: a data-base processor with a content-addressable memory for telephone directory use and similar applications. Final British Post Office directory trials on ICL's content-addressable file-store system should be complete within a year. Then the computer giant plans to market the system as a data-base processor. **Designed for simultaneously searching a number of files without involving the central processor, CAFS reportedly comprises an array of parallel processors linked to a disk subsystem,** each processor searching its disk sector for matches for content rather than address. Information retrieval systems so engineered offer low costs with fast response. Because CAFS is content-addressable, telephone inquiries giving only a part of a name, address, or location will call up a list of candidates.

International newsletter

BPO sees Viewdata serving users for message interchange

A service allowing persons to interchange typed messages over a television set and a linked keyboard will become a regular feature of the British Post Office's Viewdata service before the end of the year. Intended primarily for the deaf, the service will be in time for the later stage of the 1,000-set market trial due to start this June. The messages are typed on a full alphanumeric keyboard, instead of the usual simple numeric Viewdata keyboard. They appear in the top half of the screen, with the reply in the bottom. When either half fills, new space is automatically allocated by erasing earlier sentences. The BPO also is exploring other message-switching applications. **Fitted with a low-cost hard-copy printer and additional controls, the service has obvious commercial attractions as an extension of Telex service.** Viewdata will be a vast computerized data bank that users can interrogate through the telephone network and a domestic TV receiver fitted with a suitable decoder. It is compatible with the more limited Teletext news and information service broadcast by the BBC and the Independent Broadcasting Authority.

Cable TV plans to cover 80% of Viennese viewers

Vienna is on its way to becoming a "wired city," what with some 450,000 households in the Austrian capital slated to be tied to a cable-TV network within the next eight years. Financing and carrying out the $140 million cable-laying project will be a newly formed company, 95% owned by Philips AG, the Austrian subsidiary of Philips Gloeilampenfabrieken of the Netherlands, and 5% belonging to the city. **Work on the project will begin this year, as will pilot programs in a sector in the city's outskirts.** Starting in 1979, about 65,000 households a year will be hooked to the system, so that by 1985 more than 80% of Vienna's populace will have cable TV. The system will enable a sizable percentage of Austrians in the eastern part of the country to receive programs from West Germany and Switzerland.

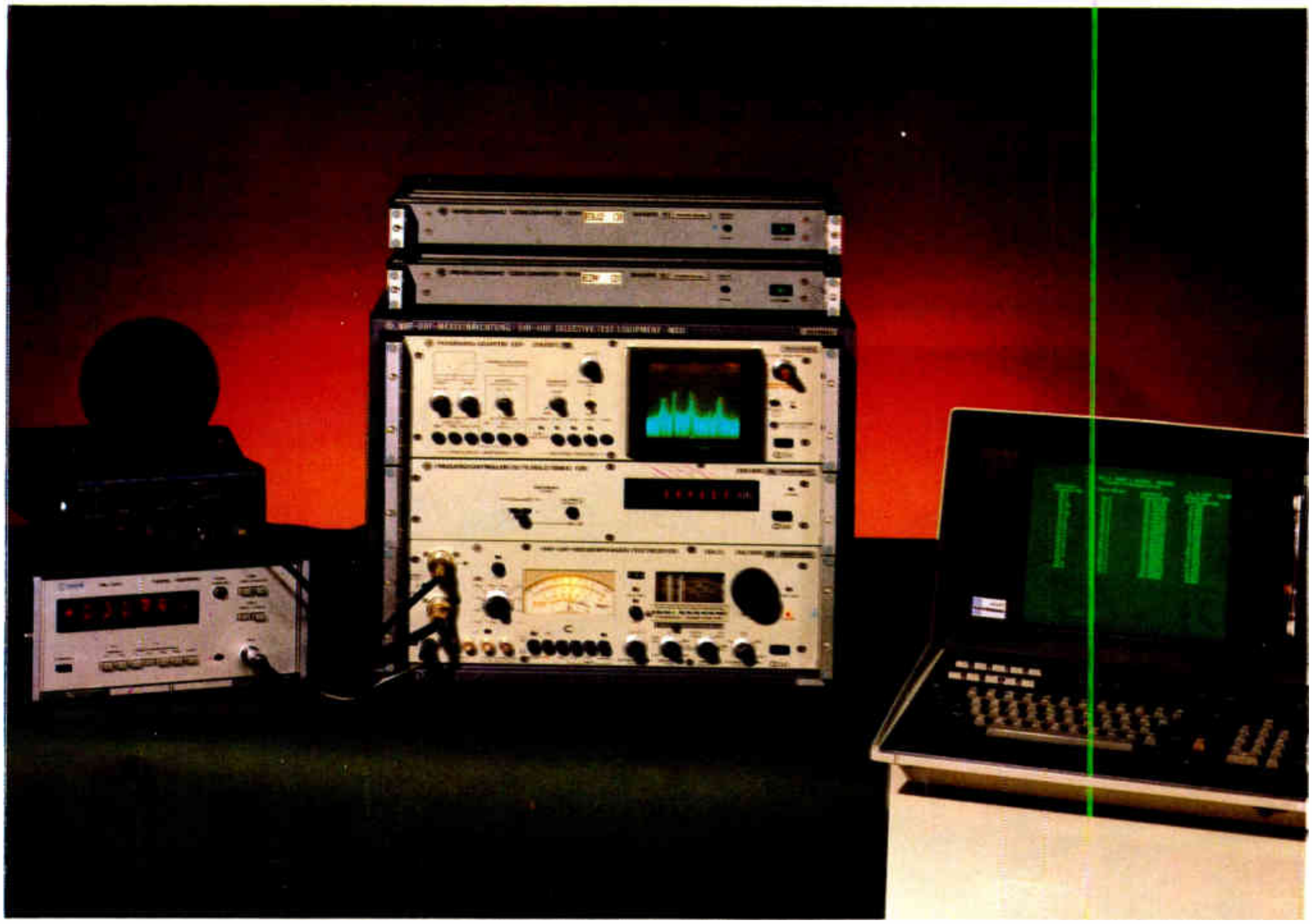
German train riders can direct-dial telephone calls

The West German Federal Railways, always known to go all out for electronic techniques to improve its services, has started something new: push-button, direct-dial telephone service from its intercity high-speed trains and its Trans-European-Express trains. The new service, begun Jan. 1, replaces a procedure whereby a railway employee had to call an operator at a nearby station to connect the caller to the wanted party. **The radio-telephone gear implementing the service comes from TE-KA-DE, a Nuremberg-based communications-equipment producer partly owned by Philips.** The service may be expanded to other types of trains. The Federal Railways also is improving the network with more trackside antennas for the radiophone signals. The move enables passengers to place calls from areas where good connections were impossible because of the topography.

Switzerland updating its TV transmitters

Swiss postal authorities have chosen West Germany's Rohde & Schwarz to supply 22 television transmitters to update the country's older TV stations operating in the very-high-frequency range. The transmitters, model NT314, **are completely solid-state except for the power tube.** They will be furnished with power outputs of 500 W and 1 kW and will be hooked into dual configurations, with one unit acting as a standby. Rohde & Schwarz has not disclosed the amount the contract is worth.

Calculator controls measuring of radio signals and interference



Automated VHF-UHF measuring setup for 25 through 1000 MHz controlled over IEC interface bus from Tektronix desktop calculator 4051. Interactive programs for essential applications plus basic software for producing user programs. Numeric and graphic display of results on storage screen.

The **VHF-UHF selective test equipment MSU** with test receiver ESU 2, frequency controller and panoramic adapter meets the needs of automated and manual measurement of radio signals and interference, of lab assignments and monitoring tasks.

The **calculator 4051** governs the operating, measuring and checking routines, makes computations and produces test readouts and diagrams on its screen.

Interactive programs for primary applications:

- radiomonitoring with level measurement and – for the first time – remote frequency measurement (using a frequency counter) acc. to CCIR Report 272-3
- search program for detecting signals
- measuring signal and interfering field strength with results allowing for antenna factors
- measuring interference to MIL specs and VG standards
- measuring radio-interference in line with CISPR and VDE (calculator-controlled for the first time)
- lab chores: measuring two-port attenuation and gain, harmonics and intermodulation

For more information quote
ESU 2 calculator-controlled

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We have a range of comparators which includes the fastest available in the world. Also from Plessey Semiconductors are ECL 10K and ECL III circuits plus Sub-Nanosecond ECL.

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ECL Logic Families

	Features
SP1600 Series 22 products	Standard second-source of Motorola MC1600 Series.
SP10100 Series 36 products	Standard second-source of Motorola MC10100 Series.
SP10200 Series 26 products	Typically 40% faster than standard SP10100.
SP10500 Series 17 products	Full military version of SP10100 Series.
Sub-Nano-second ECL 3 products	SP16F60 – 0.5nS Delay SP10F131 – 650MHz Clock Rate SP10S131 – 350MHz Clock Rate

Comparators

This range is expanding and includes *the fastest comparator in the world*–SP9685, a single latched comparator with I/P's and O/P's ECL compatible and offering the following performance:

Minimum Set-Up Time	1nS (max.)
Propagation Delay	2nS (max.)
Input Offset	±5mV

This device is pin-compatible with the AM685 but is 3 *times faster.*

The SP750B is a fast latched comparator with additional features to give minimum device count in ultra-fast A–D converters for high speed signal processing in video and radar systems.

A/D performance achievable by using the SP750B can be:
4 bit, 100 Megasamples/Sec.
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Circle 180

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Whatever your requirement Plessey Semiconductors has a team who will understand your problem, know how to tackle it and provide the necessary capability.

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Because our products are subject to mil. type test procedures and quality control, our quality and reliability are of the highest order.

Examples of our capability include the most comprehensive range of standard TV circuits, the world's most advanced TV tuning system and the new Surface Acoustic Wave technology for producing at low cost and in high volume TV IF filters.

If you want top quality consumer ICs in large or small quantities we can supply them.

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Radio Communications

No one supplier can match the Plessey Semiconductors range of ICs *specifically designed* for low power hand-held and mobile radio.

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SL660, SL664, SL665.
These are IF circuits purpose designed for narrow band FM. Power consumption is only 1.5 mA at 6V.
They have low external component count and feature adjustable squelch for different signal to noise ratios. They are ideal for low power IF/AF, narrow band FM and hand held and mobile radio.

Designed for use as complete IF amplifiers, detectors and squelch systems. They use both phase lock loop and quadrature demodulators. They can be used for Narrow Band FM applications with input frequencies up to 25MHz and deviations up to 10 KHz. The squelch systems detect carrier squelch and can be adjusted to operate at the required signal-to-noise ratio.

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We have a complete range of Prescalers and 2 modulus Dividers purpose designed for mobile radio.

All have extremely low power consumption, are ideal for VHF/UHF operation and have TTL/CMOS compatability.

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The SP8690 can be programmed to divide by 10 or 11 which allows effective programmable division at VHF.
The frequency of operation is 200 MHz and power consumption only 70 mW typical.

Circle 183

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Circle 218 on reader service card

Associative processor on a chip due from British laboratory

Design will use I²L process; one masking operation will also give a two-chip version for assembling big processors

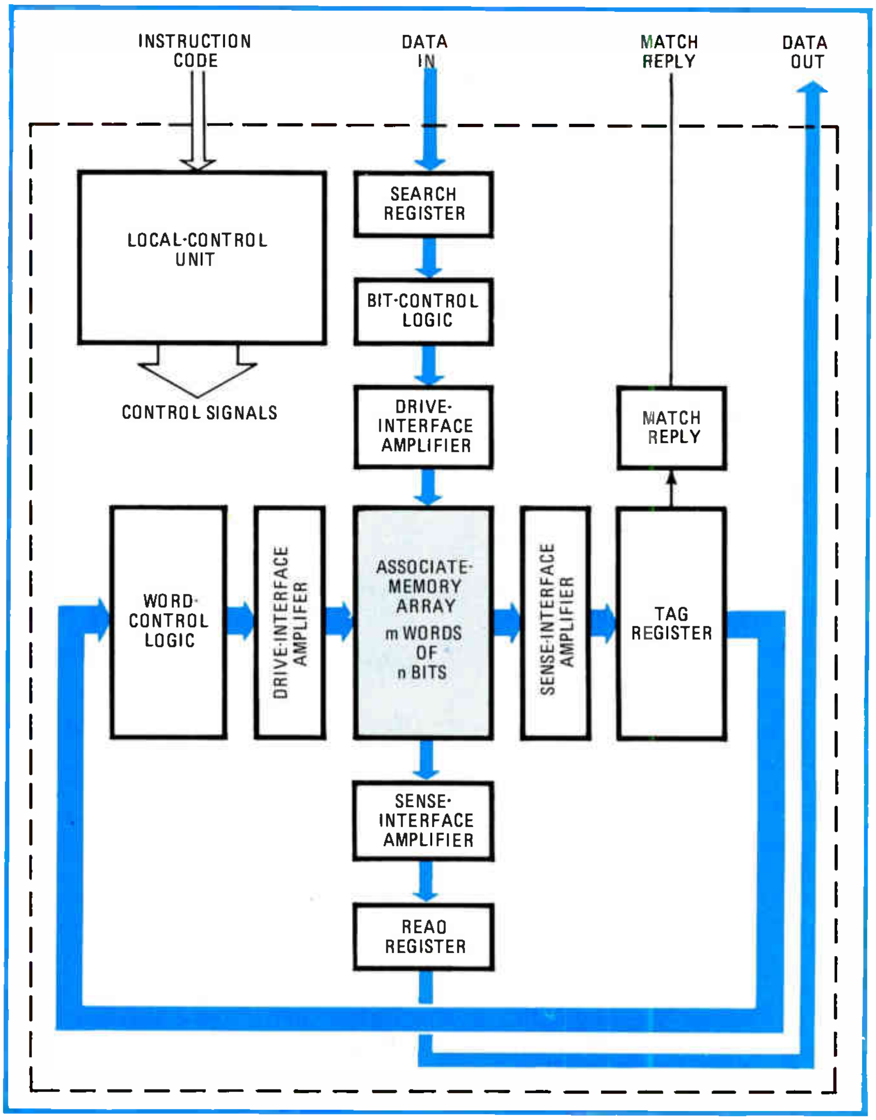
Retrieving data from memories by identifying its content, rather than by calling its addresses, has a lot of appeal for computer-system designers. Coupling such a content-addressable memory with a control processor can speed operations on texts and numbers. The memory performs parallel operations on data sets under control of the serial processor. In particular, microcomputer-sized processors with mainframe speeds would be attractive in information retrieval systems and as text compression devices in archival text-oriented storage.

But the additional complexity of the associative memory and related control logic has meant that few hardware components have appeared. For example, every bit cell has associated logic that compares its contents with the corresponding bit in the word calling up the data.

One designer wrestling the problem is R. M. Lea of the electrical engineering and electronics department at Brunel University, Uxbridge, England. Among other advances in the past five years, he has managed to simplify his speedy associative-memory design by reducing the gates per bit from 14 to 6.

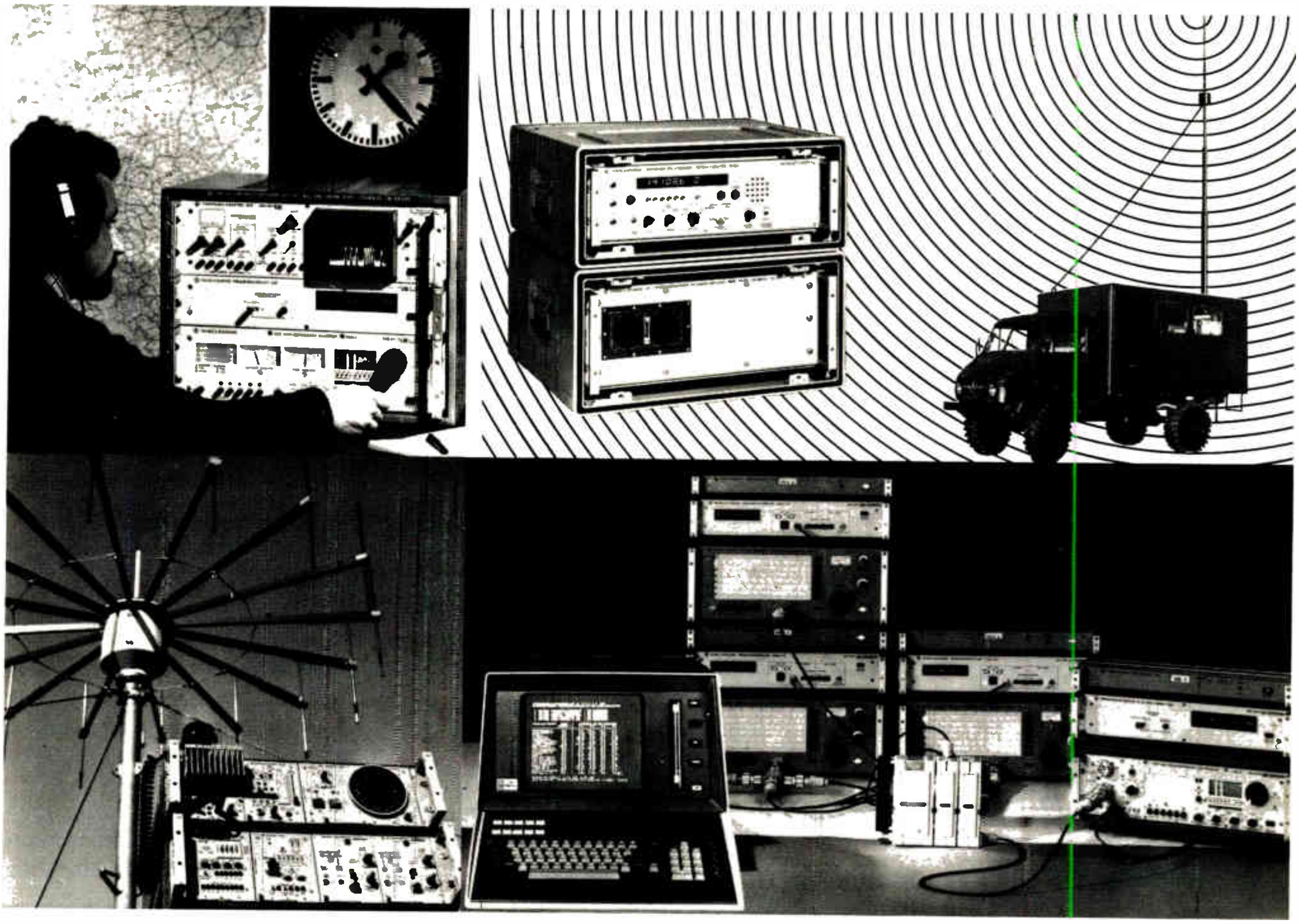
Now Lea plans to fabricate a complete associative processor on a chip, incorporating a small content-addressable memory and the necessary microprocessor control logic to perform search-modify-write and search-modify-read operations in less than 200 nanoseconds [*Electronics*, Jan 5 p. 75]. Key to this is a high-density integrated-injection-logic process from Plessey.

As a byproduct of this development, he is also laying out two building-block chips that will be used to



Associative power. One-chip prototype of an associative parallel processor will include memory and control logic. It will be built with Plessey's proprietary I²L process.

Radio communication, location and measurement



Everything from a single source for AF through SHF: equipment and systems of the highest quality and precision, featuring up-to-date technology, for stationary or mobile use, in line with international standards, and also for adverse climates. Furthermore: system planning, training, documentation and servicing. Examples:

Radio-detection receiving system (top left) for 25 through 1000 MHz. Broadband and IF panoramic display, remotely controllable. Connection of slave receivers and recording apparatus.

Transmitter/receiver system (top right) for telephony (A3J), telegraphy (A1) and RTTY (F1) from 1.5 to 30 MHz. Continuous transmitting power 100 W. Automatic antenna tuning with muting (no RF radiation) on rod, whip, longwire and broadband antennas; on any antenna without matching for emergency operation. Maximum availability through built-in microcomputer test device and modular design, line- or battery-powered.

VHF-UHF Doppler direction finder (bottom left) for aeronautical and marine radio. Compact system with antenna diameter of only 3.3 m also suitable for rooftops and mobile applications.

Computer-controlled RF test assembly (bottom right) for 25 to 1000 MHz for automatically measuring intermodulation rejection acc. to DIN 45004 and method K, cross-modulation acc. to method B and intermodulation by the difference-tone technique, plus gain and frequency response.

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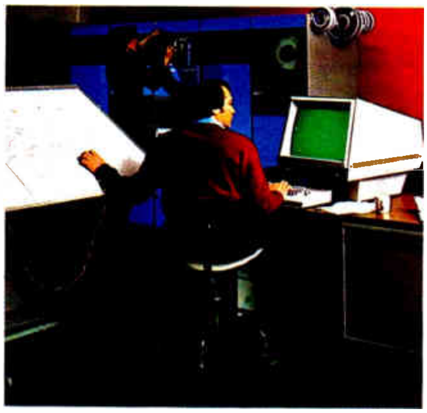

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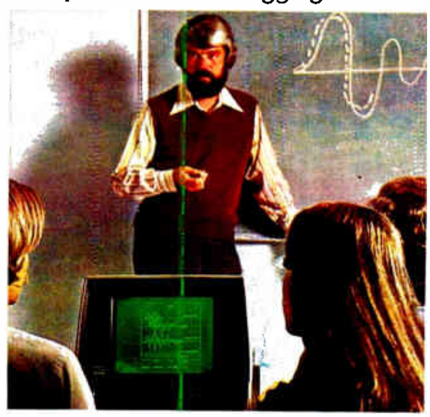

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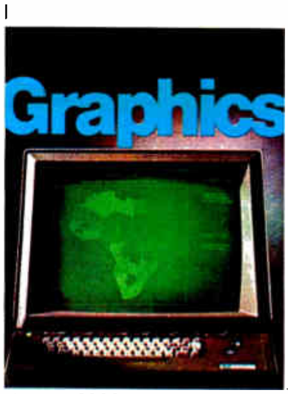

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It has a switching capacity of 10 VA max. and a guaranteed life of 100 million operations at signal level loads, and 5 million operations at rated loads.
Designed primarily for industrial and telecommunications use, the CUP (Clare Universal Package) relay is available in a CUPS open version, a CUPC version with cover and a CUPP version which is covered and potted to give a 2kV breakdown voltage.
It is available in contact configurations ranging from one to five poles with normally open and/or closed contacts.

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GENERAL INSTRUMENT CORPORATION

drain configuration. The depth of the diffusion at the contacts is more than 1 μm, but at the active regions it is less than 1 μm. □

West Germany

Auto seat control remembers positions

Yet another automotive control function where an electronic unit might displace a mechanical setup is seat positioning. Under development by two West German firms, a programmable system will provide as many as four adjustments of the seat, with the push of a button.

The system, from Robert Bosch GmbH and Keiper Automobiltechnik, is fairly simple. The driver adjusts the seat for the position he (or she) finds most comfortable. He does this by manipulating a joystick controlling either three or four small electric motors in the seat frame. When the driver has found the position he wants, he pushes a button on an electronic control unit. This action feeds the position values, picked off each motor's spindle potentiometer and then digitized, into a digital memory in the control unit for permanent storage.

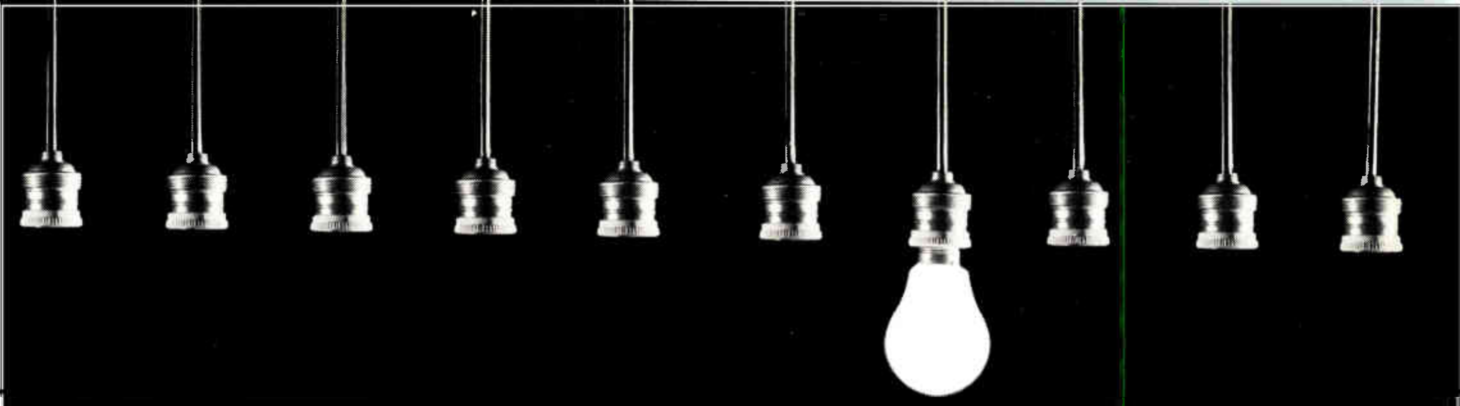
Another driver in the same car would go through the same procedure and feed the values corresponding to his most comfortable position into the memory. In this way, two or more seating positions are stored.

Return. To recall his position, the driver pushes his button. It kicks in relays applying power to the motors, which adjust the seat until the values stored in the memory are reached.

The position values are retained as long as the control unit is supplied with power from the car's battery. If the battery is disconnected—during servicing, say—the memory will lose its contents.

The Bosch/Keiper system will probably come in two versions: one with three control motors for backrest and height adjustments as well as for fore and aft positioning, and the other with an additional motor, which will tilt the seat surface. Since the system is still in development, some technical details are not available. The firm is likely to use a standard metal-oxide-semiconductor random-access memory.

Cost. Nor are cost figures available, but a Bosch spokesman concedes that the system will not come at bargain prices, what with three or four motors needed for seat control. The Stuttgart-based firm thinks that automatic adjustment will prove to be a safety factor, since many drivers neglect to adjust the seat until the vehicle is under way. □



Cut your power bills by a factor of 10

...with THOMSON-CSF's silicon-target vidicons!

Why continue burning up those kilowatts when, by replacing your conventional vidicons with THOMSON-CSF's silicon-target vidicons, you can reduce your lighting requirements by up to 10 times?
THOMSON-CSF can deliver ... from stock... 1" silicon-target vidicons that feature low blooming, burn-resistance, and a spectral sensitivity that extends out to the near infrared. Available tubes include direct plug-in replacements for some of the more commonly encountered standard vidicons.

Where direct replacement is not possible, conversion is usually only a matter of ten minutes work for the average qualified laboratory technician (if in doubt, please specify the camera, and the tube to be replaced, when ordering, and we will be pleased to indicate if, and where any modifications are required). Tubes are available in 160, 130 and 100 mm lengths, the last type featuring integral focusing and deflection coils. Ruggedized versions are available for severe environmental conditions.

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You'll find everything you need to feed your powerful mini systems, in a T1000 configuration. These are not only our most advanced, most flexible tape transports produced today—they're built by Pertec to fit tomorrow's data processing applications to a T.

Ask for 6250 bpi GCR. In addition to dual NRZI/PE modes available, T1000 drives offer OEMs the only Group-Coded Recording at 125 ips—*with* a vacuum capstan to protect high-speed operations with a friction-free instant grip, for safer fast starts and stops.

Ask for operational convenience. T1000 makes life easier for your customers: *with* cartridge auto-load, automatic threading, and automatic load point seek. *With* a built-in daisy-chain capability. *With* front access to all electronics to simplify maintenance.

Ask for internal data formatting. Intelligence can be built into T1000 NRZI/PE configurations (as well as our tension-arm 7" reel FT7000 and 10½" reel FT8000, and our 37.5-to-75 ips FT9000 vacuum column series). Pertec is now installing our Microformatter inside these units, on order, to simplify interfacing, and reduce system costs.

Now complete the picture: ask for Pertec. Making it still tougher on the competition, our broad line of tape transports covers the full spectrum of OEM requirements. With the same total commitment backing T1000: Pertec, the world's largest independent manufacturer of peripheral equipment, backs *all* its products with the international sales, support and service operations of Pertec Computer Corporation.

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☐ Send pricing information as indicated on the RFQ below (no obligation or cost).

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Circle 226 on reader service card

Self-calibration is built into 3½-digit multimeter

by John Gosch, Frankfurt bureau manager

Five-function instrument marketed by German firm carries $250 price tag, measures currents to 10 A

A wide current range, a built-in calibration facility, and line-power-independent operation—all in a moderately priced instrument—are the prime features of a 3½-digit, five-function multimeter that West Germany's Kontron Elektronik GmbH is putting on the market.

Designed and now being produced for Kontron at Israel's Tabor, a Haifa-based electronics company partly owned by the West German firm, the DMM3020 carries a basic price tag of $250. That buys a digital multimeter capable of measuring ac and dc currents up to 10 A. "Most other DMMs in this price range get up to only 2 A," says Dieter Hirschmann, product manager for digital instruments at Kontron. The 3020's wide current range—from 0.2 mA to 10 A—makes the instrument suitable for measurements not only in electronics but also in power engineering. Basically, the 3020 is accurate to within 0.1% of measured value.

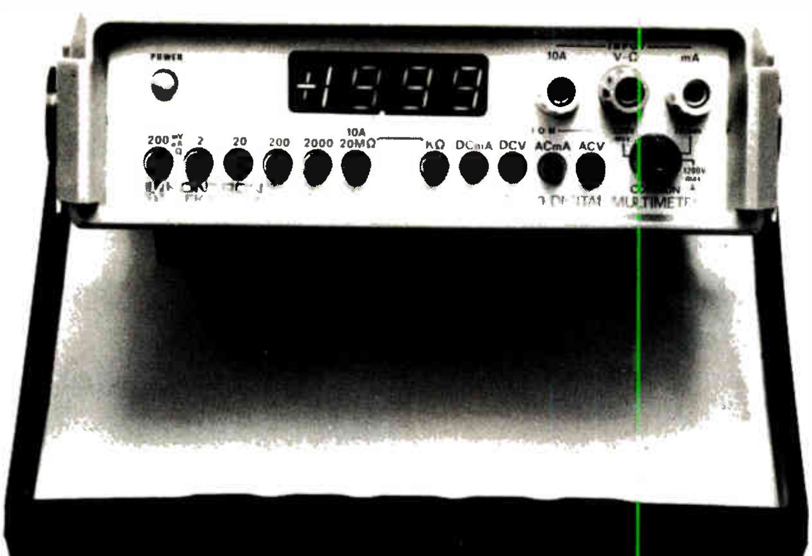
Rarely found on digital multimeters of the 3020's price class, Hirschmann adds, is its built-in calibrator, which uses a special reference source in the instrument. With only three internal trimmers and several push buttons on the front panel, the user can check and recalibrate the instrument without the need for any external devices. A complete checkout, done according to a table on the bottom cover, takes no more than two minutes. It includes not only a check of the voltage-, current-, and resistance-measuring circuits but also a segment test of the light-emitting-diode display and a check of the optional rechargeable batteries.

The battery option is available on a model that sells for an extra $17, or $267. The built-in nickel-cadmium batteries are rechargeable by the instrument's internal power supply. The batteries are four size D units that provide eight hours of operation after a complete charge cycle without the instrument's being connected to the power line.

Another option, this one available on the C version of the 3020, is a built-in, fully parallel binary-coded-decimal output. This option enables the user to make a permanent record of measurements on a digital data printer or to feed the results to a computer or to peripheral equipment. The DMM3020C is priced at $313.

All 3020 models take voltage, current, and resistance measurements in 28 ranges. Dc and ac voltages are measured in five ranges from 0.2 to 1,200 V with a maximum resolution of 100 μV. The ac and dc currents are measured in six ranges with a maximum resolution of 100 nA. The instrument has six ranges for resistance measurements—from 200 Ω to 20 MΩ, with 100 mΩ the maximum resolution.

Well protected against transients and overloads, the 3020 can withstand up to ±1,200 V in any voltage range. The current ranges (except those for 10 A) are protected by a 2-A wire fuse. The 10-A ranges withstand inputs up to 15 A. All resist-



News from Philips

Integrated circuits • Semiconductors • Electron tubes • Components • Assemblies • Materials

HIGH PERFORMANCE JFET OP-AMPS

Signetics' new series of high performance operational amplifiers types LF355/355A/356A/357/357A are commercial temperature range versions of industrial versions LF255/256/257 and military versions LF155/156/157/A and employ the same well matched JFET input structures on the same chip with bipolar transistors.
Designed for use over the temperature range 0 to + 70 °C, these amplifiers feature low input bias and offset currents of 30 pA and 3 pA, respectively. The input offset voltage is low, being only 3 mV (1 mV for the "A" versions) with a drift of only 5 μV/°C (3 μV/°C for the "A" versions). The devices are also designed for a high slew rate (50 V/μs for the LF357/357A), wide bandwidth up to 20 MHz, and extremely fast settling time (1,5 μs for some types). Low noise is also a feature of the new op-amps, being as low as 12 nA/√Hz in some cases.
Intended for use with a supply voltage of ± 15 V, a low supply current of only 2 mA (typical) is required for the LM355/355A, and 5 mA for the other types.

Circle 271 on reader service card

ORGAN IC CUTS COMPONENT COUNT

The TDA1008 gating/frequency divider for electronic musical instruments is a monolithic bipolar integrated circuit based on I²L, with frequency dividers directly coupled to the gating matrix. In electronic organs using a top octave synthesizer directly coupled to twelve TDA1008s, only one busbar per manual is needed to obtain five octave-related tones per key.
In addition to simplification of key contact construction and tone generator designs, features like sustain and percussion can be obtained by adding only a few resistors and capacitors. Overall component count is reduced, with consequent greater reliability and easier servicing.
In the TDA1008, the outputs of the dividers, together with the input signal, are applied internally to nine gate inputs. By activating a key input, five successive signals out of the nine are selected and transferred to the outputs. Five key inputs are available, each selecting a different combination. The output voltage is proportional to the voltage on the key inputs; this output voltage has no d.c. component, so clicks and plops will never occur.

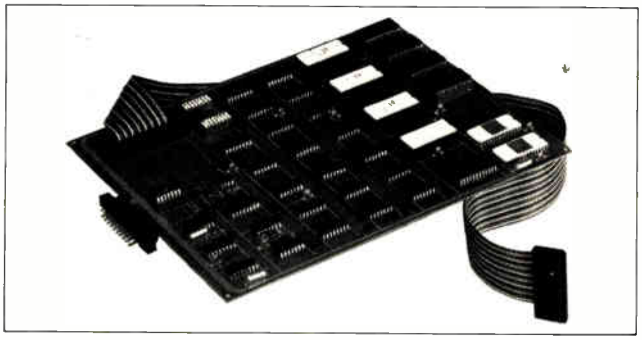
Circle 268 on reader service card

DUAL TRACKING VOLTAGE REGULATORS WITHOUT FRILLS

Where dual power supplies must track to close tolerance, the Signetics 5551 family of dual tracking voltage regulators provide high performance on-card regulation. Designed to produce continuously adjustable balanced or unbalanced output voltages from 5 V to 20 V with up to 300 mA output current, the 5551 family employ current limiting and thermal shutdown protection on the chip. Input voltage may be as high as ± 32 V.
Both regulators are differential amplifiers followed by a gain stage and a Darlington with current limit. The negative regulator is the complement of the positive with the exception that the output stage is a compound p-n-p and a zener controlled current source is used as reference with a forward biased diode for temperature compensation. The voltage dividers around the zener set the actual reference to 5 V and allow positive and negative output voltages to be programmed conveniently. The resistor values obtained with different mask options enable standard fixed voltages to be obtained: ± 5, ± 6, ± 12, ± 15 and + 5, − 12 V. These can be made continuously variable by means of external balance and control potentiometers.
Tolerance on output voltage is 5%, with regulation 1%. The temperature coefficient is 65 ppm/°C, and the noise is 55 μVrms between 10 HZ and 10 kHz. Intended for use on op-amp supplies, analogue signal processors, MOS/LSI systems, sense amplifier supplies and communications circuits, the 5551 family is designed to provide a customer with a device intended for his needs without including costly redundant features.

Circle 270 on reader service card

2-CHIP MICROCOMPUTER FOR COST-EFFECTIVE PROFESSIONAL USE



Signetics' 2650 8-bit N-MOS microprocessor and the new 2656 system memory interface (SMI) chip provide a 2-chip microcomputer with 2048 x 8 bits of ROM, 128 x 8 bits of RAM, an 8-bit input/output port, and an on-chip clock generator.
The programmable features of the new 2656 SMI are numerous. The individual pins of the 8-bit I/O port can be input, output, or generate chip enable signals for larger systems with more ROM, RAM and I/O. The RAM area may overlap the ROM area if the address overlap is intentionally mask programmed. The RAM can be disabled by a mask option. Both the ROM and RAM base addresses are mask programmable over the entire μP address range. The 2656 also features clock circuitry with crystal, RC, or external timing source. System power-on reset output pulses are also provided.
The 2656 is supplied in a 40-pin dual-in-line package and it requires only a +5 V supply, like the 2650 microprocessor. All signals are TTL compatible.
For microcomputer applications where space is at a premium and yet flexibility is required, the combination of the 2650 and the 2656 can prove most cost-effective.
For prototyping purposes, Signetics has introduced the 2650PC4000 2656 emulator board. A 40-pin DIL connector at the end of a 60 cm cable fits into the 2656 socket of the final system. 2656 ROM and PGA (programmable gate array) patterns can be implemented on and tested with the PC4000 board.

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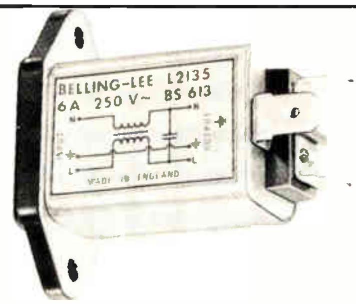

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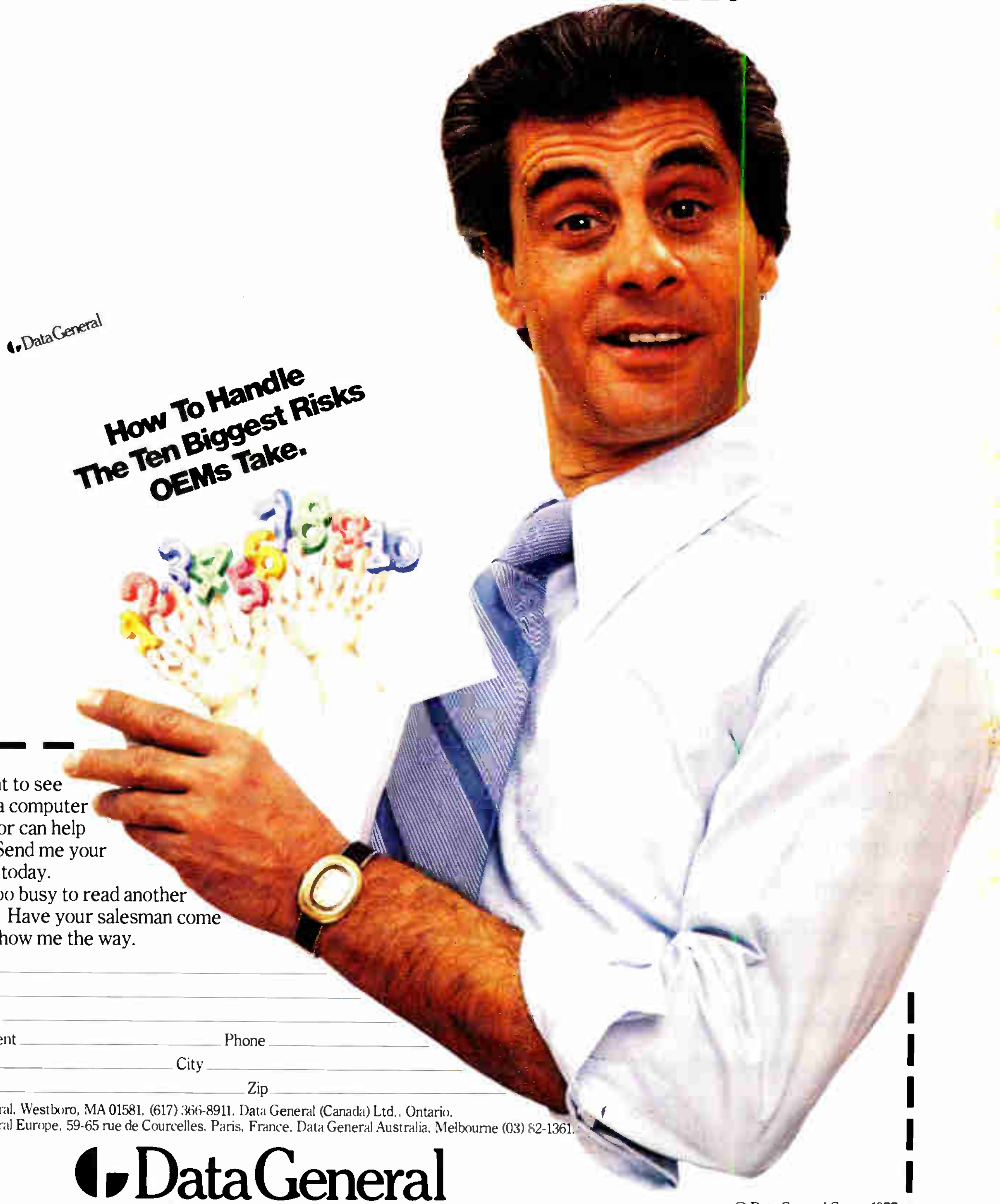

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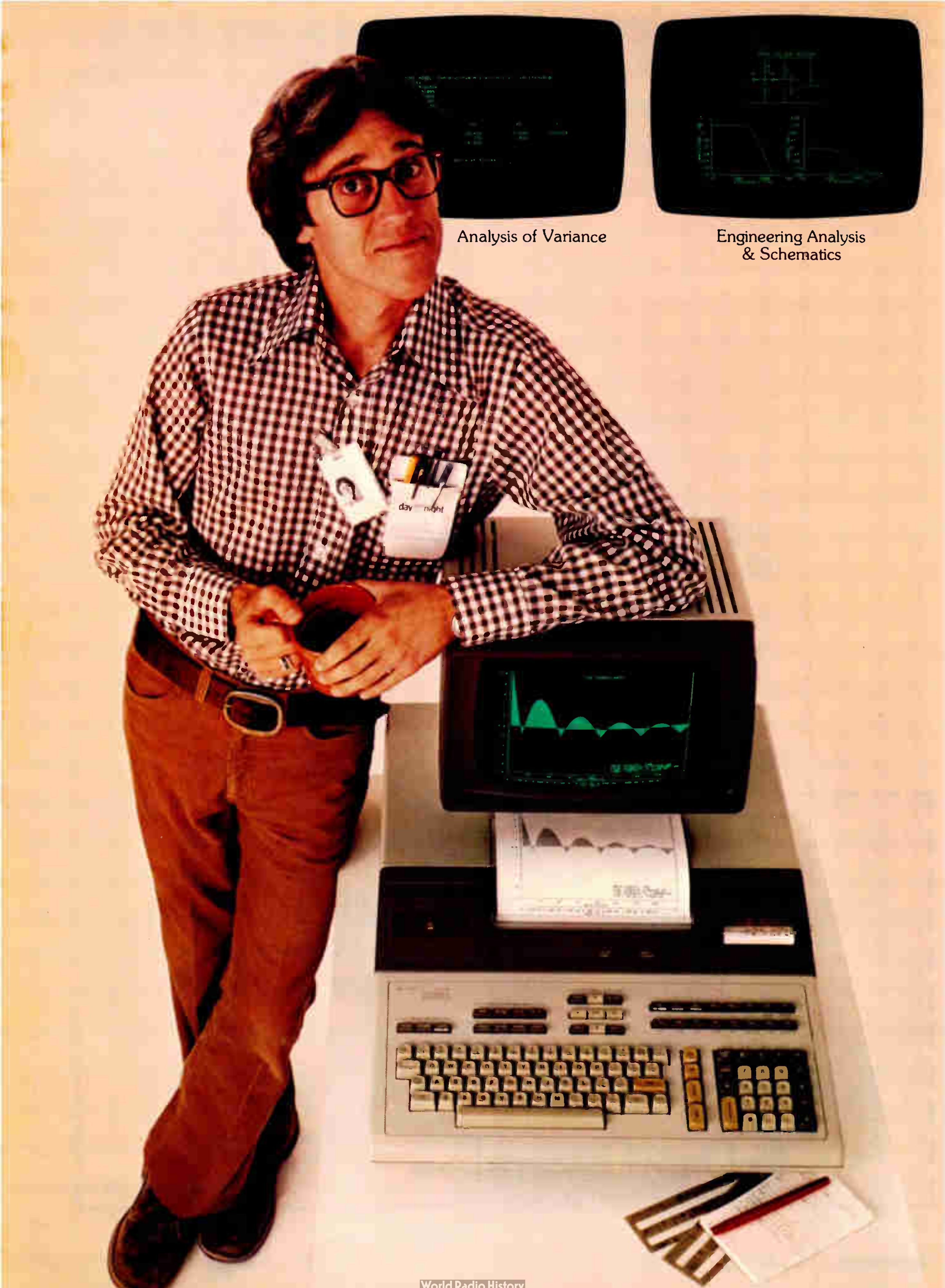

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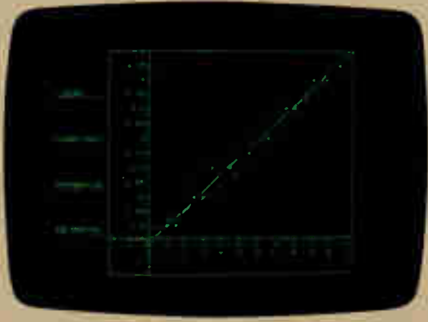

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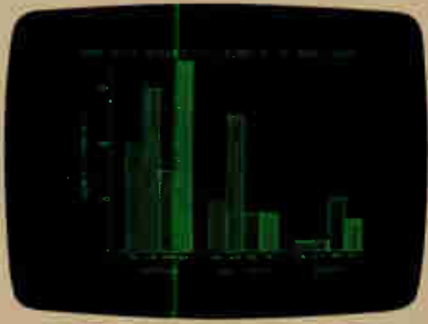

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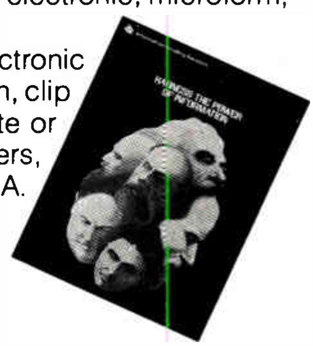

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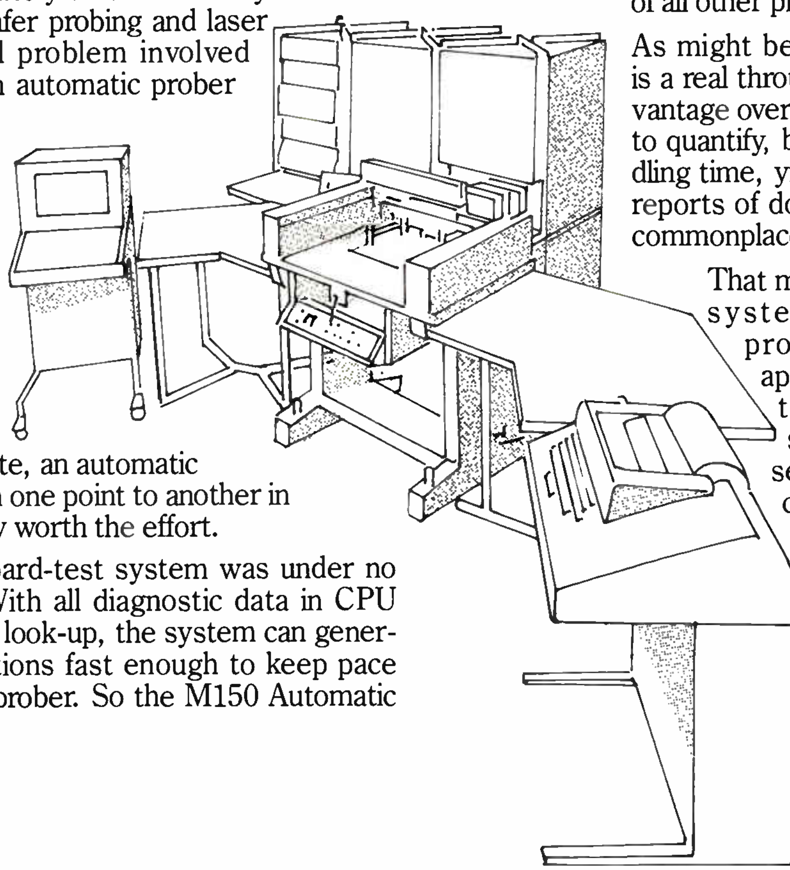
Automatic circuit-board probing

Avoiding potholes on the road to higher throughput.

Ever since Teradyne introduced the concept of "guided probing" to circuit-board testing in 1972, anyone who thought about the subject could see that guided probing, for all its obvious benefits, was only a way station on the road to automatic probing. The human hand is, after all, no match for a well-designed x-y table when it comes to positioning speed (if God had only had money…), and even with the most competent operators, human error is an ever-lurking danger. So engineers have sought to automate the probing process for some years now, in the interest of both better testing and higher throughput.

The physical challenge of getting a probe from point to point in a hurry (and repeatably) wasn't especially frightening to an industry that had already mastered the mechanics of wafer probing and laser trimming. The real problem involved the integration of an automatic prober into a system in such a way that its high-speed positioning would be of real economic value. If, for example, a board-test system has to sit on each probe point for 2 or 3 seconds to allow a simulator and disc to operate, an automatic prober that zips from one point to another in milliseconds is hardly worth the effort.

Teradyne's L125 board-test system was under no such constraints. With all diagnostic data in CPU memory for straight look-up, the system can generate probing instructions fast enough to keep pace with any automatic prober. So the M150 Automatic Prober was born, and those who have used it tell us that it's the only way to go.



An automatic prober has to know its way around each circuit board, naturally, which means that coordinates of all the probe points must be added to the software.

How does one get all that geometry into the test program? Very painlessly, it turns out. The x-y coordinates can be self-learned from a "walk-through," with the probe itself digitizing the locations, or they can be written into the job plan. In either case, the programming chore is simplified by software that, for instance, can translate the location of a single IC pin (plus package type and orientation) into the locations of all other pins on the IC.

As might be expected, the M150 is a real throughput-booster. Its advantage over manual probing is hard to quantify, being a function of handling time, yield, and test time, but reports of doubling and tripling are commonplace.

That means that a single test system with automatic prober can in certain applications outproduce two or three manual systems. That represents Big Money, and a competitive advantage that's hard to overlook. A growing number of major electronics manufacturers aren't overlooking it at all.

TERADYNE

TENS by the millions

That stands for transcutaneous electronic nerve stimulators, pain-killing devices that could become a $500 million market

by Stephen E. Scrupski, Instrumentation Editor

Electronic technology, having proved its efficacy and reliability in controlling the human heart with electronic pacemakers, is moving into a new area—pain control. Upwards of 40 companies are now manufacturing transcutaneous electronic nerve stimulators (TENS)—electronic pulse generators that when attached to the skin, generate signals that in some way relieve pain.

"We are working very empirically at this time," says Patricia Garland, product manager for Stimtech Inc., a Minneapolis-based manufacturer of the stimulators. "The more the medical community finds out, the more we realize that we don't know exactly how they work." But basically, she says, the stimulators "interfere with the passage of pain signals along the nerve to the brain."

For whatever reason, they evidently do alleviate pain, and the potential market is large. "The University of Colorado Medical Center recently estimated that there are between 20 million and 40 million chronic pain patients in the U. S.," says Michael Halleck, general manager of Staodynamics Inc., Longmont, Colo., another major manufacturer of the electronic pain-control devices. Citing a recent report from market research firm Frost and Sullivan Inc., Halleck notes that the market was about $9 million in 1976 and could grow to anywhere between $100 million and $500 million in the next five years. Thus, he says, "the surface hasn't even been scratched."

Medtronic Inc., Minneapolis, sees the TENS market growing at a rate that exceeds 50% per year. "There are 40 million patients that see a doctor for pain each year; 30 million for chronic pain and 10 million for acute pain," points out Jerry Donahue, general manager for Medtronic's Roseville, Minn., Neuro division. Predicasts Inc., a Cleveland business information and market research firm, is more conservative in its estimate of growth for the TENS market, pegging it at about 25% per year. Even at that, rate, TENS devices would place at the top of the list as far as growth rates of biomedical equipment are concerned. They would outstrip, for example, computerized tomography and diagnostic ultrasound, each with an expected 13% growth rate.

Medtronic got into the pain-management business seven years ago with implanted nerve-stimulation devices and then developed its transcutaneous nerve stimulator, called Neuromod, in order to screen patients for the eventual implants. The device now sells for $350 to $450, depending on features, and requires a physician's prescription.

There appears to be general agreement on the four leaders in the field, who together control about 80% of the market. They are three Minneapolis-based firms, Medtronic, Med General Inc., and Stimtech, plus Staodynamics. Their ranking, however, depends on which one you ask.

Pulse generators. In essence, the devices are simply pulse generators with variable pulse widths, levels, and repetition rates, all three parameters being independently adjustable by the patient. A typical Stimtech unit, for example, delivers constant

Marketing: a network of pain-control centers

One of the early workers in the electronic pain-killer field is a physician, C. Norman Shealy, now director of the Pain and Health Rehabilitation Center, LaCrosse, Wis. "The only way electronic stimulators will manifest themselves in the medical field is through independent pain-control centers that will fill prescriptions from physicians," Shealy says. "This will never be an office procedure, since the average physician probably does not see enough pain patients to justify training an associate in the use of transcutaneous electronic nerve stimulators, and also because he has limited time to spend with each patient and patient selection and education in the use of the devices can be time-consuming."

For example, Med General Inc., one of the leading manufacturers of electronic pain-killing devices, was instrumental in setting up Pain Control Centers Inc., which became a publicly held company in December. The company expects to have about 40 centers located across the country by the end of this year.

The devices also have been used to treat athletes—the National Football League, for example, approved their use in a game by the Detroit Lions' Charlie Sanders, who wore one under his uniform. In the National Basketball Association, the Philadelphia 76ers' Daryl Dawkins played a full game with a unit attached to his shoulder. According to Dr. Shealy, users have found the devices to be safe, in that they do not fully mask all pain and thus players do not run the risk of further damage that can be incurred because they are unaware of new injuries.

Probing the news

currents between 0 and 50 milliamperes, pulse widths variable between 50 and 250 microseconds, and repetition rates variable between 10 and 150 hertz.

A new Stimtech unit is built around a custom bipolar integrated circuit that includes most of the device's circuitry, according to Stimtech engineer Dennis Digby (who will not reveal the manufacturer of the circuit). It comprises a multivibrator-type oscillator with a discrete output transistor to drive a step-up transformer that in turn drives the electrodes attached to the patient's skin. The unit uses rechargeable batteries and comes in two forms—single- and dual-channel. The second is useful to patients with low back pain, for example, who often complain of pain radiating down one leg and so require a second set of electrodes with independent adjustments to control the feelings at the second pain site.

Med General, on the other hand, uses commercially available components, except for custom batteries made by Gould Inc. The Med General instruments employ simple unijunction transistors as the oscillator elements. They need much less power than, say, a 555 timer, according to David Housen, Med General's director of new product ventures. However, Housen says that his engineers now are considering complementary-MOS circuits for future devices because they use less power.

Staodynamics says its patented method causes the patient to feel a tingling sensation for about the first 60 seconds. According to Halleck, the user sets the unit to the point where it produces slight muscle spasms and then backs off from this point slightly. As a result, the control affects pain transmissions but not muscular or sensory responses. Halleck says his company views the human body as an equivalent circuit of about 2.2 kilohms in parallel with about 0.05 microfarad, both in series with about 100 ohms. When this network is taken into account in the stimulus output circuitry and with a certain waveform, he says, the disappearing sensation effect can be achieved.

Relief. TENS device from Stimtech measures 4 by 2¾ by 1 inch and weighs 8 ounces.

Others in the industry, though, consider this an oversimplified view of the pain-suppression process and the complex equivalent circuit presented to the stimulator by the body. Med General's Housen points out that there are many time constants involved in the path between the electrodes and the actual nerve sites. Even if the input pulse has sharp edges, he says, there is a lot of filtering to round off the edges before it takes effect, and thus more work is needed before any definitive statements can be made about best waveforms.

But the electrode system remains the No. 1 problem, according to Dr. C. Norman Shealy, a pioneer worker with the nerve stimulators. nothing is interchangeable, he notes, since each manufacturer uses different plugs, while the electrodes themselves also require improvement. Silicone rubber electrodes, the most commonly used, are a bit slimy to the touch, he says, but a significant number of patients cannot tolerate tape of any kind, since they develop skin blisters. He does add that there are many new electrode creams and gells coming on the market that help with this problem.

He also observes that some manufacturers have not made the equipment as refined as it could be. Knob turning on some units is terrible, he says. "Some patients actually find it painful to turn the knobs, which are often recessed and difficult to reach," he says. □

Electronics abroad

Britain ready to break out black ink

Infusion of North Sea oil could mean 3% growth in economy, with electronics industries forecasting growth of 11.6%

by Kevin Smith, London bureau manager

North Sea oil has started to take some of the squeaks out of the creaky British economy, and for the first time in years economists think the country might be ready to rattle ahead once more. They forecast that real growth in output of goods and services this year should run something like 3%. That is certainly not sensational, but all the same, it is a solid improvement over the next-to-nothing growth of the past few years.

But there is more needed than just North Sea oil—even though some 800,000 barrels of it are now pouring ashore every day—to fuel the growth. The turnaround that seems to have taken hold during 1977 was greatly helped by heroic wage restraints by the unions. However, if James Callaghan's Labour government can not persuade the aggressive miners' and electric-utility unions to accept raises close to its 10% guideline, the solid export-led growth that he wants could easily deteriorate into a short-lived domestic consumer boom.

The coming year, then, could be a critical one for Britain's economy. Even so, there will be reasonable growth for the major electronics equipment markets, color television excepted. *Electronics'* annual survey puts 1978 shipments at $3.904 billion, up 11.6% over last year's figures. As for components, they are forecast to do a little better, up 13% to $1.524 billion. (Throughout this article, pounds sterling were converted to dollars at an exchange rate of 55.5 pence to $1.)

Entertainment. No one expects more than a marginal improvement this year in the color-TV market, which fared poorly in 1977. "Sales will reach 1.6 million sets for 1977, 1.7 million in 1978, and 1.8 million in 1979," predicts David Benda, industrial and component market-research manager for Mullard Ltd., the Philips Group's parts-producing company in the United Kingdom. Derek Clark, product manager television at Thorn Consumer Electronics Ltd., concurs. "I'm taking a view of cautious optimism." But the kind of growth expected will not do much to solve the industry's long-term problems. Already, it is working at only 60% of capacity, and, to make matters worse, imports are rising, as is local production by Japanese set makers.

The audio market sounded loud and clear in 1977 and should do the same this year. Most of the decibels are coming from units combining a tuner-amplifier, a turntable, and a tape deck, priced between $320 and

Military test. Racal Automation has started to make automatic test equipment. This is the ruggedized version of its Micro-CAFF RTL5M, for use in the field by the Army.

BRITISH ELECTRONICS MARKETS FORECAST
(IN MILLIONS OF DOLLARS)

	1976	1977	1978
Total assembled equipment	3,124	3,497	3,904
Consumer electronics	905	939	1,076
Communications equipment	900	1,021	1,166
Computers and related hardware	851	971	1,097
Industrial electronics	239	253	270
Medical electronics	126	150	172
Test and measurement equipment	80	89	97
Power supplies	23	24	26
Total components	1,152	1,347	1,524
Passives	612	682	757
Semiconductors	305	385	455
Tubes	235	280	312

(Exchange rate: $1 = 55.5 pence; £1 = $1.80)

Note: Figures in this chart are consensus estimates of consumption of electronic equipment obtained from a survey made by *Electronics* magazine in September and October 1977. Domestic hardware is valued at factory sales prices and imports at landed costs.

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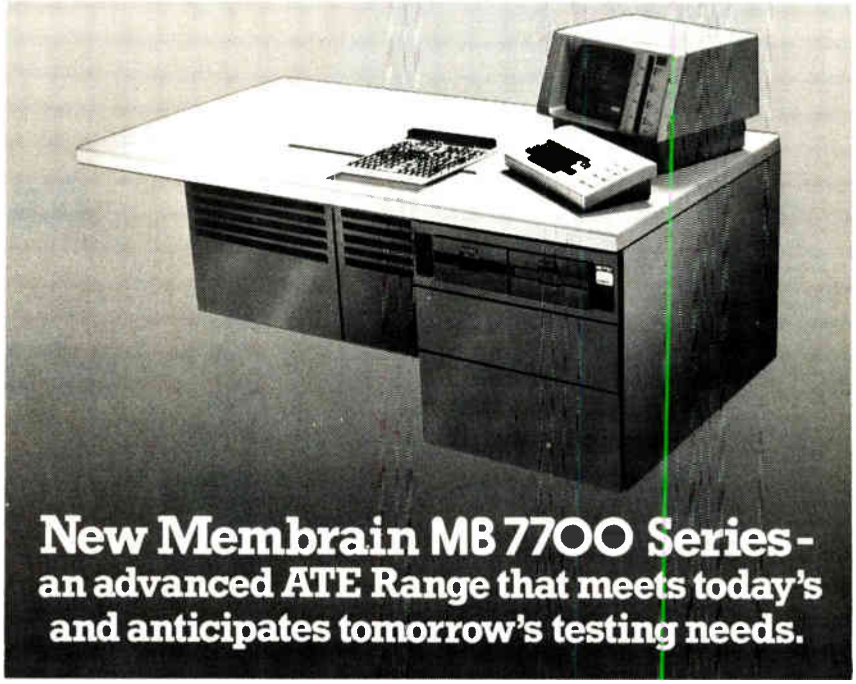

Keeping pace with fast-changing needs.

Today's digital PCBs have 100 times the logic-gate density of those five years ago. In the last two years alone there has been a factor-of-ten increase. To make production of these boards economically feasible computer-aided testing is essential.

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Circle 202 on reader service card

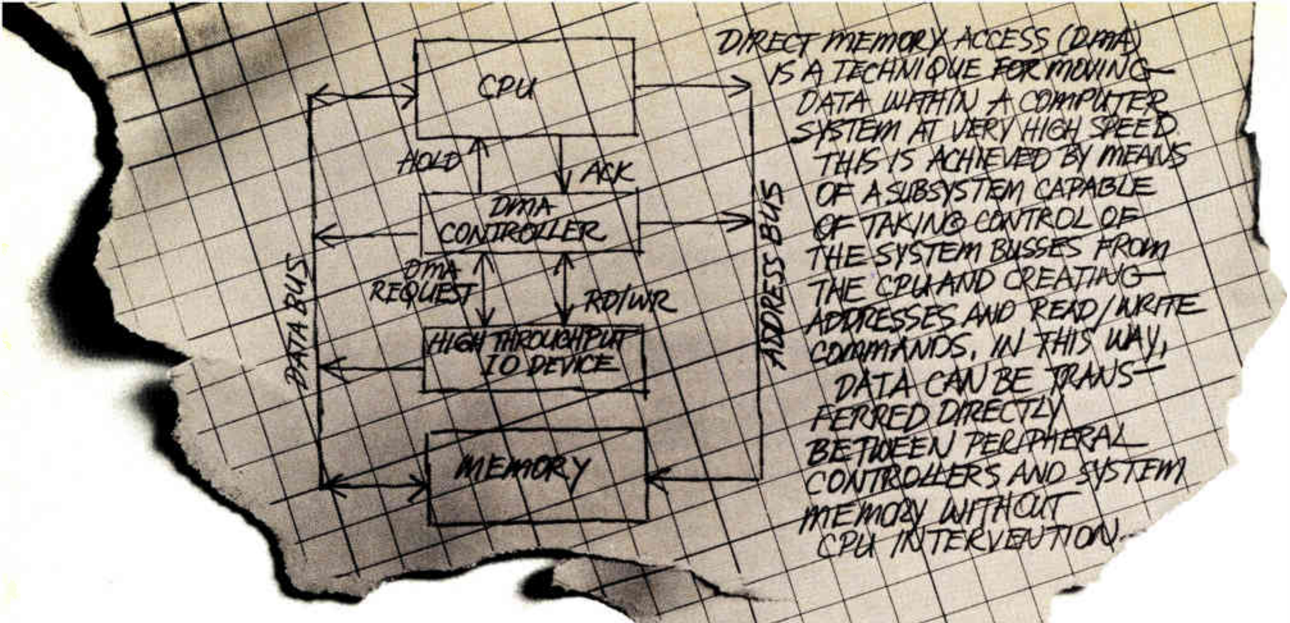
month. Overall, the boosts come to 8% to 10% over prices at the end of 1976, although actual price depends on individual models. For instance, one 19-inch color TV set that was $281 is now $298. The firm's vice president of sales, Ron Friedlander, points out that the end may not be in sight—today's rate of 240 yen to the dollar rate could go as low as 230 yen this year. "There's no question that today the yen is more of a problem to us than the TV quotas," he says. His company recently announced a joint venture with General Electric to produce TV sets in America, using GE's facilities in Portsmouth, Va.

Sony Corp. did not boost tags on TV during 1977, but will do so for audio products. "We did not increase TV prices because we could not have remained competitive," a spokesman admits.

Recorders. The situation is as troublesome to the video cassette recorder market. Sales just began to take off last year, as the Japanese producers began landing recorders of their own plus those made for U. S. companies. There was an almost immediate downward pressure on prices as companies sought to get a jump in the competition with tags reading under $1,000. Now, even though everyone agrees that sales will increase far more rapidly at prices in the $800 neighborhood, there is more pressure to increase prices. What is likely to happen, therefore, is that new models with additional features such as programmable timers or built-in monitors will be introduced at higher price points.

"The under-$1,000 price should have been there in the first place," says Jack Sauter, marketing manager for RCA. "It helped move the product during 1977. This year I see no pricing shift; if anything, the yen change will provide pressure to move up. There will probably be little change due to technology, because VCR is an old technology not likely to provide dramatic changes in costs."

Dick O'Brion, head of marketing for JVC America Inc., agrees. "We expect stable prices for VCR with added features becoming available. VCR represents a big profit opportunity, if prices remain stable." □



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Packaging & production

Fine-line printed circuits catch on

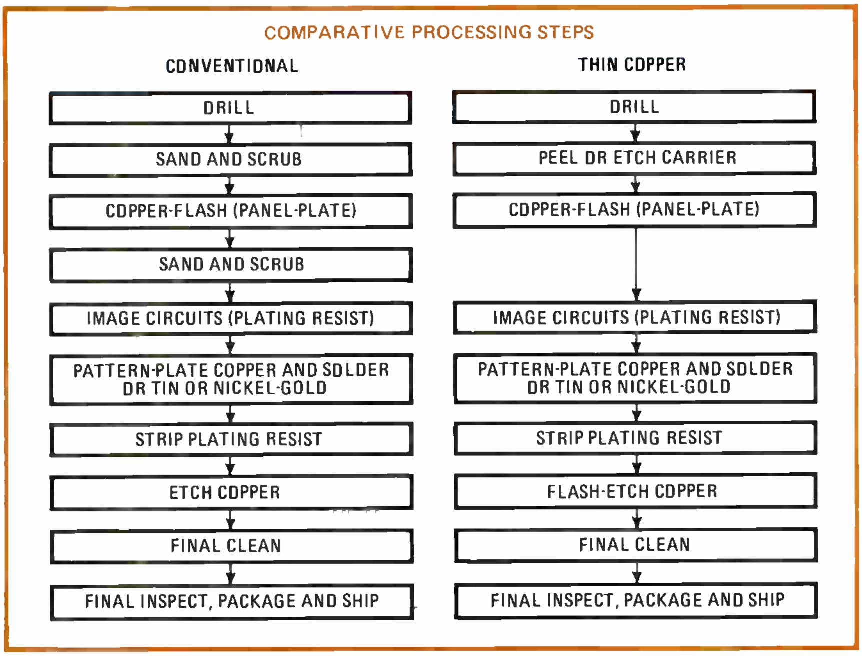
Technique uses ultra-thin copper foil and yields much greater density than can be obtained with conventional packaging processes

by Jerry Lyman, Packaging & Production Editor

A printed-circuit process that produces much denser circuits than the current norm is beginning to win a following. In the fine-line process, 5- to 10-mil-wide conductors and spaces are subtractively etched from 5- to 10-micrometer-thick copper foil. Conventional techniques use 40-micrometer-thick foil to get elements 10 to 20 mils wide.

Sales figures from two of the largest producers of thin copper foils, divisions of Gould Inc. in Cleveland and Yates Industries Inc. in Beaumont, Calif., put such fine-line pc boards at 5% to 10% of the total pc market now. Most of these end up as densely packaged, high-speed digital boards in computers and computer peripherals. Eventually, the technique may also dominate specialized boards.

While the fine-line approach also offers processing advantages, it is the increased density that brings a gleam to users' eyes. "This technique provides 20% more packaging density and capacity than a standard IC-socket wire-wrapped panel and achieves twice the packaging density of conventional two-sided boards," says Jeff Waxweiler, president at Algorex Corp., a Syosset, N. Y., firm that produces both the fine-line boards and computer-designed artwork for them. What's more, he adds, "the densities can equal or exceed those of more expensive techniques, like multilayer boards or multiwire. It's possible to use two-sided fine-line pc boards and still get more than two dual in-line packages into the square inch." With such a board, two to three conductors could be run between DIP leads—an impossibility with conventional pc traces.



At many independent pc firms like Multi-Circuits Inc., Manchester, Conn.; Metropolitan Circuits Inc., Franklin Park, Ill.; and Cirtel Inc., Irvine, Calif., 20% to 30% of the boards being produced are already fine-line types. In fact, Mike Busby, president of Cirtel, expects a third to a half of his company's output will be fine-line by 1980.

At Memorex Corp.'s operation in Eau Claire, Wis., where all of the firm's own and custom pc work is done, product control manager Jim Berry, says, "Fine-line is the way of the future." Memorex has already committed itself to the fine-line geometry in all of its new products with boards for high-speed logic. IBM Corp. and Western Electric are also heavily involved with it.

The process. The fine-line technique resembles the older, conventional process, based on 40-μm foils, in most of its steps, but eliminates several of them (see chart). Its ability to produce finer lines is due to the speed with which the thin foil can be etched—fast enough not to undercut the final circuit pattern.

Additionally, the microfoil's thinness means less etching time is required, so costs of chemicals are reduced: process users indicate that time and costs are about 25% of those rung up with 40-μm foils. Less etchant also means that waste treatment of the liquid is less of a problem than in standard production work.

Also indirectly responsible for the fine-line process's advantages is a copper or aluminum protective carrier about 2 mils thick that can be supplied with the copper foil. The carrier decreases drilling time, thus extending drill life, and the drill

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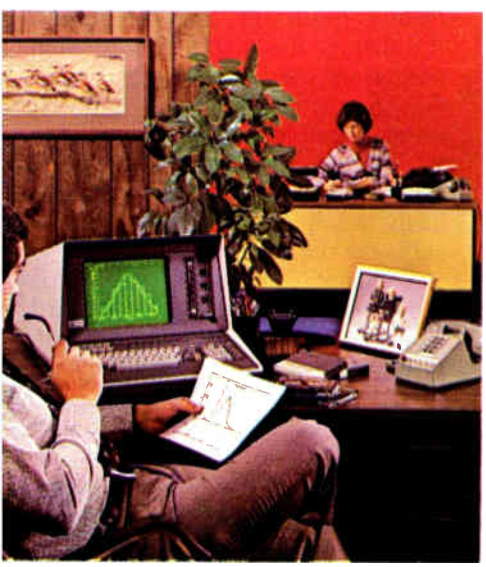

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Finally, any circuit manufacturer can use thin-foil copper laminates with present subtractive equipment. He need only add machinery for carrier removal.

Dissenters. Not all pc-board companies are sold on the new process, however. One of the larger independents, Circuit-Wise Inc. of North Haven, Conn., is sticking to conventional subtractive and additive processes. "Our pc lines are highly automated—it simply would not be cost-effective for us to invest added capital in redesigned automated pc lines for fine-line," says vice president John Mettler,

Another independent resisting the trend is the Photocircuits division of Kollmorgen Corp., Glen Cove, N. Y. Its engineers use a semi-additive rather than thin-foil process for boards with fine-line conductors. John Dennis-Browne, its manager of technology sales and licensing, says that despite undeniable improvements in the subtractively etched thin-foil method, the semi-additive process is the less costly and also produces boards that can be reworked instead of having to be scrapped. He points out, too, that the thin-foil process can only be used with FR-4 (glass-epoxy) boards, while the semi-additive process is usable with many types.

The cost of the thin copper laminates is undoubtedly one factor holding back fine-line pc boards. Another is the added process step needed for carrier removal, and the fact that pc manufacturers have not standardized on any one method for it. The copper carrier/copper foil furnished by Yates must be mechanically stripped and the carrier is salvageable. An aluminum carrier/copper foil supplied by Gould is also mechanically strippable. A third material supplied by the Swedish firm Perstorp AB has an aluminum carrier that can be etched away.

Still others—pc firms like Cirtel and the Collins Radio Group of Rockwell International Corp., Cedar Rapids, Iowa—are successfully working with unprotected foil, eliminating the peeling step. □

Gould OS4000
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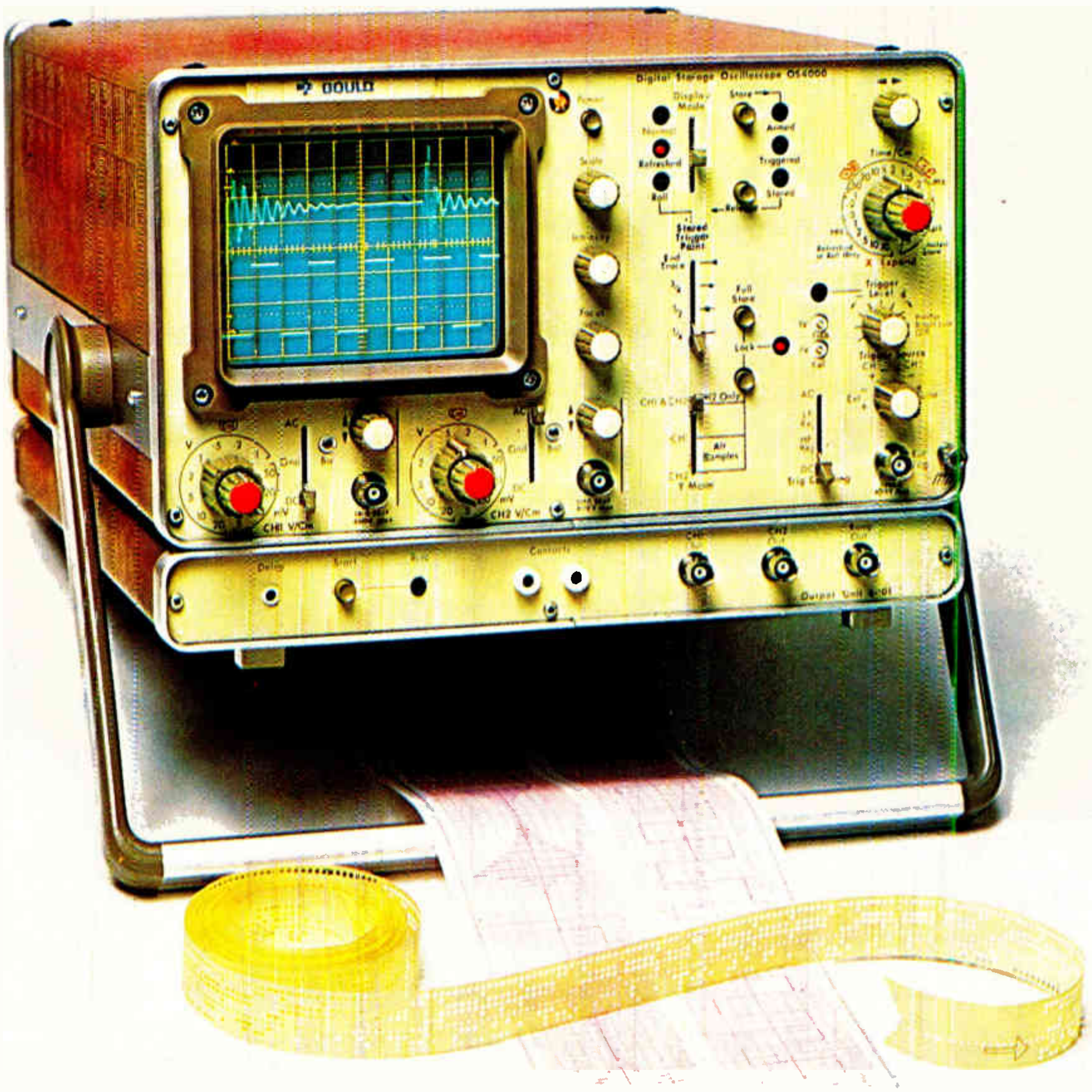

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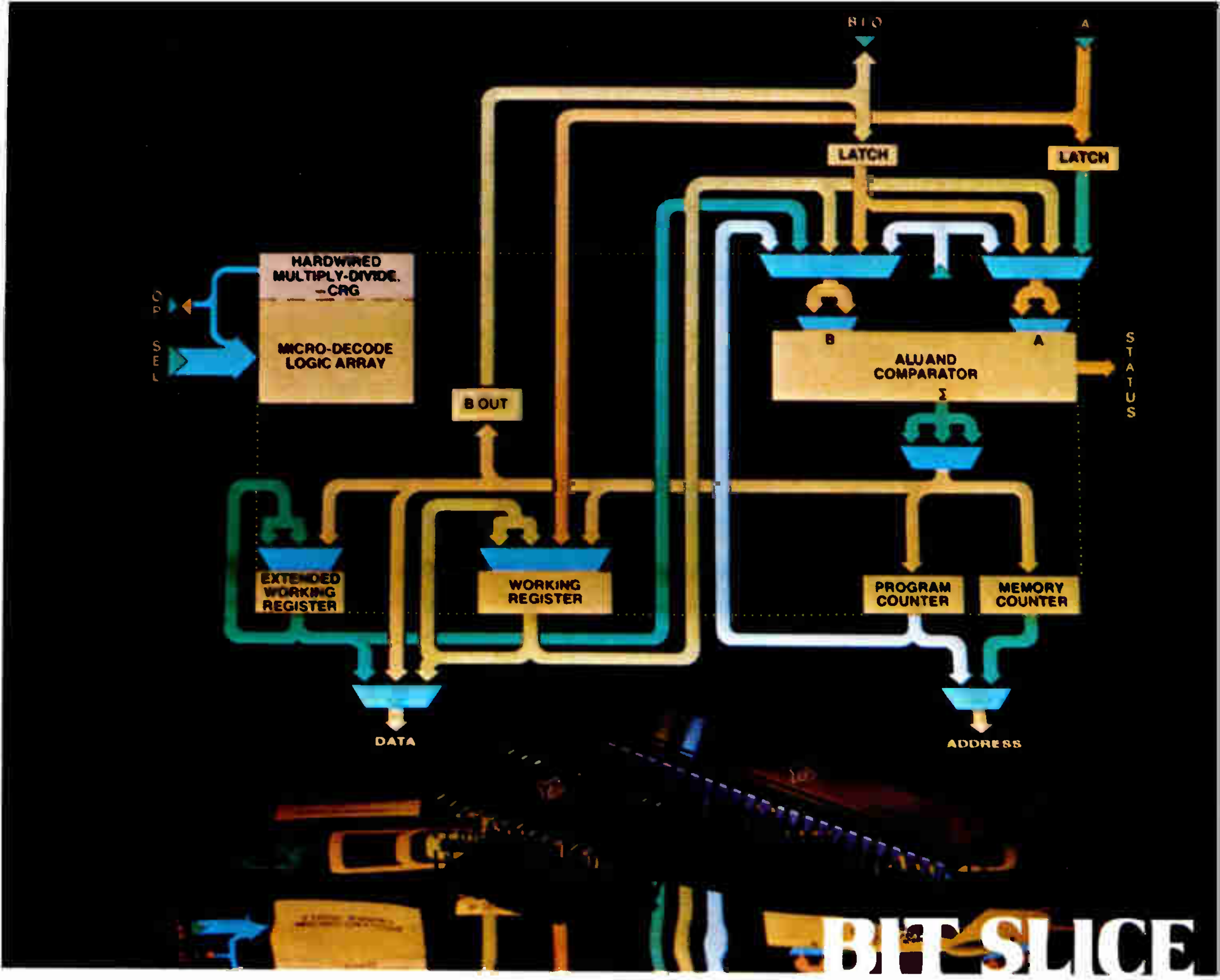

From Texas Instruments

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Having the S481/LS481 microcomputer chip set among its members, TI's 9900 First Family offers you a completely integrated, standardized design capability. All the way from components through boards through systems. Having common hardware. Common software. Common support. Allowing you to move over a wide range of applications with greater economy. Greater software retention. Less relearning. Less obsolescence.

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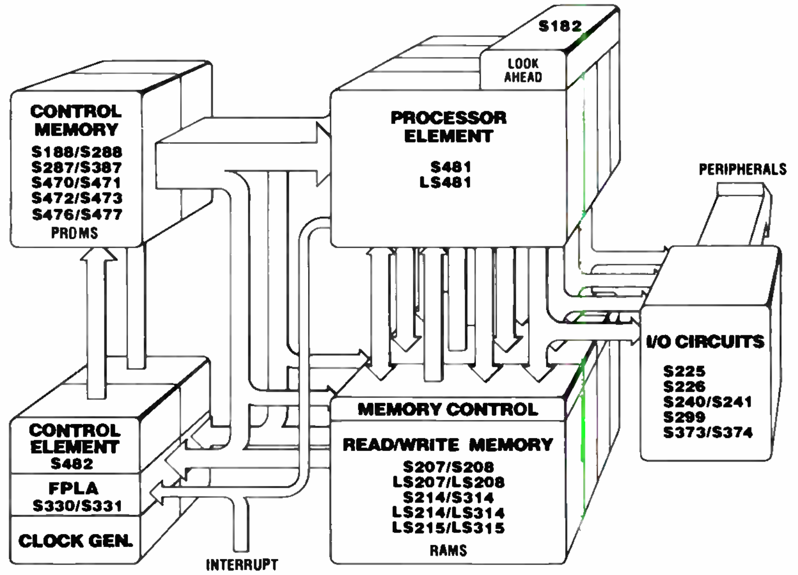

S481/LS481 Microcomputer Chip Set can be assembled from building block components to tailor performance to your application.

Processor performance choices

Both the S481 and LS481 are expandable, 4-bit slice processor elements. Both are micro and macroprogrammable.

Where maximum performance is your driving design criterion, use TI's S481 processor element. Clock frequency: up to 10 MHz for automatic multiply/divide.

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Both processor elements come in a choice of packages. The space-saving, quad-in-line ceramic package (J suffix) permits maximum board density. The new 48-pin, dual-in-line plastic package (N suffix) offers a more economical cost.

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Extraordinary capability

Each processor element recognizes, decodes, and executes 24,780 instructions.

For example, either element performs compound operations—select two operands, add, sign protected shift, generate status and update memory—all within a single clock cycle.

Only the S481/LS481 bit slice provides on-chip algorithms for automatically sequencing the iterative multiply and divide—both signed and unsigned. And cyclical-redundancy character update is also provided.

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Behind this outstanding capability: TI's advanced Schottky TTL process technology. Plus TI's advanced 9900 Family memory-to-memory architecture.

This is a complete architecture that places register files in main memory. As a result, the number of available general-purpose registers is limited only by the size of the program memory. Instructions do more work, use less memory space. Interrupts are handled faster.

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- Full function ALU with carry look-ahead capability and magnitude status generation.
- Double-length accumulator with full shifting capability, sign-bit handling, and impending overflow signal.
- On-chip dual memory address generators.

Performance-matched support functions

Complementing the speed and efficiency of the processor elements are these Schottky TTL support functions:

Device No.	Function	Package
S225	16W x 5B FIFO	N,J
S226	Latched transceiver	N,J
S240,S241	Octal bus drivers	N,J
S330,S331	12 input, 50 term, 6 output FPLAs	N,J
S373	Octal latch	N,J
S374	Octal flip flop	N,J
S482	Control element	N,J

The S481/LS481 chip set components are available now. For maximum speed. Maximum flexibility. Maximum efficiency. To implement advanced micro, mini and midicomputers. Controllers. And super processors.

To order the S481/LS481 bit slice, or any chip set building block, call your local TI sales office or nearest authorized TI distributor. For your copy of The Bipolar Microcomputer Components Data Book (LCC-4270A), write Texas Instruments Incorporated, P.O. Box 5012, M/S 308, Dallas, Texas 75222.

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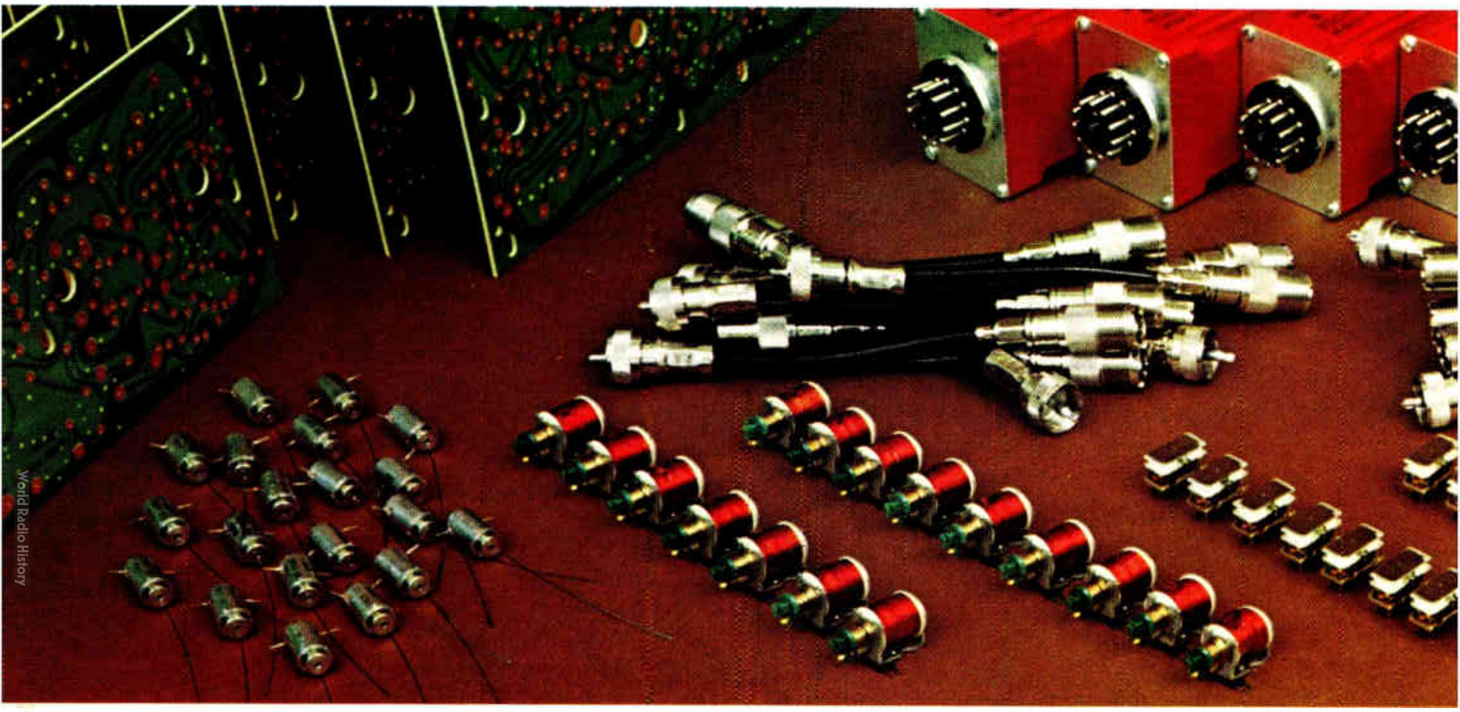

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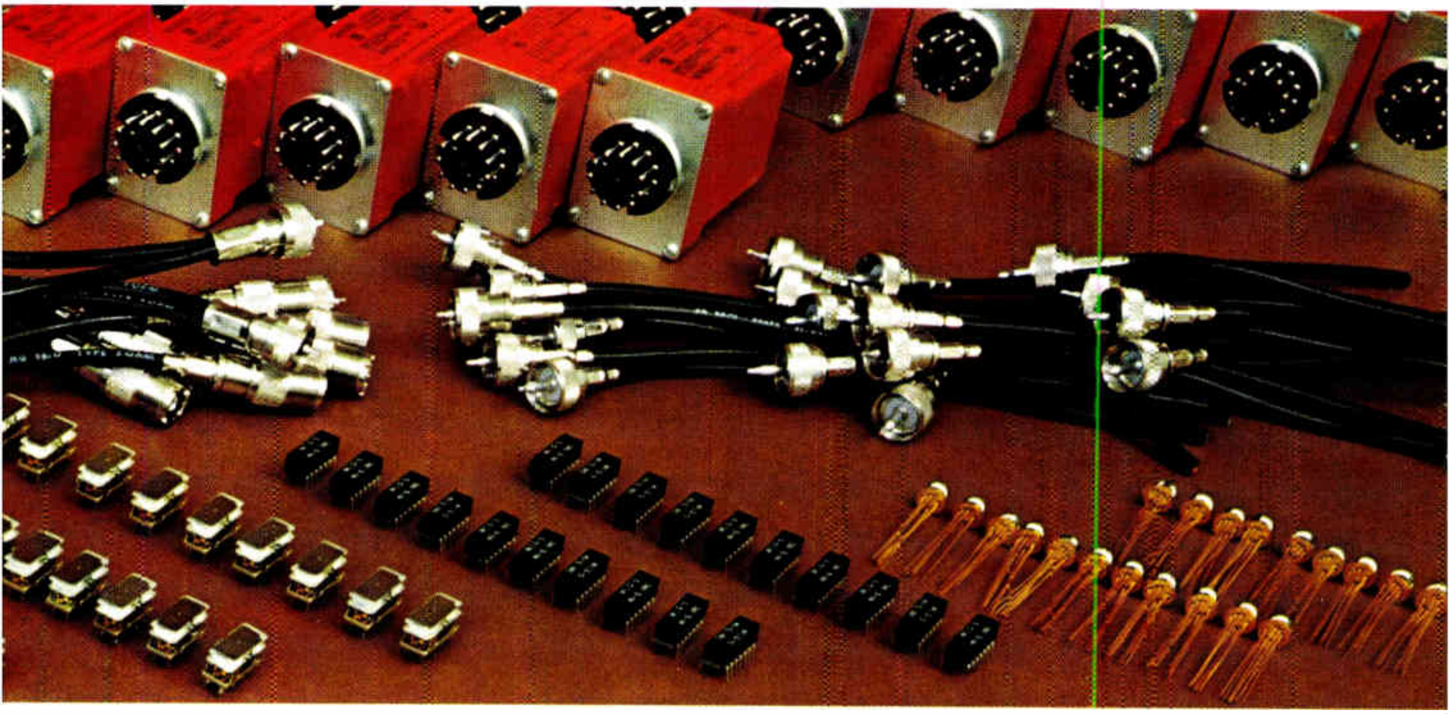

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How software modules communicate

When a software design is broken down into modules, those modules or subroutines have to be able to hand data to and fro among themselves. They do so by parameter passing. The types of parameter they pass range from simple data words, addresses, pointers, and flags/switches, to error and completion codes. Their methods of parameter passing use memory of different kinds in different ways that suit different interface needs.

The microprocessor registers are perhaps the most popular means (an example is use of the A register to pass a data byte). Implementation is easy, and interrogation of past data is straightforward but the amount of data that can be passed is limited unless a pointer is used.

The designer's main concern here is to ensure that the subroutine calling on the register preserves all the register's contents in order to be able on return to restore it to its entry value. Otherwise, the calling subroutine may receive values that cause problems. Alternatively, if the subroutine deliberately modifies the register's contents before returning them, this action must be accounted for so that the calling routine proceeds properly.

A fixed, global area of random-access memory may be set aside for parameter overlays, its location being known to all system modules. RAM requirements can thus be limited, provided that many routines can use the same storage area without conflict. Examples are a fixed-location system output buffer or a scratchpad area shared by many routines.

The predefined technique of parameter passing employs known system addresses like input/output ports (memory-mapped I/O), flag or switch locations, and "mail boxes" (fixed locations that any subroutine can interrogate and/or set for information storage and transfer). Redefinition of the address will of course cause the using subroutine to fail.

Using a push-down stack to store the parameters makes them easily accessible to the calling subroutine but requires the microprocessor to have a control for balancing the stack. The approach provides an interrupt-driven system with trace capability (information on the changes effected by certain instructions) and routine reentrancy (that is, the routine or subroutine can be interrupted and later reentered at that same point).

A combination of one or more of the above techniques may be required in complex systems that use interrupts, pointers, control blocks, and message passing in subroutines and/or task control. But being complicated, this should be done only as a last resort. On occasion, no parameters may need to be passed, and then the software has only a simple execute function to fulfill.

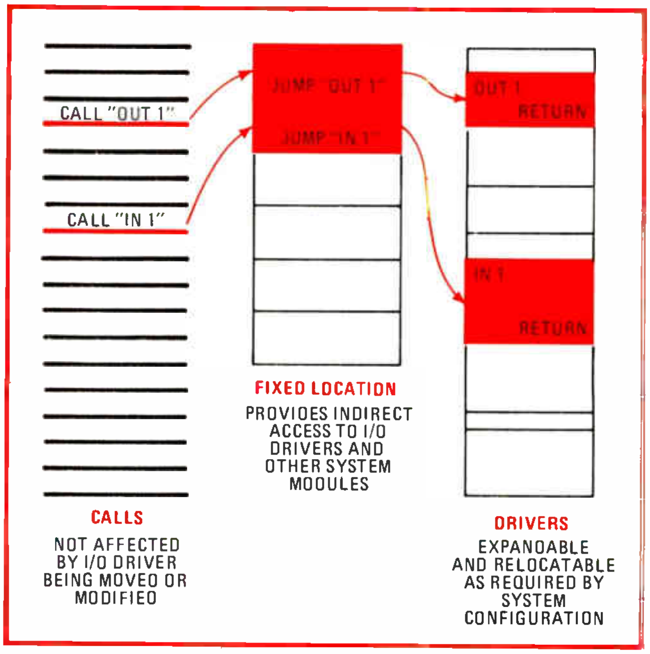
important as signal interface specifications in hardware design. Not only should the type of parameters be specified, including their characteristics, values, and number, but also the mode of parameter passing (see "How software modules communicate,").

The key to success in parameter passing is, as before, consistency. Once a method has been selected, stick with it. Changes can cause confusion and incompatibility at system integration time. In addition, keep the number of parameters required for a particular interface as low as possible, with three being the maximum for most cases.

Getting the I/O routines straight

The hardware and software in a microprocessor system meet in the I/O driver routines for that system. Microprocessor-based control systems are generally used to convert inputs from sensors, switches, converters, and terminals into output signals that control devices and machines, write messages to receiving devices, drive test equipment and even talk to other computers. In fact, the I/O drivers for a system will determine the total performance of that system in a dedicated control application.

These I/O routines can range from a single load or store instruction all the way up to the driver for an interrupt-driven, block-directed I/O controller with possible dynamic error correction. But, no matter how trivial or complicated the I/O routine, it must fit exactly the specific hardware interface to which it talks. Addresses, flags, data timing, system timing, data codes, and possible handshaking sequences (for data-transmission synchronization) are all part of the requirements for an I/O routine. The job of the hardware at the I/O interface is to make the physical connection between the system's I/O ports and the system data bus. The software routines will request all data transfers and/or process them and will return status information to the calling routines on completion of the requested data movement.



2. Making a jump. One of the software designer's most useful tools is the table-isolated input/output. Indirect access to system modules via a vector or jump table makes it possible to keep track of and modify the interface between the calling program and system drivers.

Because I/O routines are so basic to a microprocessor-based system, in that their characteristics determine its physical configuration, they should be provided with as much flexibility as possible. One way to do so is called table-isolated I/O (Fig. 2). This technique isolates the physical I/O drivers (subroutines) from the calling tines and external data locations), I/O port names and addresses, and immediate data definitions. Next should come any required branch isolation tables (vector tables) for both internal and external routines. The internal entries are for use by other modules when branching into this source program, while external entries are for use by this module to get to external routines such as I/O vector tables. Then the main program follows with the main line first and the lower-level modules (subroutines) following. Finally, the areas of fixed and variable data follow, with separation of these areas as required by the ROM/RAM implementation of the module.

Without documentation, you're lost

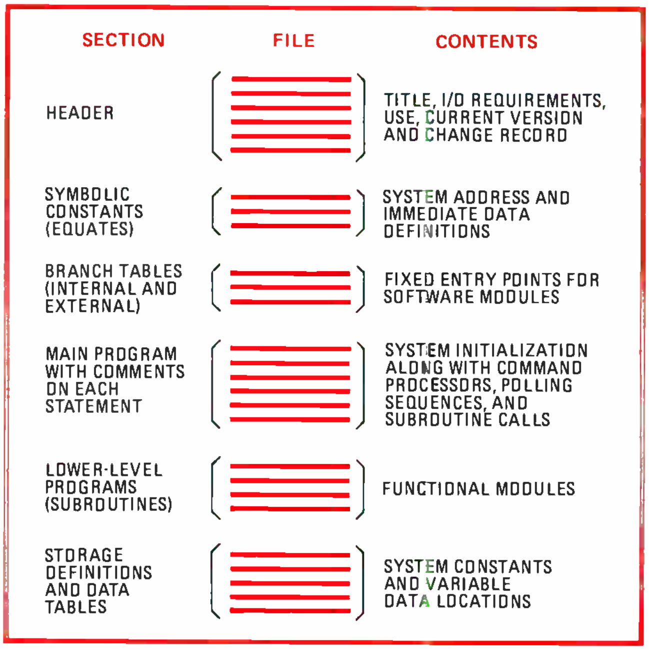
Just as the schematic diagram and functional description are essential in hardware system design, the flow charts, memory maps, I/O specifications, and program description for a software system should contain all the information necessary to understand, modify, use, and above all to maintain the system on the selected microcomputer configuration. These documents, some of which have already been mentioned, should include:

- A master memory map.
- I/O port assignments within the initialization requirements for programmable I/O ports.
- The format of subroutine pass parameters.
- The functional specification for major system blocks and modules.
- Operational description of programs.
- Module memory maps where required.
- System I/O requirements to include timing constraints, data coding, and required hardware interfaces.
- External subroutine requirements.
- Module and/or system source listings in a standard format with comments.
- System and module flow charts.

In addition, because no software system is static forever, a change record should be included for the system to show all applied modifications and the current version of the system. Besides the obvious needs for good documentation, complete descriptions of programs and subroutines will make it possible to reuse them in future software design efforts.

Higher-level software tools

Because of the time and money involved in developing microcomputer software, the use of higher-level software tools is essential. Assemblers, macro-assemblers, linking/loaders, on-line editors, interpreters, and compilers can all make the software development task easier. Do not even consider using the old method of programming in machine language for any serious software development. Instead, the minimal level should be assembly language using a resident assembler or a cross-assembler or (one step up) a resident macro-assembler. The assembler allows code to be written with mnemonics and symbols, which it translates directly into object code for the target machine. A macro-assembler adds to the assembly process the capability of macro-definitions, which make it possible to produce several assembly language statements with one macro-instruction. It is a very useful tool for establishing standard system parameters and subroutine sequences in the program.



4. Keeping track. Just like a standard drawing format, a standard source program layout is required for good software documentation. It provides for easier source program reading and makes modifications less of a hassle because the program structure is known.

As software development continues, the need for a dedicated software development system will become more evident. The development system should contain executive software (an operating system) that supports a file system for storing and retrieving programs (most likely on a disk) and provides on-line editing capability for program development. This dedicated development tool and its supporting system software become the central element in any software development program. Investment in a good development system is worth the price for the markedly increased software productivity that it provides.

Although most microprocessor applications are today being written in assembly language, the trend is toward higher-level languages like MPL, PLM, Basic, and Fortran. This transition will make the software development effort easier for the engineer lacking experience in this area, for it will eliminate many of the details required at the assembly-language level and will thus shorten the design cycle for a given application.

The problem is that a higher-level language still has to be tailored to the dedicated control microcomputer environment: the language must contain a flexible and adaptable I/O structure, have the mechanisms for easy linking to subroutines written in assembly language and produce relocatable object code with the ability to separate fixed procedure and variables. Moreover, the compilers, interpreters, and related equipment needed to implement such a language do not produce as efficient code, either in size or execution speed, as assembly-level programming. Thus, assembly-language programming will still be required for dedicated I/O routines, time-critical applications, interrupt-driven systems, and most small dedicated applications. □

Computer-engineer partnerships produce precise layouts fast

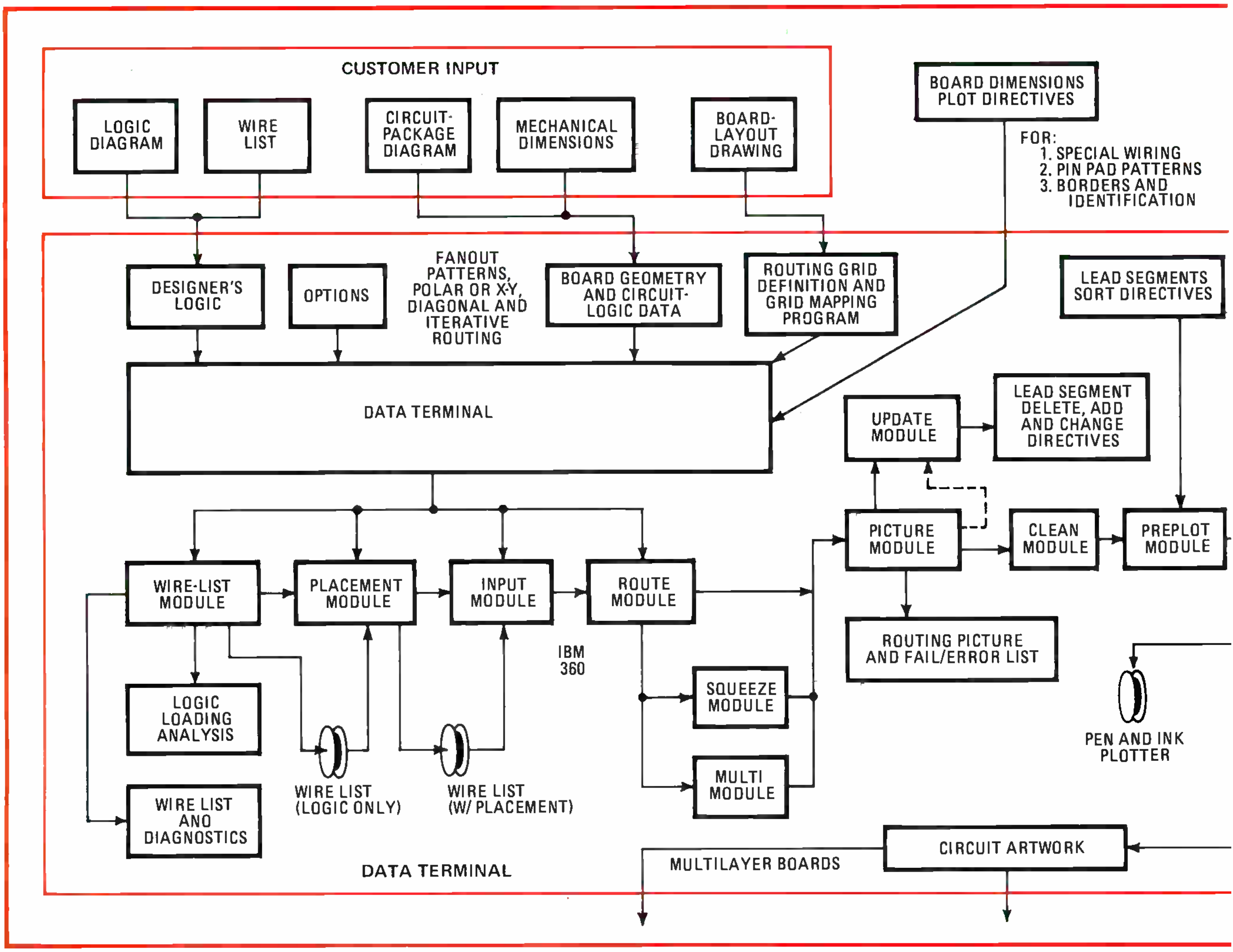
With the evolution of design automation, a tool for the placement and routing of complex boards has been added to the designer's repertoire

by Richard Larson, *Automated Systems Inc., El Segundo, Calif.*

☐ Mating the ingenuity of man and the untiring rapidity of the machine is an old story, but only now is it coming into full flower in the design end of electronics. As digital circuitry steadily becomes more complex and more densely packaged, designers are finding computer-controlled techniques to be invaluable tools in laying out their circuit boards.

These tools have progressed beyond the point where the computer simply functions as an assistant to the designer, as in computer-aided design techniques. In many cases, the computers can take over the job of circuit routing, using design-automation techniques that have evolved to the point where software modules have given them a broad range of capabilities (Fig. 1).

The lineage of design automation can be traced directly back to nonautomated techniques. To solve the problems inherent in drawing highly precise artwork, digitizing techniques appeared. Then CAD techniques came along to meet the constraints of time, cost, and output that grew in importance as large-scale integration



developed. Each of these alternatives has its place in present-day design depending upon the factors involved (table). However, assessing these factors does require some comparisons of the four approaches.

Design without computers

Most printed-circuit boards are designed by engineers working without computer-controlled tools. The designers at the drawing boards place components and route interconnections by trial and error. They prepare the finished artwork either with pen and ink or by hand taping. This preparation is a tedious and time-consuming task, and finished art is frequently less than exact. However, the nonautomated approach will do the job—given a board featuring 50 or 60 mostly discrete components, densities in the area of 0.13 square inch per interconnect, and ample tolerance in the precision of the artwork that must be turned out.

The introduction of big multilayer boards carrying large numbers of digital integrated circuits in dual in-line packages or flat packs has relegated the nonautomated method to the design of simpler boards. The multilayer board's artwork with its requirement for registration of multiple layers, its increased component density, and the complex routing of its interconnections requires a degree of precision that sorely taxes the designer working without computer-controlled tools.

To meet the need for precision artwork in the design of these densely packed boards, digitizing evolved. Sitting at a large back-lit drawing board, a designer works from the printed-circuit layout he has developed. He uses a digitizing pen, a cursor, connected to a minicomputer that encodes the X and Y coordinates of each circuit feature. The resulting punched paper tape or cards can be used with a simple line plotter or a photoplotter to generate artwork of the required quality.

Checking with digitizing

The latest generation of digitizers can make some design checks. In fact, it is now possible to encode both the wire list for a board and its design specifications. After the design has been plotted, it can be taken to a computer to be checked against this input to be sure that all interconnections have been made correctly. It is also possible to check such specifications as minimum clearances between pads and lines and so on.

However, these are historical checks. If errors have been made, it's back to the drawing board and to the digitizing board for redesign and replotting. Because of this factor and because digitizing does not help the initial design of the board, this design tool is probably best suited for the simplest of today's complex boards.

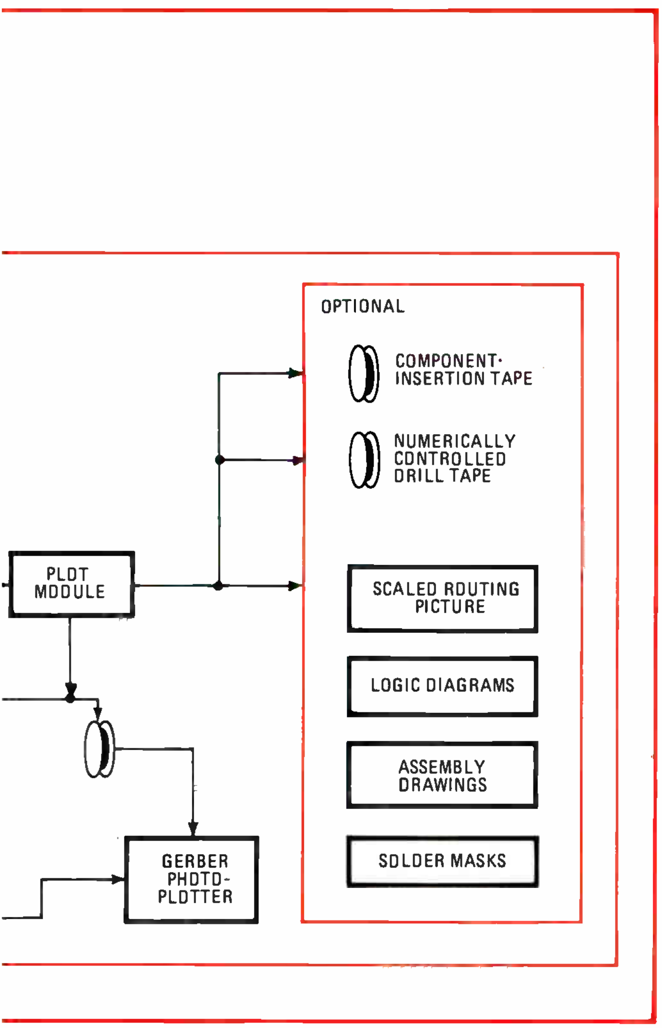
The next step up in the design hierarchy is the interactive CAD technique in which a cathode-ray-tube terminal, keyboard, and a small digitizer combine with a computer or minicomputer. This combination gives the designer what amounts to an automated drawing board from which to work during the design process.

In a CAD setup, a designer places and routes a board and sees his result displayed on the terminal. If a design specification programmed into the computer is violated, that fact is announced in real time on the CRT. Some systems have refined this process, with software programs that enable the computer to make suggestions about routing to the designer.

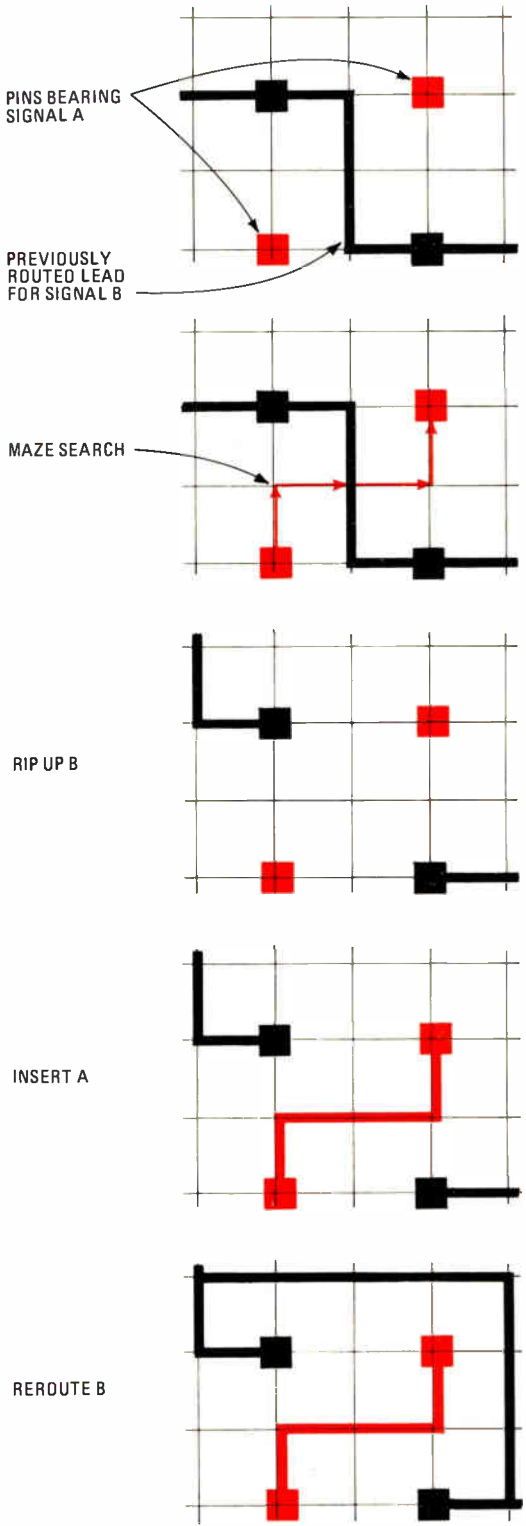
CAD helps out

Such systems can work with varying amounts of input, ranging from simple mechanical dimensions of the board and descriptions of devices to complete design specifications and wire lists. This flexibility is especially useful in the case of a design of a single board. The designer can bypass some of the initial setup costs of more sophisticated design-automation systems. CAD systems are also useful for analog boards with components of a wide variety of sizes and shapes, since topographic placement problems can be solved by the engineer as the design evolves towards completion.

Anyone with a CAD system in house should probably be looking for boards that can be designed interactively in about a third the time otherwise required. To achieve a two-year payback, the design volume must keep the



1. Design flow. A design-automation system accepts the five parameters shown on the customer-input block. The system's primary output is 1:1 printed-circuit artwork, but control tapes for component insertion, numerically controlled drill tapes, solder-mask and assembly drawings, and diagnostics also can be produced.



2. Software eraser. Iterative routing is a method for modifying computer-designed artwork. This scheme allows a design-automation system to rip up a previously routed lead to permit insertion of a new interconnection and the rerouting of the old path.

they send the decks of cards to the service bureau and get back decks that operate their photoplotters. Turnaround time is typically 10 days for a series of designs compared to 2 to 3 weeks for design automation alone, and cost savings are significant.

Assessing cost effectiveness

Because of the fixed overhead associated with computer-based systems, there is a threshold of design complexity before either design automation or CAD is cost-competitive with nonautomated design. Boards with fewer than 20 ICs usually should be laid out without the help even of digitizing. For boards with more than 150 ICs, design automation is imperative because of the difficulty of doing the layout by hand. The single exception to this rule is a design in which routing and use of via rules are so tight that it is impossible to place the components logically on a grid. Then the designer must do it himself or herself.

In the range between 20 and 150 ICs, several other factors influence the choice between design automation and CAD—for example, the number of boards of each type involved. In a one-board project, design automation can be ruled out as a cost-effective procedure. Every dimension and special ground rule of the single board must be described to the computer in detail as part of the start-up procedure. The cost of this process is typically about $500, and, amortized over three or more boards, it becomes increasingly nominal. For a single board, it can be a major part of the expense. However, with computer-aided design, board parameters are simply drawn in, and so initial setup costs are low.

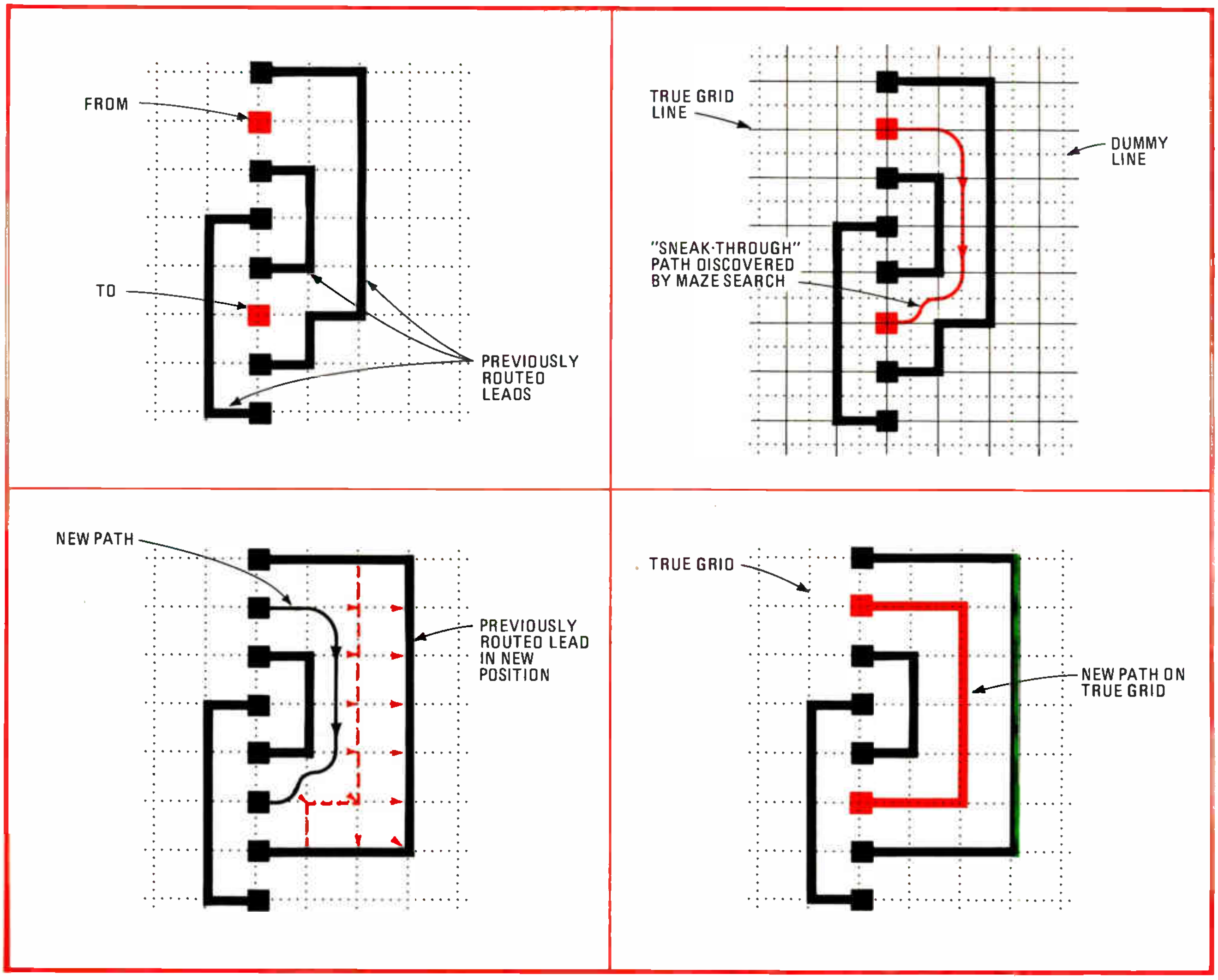
Conversely, the greater the number of boards in a group, the more likely a CAD system is to become a bottleneck to the rapid work. Once the front-end programming is complete, design automation can rapidly turn out one layout after another. Any given CAD system has a maximum capacity, and the last board takes as long to design as the first.

Another point to keep in mind is the percentage of discrete components per board. Design automation can assign logic elements to multielement packages or place DIPs or flat packs of uniform package types to minimize the length of interconnections. If pc boards contain 50% or more discrete components, it is better to go with placement by the designer, perhaps aided by CAD.

Tightness of the design ground rules is another consideration. The computer cannot employ discretionary "cheating" as a manual designer can. Therefore, where ground rules are discretionary rather than absolute and crossing counts indicate the board may be difficult to route, higher densities may be achieved with nonautomated or computer-aided design.

Quantity is a key

The cost effectiveness of design automation vs CAD vs manual design and artwork may be directly dependent on the number of boards to be fabricated from each design. For less than 5 or 10 boards per design, it pays to tell the fabricator to take extra care in producing the boards. High-precision artwork supplied by the designer is not as vital as it would be for larger production runs,



3. Squeeze. Another approach to inserting new paths is the "squeeze through" algorithm. This temporarily inserts an extra grid within an existing one (top right). Then previously routed lines are shoved aside (bottom left), and the new path is fitted to the new grid.

and design by hand may be adequate for the production of the boards.

With greater quantities, ease of manufacturability becomes a major cost-saving item. Computer input becomes the treatment of choice.

Using a designer

If there are more than 1,000 boards to be produced per design, manufacturing costs will be far lower if the board under consideration is limited to a two-sided, rather than a multilayer, design. Under these conditions, one can have a designer spend an additional month on a single design just to eliminate a few vias. (Given unlimited time and infinite patience, a skilled designer may be able to improve slightly on the densities achieved by design automation.) However, since very minor differences in the quality of the artwork can make big differences in yield, in all probability it will be valuable to digitize the design.

Firms that have tight delivery schedules cannot afford mistakes that demand extensive debugging and reworking further down the line. Therefore it is important to have diagnostic checks available along the way. Computer-aided-design systems are usually limited to physical design checks, such as adherence to line-width and spacing requirements. Design automation assures adherence to these requirements automatically, and it also can check conductor traces for conformance to the original wire list.

Obviously few boards and few operations are going to fit precisely the ideal requirements for any one of the four basic approaches to pc-board layout. A designer must consider all the variables, including delivery schedules and design loads, to discover which approach or combination of approaches will be most generally cost-effective for his operation.

The choice

In general, the more complex and highly dense the board and the larger the group of mechanically similar boards, the more likely is design automation the best choice. Moreover, unless the task involves very simple boards (20 ICs or less) to be produced in small quantities (5 or 10 per design), it probably will be profitable to investigate the various degrees of help obtainable from today's computer technology. □

Split current source damps reactive load oscillations

by Yishay Netzer
Haifa, Israel

A standard bilateral current source of the type shown in the first part of the figure (a) will often generate oscillations in circuit loads that are grounded and have an impedance (Z_L) that is not purely resistive. Inductive loads such as cathode-ray-tube deflection yokes and torque motors are best driven by the modified circuit shown in the second part of the figure (b). Adding the differential amplifier and feedback network to the circuit eliminates undesirable responses while ensuring that the output current will be virtually independent of the load impedance.

When the load is reactive, it may cause the circuit's step response to be underdamped and consequently unstable, with the result that the output current will become dependent on the load impedance. As shown in the equation in (a), the output current is dependent on the circuit transfer function, which is:

$$G(s) = K\frac{\omega_o^2}{s^2 + 2\zeta\omega_o s + w_o^2}$$

where ω_o is the natural undamped frequency of the circuit, K is a constant, and ζ is the damping factor.

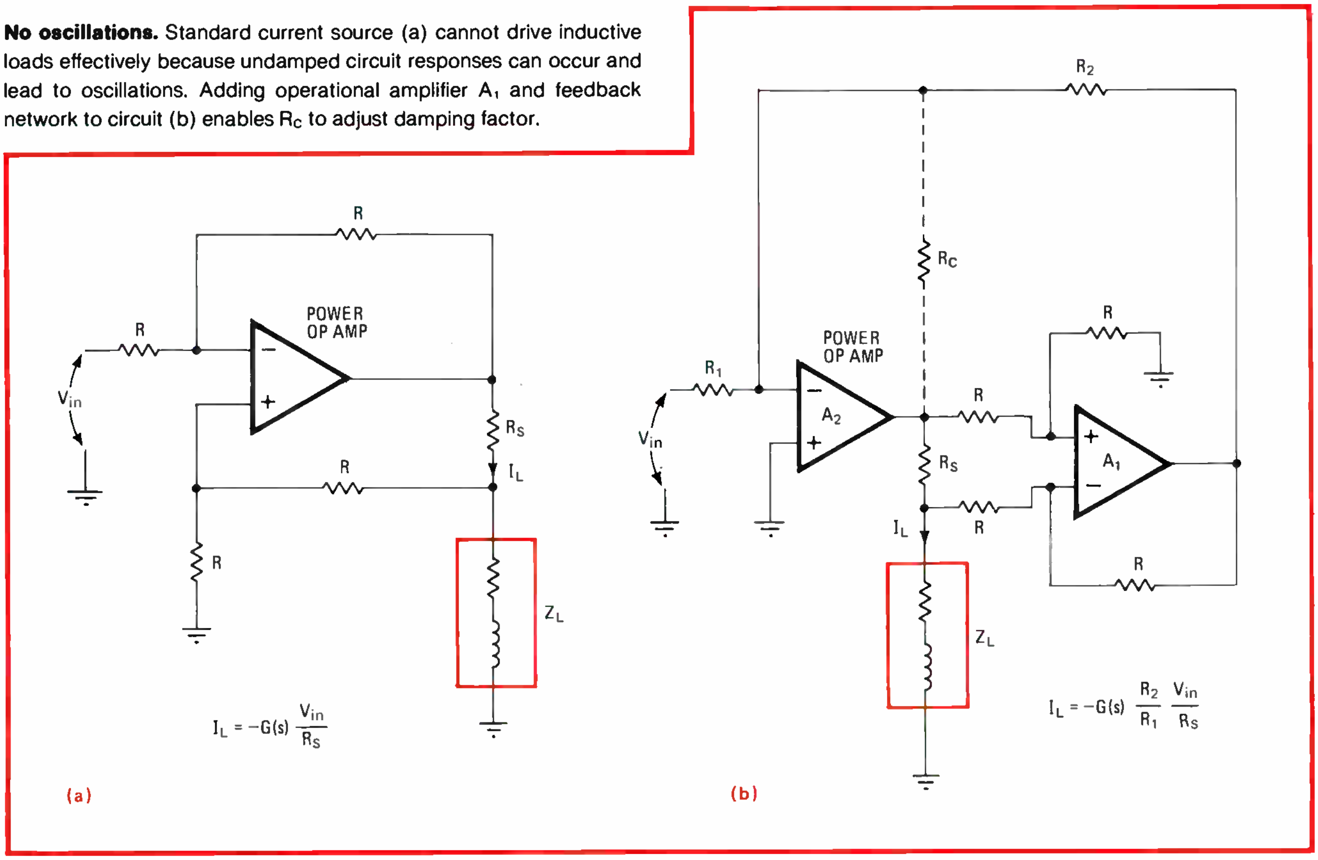
The various parameters are determined by circuit constants R, R_S, and Z_L. Of particular importance is the fact that once determined by the circuit configuration, ζ cannot be modified, and that is why oscillations can result. Furthermore, the oscillations may be impossible to eliminate in the standard circuit because adding components may affect the output impedance, making any type of compensation impractical.

The circuit in (b) circumvents the problem by splitting the current source into two parts:

- A balanced difference amplifier (A_1), which converts the load current into a single-ended voltage feedback signal.
- A power amplifier (A_2), which, aside from assuming its original function, reduces the effect of Z_L upon I_L by making use of the feedback voltage.

Note that by adding the feedback network, resistor R_C has been introduced to the circuit, and therein lies the major advantage of this circuit. R_C can vary (compensate) ζ right down to its optimum value ($2^{1/2}$ in this case), without disturbing the proportional relation of V_{in} to I_L throughout the useful range of the circuit; that is, below ω_o. The basic transfer function of the circuit is not

No oscillations. Standard current source (a) cannot drive inductive loads effectively because undamped circuit responses can occur and lead to oscillations. Adding operational amplifier A_1 and feedback network to circuit (b) enables R_C to adjust damping factor.



altered by the modified configuration, either.

The value of R_C is best found experimentally while observing the circuit response to a square-wave input. Note that the constant, K, in G(s) will be slightly smaller than its original value because of the feedback currents through R_C. □

Exclusive-OR gate and flip-flops make half-integer divider

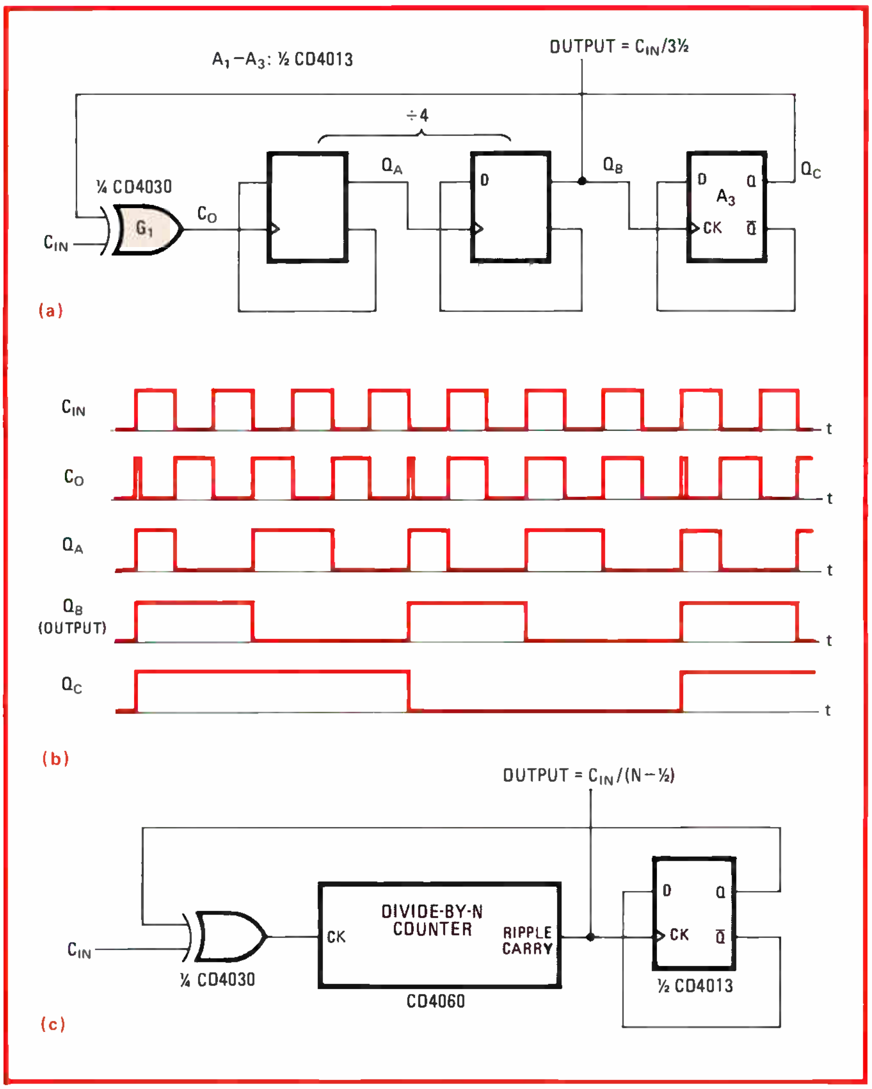
by Tung-sun Tung
University of Illinois, Urbana, Ill.

A simple and inexpensive divide-by-(N − ½) counter can be built with D flip-flops and an exclusive-OR gate. The circuit uses very few parts, largely because, unlike many such dividers, it does not rely on a collection of monostable multivibrators. Nor are there difficult timing considerations, which would also complicate the circuit and act to increase its parts count.

Various logic circuits need to be driven by what may be termed a half-integer clock signal that is derived from a master clock. For instance, the MM-57100 video-game integrated circuit is driven by a 1.0227-megahertz signal, which the chip's manufacturer (National Semiconductor Corp.) recommends be derived from the television set's 3.579545-MHz color-burst crystal oscillator. This application requires a divide-by-3½ counter, which may be built by modifying a divide-by-4 circuit as shown in Fig. 1a.

Flip-flops A_1 and A_2 form the divide-by-4 counter. The master clock, C_{IN}, drives A_1 through the exclusive-OR gate, G_1. However, the output state of G_1 is additionally controlled by A_3.

As a result, A_3 converts the divider to a divide-by-3½ counter. A_3 is situated in the feedback loop such that it enables generation of a short pulse at C_O for every 3½ counts of C_{IN}. The pulse is generated if C_{IN} either falls to logic 0 or rises to logic 1, which depends on the state of Q_C. Its shortness is due to the delay between the initial



Half-integer divider. Divide-by-3½ counter is divide-by-4 circuit modified by flip-flop A_3 and exclusive-OR gate G_1 (a). Timing diagram details operation (b). Method may be extended to form a divide-by-(N − ½) counter by replacing flip-flops A_1 and A_2 by ripple-carry, divide-by-N counter (c).

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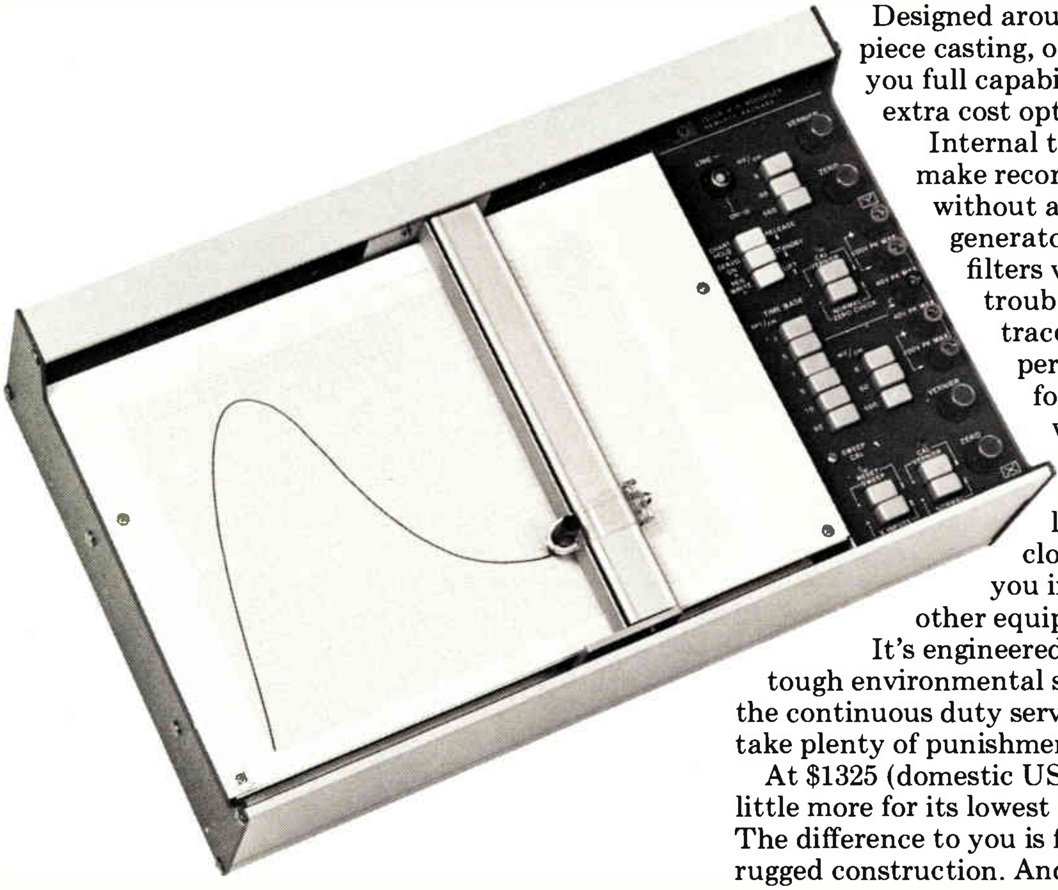

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0-to-1 transition of C_O (caused by C_{IN}) and the change of state of Q_C—as Q_C changes state, it disables gate G_1, causing C_O to fall almost immediately after it has reached logic 1. The timing diagram given in Fig. 1b details circuit operation.

This method may be extended to the general case of the divide-by-(N−½) counter, as shown in Fig. 1c, simply by substituting a single synchronous or asynchronous counter for the flip-flops A_i that would otherwise be required. □

Dc-dc power supply regulates down to 0 volt

by P.R.K. Chetty and A. Barnaba
ISSP, Bangalore, India, and CNES, Toulouse, France

In most dc-input, regulated power supplies, regulation is poor when the desired output voltage is less than the source's internal reference voltage. In addition, circuit considerations usually limit the minimum reference voltage attainable and consequently the minimum regulated output voltage possible. This circuit, however, with a configuration that can bring the reference voltage to virtually zero, overcomes both problems.

The LM723 voltage regulator shown, which provides 12 volts at 1 ampere, must be biased with a negative supply voltage at its $-V_{in}$ port (pin 5) for proper operation. This voltage is provided by the switching inverter shown within the dotted lines.

The LM111 voltage comparator is configured as an astable multivibrator that oscillates at a frequency of about 10 kilohertz. With the aid of the 1-millihenry inductor, which generates the counterelectromotive force required to produce a negative potential from a switched-source voltage, the inverter delivers a well-regulated −7.5 v to the $-V_{in}$ port of the 723.

The magnitude of this voltage is essentially equal to that of the regulator's internal reference voltage, V_{REF}, appearing at pin 4, and properly biases its voltage-reference amplifier. This condition in turn precipitates a condition in the amplifier whereby V_{REF} clamps to ground potential. Thus the output voltage may be adjusted throughout its maximum possible range by potentiometers R_1 and R_2. Although the potential of V_{REF} as measured with respect to ground has been changed, the circuit will retain the regulating properties of the 723. Both the line and the load regulation of the supply are 0.4%. □

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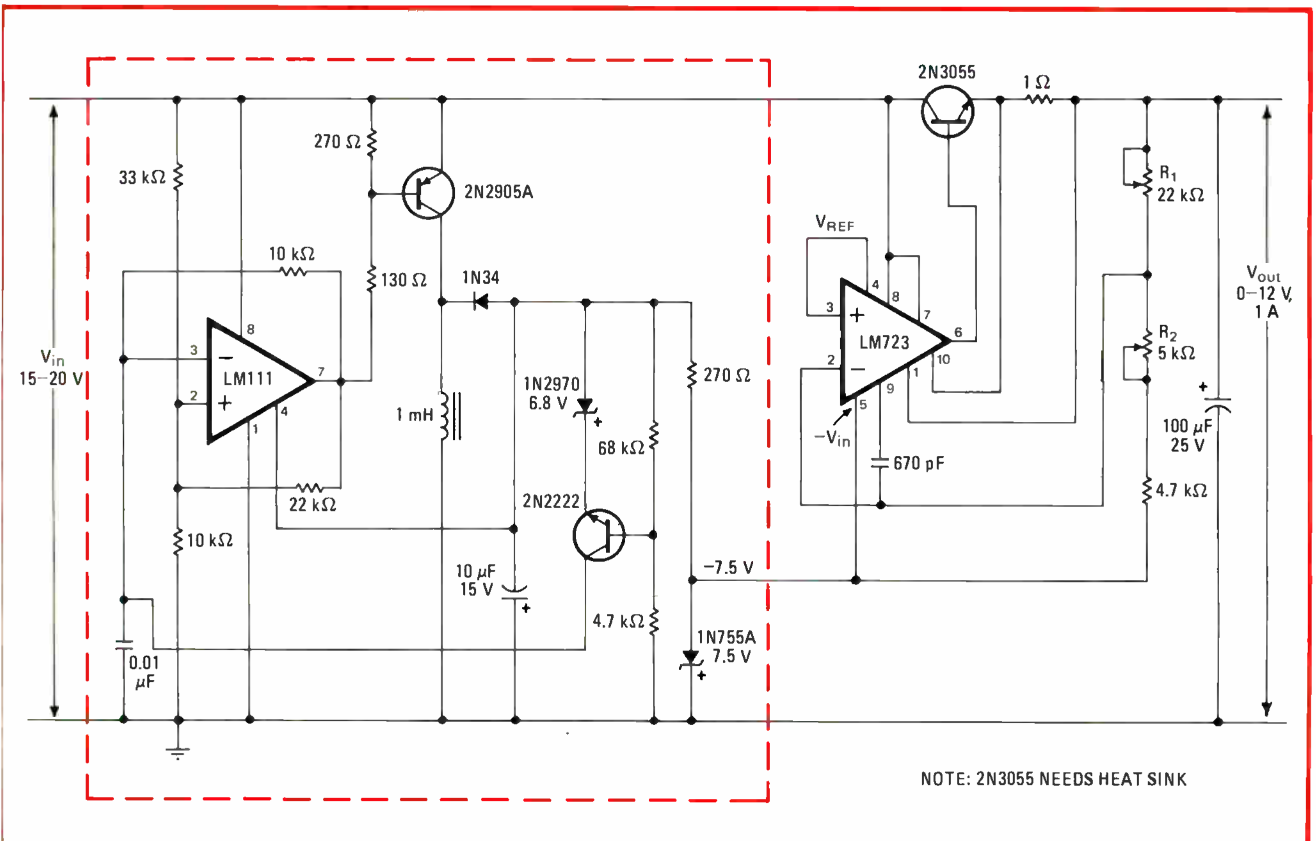

Full-range regulation. Dc-input supply is regulated all the way down to 0 V. LM111 and associated circuitry provide negative bias required for LM723 regulator. Regulator's internal-reference voltage, V_{REF}, is clamped to ground; output voltage is thus adjustable from 0 to 12 V.

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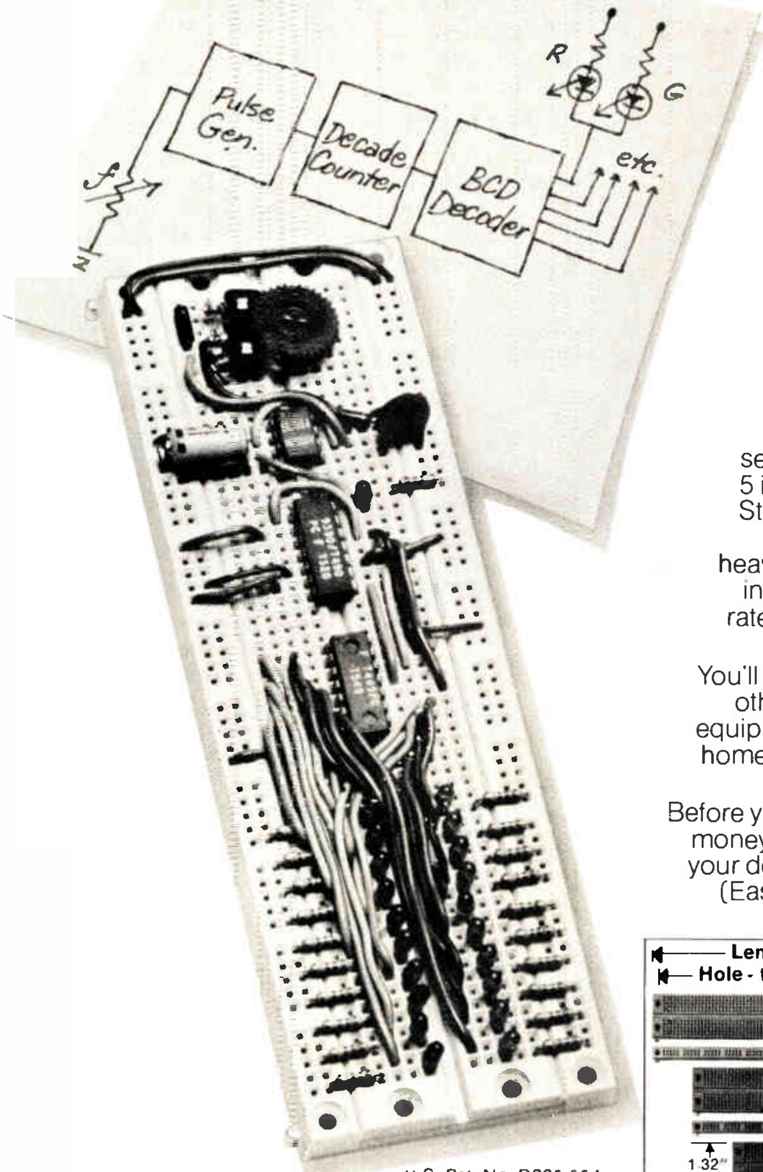

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What to look for in analog input/output boards

For a given microcomputer application, the architecture of an analog I/O board matters as much as its specifications

by Norman Bernstein, *Analog Devices Inc., Modular Instrumentation Division, Norwood, Mass.*

☐ Analog input/output boards are riding high on the success of single-board computers. As a convenient and relatively inexpensive way of interfacing these machines to the real world, they are becoming steadily more and more popular with designers who must incorporate analog data functions into all sorts of instruments and control systems.

By now there is quite a variety of analog boards from which to choose a partner for a wide range of board-level microcomputers. Running in price from less than $200 to over $1,500, these subsystems come in input or output versions or even as combination I/O boards. Options abound, and architecture may differ greatly between the boards made by various manufacturers for the same microcomputer. So selecting the right board for a given application means the designer must understand the differences between the architectures and the advantages of the various options.

Input board for data acquisition

Although commercial data-acquisition or analog input boards vary greatly with respect to individual design details, most share the same basic architecture (Fig. 1). A multiplexer selects one of 16 or 32 input signals and routes it to an instrumentation amplifier. Besides amplifying the signal to the specified range of an analog-to-digital converter, the amplifier drives a sample-and-hold circuit, which tracks the signal between data conversions and holds it during the conversion. The a-d converter produces an 8-, 10-, or 12-bit digital representation of the input signal, and this result is then made available to the microcomputer's data bus. Interface logic controls the entire process, accepting commands from the microcomputer and actuating the control inputs of the data-acquisition elements.

While the basic architectures of all input boards are similar, the relative merits of a particular board cannot be assessed purely in terms of numerical specifications. The most linear a-d converter or fastest instrumentation amplifier is useless if the board architecture is not designed to take advantage of these properties.

Almost universally, input boards employ complementary-metal-oxide-semiconductor multiplexers for input channel selection, because these devices provide economy, low power, high speed, high density, and compatibility with transistor-transistor logic. In general, most boards offer one or more multiplexer configurations, while some must be ordered with a certain configuration, and still others may be tailored by the user by means of jumpers or straps.

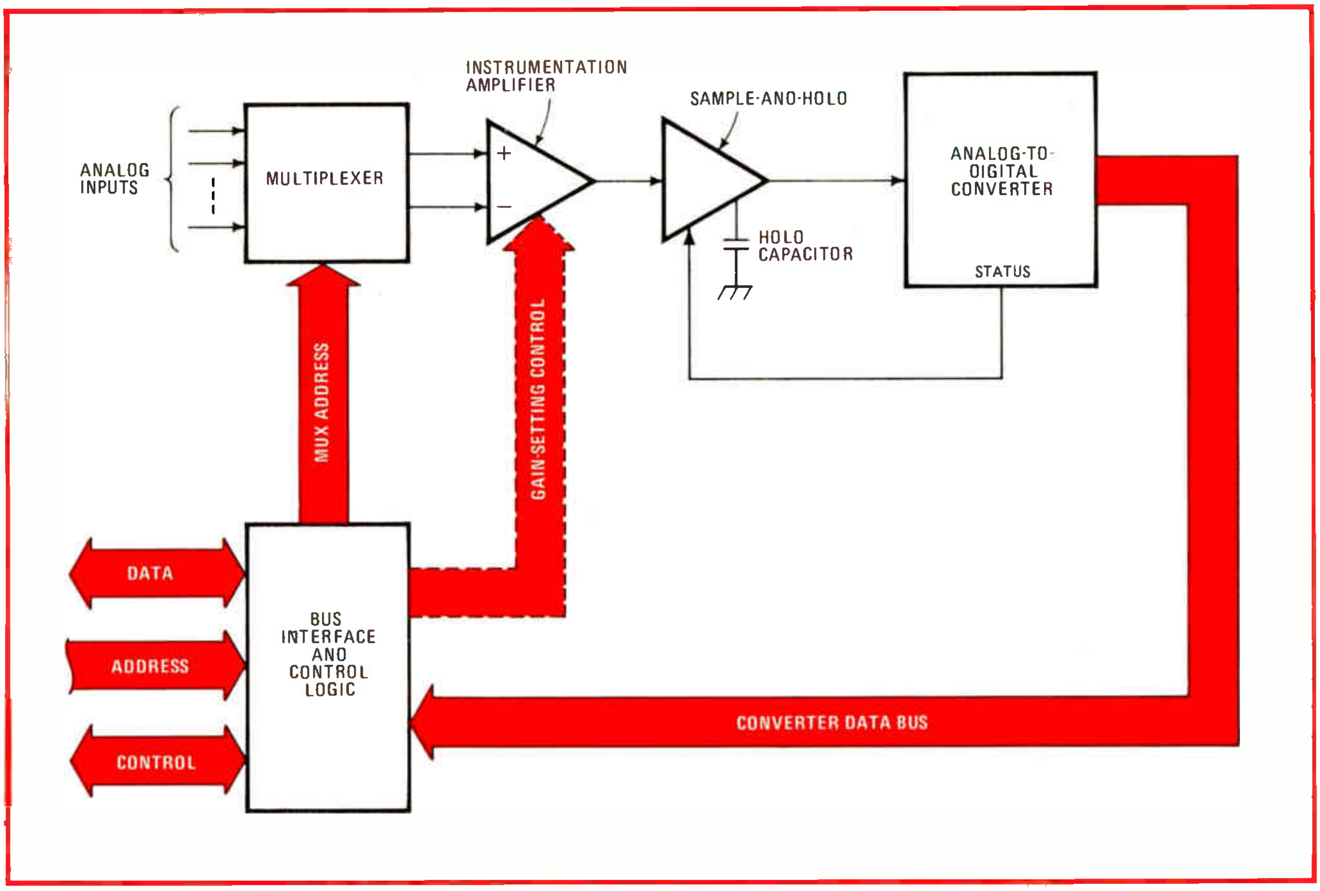
All about multiplexer configurations

The fundamental multiplexer configuration is the single-ended mode (Fig. 2a), in which each input is independently selected and assumed to be referred to the analog ground of the board. This architecture is optimum when the number of input channels must be maximum and all signals are measured with respect to system analog common.

For differential-mode operation, the multiplexers and the instrumentation amplifier are configured as shown in Fig. 2b, giving separate high and low connections associated with each input. In this mode, the multiplexers are simultaneously enabled to select both the high and low inputs of each channel, and the number of input channels is half that available with the single-ended mode. Differential operation is required in applications where several inputs are referenced to independent levels or where long signal leads would result in common-mode interference, such as 60-hertz pickup. With the differential mode, then, the selected channel can take full advantage of the common-mode rejection of the instrumentation amplifier.

Another useful mode is the pseudo-differential configuration, which may be employed if the board makes the inverting input of the instrumentation amplifier accessible, as noted in Fig. 2c. The pseudo-differential mode is useful in systems where all inputs are referred to a common potential that may, in turn, float with respect to the analog common of the data-acquisition board. Many applications can take advantage of this operating mode—for example, a number of sensors, all within the influence of a strong 60-Hz field, need not have independent returns, since the interference is common to all of them. With pseudo-differential operation, the virtues of common-mode rejection can be preserved without halving the number of inputs available.

Most boards offer some level of input protection to prevent damage to the C-MOS multiplexers. Those boards built with internally protected chips are usually safe for signals going up to ±20 volts beyond the analog power supplies—a level that is adequate for most applications.



1. Input board. Most available analog input boards have this basic architecture, incorporating an instrumentation amplifier and a sample-and-hold circuit. The gain of the amplifier is usually adjustable, through either an external resistor network or software programming.

Some boards offer a more elaborate measure of protection, incorporating active input clamps and series fusing resistors that open in response to a catastrophic accident, like shorting a 60-Hz power lead to the input. Such series resistors also serve as input current limiters.

A closer look at the instrumentation amplifier

Nearly all analog input boards follow the multiplexer with an instrumentation amplifier. It provides front-end gain on a resistor-programmable or software-programmable basis, as well as common-mode rejection for a differential multiplexer configuration. The performance of this amplifier—its settling time, offset and gain drifts, noise, and common-mode rejection—is a very important factor in determining the board's overall performance

With resistor-programmable gain, the resistance value selected by the user determines the gain of the amplifier. This method allows the user to optimize the front-end gain to suit a specific application, although all input channels will have the same gain. In general, the technique is best suited to applications where all input channels are driven from a similar type of signal source. Gains of from 1 to 1,000 are usually possible; however, very high gains may be impractical in certain situations.

Even under optimum conditions, high gains may reduce amplifier speed and accuracy. As gain increases, for instance, so does amplifier nonlinearity (as a function of full scale). Furthermore, settling time for step inputs may increase somewhat at high gains. The board's interface timing should be capable of taking this increase into account so that the amplifier has sufficient time to settle before a conversion takes place.

Also, amplifier noise consists of two components—one that is independent of gain and one that is proportional to gain. At low gains, the gain-independent component predominates, but as gain increases, the gain-dependent component becomes larger and ultimately dominant. Consider, too, that externally generated input noise will be amplified proportionally. At a gain of 1,000, for example, 10 microvolts of system-induced noise on the inputs will amount to 2 or more least significant bits of the amplifier's full-scale output. As with noise, the amplifier's offset drift has a constant component and one that is proportional to gain. To achieve good drift performance at very high gains, the latter component must be quite low.

Changing gain through software

Some input boards offer true programmable gain, permitting the use of software to invoke precalibrated gains of 1, 2, 4, or 8—the user simply writes a specific code into one of the bytes (or several bits) of the microcomputer's I/O image. Software-programmable gain expands the dynamic range of the front end, an advantage in applications where several types of input signals must be acquired by the same board.

With software-programmable gain, though, the amplifier may need extra settling time, as its output must swing by a factor of two for each increase or decrease in gain. A well-designed board should take this into account, calling on hardware mechanisms to delay the onset of conversion until the amplifier has had a chance to settle out after a gain change.

Gain-ranging software permits the user to extend the dynamic range of the system to 15 bits (assuming programmable gains of 1, 2, 4, and 8, and a 12-bit a-d converter). However, gain-ratio errors may degrade system accuracy for gains other than the one chosen as a reference. To preserve accuracy over the entire 15 bits, the amplifier's gain-ratio accuracy should be commensurate with the accuracy of the a-d converter.

Moreover, the I/O byte that determines gain should be allotted its own position within the I/O image of the interface, so as to allow for each gain change without the need for masking insignificant bits. Additionally, the gain byte should have read-back capability to permit the use of memory incrementing and decrementing instructions. In practice, the user should start from the lowest gain range and work upwards, lest he create an over-range condition that saturates the amplifier—and overload recovery may take far longer than the amplifier's settling response.

To determine whether or not a change in the front-end gain is required, the microcomputer must read the two most significant bits of the a-d conversion data. (Two bits are needed because with bipolar data the MSB indicates sign rather than magnitude). An efficiently designed board should incorporate the 2 MSBs within the status word. Since this word is normally accessed after every conversion, the ranging data will therefore be available to the microcomputer without the need for a separate data-access instruction.

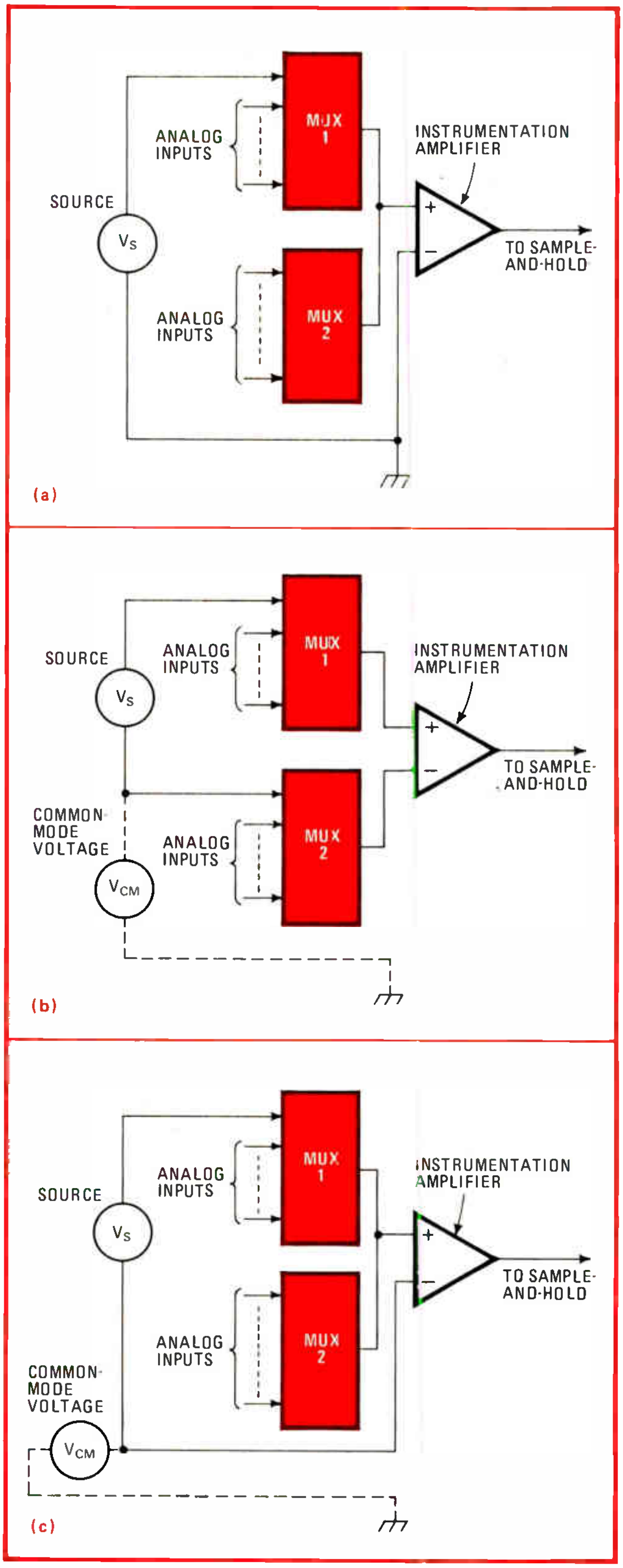
Sample-and-hold reduces possible errors

Coming just ahead of the a-d converter, the sample-and-hold circuit is a must for accurately digitizing signals that, in the time it takes to complete the conversion, may slew many LSBs. (Fast conversion times do not eliminate the need for a sample-and-hold, even though some manufacturers omit it on boards sporting converters that operate in the 2-microsecond range.)

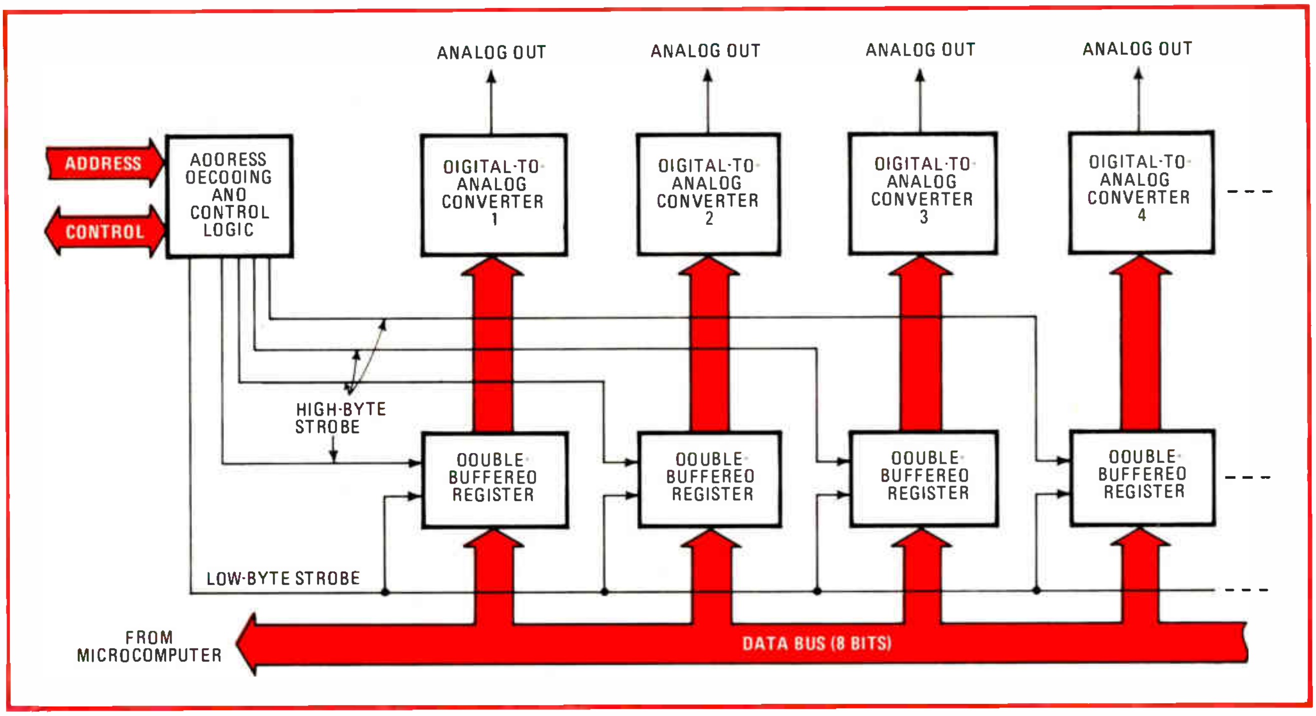
Essentially, a sample-and-hold restricts data uncertainty to approximately 150 nanoseconds, which represents the sum of its errors, such as aperture uncertainty, jitter, and aperture width. Conversely, the lack of a sample-and-hold will result in errors if the signal is not completely static during the conversion. How long the conversion takes will determine the time uncertainty of the data. Obviously, a sample-and-hold is a necessity for the user who requires broad-bandwidth performance and who must know the precise moment of the sample.

Output boards for control

Separate analog output boards (Fig. 3) usually contain from two to eight independent d-a channels, while a combination I/O board has only one or two d-a channels. The analog outputs can be put to work driving oscilloscopes, chart recorders, servomechanisms, and transducers. Like the a-d input channels, each d-a output provides selectable ranges and data coding and has its



2. A trio of multiplexer configurations. With single-ended operation (a), all inputs are referred to the analog ground of the board. The differential mode (b) allows each input to float on a common-mode voltage but halves the number of channels. Pseudo-differential operation (c) preserves the virtues of common-mode rejection while retaining the same number of channels as single-ended operation.



3. Output board. Providing up to eight independent channels, analog output boards are useful for driving oscilloscopes and recorders. When the data to be converted requires more than one byte, double-buffered registers are needed to prevent intermediate outputs.

own 1-, 2-, or 3-byte I/O image. To set a d-a converter for a given data point, the data is merely written into the appropriate address.

If the data will require more than one byte, as in the case of 10- and 12-bit resolutions, a double-buffering arrangement should be employed to hold the first byte of data until the second one is loaded. Then both bytes are presented to the converter simultaneously. Such double buffering prevents intermediate outputs from occurring and assures clean transitions from one output value to another. Some output boards also include a circuit that sets each converter output to zero when the power is first turned on or when the system is reset. This feature helps to minimize the effect of turn-on transients on devices connected to the output channels.

In general, these boards offer voltage outputs capable of driving 2-kilohm loads over ranges of 0 to 10, ±5, and ±10 V. Each output, moreover, should be capable of handling moderately capacitive loads without oscillation, so as to allow for cabling capacitance. Some boards also provide remote-sense operation for minimizing voltage drops when heavy loads are driven over long lead lengths or through interconnects.

A single reference for good tracking

To assure good tracking between multiple converters on the same board, a single voltage reference should be used, thus reducing the effect of reference drift. In combination boards, tracking between the input and output ends will be enhanced if the same reference is used for the d-a converters and the a-d converter. When the output board contains converters capable of multiplying operation and provides inputs for external references, then the converters can be used as programmable attenuators, filters, and the like.

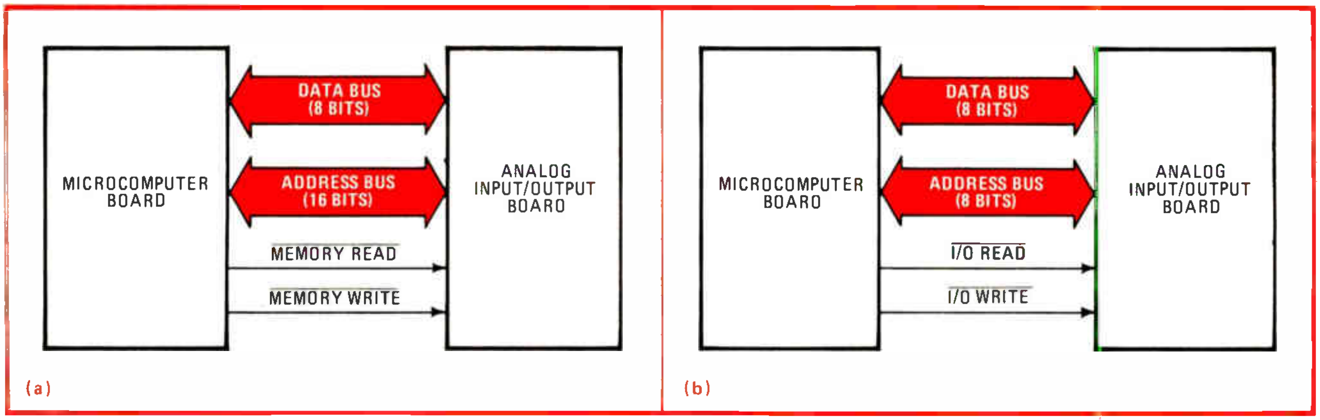
Some boards have optional voltage-to-current converters that provide a proportional output current of 4 to 20 milliamperes. Such converters can be extremely useful in industrial control applications, since many industrial transducers are designed for 4-to-20-mA operation. The current output, though, should have good compliance so that it can tolerate nonlinear loads, as well as the voltage drops associated with driving long lines. To give additional margin when driving high-impedance loads or several loads in series, the board should provide for operating the voltage-to-current converter with an external-loop supply.

Examining the interface

Every analog board must contain a bus interface that is functionally and parametrically compatible with the particular microcomputer bus structure for which it is intended, since microcomputers have different bus structures and software.

For several microcomputers—particularly those based on the popular 8080 8-bit microprocessor—there are two principal methods of I/O interface: accumulator I/O (or dedicated I/O) and memory-imaging I/O (or memory-mapping I/O). The latter technique (Fig. 4a) involves the use of all 16 address lines, along with the normal memory strobe signals. The analog board appears as a number of sequential bytes in the memory space and is accessed using any memory reference instruction. In contrast, with accumulator I/O (Fig. 4b), the data bus functions much the way it does for normal memory access, but only eight address lines are significant. There are separate strobe lines, and only specific I/O instructions may be used.

While accumulator I/O may seem simpler, in that fewer address lines need be decoded, it is not well suited



4. Choice of interfaces. Memory-imaging I/O (a) utilizes the same address, data, read, and write signals as conventional memory. In contrast, accumulator I/O (b) uses only a subset of the address lines and those read and write strobes specifically reserved for I/O.

to analog I/O interfacing. As it is inherently a single-byte technique, two instructions must be used to access 12-bit data. Since each instruction must go through the accumulator register of the microprocessor, extra instructions are needed to reserve the data between bytes. Also, because the control instructions are direct-addressed (the instruction contains the port address in the second byte), unnecessary overhead is carried when making repeated access to a single I/O port. Furthermore, the control instructions are comparatively slow to execute, limiting the speed of the interface.

Memory imaging, on the other hand, permits both direct addressing and indexed instructions to be employed. Since double-byte instructions are available, a 12-bit data word may be accessed in a single instruction. Moreover, execution is faster for memory reference instructions than for control instructions. Although memory imaging does decrease the room available for conventional memory, few applications require more than a few bytes of the total memory address space for the analog interface—a small fraction of the tens of thousands of bytes available.

As long as a memory-mapped analog board has provisions for strapping it into an unused address space, there is no need to worry about memory space. Since the user's utilization of memory (and therefore address space) will differ from application to application, the jumpering provision must allow for selection of a convenient address at which to place the I/O image. At least 4 bits of address jumpering are desirable, giving 16 possible positions for the interface.

Address jumpering

The jumpering may be implemented with a nondestructive technique, by means of a socket for a dual in-line package or wirewrap pins. Some boards have plated-through holes that must be drilled out to establish the card address, a technique that makes changes sloppy and more difficult. A DIP socket lets the user install a DIP switch that allows instant address modification. For permanent installation, a plug containing shorting pins can be inserted in the socket.

When more than one analog board is used in a single system, each board may be located at a different address and thereby exhibit a unique I/O image. However, a software inefficiency may result because some microprocessors make extensive use of direct-addressed instructions. For instance, in a system having two separately addressed analog boards, the software routines containing direct-addressed instructions cannot be utilized for both boards. In this case, the user must either set up separate routines to access each board or use only indexed instructions.

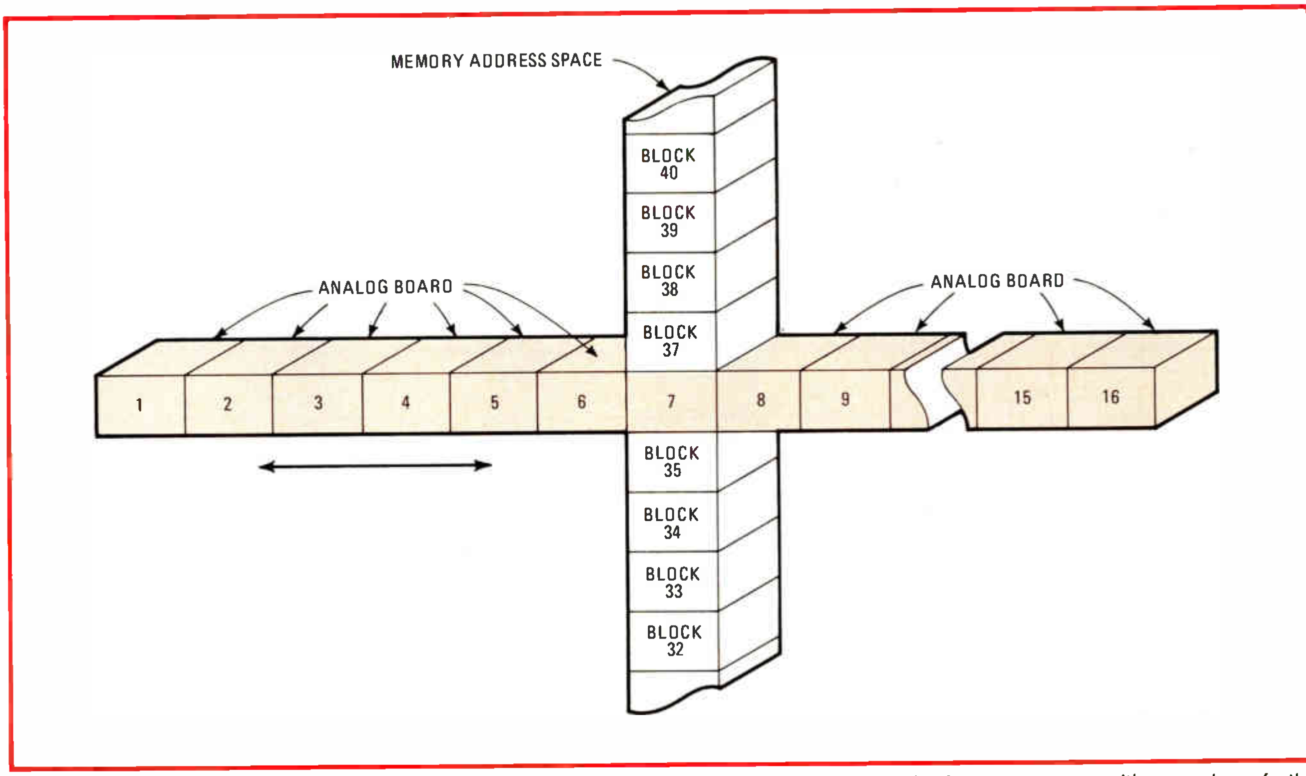
There is an addressing technique, however, that neatly circumvents this problem and often dramatically reduces software. Called card select, the technique allows multiple boards to share the same address space, much as in memory paging.

Briefly, card select (Fig. 5) works like this. Each board is given the same address and assigned (by means of jumpers similar to the address jumpers) a unique 4-bit code. When an assigned code is written to a specified memory location within the I/O image, the board associated with that code is activated and has access to the bus. In effect, all other boards disappear from the bus but are listening for the microcomputer to write their code into the select byte. The unselected board does not interfere with the normal bus operation, however; most on-board processes, such as an externally triggered conversion, may take place.

Controlling the data process

Just as equipment controls should be logically arranged and easy to use, the organization and arrangement of the bytes that make up the control and interface to an analog board should not be so complicated as to cause confusion nor so simplified as to prevent the implementation of a sophisticated application. The most critical aspect of handling the digitized analog data is the arrangement of the data bytes coming from an input board or going to an output board. Since most boards deal with data that is 12 bits or less in length, the data may be either right-justified or left-justified within the 16-bit field created by two bytes. In general, board manufacturers opt for right-justified data, because trailing zeros would be meaningless.

The disposition of the leading bits in right-justified data depends on the type of data being accessed. For example, with unipolar data, the leading bit positions should read as zero. But when bipolar data is expected,



5. Sharing. Card-select feature permits a memory-imaged analog board to share a single block of memory space with a number of other boards in the same system. Direct-addressed instructions may be common to all boards, often making software reduction possible.

the MSB of data must be inverted and then extended into all leading bit positions. This brings it into conformity with the 2's complement notation that is generally used by microprocessors to execute arithmetic instructions. Of course, the board should permit the data coding to be configured independently of the range of the a-d or d-a converter and offset configuration, since some applications might call for bipolar analog signals to be represented as offset-binary data, rather than 2's complement.

Occasionally, an application for an input board might require access to an 8-bit representation of the data from the a-d converter. For example, data screening could be done much faster on a single-byte basis than if all 12 bits must be accessed. Some input boards allow for this truncation by incorporating an independent byte containing just the 8 MSBs. Such a feature saves a great deal of microcomputer time that would otherwise have to be spent in executing a data-shifting algorithm.

Accessing data

With an input board, before data may be accessed, the a-d conversion must be initiated, and the microcomputer informed when valid data is available for reading from the a-d converter. For microcomputer-initiated conversions, a separate, data-insensitive byte should be reserved that performs this function when activated. The data insensitivity makes it unnecessary to load data into the microprocessor's accumulator register before initiating the conversion. Once the conversion is in process, the microcomputer may examine the status byte to determine, among other things, the condition of the converter.

The most fundamental piece of information within the status byte is the end-of-conversion flag. Another piece of information available in the status word could be a conversion-delayed flag, which invokes on-board mechanisms to delay the onset of conversion in the event of a recent change in multiplexer address or gain selection. In addition, a busy flag within the status word could signal that a conversion is currently taking place.

Channel selection is usually accomplished via a separate byte. To permit the use of memory incrementing and decrementing instructions, it is essential that the data be right-justified, as well as readable. The same criteria apply to the gain-select byte, on input boards offering software-programmable gain. Additional ancillary functions might include a byte to control the operation of any interrupt function or a byte to control any accessory driver outputs.

The sequence of the bytes is not random. Rather, for easy addressing, their arrangement should correspond to the normal execution sequence of standard data routines. For example, with an input board, the byte sequence of gain selection, multiplexer addressing, conversion initiation, converter status, and data accessing matches the order in which these routines are normally performed. Such an arrangement is conceptually convenient and also simplifies the use of indexed addressing, since the index register need merely be incremented between references to successive control and data bytes.

Memory map tells all

For a memory-imaged analog board, the interface bytes may be fully illustrated by a memory map, like the one shown in Fig. 6 for a typical combination board for the SBC-80 microcomputer. Such a map concisely depicts a board's architecture, indicating the address of

BYTE ADDRESS	7	6	5	4	3	2	1	0	BYTE NAME	OPERATION
XFFF	φ	φ	φ	φ	S_3	S_2	S_1	S_0	CARD SELECT	WRITE
XFFE	0 / $\overline{MSB}$	0 / $\overline{MSB}$	0 / $\overline{MSB}$	0 / $\overline{MSB}$	MSB / $\overline{MSB}$	B_{10}	B_9	B_8	ADC DATA	READ
XFFD	B_7	B_6	B_5	B_4	B_3	B_2	B_1	LSB	ADC DATA	READ
XFFC	END OF CONV.	BUSY	CONV. DLYD.	MSB	B_{10}	φ	φ	TIME MARK	STATUS	READ
XFFB	φ	φ	φ	φ	φ	φ	φ	φ	CONVERT COMMAND	WRITE
XFFA	ϕ_0	ϕ_0	ϕ_0	A_4	A_3	A_2	A_1	A_0	MUX ADDR	WRITE, READ
XFF9	ϕ_0	ϕ_0	ϕ_0	ϕ_0	ϕ_0	ϕ_0	G_1	G_0	GAIN SELECT	WRITE, READ
XFF8	MSB / $\overline{MSB}$	B_{10}	B_9	B_8	B_7	B_6	B_5	B_4	ADC DATA	READ
XFF7	φ	φ	φ	φ	MSB / $\overline{MSB}$	B_{10}	B_9	B_8	DAC 1 DATA	WRITE
XFF6	B_7	B_6	B_5	B_4	B_3	B_2	B_1	LSB	DAC 1 DATA	WRITE
XFF5	φ	φ	φ	φ	MSB / $\overline{MSB}$	B_{10}	B_9	B_8	DAC 2 DATA	WRITE
XFF4	B_7	B_6	B_5	B_4	B_3	B_2	B_1	LSB	DAC 2 DATA	WRITE
XFF3	φ	φ	φ	φ	φ	φ	D_1	D_0	DRIVERS	WRITE
XFF2		NOT USED								
XFF1		NOT USED								
XFF0	END OF CONV. INTERRUPT ENABLE	φ	φ	φ	φ	PACER FUNCTION	PACER SELECT		SETUP	WRITE

- The symbol φ means the bit is ignored.
- Bits shown as ⊟ have the upper value for unipolar codes and the lower value for bipolar coding.
- The symbol ϕ_0 means that the bit is ignored during a WRITE, and read as a 0 during a READ.

6. Mapping the interface. For memory-imaged analog boards, a memory map like this concisely illustrates the interface bytes, indicating the address and format of each byte, as well as the sequence of execution, and such special features as a real-time clock.

each byte, the format within each byte, and the sequence of execution. It also shows all the special features available to the user, like the inclusion of a real-time clock for synchronizing the conversion.

Few signals in the real world are fully static, so it is often necessary to synchronize the conversion to real time or some external event. While some analog boards offer a choice of ways to initiate a conversion, most allow for either microcomputer-generated or externally triggered conversions.

The former is useful when exact conversion timing is not important, such as the monitoring of dc levels or the acquisition of narrow-bandwidth signals like those from temperature transducers. In this case, the user generally performs a write instruction to a specified byte in the I/O image, thereby triggering the conversion. For situations where precise synchronization to an external event is required, the conversion should be externally triggered. The user supplies a TTL-compatible pulse that causes a conversion to occur, so that the relationship of the data to the synchronization pulse is known precisely.

Using a real-time clock

Such techniques are adequate for most applications. High-performance systems, though, generally require a real-time clock, sometimes called a pacer clock. Many a-d processes are inherently related to real time—for example, spectral analysis of a signal requires a series of precisely spaced data points. If the board has no real-time clock, the user must supply one himself—an extra that takes up room in the card cage and also adds to the cost of the system.

The real-time clock has two fundamental functions: to initiate conversions and to generate interrupts. Clock-generated conversions, which are precisely located in time with respect to one another, are useful for analyzing spectral characteristics, rate information (differentiation or integration), and the like. Clock-generated interrupts are useful when data-acquisition routines are executed in response to clocked interrupts. They can also be helpful in more general tasks, such as time-of-day clock maintenance and periodic keyboard or sensor scanning.

For data acquisition, there are three fundamental types of real-time clocks—crystal-controlled, RC-controlled, and externally controlled. Many clock-related functions require the precision and stability of a crystal, like Fourier analysis and time-of-day maintenance. Since most small-can crystals are only available for operation (in fundamental mode) from approximately 1 to 22 megahertz, a digital divider string must be employed to bring the clock rate down to a usable value.

On the other hand, the potentiometer-variable RC-controlled clock allows the user to adjust for those intermediate rates not available from the crystal type. It is useful for optimizing the response characteristics of microcomputer-linked servo loops without software parameters having to be adjusted. In a data-acquisition board containing a pacer system, it is conceptually convenient to treat the external trigger input as a real-time clock. If it is included along with the other clock sources, it can share the same control structure.

Of course, when there are several clock sources on one board, there must be a means of selecting both the source (crystal, RC, or external) and the effect (clock-triggered conversions or clock-triggered interrupts). These control functions constitute a byte within the I/O image. When used in conjunction with the status flags normally provided, the microcomputer can maintain complete control over the board's timing-and-synchronization characteristics. □

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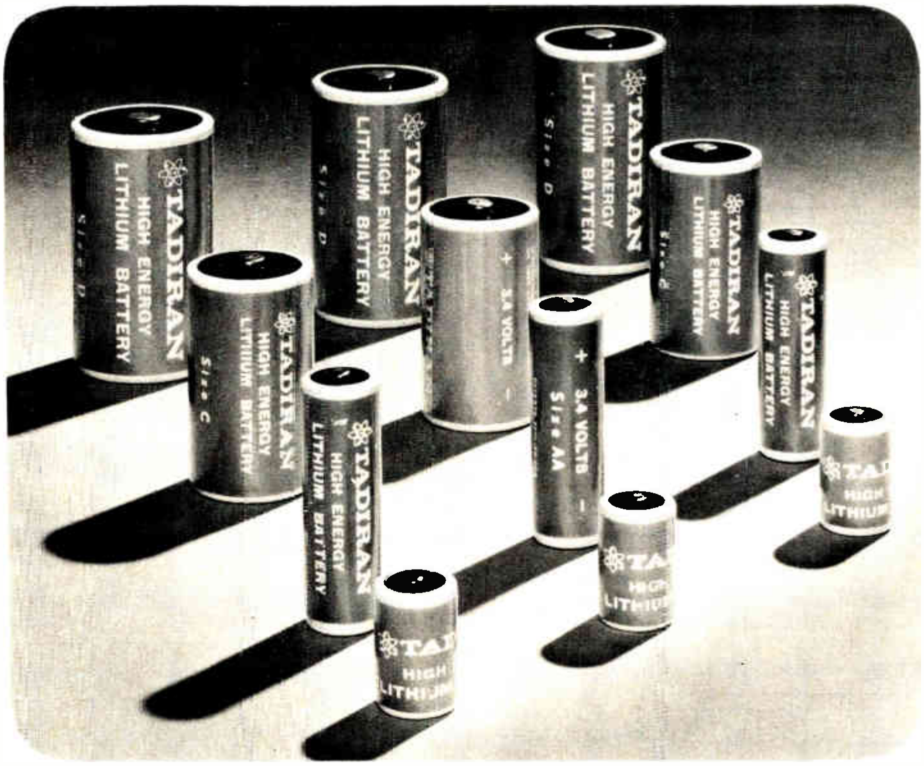

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Differential optical coupler hits new high in linearity, stability

For analog applications, pair of matched photodiodes in differential configuration cancel light-emitting diode's errors

by Bill Olschewski,
Burr-Brown Research Corp., Tucson, Ariz.

☐ Although conventional optical couplers are fine for separating grounds and eliminating noise in digital systems, they do not always work well in analog applications because of their lack of stability and fairly high nonlinearity. The light-emitting diode is largely to blame, the photosensor less so. However, a differential circuit technique can correct for most of the inaccuracies, permitting the designer to couple analog signals optically while holding linearity error to as little as 0.01% and instability to better than 0.1%.

There are four chief sources of error. The conventional coupler owes most of its 1% to 5% nonlinearity to the nonlinear relationship between the LED's light output and its forward bias current. Its poor temperature coefficient is due to the LED's negative tempco, which exceeds the photosensor's positive one. Its high noise comes from the LED at forward currents above 1 milliampere, the photosensor at currents below this. Finally, the coupler's characteristics change with time because the conversion efficiency of the LED degrades with age.

Two circuit techniques aim to get rid of these problems. The earlier and less successful, called the compensated technique, uses a matched pair of photodiode couplers to balance out the linearity and tempco errors, so that accuracy may be as tight as 0.15%. The improved, differential approach produces but a fraction of this linearity error. It puts a matched pair of photodiodes, illuminated by the same LED, in a differential configuration that cancels out the conventional coupler's four major shortcomings.

The three approaches to optical coupling are compared in Table 1. From the improved parameters, shown shaded in, it is obvious that the compensated version can be viewed as just an interim step to the ultimate, differential design. As of now, only RCA Corp. and Burr-Brown Research Corp. have such devices, but Hewlett-Packard Co. and Bell Telephone Laboratories are working on similar devices, and others are bound to appear on the market soon.

The key parameter

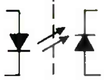
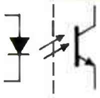
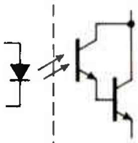
The current transfer ratio is the key parameter of all optical couplers. The conventional optical coupler consists of a single light emitter, usually an LED, and a single light sensor, which may be a photodiode, a phototransistor, or a photo-Darlington device (Table 2). The basic photodiode coupler has the lowest CTR, and

TABLE 1: PERFORMANCE OF LINEAR OPTICAL COUPLERS

	Conventional	Compensated	Differential
Gain or CTR stability over 100,000 hours at 25°C	5 – 20%	3 – 18%	0.075%*
CTR vs temperature	−0.5%/°C	0.03 – 0.1%/°C	0.005 – 0.03%/°C*
Nonlinearity	1 – 5%	0.15 – 1%	0.01 – 0.2%*
Signal-to-noise ratio from 0.05 to 100 Hz	85 – 86 dB	65 – 86 dB	110 dB*
Frequency response at −3 dB	0.1 – 10 MHz	0.02 – 1 MHz	0.015* – 1 MHz

*Performance range of Burr-Brown 3650/3652 isolation amplifiers.

TABLE 2: COMPARING CONVENTIONAL OPTICAL COUPLERS

Emitter	Sensor	Key characteristics		
		CTR	Bandwidth	Noise
light-emitting diode	 photodiode	0.1 – 0.3%	high	low
light-emitting diode	 phototransistor	30 – 100%	low	medium
light-emitting diode	 photo-Darlington	100 – 1,000%	very low	high

the Darlington types have the highest.

The CTR is determined by four factors: the conversion efficiency of the LED, the quantum efficiency of the photosensitive junction, transmission path losses, and the internal current gain of the coupler.

The temperature sensitivity of the CTR is mainly a function of the negative temperature coefficient of the LED and the positive tempco of the photodiode. The LED drift predominates, however, and this results in an overall CTR tempco of approximately −0.5%/°C for most commercially available optical couplers.

The most stable CTR is achieved with simple photodiode couplers, since the quantum efficiency of a photodiode is inherently more stable than the current gain of a phototransistor or photo-Darlington. But the major causes of CTR instability are the noise and drift characteristics of the LED. From the long-term stability data on some of the best LEDs available (Fig. 1), it is clear their stability is best at lower currents and temperature.

Unfortunately, a higher forward current would improve LED linearity—and as already stated, the nonlinear relationship between a LED's light output and its forward current is the main cause of CTR nonlinearity (Fig. 2).

Compensated couplers

Compensated optical couplers use negative feedback to cancel the errors in linearity and gain of two matched couplers. The compensated circuits that are shown in Fig. 3 are a current-to-current configuration and a voltage-to-voltage configuration.

In Fig. 3a, the LED in coupler 1 is driven by a current source of positive polarity and illuminates photodiode D_1. The photodiode, in turn, develops a negative voltage between the inverting and noninverting input of operational amplifier A_1, causing its output to go positive. The positive output drives a current through the LED of coupler 2, illuminating photodiode D_2. The output of the op amp will remain positive until $I_{D1} = I_{D2}$. This, of course, assumes that the op amp's input impedance is very high and its bias current very low. The resulting transfer function is:

$$I_{out} = I_{in}(CTR_2/CTR_1)$$

The quality of the match between CTR_1 and CTR_2 determines the linearity of the overall transfer function. A nonlinearity of 1% can easily be achieved using couplers of the same type, and 0.15% is possible with careful matching of the couplers. If $CTR_1 = CTR_2$, of course, the circuit will have unity current gain.

Compensated optical coupling will also raise the gain-temperature stability well above that of individual couplers, since gain vs temperature of the CTR will track

Why specify current transfer ratio?

As with any four-terminal device, the optical coupler could be treated as a current-source that is current- or voltage-dependent or as a voltage source that is current- or voltage-dependent. Of these, the current-to-current function, or current transfer ratio (CTR), is the most linear because of the inherent characteristics of the coupler's light source(s) and detector(s)—its light-emitting diode(s) and photodiode(s) or phototransistor(s).

The current input of an LED bears a more linear relationship to its light output than does a voltage input. The current output of a photodiode or phototransistor bears a linear relationship to its light input, whereas its voltage output does not. The result is that a reasonably linear relationship exists between an optical coupler's input and output current. Since this linearity is an easy parameter to test and convenient for the circuit designer to apply, it has become a standard industry specification.

In more detail, the equation for the light source quantum efficiency (η_s) of an LED is:

$$\eta_s = \frac{q N_s}{I_F}$$

where N_s = the external photon rate
q = the charge of an electron
I_F = forward current.

This equation gives rise to a linear relationship between forward current and light output, but due to process limitations and material imperfections, present-day LEDs do have nonlinearities of several percent. However, errors found in the voltage-to-light mode are many times greater because of the nonlinear and indeed logarithmic relationship of the LED threshold voltage to the amount of light it gives out.

The photocurrent, I_λ, of a photodiode is similarly a linear function of the incident illumination on the active optical junction. This relationship is given by:

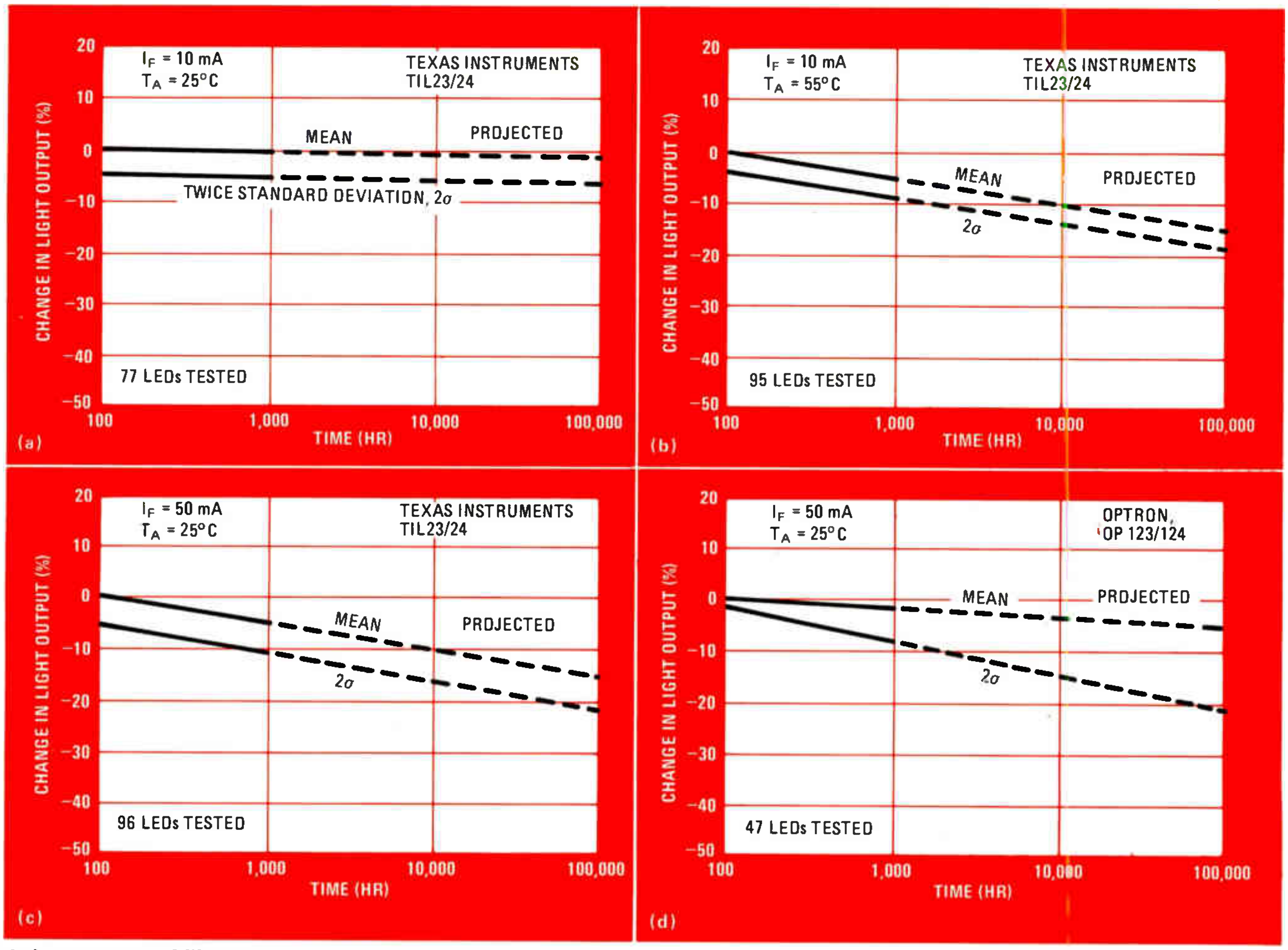
$$I_\lambda = I_o + \eta F q A$$

where
I_o = dark (leakage) current
η = quantum efficiency of the photodiode
F = incident photons transmitted by the crystal
q = charge of an electron
A = area of active optical junction.

The collector current of a phototransistor I_c is also approximately linear with respect to the base current. In this case the photocurrent is expressed as:

$$I_c = (h_{FE} + 1)I$$

where h_{FE} = the current gain of the phototransistor.



1. Long-term stability. Although the stability of LEDs varies from manufacturer to manufacturer, the curves shown are typical of commonly used LEDs, whose power output over operating life decreases more rapidly at higher input currents and at elevated temperatures.

to within a few percent. For very high temperature stability, however, the temperature coefficients of the two couplers should be matched.

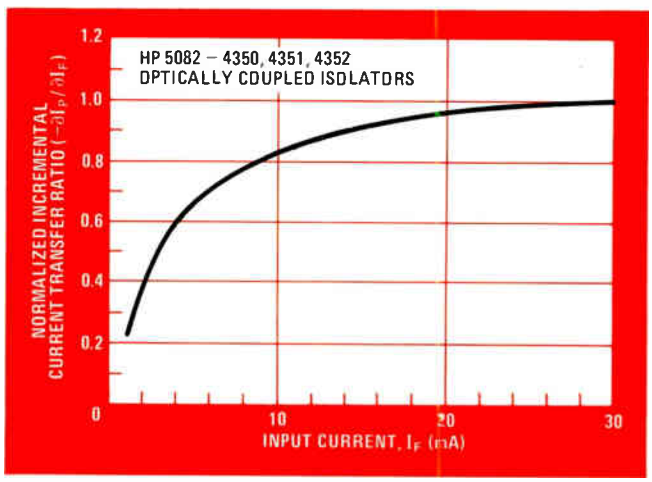
A voltage-to-voltage transfer function is possible by adding two resistors to the basic compensated optical coupling circuit, as shown in Fig. 3b. This circuit is not as linear as the current-to-current configuration of Fig. 3a because of the nonlinear (natural log function) threshold voltage of the LED. However, with an input voltage in excess of 5 V and $R_{in} = R_{out}$, a circuit nonlinearity of 0.3% is possible.

Noise and long-term stability are not improved with the compensated coupler because the optical link of photocoupler 1 is outside of the feedback loop. And the frequency response of all compensated optical couplers is limited by the op amp's closed-loop bandwidth, which is determined by system stability requirements.

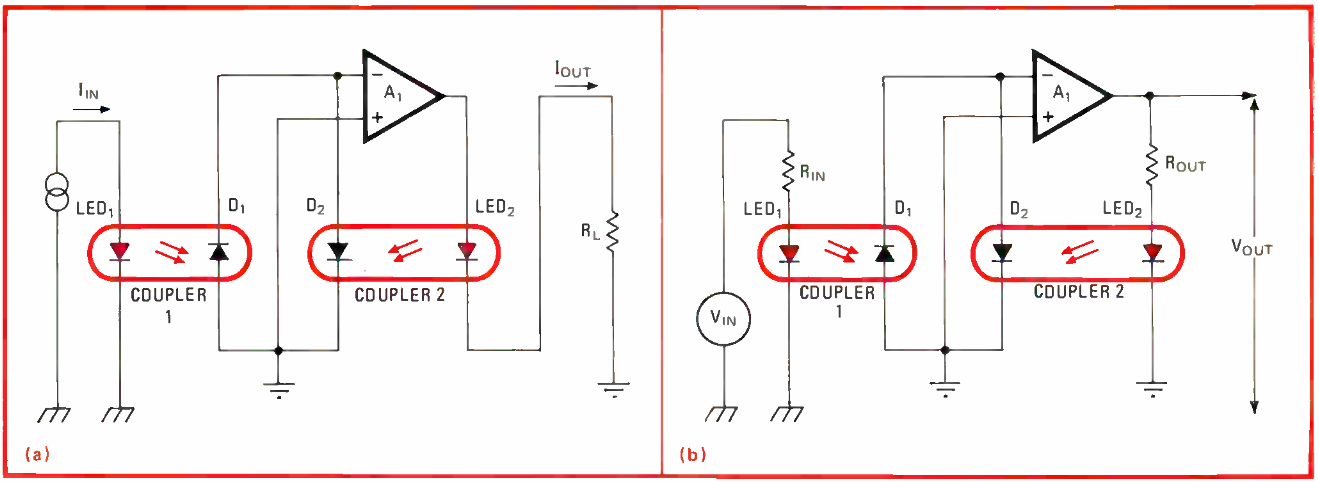
If bidirectional (positive and negative) signal operation or a more linear voltage-to-voltage transfer characteristic is required, the LEDs can be biased on with current sources. To further optimize linearity and stability, additional op amps can be employed in both the voltage-to-current and current-to-voltage conversation modes, as shown in Fig. 4.

Differential optical coupling improves in the performance of the compensated circuit and makes a major advance in linearity and stability.

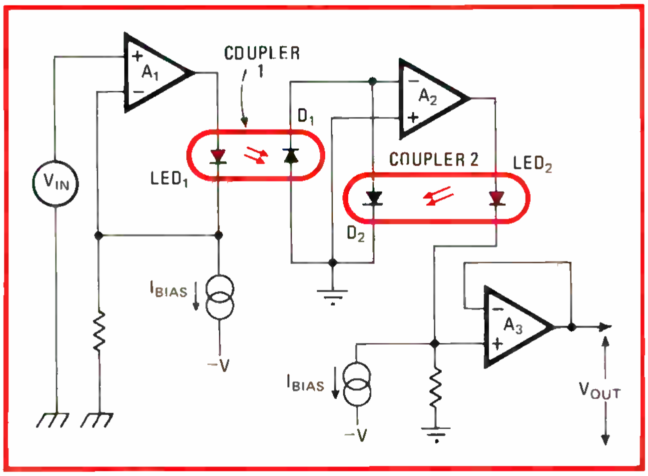
Figure 5 shows a very simple implementation of differential optical coupling using one LED, two photodiodes, and two op amps for both unidirectional (a) and bidirectional (b) operation. Unidirectional operation limits



2. Key parameter. The main cause of nonlinearity in current transfer ratio, CTR, is the nonlinear relationship between the LED power output and the forward current through the LED. LED linearity is best at higher current, but this limits the device's operating life.



3. Compensated circuits. Negative feedback cancels errors in linearity and gain of the two matched couplers. The circuit shown in (a) operates in a current-to-current mode, but adding two resistors (b) allows it to function in a voltage-to-voltage mode.



4. Improved linearity. Nonlinearity of optical couplers is lowest when the LED is driven from a current source. In this circuit both LEDs are biased from separate current sources, and an operational amplifier serves as a voltage-to-current converter.

amplification to positive signals only, whereas bidirectional handles both positive and negative signals by providing a bias current source for the photodiodes.

Circuit operation is straightforward. The LED infrared emitter is driven by A_1; diodes D_1 and D_2 are matched differential photodiodes receiving an equal amount of light from the LED. Diode D_1 closes the feedback loop around A_1, so that A_1 drives the LED until:

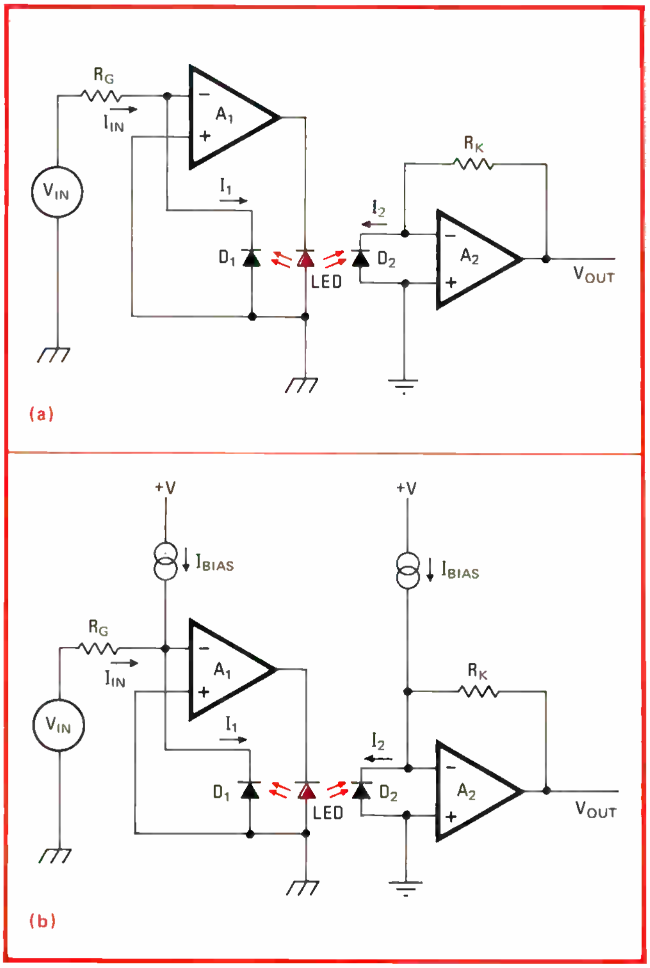
$$I_1 = I_{in} = V_{in}/R_G$$

where I_1 is the current generated by diode D_1 and amplifier A_1 is assumed an ideal op amp with infinite open-loop gain and zero bias current.

The current I_2 is generated by D_2, which is used to feed an equal current to the current-to-voltage converter on the output side of the optically coupled amplifier. The transfer function can be written as:

$$V_{out} = I_2R_K$$

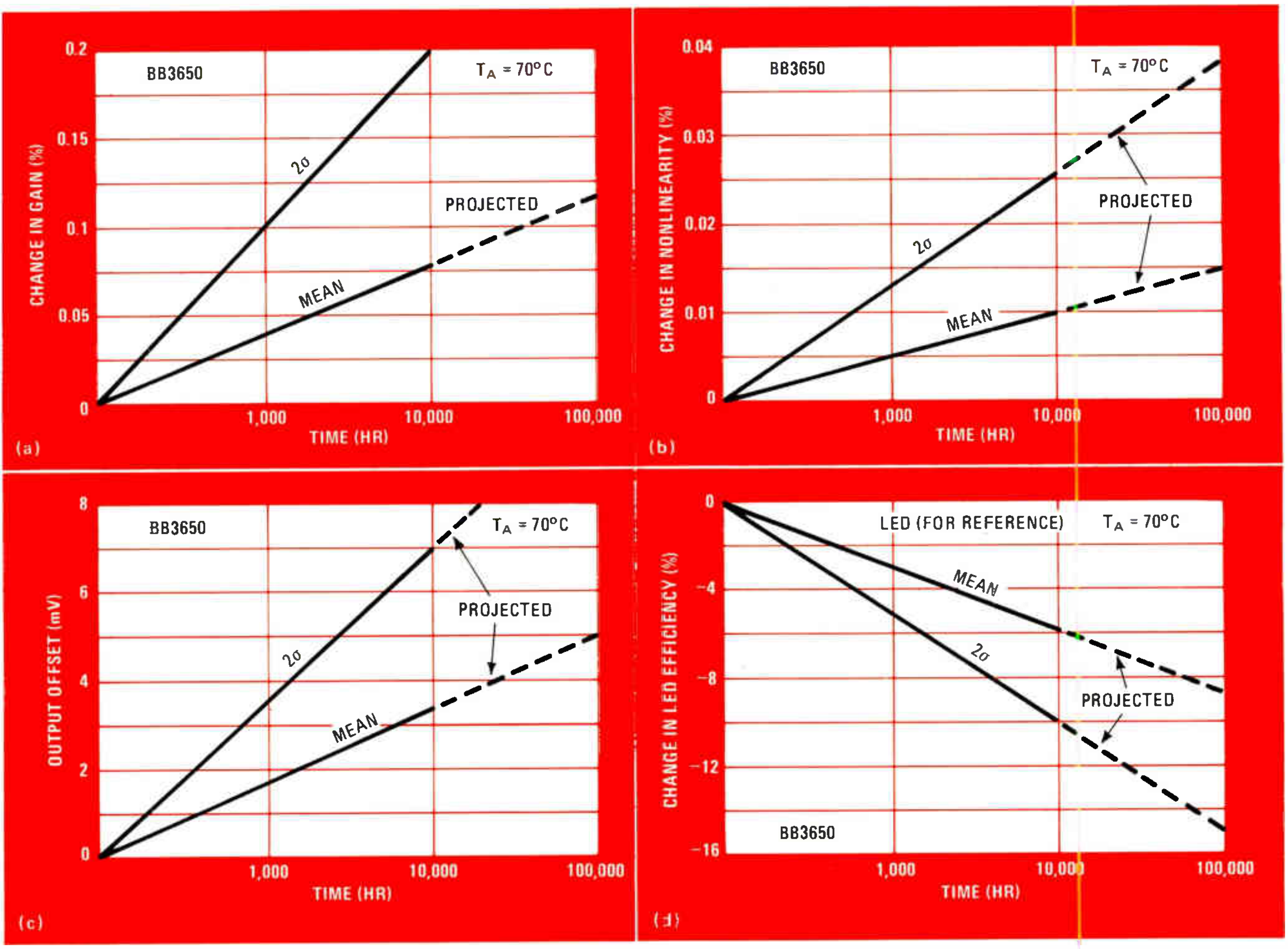
where R_K is the feedback resistance for amplifier A_2, which is assumed to be a perfect op amp. For equal light input, if the photodiodes are matched in quantum efficiency, then $I_2 = I_1 = I_{in}$, and the transfer function for the entire circuit becomes:



5. Better performance. Additional photodiode matched to the primary light source's sensor diode can virtually eliminate nonlinearity and temperature drift errors of an optical coupler. The circuit of (a) is for unidirectional operation; the one in (b) is bidirectional.

$$V_{out} = I_{in}R_K = (V_{in}/R_G)R_K$$

This equation is independent of LED parameters, for



6. Long-term stability. Differential optical coupling improves stability by two orders of magnitude over conventional optical couplers. In these tests on a sample of 10 LEDs, although LED efficiency fell 6% over 10,000 hours (d), gain (a) and nonlinearity (b) changed much less.

the feedback loop is closed around the LED, so that its characteristics do not contribute to the errors of the circuit except to the extent that amplifier A_1 is imperfect. Therefore most detrimental characteristics of the LED such as nonlinearity, poor long-term stability, and high noise disappear.

The accuracy of the circuit depends only on the match of the photodiodes, the match of the light transmission paths, and the tracking of these matches over temperature. But all this can be controlled to a high degree.

The only circuit limitations imposed by the LED are frequency response, minimum efficiency near end of life, and unipolar input and output. The frequency response of the LED and the speed of available op amps limit the circuit's frequency response to less than 1 megahertz just as in the compensated optical coupling circuit. The minimum efficiency anticipated over the life of the LED forces the designer to provide a minimum (worst-case) output current from the op amp A_1 to avoid a reduced output swing capability due to a degradation in light output near the end of the LED's life. To overcome the unipolar nature of the LED and photodiodes, a bias current source can be employed as shown in Fig. 5.

Figure 6 shows the excellent long-term stability of Burr-Brown's optical isolation amplifiers 3650/3652, using differential optical coupling. Elevated temperature (70°C) life tests of 10 standard 3650s were performed per MIL883 Method 1005, Condition D (±5-mA output, 1-kilohertz sine wave). The life test was interrupted at 168, 1,000, 2,000, 5,000, and 10,000 hours to retest the units on computerized in-house testers.

The results for gain, linearity and dc-offset stability are shown in Fig. 6a, 6b, and 6c, respectively. For reference, Fig. 6d shows the degradation in LED efficiency calculated from the measured increase in input supply current. The tests show that the stability of differential optical coupling is independent of LED aging. For example, the mean gain change of only 0.075% at the end of 10,000 hours does not correlate with the 6% degradation in LED efficiency. In fact, the gain change is mainly due to the instability of the thick-film resistors used in the current-to-voltage converter. □

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Counter, scope team up for precise timing measurements

by Emory Harry
Tektronix Inc., Beaverton, Ore.

A universal counter, when combined with a dual-trace, delayed-sweep oscilloscope, can precisely measure the period, width, or time interval between nonadjacent pulses of any waveform. An oscilloscope alone can perform these measurements, of course, but not with the speed and accuracy of a counter. On the other hand, with the counter alone, most of these measurements are almost impossible to perform, because the instrument itself cannot isolate any one region of the waveform to measure. Uniting both instruments makes a superior measurement system.

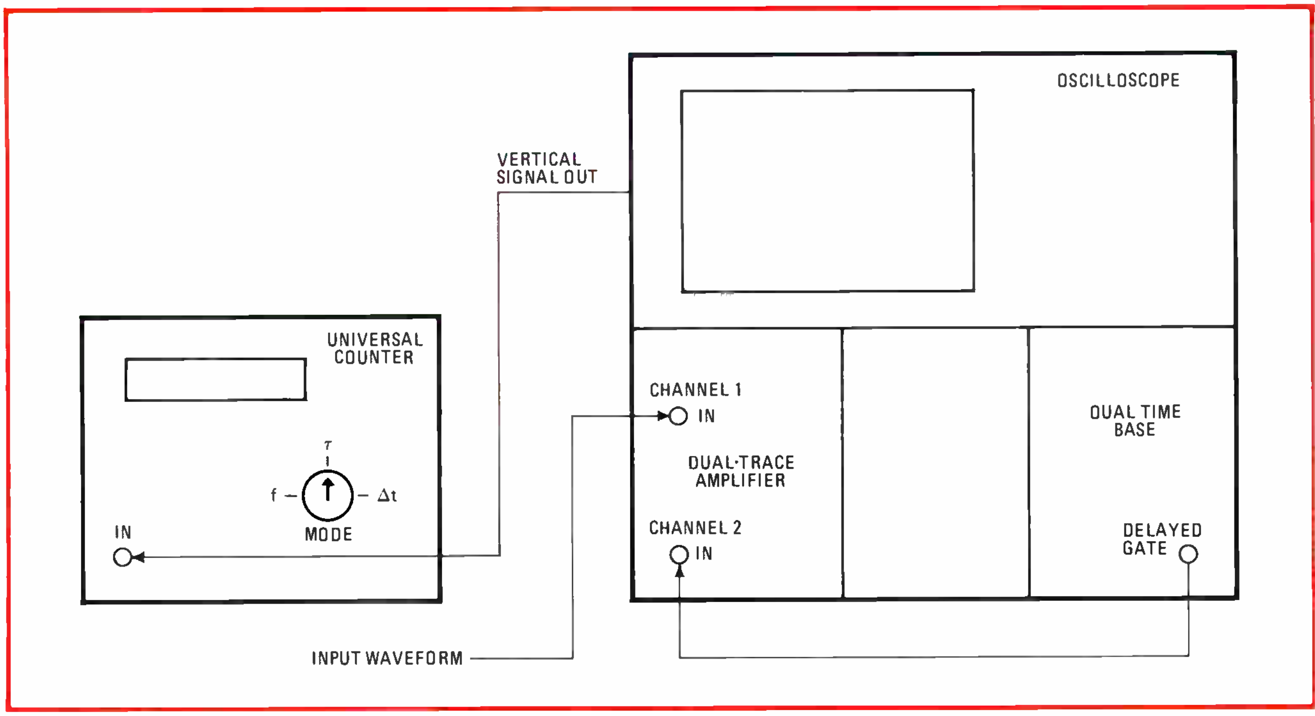
For the counter to measure the period, width, or time interval between two given points of a specific waveform, the scope must isolate the interval of interest and so provide the gating necessary for counting. Thus a scope with a delayed-sweep option is required.

As shown in Fig. 1, the delayed-gate output of the scope (whose pulse width and position are identical to the portion of the input waveform that is intensified) is connected to one of the vertical input channels and the waveform to be measured is connected to the other. The scope is then placed in the input channels' algebraic-add mode. With the scope's horizontal-mode switch in the intensified position, the portion of the waveform of interest is then selected with the delay-time multiplier control. The section of input waveform that the user has chosen to intensify will be elevated above ground potential (Fig. 2). It is then a simple matter to adjust the counter's threshold control to trigger at a selected point on the elevated section of the waveform appearing at the scope's vertical-signal output port.

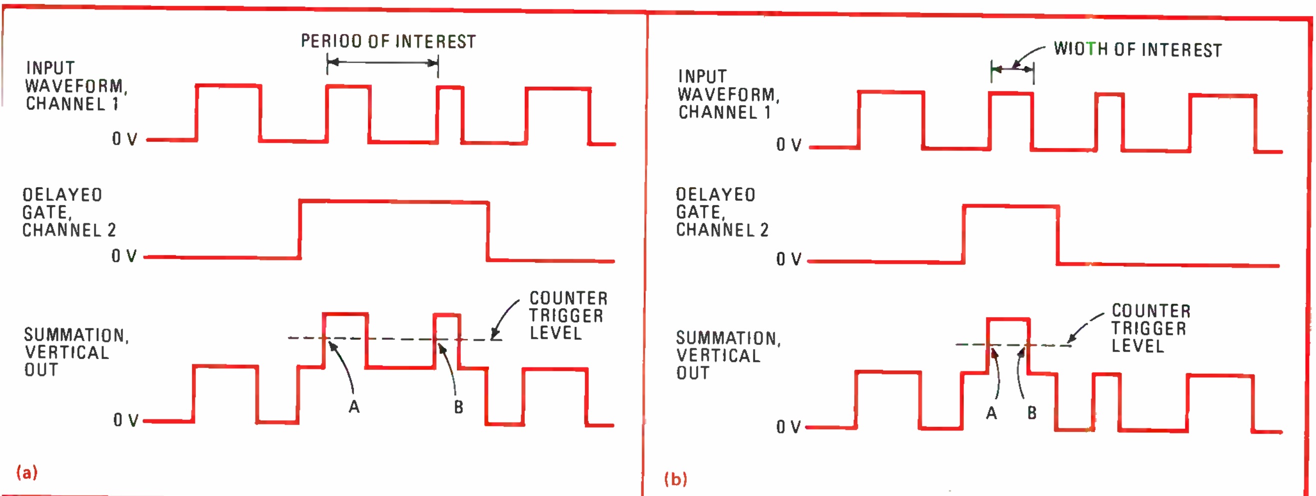
The type of measurement performed dictates the positioning of the elevated pulses. For instance, to make a period measurement (Fig. 2a), the voltage pedestal produced should be positioned so that the entire period of interest is intensified (and thereby elevated). The counter should be adjusted to trigger on the first positive (A) or negative slope of the waveform that is intensified and at the same time on the next cycle (B).

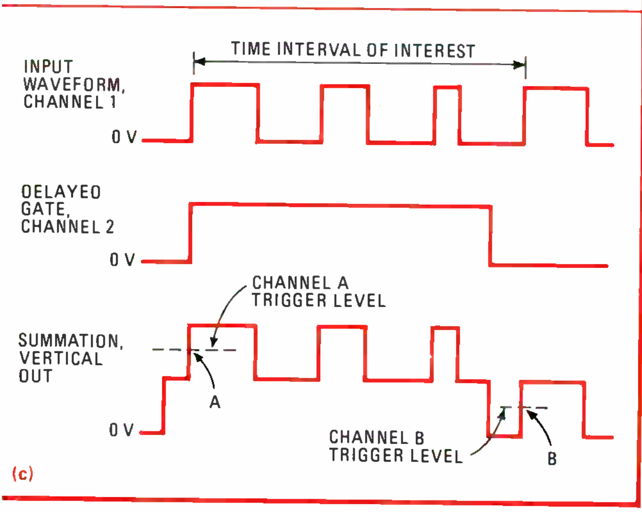
To measure pulse width, the pedestal need only be wide enough to elevate the width of interest (Fig. 2b). Place the counter in the width mode. The time measured will be that between the point on the rising edge of the isolated waveform and a corresponding point on its falling edge, as shown.

To make a time-interval measurement, the procedure is noticeably different. Here, the elevated portion of the desired waveform serves only to initiate or terminate the count time. Also, full use must be made of the scope's



1. Precise readings. Together, a counter and scope can perform more types of measurements, more accurately, on waveforms than either instrument can alone. Scope's delayed gate option is used to initiate and terminate count by elevating interval of interest of given waveform above normal potential. Counter's threshold is then adjusted to appropriate trigger point for detecting elevated signal.





2. Application. The type of waveform measurement performed dictates the interval of interest isolated. To measure period or width between A and B, the entire cycle must be intensified, i.e., elevated (a, b). For time-interval measurements, independent scope-channel trigger levels are set (c), as detailed in text.

selectable slope and triggering-level options.

Assume that the counter must measure the time between points A and B, as shown in Fig. 2c. Place the counter in its time-interval, or Δt, mode, and make sure that channel B of the counter will not trigger until channel A has done so. The threshold of each channel is set so that the first rising edge of the elevated waveform triggers channel A of the counter, and channel B triggers after the elevated pulse has returned to its normal level. Thus the middle region of pulses contained in the elevated waveform will be ignored by the counter. □

;alculator notes

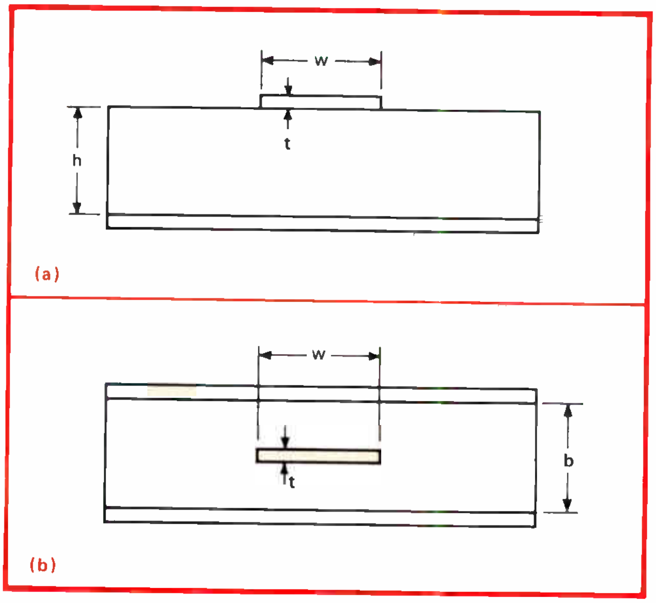
·IP-67 aids the design of nicrostrip, strip-line elements

y Albert E. Hayes Jr.
ıllerton, Calif.

'his 93-step, HP-67/97 program will speed the design of ıicrostrip and strip-line elements, two types of low-loss ·ansmission lines that are often needed at microwave ·equencies. When given the characteristic impedance of ıe line (Z_o), the substrate thickness (h or b), the ɔnductor (trace) thickness (t), and the dielectric ɔnstant of the material separating the conductors (e_r), ıe program determines the width (w) of the microstrip · strip-line trace required and the line's velocity factor '.p.). Element dimensions are defined in the figure.

The program solves a transposed version of two equaons contained in the MECL System Design Handbook.[1] he equation for the microstrip circuits is given by:

$$Z_o = \frac{87}{(e_r + 1.41)^{1/2}} \ln\left[\frac{5.98h}{0.8w + t}\right] \quad (1)$$



Microwave transmission lines. Cross-sectional view of microstrip (a) and strip-line elements (b) are shown. Program finds conductor width (w), given the distance separating conductors (h or b) and metal thickness (t). Impedance of line (Z_o) and dielectric constant (e_r) of material separating conductors must also be known.

and the one for the strip-line circuit is:

$$Z_o = \frac{60}{e_r^{1/2}} \ln\left[\frac{4b}{0.67\pi w\,(0.8 + t/w)}\right] \qquad (2)$$

Unfortunately, the equations cannot readily be used, for the design engineer must find w, not Z_o, given values for Z_o, h or b, t, and e_r. Therefore Eqs. 1 and 2 have been manipulated thus, for the calculator to solve:

$$w_{ms} = 1.25\left[\frac{5.98h}{\exp(Z_o(e_r + 1.41)^{1/2}/87)} - t\right] \qquad (3)$$

$$w_{sl} = 0.59\left[\frac{4b}{\exp(Z_o e_r^{1/2}/60)} - 2.1t\right] \qquad (4)$$

The relative velocity of propagation is also found from:

$$(v.p.)_{ms} = \frac{1}{(0.475e_r + 0.67)^{1/2}} \qquad (5)$$

$$(v.p.)_{sl} = \frac{1}{e_r^{1/2}} \qquad (6)$$

Microwave transmission lines may now be easily and quickly designed. As an example, assume a microstrip circuit has the following parameters:

$Z_o = 80$, h = 0.06 in., t = 0.0015 in., $e_r = 4.7$

If 80, A, 0.0015, B, 0.06, C, 4.7, E, is keyed into the calculator, it is found that w is equal to 0.044 inch. Pressing R/S will yield the velocity factor, which is 0.59 in this case, or 59% of the speed of light.

For a sample case of a strip-line circuit with the following parameters:

$Z_o = 70$, b = 0.1 in., t = 0.0015 in., $e_r = 4.7$

the procedure is to key in 70, A, 0.015, B, 0.1, D, 4.7, E. It will be found that w is equal to 0.017 inch, and the velocity factor is 0.46.

Note that the equations are valid for any consistent set of dimensional units, so h, b, and t may be expressed in inches or metric units. It should also be noted that upon entering the dielectric constant, e_r, the calculation for w is initiated, and therefore all data must be entered in the order specified in the instructions. □

References

1. "MECL System Design Handbook," William R. Blood Jr., Motorola Corp., 1972.

HP-97 PRINTER LISTING — MICROSTRIP OR STRIP-LINE PROGRAM

001	*LBLA	025	÷	049	*LBL1	073	1
002	STO1	026	e^x	050	RCL5	074	.
003	RTN	027	RCL4	051	1	075	2
004	*LBLB	028	4	052	.	076	5
005	STO2	029	×	053	4	077	×
006	RTN	030	X⇄Y	054	1	078	DSP3
007	*LBLC	031	÷	055	+	079	R/S
008	STO3	032	RCL2	056	√X	080	RCL5
009	SF1	033	2	057	RCL1	081	.
010	RTN	034	.	058	×	082	4
011	*LBLD	035	1	059	8	083	7
012	STO4	036	×	060	7	084	5
013	CF1	037	−	061	÷	085	×
014	RTN	038	.	062	e^x	086	.
015	*LBLE	039	5	063	RCL3	087	6
016	STO5	040	9	064	5	088	7
017	F1?	041	×	065	.	089	+
018	GTO1	042	DSP3	066	9	090	√X
019	RCL1	043	R/S	067	8	091	1/X
020	RCL5	044	RCL5	068	×	092	DSP2
021	√X	045	√X	069	X⇄Y	093	R/S
022	×	046	1/X	070	÷		
023	6	047	DSP2	071	RCL2		
024	0	048	R/S	072	−		

INSTRUCTIONS

- Key in program
- Enter desired characteristic impedance of microstrip or strip-line element
  (Z_0), A
- Enter conductor or trace thickness
  (t), B
- Enter either the microstrip substrate thickness or the strip-line dielectric thickness
  (h), C or (b), D
- Enter relative dielectric constant (air = 1.0)
  (e_r), E
  The trace width (w) will be displayed
- Press R/S to find the relative velocity of propagation (v.p.)
- Units of t, h, and b are arbitrary but must be consistent throughout run

HYBRID

IN A MARKET FULL OF DROPOUTS, OUR NEW REGULATORS ARE PHI BETA KAPPA.

Fairchild is introducing two new Linear regulators that are a study in efficiency. Our µA78HO5ASC 5-amp positive voltage regulator. And our µA78PO5SC 10-amp positive voltage regulator.

They're designed to provide extremely low dropout voltage — typically 2 volts at 5 amps on the µA78HO5ASC and 2.2 volts at 10 amps on the µA78PO5SC. And as any student of regulators knows, dropout like this just isn't available with monolithic designs.

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Circle 128 on reader service card

Engineer's newsletter

Prices of digital panel meters hitting bottom?

The asymptote for prices of 3½-digit panel meters may be in sight. Their prices have been dropping steadily as suitable analog-to-digital converter and display driver chips have become available. In fact, a few semiconductor manufacturers have begun entering the market themselves with complete low-cost parts kits—Intersil's costs only $15 in large quantities. In response some meter makers have cut prices to the bone: for example, Datel Systems Inc. is selling its DM-3100L for only $29 in hundreds, $45 in quantities of 1 to 9. Others have spun off the chips for separate sales. Analog Devices' integrated-injection-logic driver chip for its AD2026 3-digit DPM sells for $5.50 in 1,000-unit quantities.

The latest step has been taken by Fairchild Systems Technology of San Jose, Calif., with its model 30 DPM, **a one-board, 3½-digit unit that will initially sell for $33 each in any quantity.** The key to that figure is the use of unpackaged LSI chips mounted directly on the printed-circuit board with a conductive epoxy and then covered with a simple plastic lid. Display light-emitting diodes are also mounted directly on the board, air-filled light pipes are added to form the display segments, and the entire board is given a moisture-proof coating.

How to get nearly 100% duty-cycle range out of the 555 timer

The 555 timer finds wide use in switching regulators, signal generators, and pulse-width modulators when it's wired as a variable-pulse-width generator. But you can get even broader duty-cycle variation from this circuit with a simple modification, says Glenn T. Darilek, a senior research engineer at Southwest Research Institute in San Antonio, Texas. As a bonus, the modification is likely to narrow the control-voltage range, too.

Instead of the timing resistor in the conventional configuration, **just use a high-value resistor in parallel with a series-connected low-value resistor and zener diode** (with its cathode facing the supply). According to Darilek, a 47-kilohm resistor shunted by a 1-kilohm resistor and a 4.7-volt zener extends the duty-cycle range from between 8% and 90% to near 0% and 100%, while decreasing the control-voltage range from between 0 and 9 V to 3.5 and 7.5 V. The only limitation on how narrow (or wide) the output pulse may be, he notes, is the timer's rise and fall times, which are typically 100 nanoseconds each.

Free bridge rectifiers for describing your application

If you have an application for silicon bridge rectifiers, Electronic Devices Inc. is willing to send you free samples of its new PB series to try out. **The units, which are rated at 25 A (300-A surge), withstand peak reverse voltages from 50 to 1,000 volts.** To get your sample, just outline your application in a letter to: Dennis Dean, Sales Manager, Electronic Devices Inc., 21 Gray Oaks Ave., Yonkers, N. Y. 10710.

Good news for users of HP-67/97 calculators

Volume users of blank programming cards for Hewlett-Packard's HP-67 and HP-97 calculators will be happy to know that the company is **reducing the price of the cards** by making them available in larger packages. A pack of 1,000 now costs only $195 (card holders not included). At 19.5¢ each, that's a better price than 37.5¢ each for the $45, 120-card pack. Delivery is three weeks. For more information, contact: Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304.

Lucinda Mattera

There's a Simpson DPM that's right for your application

All Simpson DPM's feature:

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- 9 stock ranges available
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Until now, fingertip programmability wasn't available in a logic test system at *any* price.

Now it's yours for less than you might pay for an ordinary system.

So, instead of toggling for hours, you can program or edit in minutes.

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You can program what the data generator generates and you can program a "compare" memory for the analyzer to store.

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The Moxon system is able to test a wide range of equipment.

It's able to trigger on *serial* data, up to 16-bit words, as well as parallel data.

And it can be formatted in hex, octal, binary and timing formats.

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“To stabilize my sweeper, all I have to do is sample its RF output and connect the 371's 'phase lock out' to the sweeper's DC coupled FM input. I tune the sweeper to within 20 MHz of the frequency I'm after, enter that frequency on the 371's microprocessor-controlled front panel keyboard, and push the LOCK button. That's all there is to it. I don't have to worry about the sweeper's FM input bandwidth and polarity. The 371 controls those automatically.

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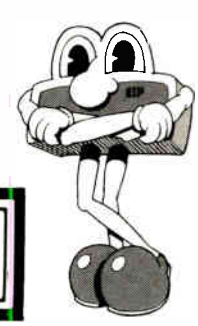
“There's only one place to get this unique counter. EIP. They're real microwave counter specialists. For more details or a demonstration, phone or drop them a line. Tell them you heard about EIP from a friend.”



EIP

EIP, Inc. / 3230 Scott Boulevard, Santa Clara, California, 95051 / Phone (408) 244-7975.
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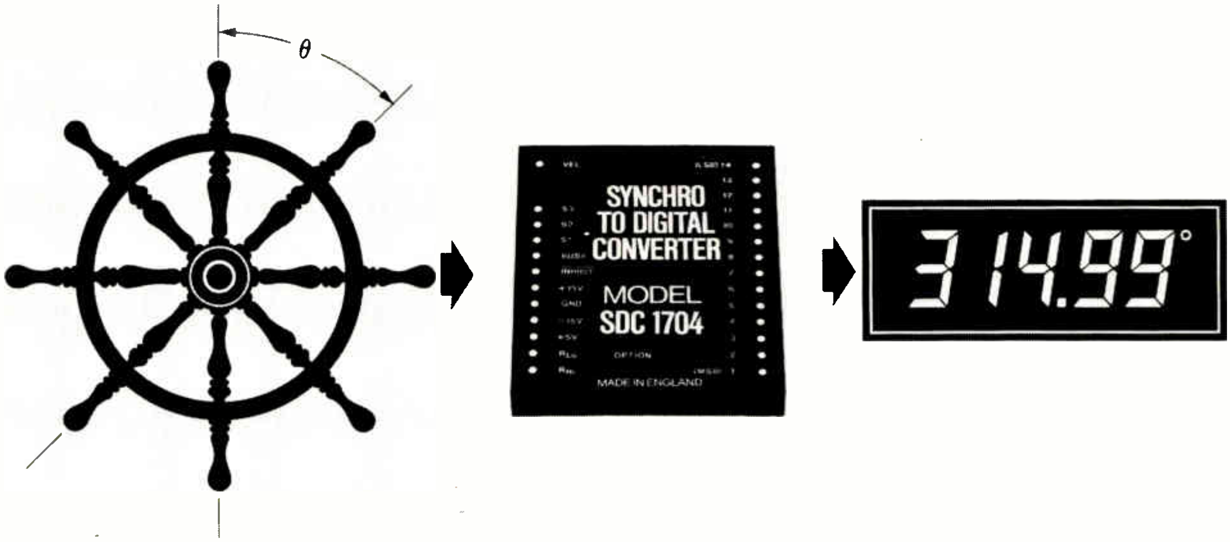
Circle 203 on reader service card

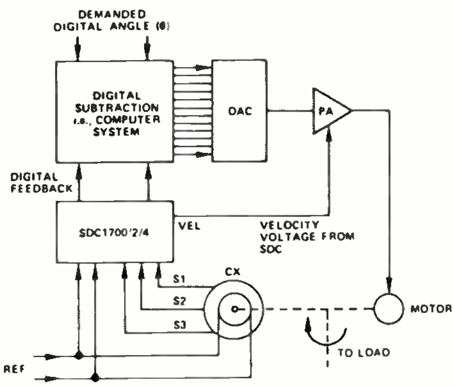
angular displacement converted to numbers



...to an accuracy of 2 mins. of arc

Numerical control, Retransmission systems, Fire control systems, Servo mechanisms, Coordinate conversions, Radar, Simulators, Navigation, Displays . . . .

The number of industrial and military problems which our synchro to digital converters can answer is endless – because most of the possible applications have not yet been perceived. Or they are currently being satisfied by other means which are probably less accurate.



An SDC Being Used in a Digitally Controlled Feedback Loop

The SDC 1704 is a synchro to digital converter having a resolution of 14 bits, (1.3 arc-minutes) and an accuracy of ± 2 arc-minutes. Input isolation is provided by micro-miniature Scott connected transformers which are contained within the 10mm high module. These will work with 50 Hz references so that no external isolating transformers are required. Tracking conversion techniques employed use a Type 2 servo to provide high acceleration and wide velocity response. No trims, adjustments, or offsetting components are required.

12 BIT and 10 BIT VERSIONS AVAILABLE

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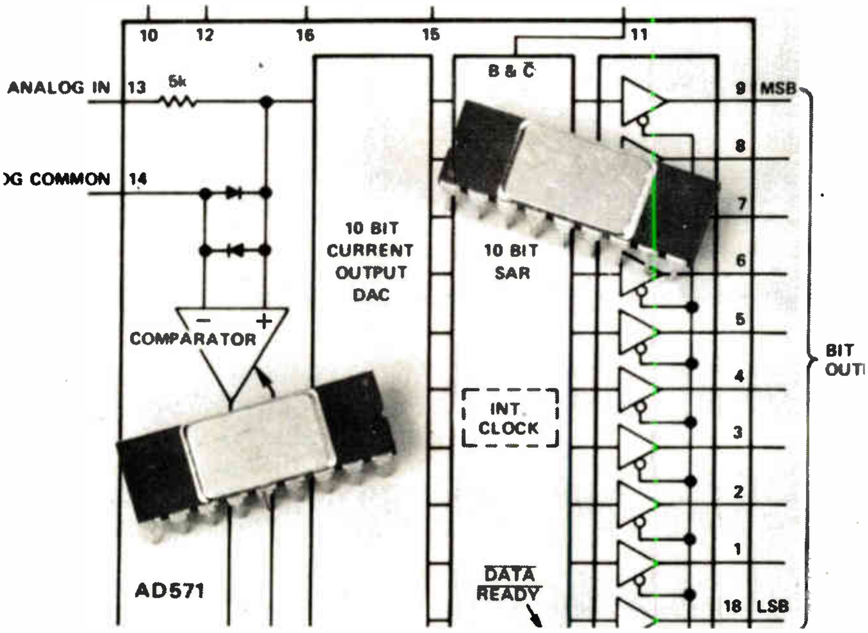
A-d converter chip resolves 10 bits

Monolithic self-contained device using successive approximation and built with I²L processing completes conversion in 25 microseconds

by Lawrence Curran, Boston bureau manager



Most monolithic successive-approximation analog-to-digital converters are 8-bit devices, and very few are self-contained. However, engineers at the Semiconductor division of Analog Devices Inc. have successfully married integrated injection logic with linear-bipolar processing to develop the industry's first complete 10-bit successive-approximation a-d converter in monolithic form. David Kress, product marketing specialist at the Wilmington, Mass., division, points out that the AD571 is also one of the first linear circuits to use I²L processing. Additionally, the chip is microprocessor-compatible, and it completes a conversion in 25 microseconds.

On the chip are: a d-a converter, buried-zener voltage reference, clock, comparator, successive-approximation register and output buffer—all on a single chip housed in an 18-pin ceramic dual in-line package. Important accomplishments in processing, wafer trimming by laser, and testing were necessary to produce the device, Kress says.

In processing, the ability inherent in I²L to invert the bipolar transistors was important to achieve fast switching, which contributes to the fast conversion time. The ability to put high-gain analog transistors on the same chip to get at least 8-bit resolution was also important. In addition, getting full 10-bit resolution required complex laser trimming of the ladder network at the wafer stage and fully automatic testing of each device over its temperature range, Kress points out.

He is not telling precisely how either is done for the 571. He says only that the semiconductor division has enhanced its laser trimming to be able to measure the results more accurately, and that "we've figured out ways to test a fully wired device without unwiring it." Regarding the buried-zener reference, Kress adds that the company essentially has taken its AD561 d-a converter, which includes such a reference, "and built the comparator and successive-approximation register around it to come up with the 571." Surface zeners, says Kress, can hold long-term drift to 1% to 2%—not good enough for 10-bit converters—while the buried zener gives long-term stability to within 0.005%.

With a maximum accuracy error of 0.1% of full scale, the 571 is suitable for true 10-bit applications. It operates on supplies of +5 to +15 v and −15 v, and accepts unipolar analog inputs of 0 to +10 v and bipolar inputs of ±5 v.

Three versions of the converter are available off the shelf. The AD571J and AD571K are designed for operation from 0°C to 70°C. The chief difference between the two is a slightly relaxed temperature coefficient for the J version. It will sell for $24 each in hundred-or-more lots and the AD571K will be priced at $35 apiece in those quantities. The AD571S, for the range from −55°C to +125°C, will carry a price of $60 each for the same amounts.

Jerry Fishman, the division's marketing manager, looks for the a-d portion to be the fastest growing part of the converter market. "As the price differential between 8-bit and 10-bit converters closes, the market for devices like the 571 will be enormous," Fishman asserts.

Analog Devices Inc., Route One Industrial Park, P. O. Box 280, Norwood, Mass., 02062. Phone (617) 329-4700 [338]

Components

Solid-state relay price drops to $2

Price applies to 10,000-lots; single in-line package has LED emitter, detector, triac

A line of solid-state relays from Theta-J Inc. may offer the first true challenge to mechanical relays because of their low price—$1.99 in quantities of 10,000 or more for some models. The MX-100 line, which is rated at 90 to 140 v ac, and the MX-200 series, for use between 90 and 280 v ac, both specify optical isolation of 3,750 v ac rms, or 5,500 v peak.

Edward T. Rodriguez, chairman and technical director of Theta-J, says that at the right price today's market of $25 million to $30 million for solid-state relays could be greatly expanded because companies that now manufacture them in house would buy outside. "Ultimately," Rodriguez says, "the price has to compete with a mechanical relay at $2. It's as simple as that."

The new units are housed in a molded-plastic, four-pin, single in-line package and contain only three components: a light-emitting-diode emitter, a cadmium-sulfide detector, and an output triac. Rodriguez maintains that the units can be assembled in less than a minute and that production speed, combined with eventual offshore assembly, accounts for the low prices.

The relays will withstand 100% overload for a full minute, which Rodriguez says is particularly good for motor-driving applications. They can be driven from any dc or full-sine-wave-rectified ac input above 1.5 v as long as a series input resistor limits the drive current to between 7 and 25 mA. The units carry a minimum dv/dt rating of 100 v per microsecond to minimize the need for external snubber networks. Response time is 16 to 32 milliseconds, which makes them immune to false triggering by transients.

Rodriguez says Theta-J has spent more than a year developing a list of volume users, most of whom make their own relays, who have said they would buy in quantities ranging from 150,000 to 300,000 at the $2 price. These users include makers of appliances, telephone equipment, and vending machines. "No one is infatuated with technology anymore," he continues, alluding to recent hybrid solid-state relays prices at $4.95 in quantities of 1,000 and up. "Price has become the forcing factor."

The MX-100 series prices range from $1.99 each in lots of 10,000 and above to $3.40 each for 100-or-more pieces. The MX-200 series prices are, respectively, $2.49 and $4 each for those amounts. There is also an MX-1 series, rated at 4.8 to 72 v ac and aimed primarily at low-voltage residential and telephone systems. It is priced the same as the MX-100 series. Deliveries will begin in February, with three to four weeks required for delivery of moderate production quantities.

Theta-J Relays Inc., 1 De Angelo Dr., Bedford, Mass. 01730. Phone (617) 275-2575 [341]

Bulk Metal power resistor can dissipate up to 10 W

This hermetically sealed power resistor with a noninductive Bulk Metal design is well suited for high-frequency power circuits, as well as for voltage-sensing, current-limiting, and attentuator applications when

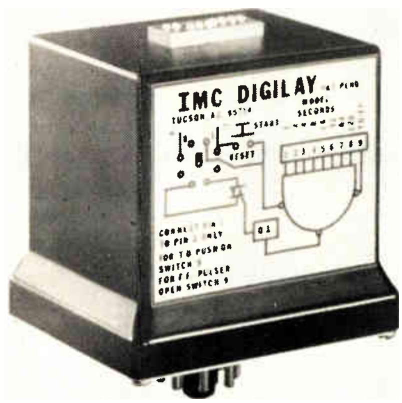
wire-wound power resistors are unsatisfactory. The model VHP-3 design results in a low temperature coefficient of resistance. Its power rating with a heat sink is 10 w; in free air it is 3 w. It is housed in a standard TO-3 case, which screw-mounts directly onto a metal chassis. The VHP-3's maximum working voltage is 750 v and the unit is available with standard tolerances to 0.01% and to 0.005% by special request.

Vishay Resistive Systems Group, 63 Lincoln Hwy., Malvern, Pa. 19355 [343]

Thumbwheel switches set digital time-delay relay

A compact, low-power solid-state time-delay relay set by direct reading thumbwheel switches operates from an input voltage of 12 v dc ± 10%. The series 280 Digilay is capable of timing in on or off delay modes from 1 ms to 9,999 s.

An external frequency-modulation feature permits fine tuning of the ocillator's base frequency or, with an



external waveform, actual modulation of the time delay. There are three switch options: single-pole, double-throw relay, spdt reed relay, and spdt triac. Reset and stop timing can be set manually or automatically. Input for test and reset functions are through a standard 11-pin base.

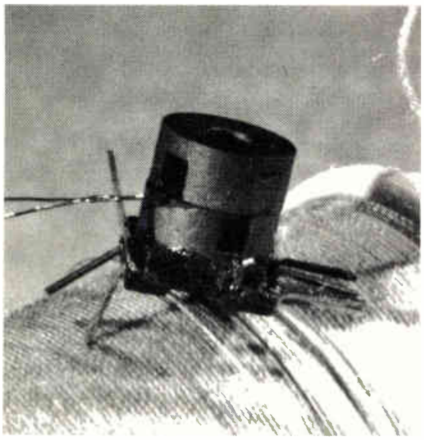
Single-unit price is $79 and delivery time is about four weeks

after receipt of order, the firm says.

International Microtronics Corp., 4016 E. Tennessee St., Tucson, Ariz. 85714. Phone (602) 748-7900 [344]

Tiny cores designed for filters and networks

What may well be the world's smallest adjustable pot core is now available from Siemens Corp. Measuring 4.6 by 4.1 mm, the core is used in filters and matching networks where extremely small size is essential. The



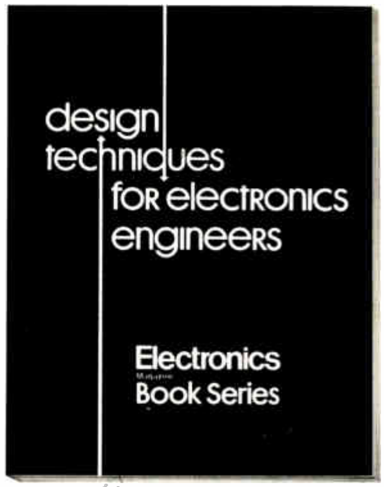
B65495 is available ungapped in N30 ferrite or gapped in N28, M33, K1, or U17 material. Adjustment parts, bobbins, and mounting bases for the cores are available. The cores are priced at 35¢ each in thousands. Delivery is from stock.

Components Group, Siemens Corp., 186 Wood Ave., Iselin, N. J. 08830. Phone (201) 494-1000 [345]

Switch-relay adapts to variety of applications

The LSR is an auxiliary relay that combines features of both a programmable remote relay and a manual override switch. It is adaptable to numerous applications and is capable of controlling up to 32 contacts in a single unit. The contacts are shock-resistant and double-wiping, with a knife-blade design. The LSR is rated at 10 A and is

New from Electronics... when you can't afford to reinvent the wheel.



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Semiconductors

Counters offer 3-state outputs

Low-power Schottky devices work with bus-type systems built around microprocessors

Counters are usually the best-selling devices in any logic family of medium-scale integrated circuits, and low-power Schottky is no exception. Now, Advanced Micro Devices Inc. is introducing counters that combine the best features of existing high-selling low-power Schottky counters and add some extras.

The AM25LS2568 and 2569 up-down 4-bit counters feature synchronous presetting, three-state outputs, and a choice of asynchronous or synchronous clearing, all in a 20-pin package. Having a three-state output means that the counters, unlike competitors, will work with bus-oriented systems organized around a microprocessor or will drive light-emitting-diode displays without going through a multiplexing circuit.

"The significance of these counters is that more and more systems are being designed as bus-oriented systems with microprocessors," says David A. Laws, marketing manager for bipolar logic and interface products. To work with microprocessors, a designer used to have to buy a counter and a three-state buffer, whereas now he can get the buffer and counter in one package, he continues.

AMD claims that the 2568 decoding counter and 2569 binary counter are the only low-power Schottky three-state counters in the industry. These building-block circuits offer the engineer a design tool for new bus-oriented systems of all types, such as minicomputers, signal processors, and data-acquisition systems. They also are particularly adaptable for use as memory address registers in minicomputer central processing units, as well as address generators where dual address control to the memory is needed, in addition to the event-counting functions normally performed by counters.

Up to now, a designer could choose the 25/54/74LS160-163 series of up counters, which feature synchronous preset with either asynchronous or synchronous resetting functions, or the 190-193 up-down counter versions, which have asynchronous presetting with either single or dual clock functions. Also available are the 168A and 169A parts, which combine the synchronous presetting features of the 160 with the up-down counting ability of the 190 series. But these two devices need extra circuitry, to get them to clear, for example.

Instead of sticking with the standard 16-pin counter packages, AMD chose a slim 20-pin pack in which to put the extra functions. What's more, the new chips occupy only 25% more board area than a conventional counter chip alone, while replacing up to four standard packages, he says.

Laws puts the maximum clock-to-output delay at 27 nanoseconds, which is comparable with the other low-power Schottky MSI counters. Other features include an internal look-ahead carry logic and two count-enable lines for high-speed cascaded operation, ripple-carry output for cascading, clock-carry output for convenient modulo configuration, and fully buffered outputs.

The 2568 and 2569 are made with the advanced technology used for AMD's second-generation high-performance AM25LS family of products but will work with almost any microprocessor family. As with all AMD products, they are processed to the screening requirements of MIL-STD-883, Class C, at no additional cost.

Price in 100-and-up quantities is $2.90 for the plastic dual in-line package with the commercial temperature range. Preproduction parts are available now, and production devices will be available in February.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif., 94085 [411]

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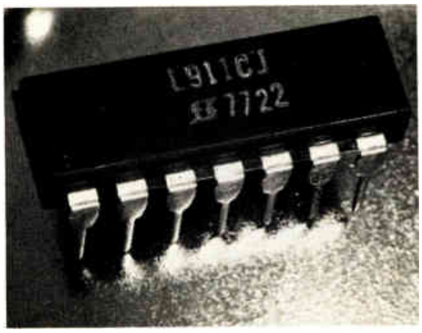
Low-power IC aims at alarm and detector applications

Designed for use in battery-powered alarm and detector systems, the L911 is an analog integrated circuit that comprises a high-impedance input comparator, a trip-point comparator, a trip-point reference, an output driver, and a pulsing output oscillator. Since it draws less than 10 μA from a 9-V supply, the L911 can be used in systems that are



designed to operate for a year or more in the standby mode, from a single 9-V alkaline battery of the size commonly used in small portable radios. Key applications of the detector circuit include smoke detectors, burglar alarms, moisture sensors for both agricultural and home use, and temperature sensors of various kinds.

Among its more important specifications are an input resistance in excess of $10^9\Omega$, a common-mode-voltage range that extends from 0 to −4 V, and output-current limiting that can be adjusted from 0.5 to 30 mA. The device is housed in a 14-pin plastic dual in-line package and sells for $2.18 each in hundreds. Delivery is from stock.

Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, Calif. 95054. Phone Jim Graham at (408) 246-8000

Analog clock circuits work with quartz crystals

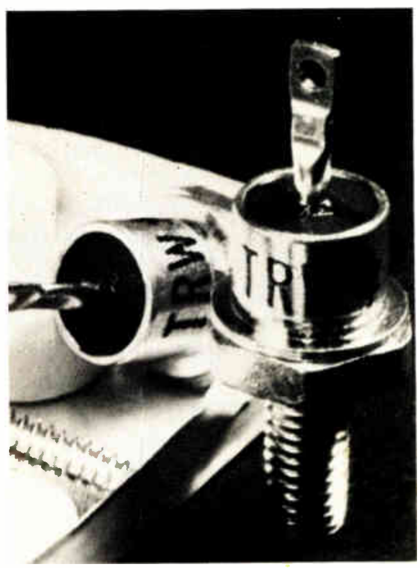
Five timing circuits, built with complementary-metal-oxide-semiconductor technology, are designed to work with quartz crystals to develop signals for driving synchronous or stepping motors in a variety of analog clocks. The circuits, types CD22011E through CD22015E, differ primarily in output pulse width, duty cycle, and frequency of the quartz crystal. Output pulse repetition rates of 1, 2, 30, 60, and 64 Hz are available from crystal frequencies in the range of about 2 to 4 MHz. All five circuits include one or more zener diodes for transient protection and one or two output drivers. Prices range from $1.30 to $1.75 each in hundreds.

RCA Solid State Division, Route 202, Somerville, N. J. 08876. [416]

Schottky diode drops only 0.55 V at 30 A

Suitable for use in industrial switching power supplies, a Schottky-barrier power rectifier has a voltage drop of only 0.55 V at a forward current of 30 A. Its dc blocking-voltage rating is 45 V. The unit can operate at junction temperatures from −55°C to 150°C. Housed in a DO-203AA (formerly DO-5) package, it sells for $5.25 in quantities of 100 to 999. Delivery time is four to eight weeks.

TRW Power Semiconductors, 14520 Aviation Blvd., Lawndale, Calif. 90260. Phone John Power at (213) 679-4561 [417]



The Space Saver
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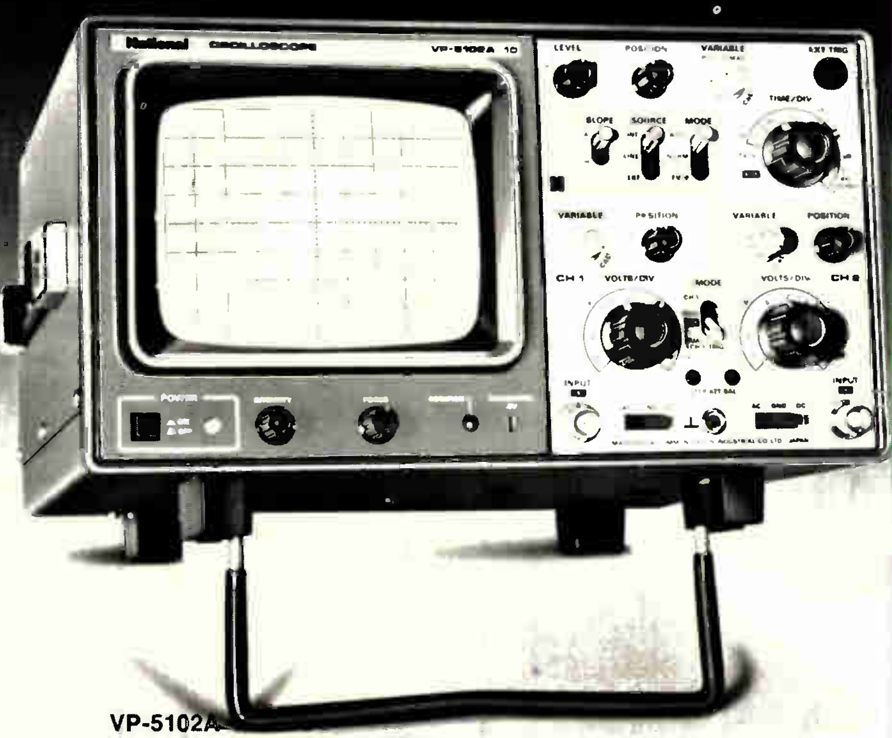

VP-5102A

Full Features in a 26cm Square

The National VP-5102A is a unique instrument designed to give you the greatest number of extra features while taking up the least amount of working space possible. Use of a newly-developed short-necked CRT enabled National to pack a dual-trace display with DC-10MHz bandwidth (−3dB) and calibrated X-Y operation, a built-in x5 sweep magnifier and an AUTO Trigger function into a cabinet that measures only 148 x 260 x 260mm and weighs only 5 kg.

Extra Sensitivity

Nor did National stop there. To guarantee 3 percent accuracy at 10mV/DIV, the VP-5102A employs an Internal Graticule CRT for this 10MHz oscilloscope. To ensure greater versatility, this unit also incorporates a tilt stand for easier trace viewing, a built-in amplitude calibrator, a front-panel trace rotation control plus TV waveform triggering circuitry. All of which combine to make the VP-5102A a great little addition to your working equipmemt.

The VP-5100A

The National VP-5100A, like the 5102A, features an Internal Graticule CRT and compact (148 x 260 x 260mm) unit size. Other features include a sensitivity of 10mV, variable control for vertical deflection factors and sweep rate plus STEP ATT BAL control.

VP-5100A

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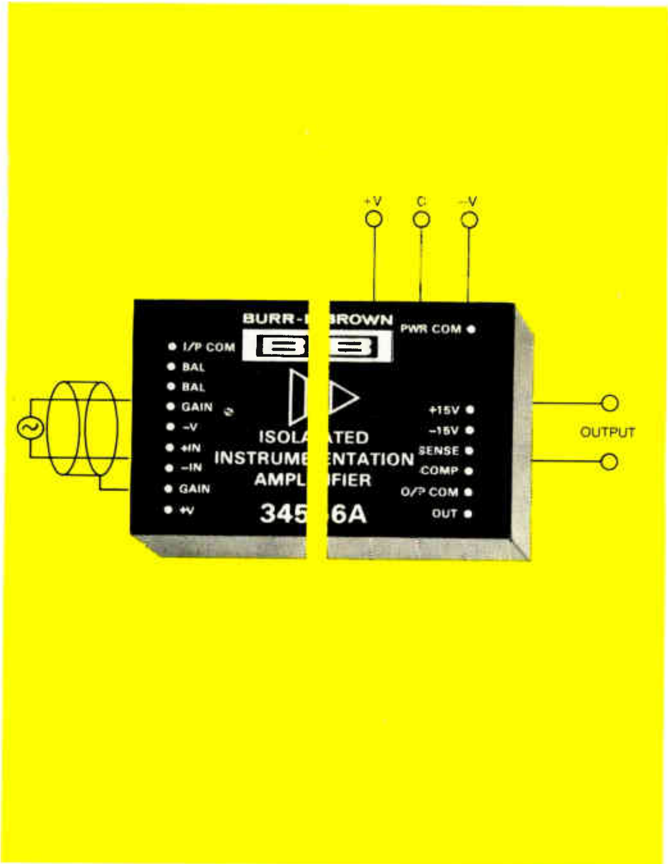
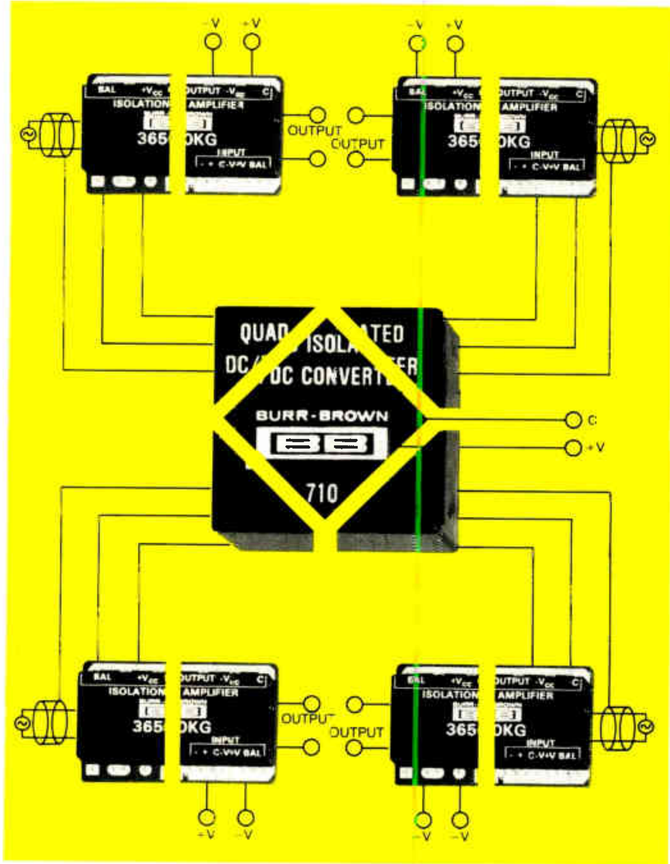
Circle 233 on reader service card

Two new ways to cut costs in isolated systems without sacrificing performance.





Choose Burr-Brown's new Isolated Instrumentation Amplifier with true three-wire input.

Burr-Brown's new 3456 gives you true three-wire instrumentation amplifier input with CMR of 110 dB min at G=100, ±0.02% max gain nonlinearity and ±1 μV/°C max input offset drift. And it provides input-to-output isolation rating of 2000V peak continuous (5000V test), isolation impedance of 10^{12} ohms in parallel with 14 pF and isolation mode rejection of 130 dB at 60 Hz.

Power four optically-coupled isolation amplifiers with our new Quad Isolated Supply.

Combine Burr-Brown's new Model 710 with four 3650KG Optical Isolation Amplifiers and you get optical isolation at low cost per channel.

The 3650KG provides ±0.05% max gain nonlinearity and ±5 μV/°C max input offset drift. Combined with the 710, each isolated channel provides 600V continuous isolation voltage channel-to-channel and input-to-output rating (2200V test) and 1 μA max leakage current at 240V/60Hz.

To get full details on these isolation amplifier developments, contact Burr-Brown, International Airport Industrial Park, Tucson, Arizona 85734. Phone (602) 294-1431.

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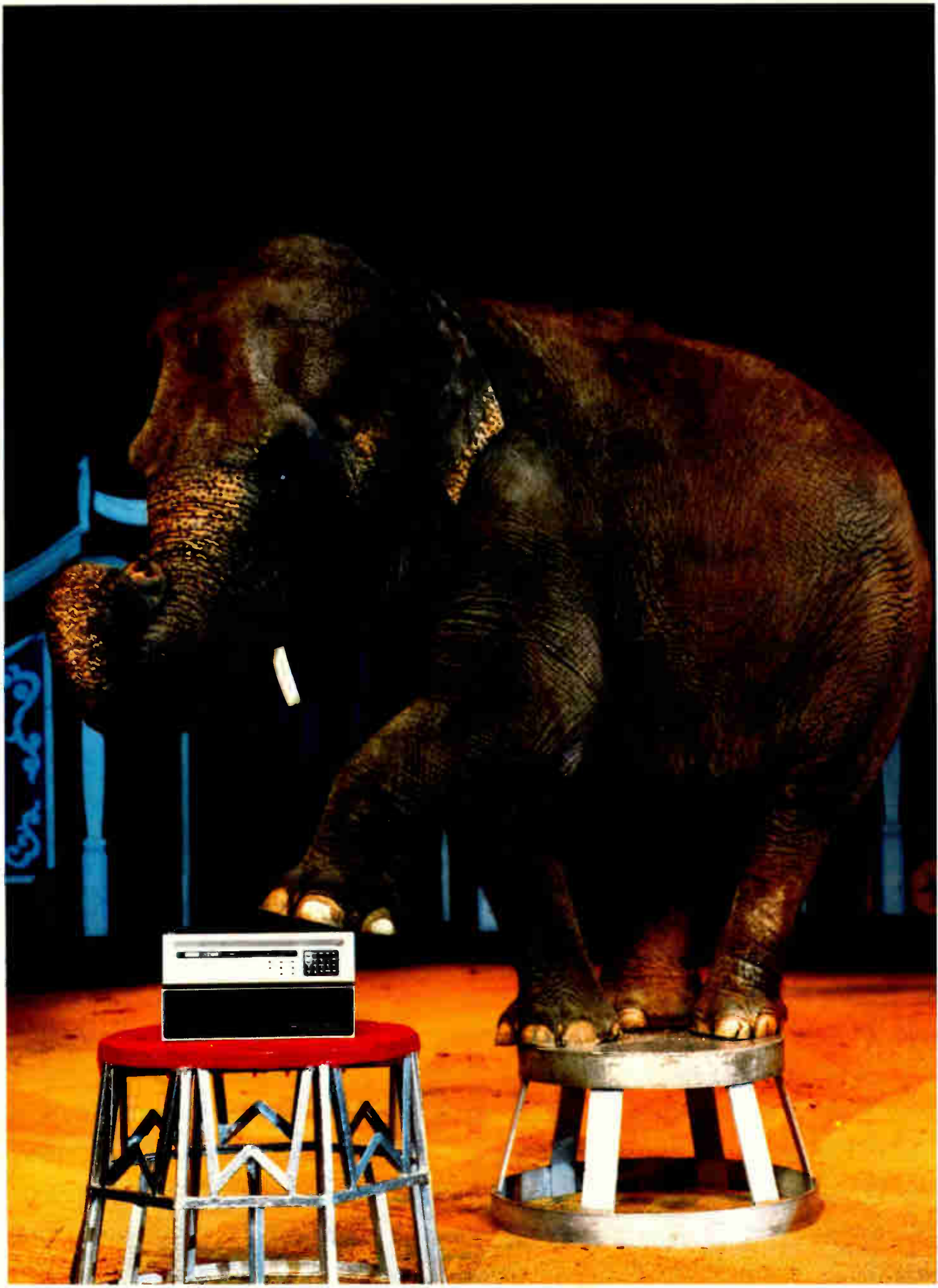

Digital announces a PDP-8 with an enormous memory.

Something big has just happened to the world's most famous small computer. In fact, something enormous.

Digital has just put 128K of memory into the PDP-8.

This act is brought to you by a powerful new memory management option called KT8-A. And by two new MOS memory modules that fit large amounts of memory into small amounts of space. Simply by adding these 16K or 32K modules in whatever combination you choose, you now expand your PDP-8/A into something bigger. What's even better, you can mix MOS and core. And that means you can protect your program in non-volatile core while you expand your data base in MOS.

And thanks to the KT8-A all this memory is under new management. Not only does the KT8-A let you address up to 128K words of memory, but it also offers you memory relocation and memory protection, while asking little in operating system overhead so you get faster system performance.

What's the cost of these enormous advancements? That's the next attraction.

The new PDP-8A MOS memory models are available at prices that are as crowd pleasing as their performance. Three models to choose from — the 8A205 with 16K, the 8A425 with 64K and the top of the line 8A625 with 128K.

They're the new big-memory Eights from Digital. Step right up.

Large memories aren't our only new trick.

New hardware and software improvements are also in the PDP-8 spotlight.

The VK8-A is a new low cost PDP-8A option that provides high quality video output plus keyboard and printer interfaces. Video character generation uses a super-sharp 9x9 dot matrix for high resolution on single or multiple CRT monitors up to one thousand feet away.

Also new for PDP-8 users is MACREL/LINKER — a sophisticated assembler with MACRO facilities that lets you implement, expand and update your system faster while reducing software development time.

And last but not least there's DECNET 8 — a series of software protocols that let you form your own PDP-8 network.

The PDP-8. Bigger. Smaller. And better than ever.

A short while ago, we made big news with DECstation 78. A low-end system that set new highs for ease of use and simplicity.

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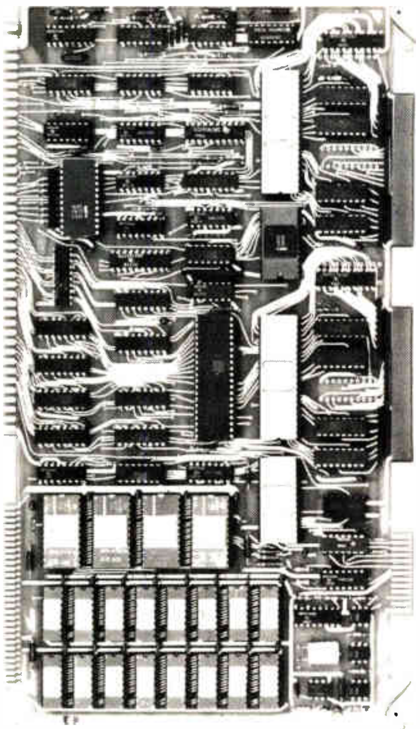
New products

Microprocessors

Single-board computer built around Z80

A single-board computer features 8,192 bytes of static random-access memory and sockets for 8 kilobytes of erasable programmable read-only memory. Designated the MSC 8001, the computer is patterned around the Z80 processor with up to 4-MHz clock speed. The MSC 8001 is electrically and mechanically compatible with SBC-80 systems, operating as a master module in the Multibus scheme.

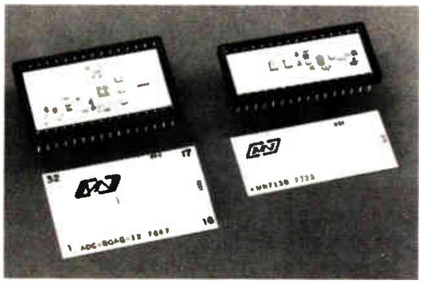
Using the Z80 processor, the computer provides 158 instructions including all 78 instructions of the 8080A for total compatibility. The two I/O ports consist of parallel peripheral interface circuits with buffers and terminators to protect the metal-oxide-semiconductor circuitry. The MSC 8001 memory is available with either 4 or 8 kilobytes of standard 18-pin, 4,046-by-1-bit static RAM. The computer is priced at $845 with all interface elements.



Monolithic Systems Corp., 14 Inverness Drive East, Englewood, Colo. 80110. Phone Dick Lorimor at (303) 770-7400 [373]

Data-acquisition system saves microprocessor space

The new MN7130 multiplexed sample-and-hold amplifier and ADC80 12-bit analog-to-digital converter have been combined to form a 12-bit, 16-channel data-acquisition system. The system, which is both physically and electrically compatible with microprocessor technology, is really built around the MN7130. This sample-and-hold unit provides

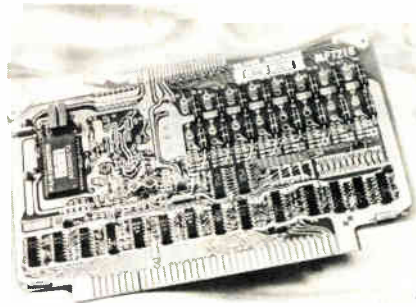


16 single-ended or 8 differential-input channels. These channels can be addressed with a single digital word and have a fast 8-µS acquisition time. The MN 7130 is $90, the ADC80 $47.50 in hundreds.

Micro Networks Corp., 324 Clark St., Worcester, Mass. [374]

Low-level analog input fits Motorola microcomputers

A 12-bit, low-cost, plug-compatible, low-level analog-input interface with 8 or 16 12-bit channels has been designed for Motorola microprocessors. The MP7218 has input signal ranges from 10mv full scale to 5 v full scale, eliminating the need for external instrumentation amplifiers for low-level signals. The unit operates from the microprocessor's 5 v dc and 12 v dc supplies and is treated as memory by the central processing unit. Two memory locations are required for each 12-bit



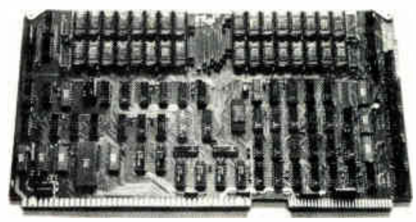
channel, and any memory reference instruction may be used as input data. The MP7218 is priced at $495 in quantities of 1 to 9.

Burr-Brown, International Airport Industrial Park, Tucson, Ariz. 85734. Phone C. R. Teeple at (602) 294-1431 [375]

High-density memory boards expand SBC 80 computers

Three Multibus-compatible expansion boards are now available for SBC 80 single-board computers. The high-density boards will reduce the cost per bit for large systems.

The Multibus design uses 16, 384-bit chips to get 32, 48 and 64 kilobytes of data storage. Memory



storage can be assigned to one computer or shared by several. To facilitate battery back-up, each board also contains an auxiliary power bus and protect control.

The boards are available from stock at single-unit prices of $1,650 for the SBC 032, $2,300 for the SRC 048, and $2,950 for the SBC 064. OEM discounts apply to quantities of 10 or more boards.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. Phone Rob Walker at (408) 349-8027 [376]

HERE'S YOUR CHANCE TO TRY FIBEROPTICS.

Here for the first time is a reasonably priced, off-the-shelf fiberoptic engineering kit with all the electronic and mechanical components necessary for use in TTL systems up to 5 mbps.

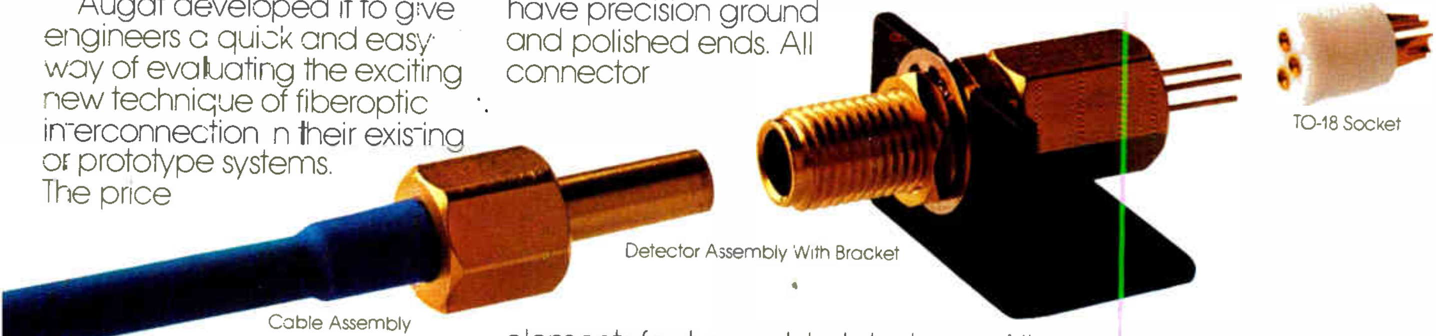
Augat developed it to give engineers a quick and easy way of evaluating the exciting new technique of fiberoptic interconnection in their existing or prototype systems.

The price is right.* And the kits are in stock at Augat's nearly 200 worldwide distributor locations.

The combination of the kit's driver, emitter, cable assembly, pre-amp, and detector provide the necessary elements for a complete TTL-compatible digital fiberoptic system. We've even included mounting brackets and sockets for convenience. And its comprehensive instruction manual will give you all you need to know to use it...even assuming no prior experience in fiberoptics.

The kit contains a 5-meter length of Hytrel†-jacketed cable terminated with ferrules that have precision ground and polished ends. All connector elements feature gold-plated brass construction to ensure the integrity of shielded enclosures.

The temperature referenced pre-amp operates from dc to 5 mbps over a temperature range of 0 to 55°C without drifts or inadvertent comparator switching usually associated with non-temperature referenced pre-amps.



TO-18 Socket

Detector Assembly With Bracket

Cable Assembly

All components of the kit are available separately. Standard accessories include butt splices, o-ring seals, and cables of other lengths. For more details and a list of Augat distributors, write Augat, Inc., 33 Perry Avenue, P.O. Box 779, Attleboro, Mass. 02703. Tel. (617) 222-2202

Driver and Pre-amp Modules

*Complete Kit (No. 698-CK-002) $190. Kit less driver and pre-amp (No. 698-CK-001) $99.50

†Dupont trademark

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Circle 161 on reader service card

Instruments

Analyzer pinpoints bus-line faults

Tester is built for instruments that are interconnected by IEEE-488 bus

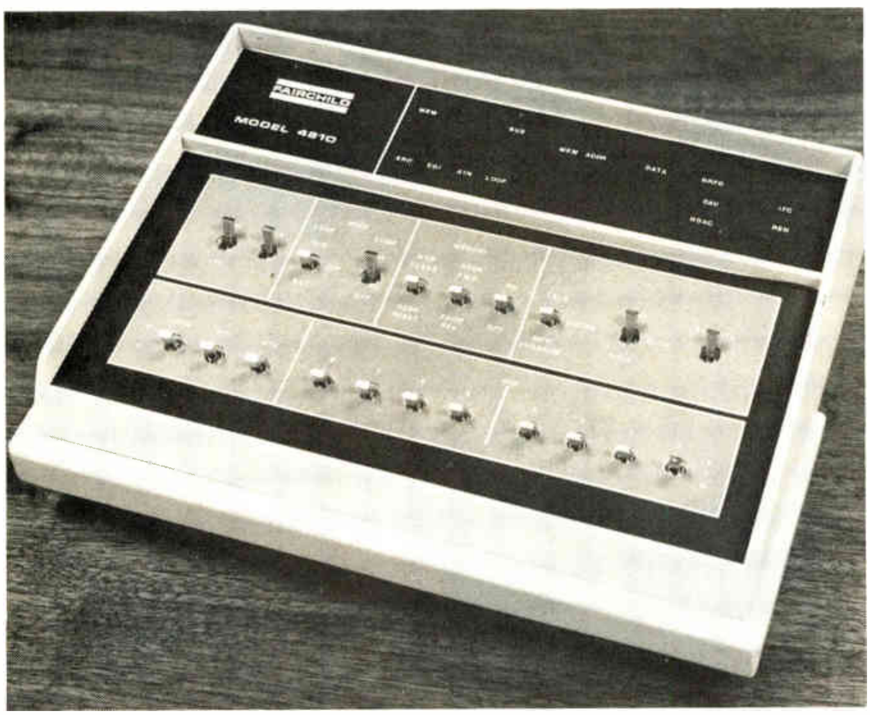
When one of several instruments in an automated system interconnected by the IEEE-488 interface bus gets out of step or fails to carry out instructions, the culprit is often hard to find. To help in such situations, Fairchild Systems Technology, San Jose, Calif., has designed the model 4810 bus fault analyzer.

The unit can function as a controller as well as a passive listener. It operates at one of three speeds—single-step, two steps per second, or at a fast rate, about 400 kilohertz—and can issue commands at any of these speeds, under control of either the memory or the front-panel switches. Its 100-word memory can be used either to store control programs or to serve as a trace memory, holding up to 100 bus states. When storing a program, the memory can be short-cycled—the program can be set up to return to its starting point or any other location without going to the end of the 100-word memory. This would be useful, for example, if a short preamble were written ahead of a program section that is to be repeated or looped, Fairchild engineers point out.

The instrument is manually programmed from the front-panel switches—eight for data, plus three for controls: SRQ (service request), EOI (end or identify), and ATN (attention). The switches are set to binary 1 or 0 for each step of the program and then stored in the memory. When running the program, the data switches are set to the first step of the loop.

In the listen mode, the analyzer will display the individual bus states in memory, storing the most recent 100 words. The data switches can be used to set the bus status on which the unit is to stop. A pulse-output connector for triggering an oscilloscope is available to the user at the rear of the instrument.

The fault analyzer is packaged in a desk-calculator type of enclosure with a sloping panel that measures about 2 inches high in front, rising to 4 in. or so at the rear.



About 12 in. wide and 10 in. deep all told, the unit also has a plastic slideout reference card, beneath the panel, containing a listing of the ASCII commands. Price of the 4810 is $1,595.

Fairchild Systems Technology, 1725 Technology Drive, San Jose, Calif. 95110. Phone (408) 998-0123 [351]

Digital multimeters measure in current or dBm modes

Designed for use at the bench and in the field, a series of portable 4½-digit multimeters have maximum dc errors of either 0.02% of reading +0.01% of full scale or 0.05% of reading +0.05% of full scale and operate with a choice of current or dBm measuring modes. The four models feature auto and manual range selection. Ac voltage measure-

ments can be made from 100 mV full scale to 750 V in five ranges; dc voltage is from ±100 mV to ±1,000 V in five ranges. In the resistance mode, measurements can be made from 200 Ω full scale to 20 MΩ. The dBm mode is offered in place of the five dc and ac manual current modes, which cover measurements from 200 μA to 2 A.

The model 7141A (0.05%) and 7141B (0.02%) sell for $395 and $450, respectively, and the models 7142A and 7142B sell for $445 and $500, respectively. The latter two units include the dBm scales. Delivery time for all four instruments is

Check data system apples before you bite

There are big differences in data logger performance. And it isn't just spec-manship. So it will pay you to investigate the Esterline Angus PD2064 before you buy any system to acquire analog and digital data from 1 to hundreds of channels

New Total Remote Programming feature lets you gather data precisely, under control of remote terminals, calculators or computers Or with local keyboard you program the microprocessor, set and modify channel gains, select data correction functions, output units, and output device. PD2064 even includes the most powerful alarm package of any data system In addition to the on board printer, output can be directed to nearby or remote tape recorders calculators. data terminals, or computers

Esterline also matches your application needs with data reduction options like true integration, and averaging Inputs include thermocouple, RTD, and thermistor multiplexing with both high and low level MUX systems. AC/DC models for field use. In accountability technology, timing relationships are critical That's why we use a buffered memory and crystal clock so scanning and measuring are independent of output rates This exclusive feature avoids skewed data.

Esterline provides accountability Ask for Bulletin B110 to keep the doctor away. Esterline Angus Instrument Corporation, Box 24000, Indianapolis, IN 46224. Tel 317-244-7611.

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Circle 163 on reader service card

currently running 30 days or less.
Systron-Donner Corp., Instrument Division, 10 Systron Dr., Concord, Calif. 94518 [354]

Fault finder locates shorted runs

A fault finder, the 911 Short Sniffer, enables technicians to locate and patch around shorted runs buried in multilayer circuit boards. This instrument can also be used as a diagnostic tool to aid in circuit-board failure analysis. Besides pinpointing the location of the short, the 911 will indicate the direction of the shorted conductors by issuing audible clicks that increase in frequency as the short is approached. The fault finder sells for $275 and is available from stock to two weeks.
Idlewild Associates, P. O. Box 41, McMinnville, Ore. 97128 [355]

Meter with LCD needs little power

Using a liquid-crystal display, a low-power digital panel meter will draw only 3 mA from a 9-V battery and 6 mA from a 5-V battery. The model DM-3100U1 is a 3½-digit instrument that features balanced differential inputs but requires additional components to function as an ohmmeter, a current meter, or a voltmeter. It will display the following

unit labels: mA, A, mV, V, Ω, dc, and ac. Automatic zero correction eliminates temperature drift. An external reference source may be used for ratiometric operation to scale to engineering units.

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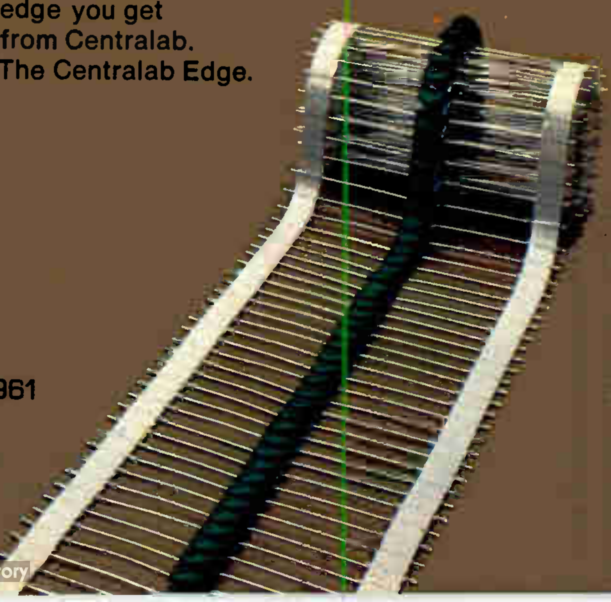

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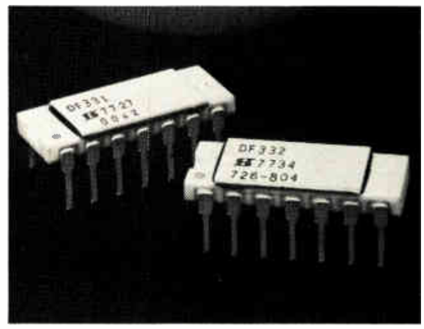
Circle 165 on reader service card

Circle 167 on reader service card

the streaming device. The model 835 MSD sells for $550 and rents for $50 a month on a two-year lease. Delivery time is 30 days.
Paradyne Corp., Largo, Fla. [405]

One-channel codec fits on two chips

The DF331 and DF332 are, respectively, a pulse-code-modulation encoder and decoder that together form a logarithmic companding codec designed to meet all Bell System



μ-255 specifications. The circuits, which are being made by Siliconix and second-sourced by Nitron, are believed to be the first such single-channel devices. Each circuit is housed in a 14-pin dual in-line package, and each requires only a single inexpensive external component to become operational. The coder requires a pull-up resistor, and the decoder requires a capacitor.

A key feature of both circuits is their complementary-metal-oxide-semiconductor technology, which gives them a typical combined power consumption of 135 mw. Not limited just to Bell System specifications, the circuits can be operated with data rates up to 3.088 MHz or to signal bandwidths as wide as 8 kHz. Pricing, in hundreds, is $9.76 for the set. The components offered by Nitron will carry the designations NC331 and NC332.

Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, Calif. 95054. Phone Jim Graham at (408) 246-8000

Nitron Inc., 10420 Bubb Rd., Cupertino, Calif. 95014. Phone Henri De Roule at (408) 255-7550, Ext. 208

New products/materials

An aerosol cleaner-degreaser, Electro-Wash, is intended for electronic, electrical, and mechanical applications. It works optimally when combined with an aerosol-pulsating attachment, Vibra-Jet. The joint unit has the cleaning power of an ultrasonic bath, dislodging even encrusted contaminants. Moreover, Vibra-Jet can remove grease, dirt, and oxidation without damaging the assembly. Electro-Wash is safe for plastics, evaporates quickly without leaving a residue, has good dielectric properties, is nonflammable for complete safety, and meets pertinent Federal and military specifications. It is also economical, giving users 97% active ingredient, instead of approximately 70% or less as with most other materials. Electro-Wash is available in 24-oz and 6-oz sizes.

Chemtronics Inc., 45 Hoffman Ave., Hauppauge, N. Y. 11787 [476]

A heat-resistant lead wire insulated with cross-linked polyethylene is designed for motor and transformer applications and is especially useful because it eliminates the processing problems of asbestos without sacrificing thermal, electrical, or mechanical properties. Polyrad 150 also does not irritate skin as does glass-braided silicone. This tough wire is available in 10 standard colors and in sizes from 30 to 4 AWG.

Brand-Rex Co., P. O. Box 498, Willimantic, Conn. 06226 [477]

Processor growth: can your small computer make the upgrade?

Product	Our HP 1000 and 21MX Computers	Your old favorite
Computers	21MX computers, with memory capacity of 1.8 million bytes, speeds up to 350 ns, and user microprogramming. All have compatible architecture, instruction sets, I/O and memory. *K-Series* computer on a board: $974* *M-Series* low-cost computer: $2,698* *E-Series* high-performance computer: $3,803* Instructions 70-100% faster than M-Series.	
Systems	HP 1000 includes 21MX-E computer, CRT console with soft keys and dual cartridges, RTE operating system. Fault control memory available to 1.8 million bytes. Easy to upgrade as your needs expand, with full selection of HP manufactured and supported peripherals. *Model 20.* 64K-byte memory-based systems: $21,000. 500K-byte flexible discs optional. *Model 30.* 64K-byte disc-based system, 15M-byte disc storage: $36,500. 5M and 50M-byte discs available. *Model 80.* 128K-byte data base management system with 15M-byte disc storage. HP-developed IMAGE DBM software, mag tape and line printer: $61,700. 50M-byte discs available.	
Software	*One upward-compatible family of Real Time Executives:* RTE manages 1.8 million bytes of main memory. BASIC, FORTRAN, Assembly and Microprogramming languages. Distributed Systems Networks. Measurement and control support.	

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22705HPDS7

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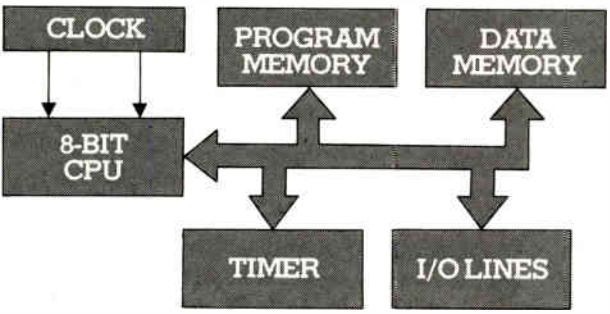

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Circle 177 on reader service card

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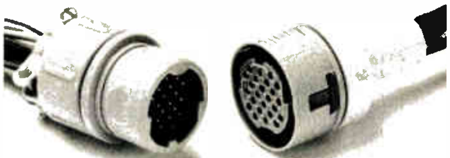

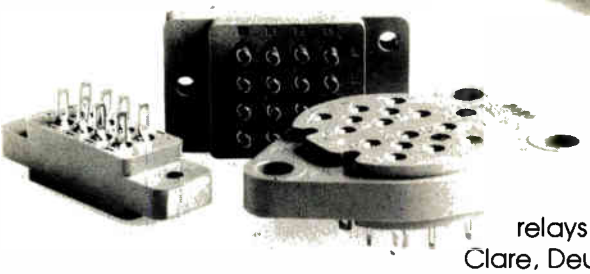

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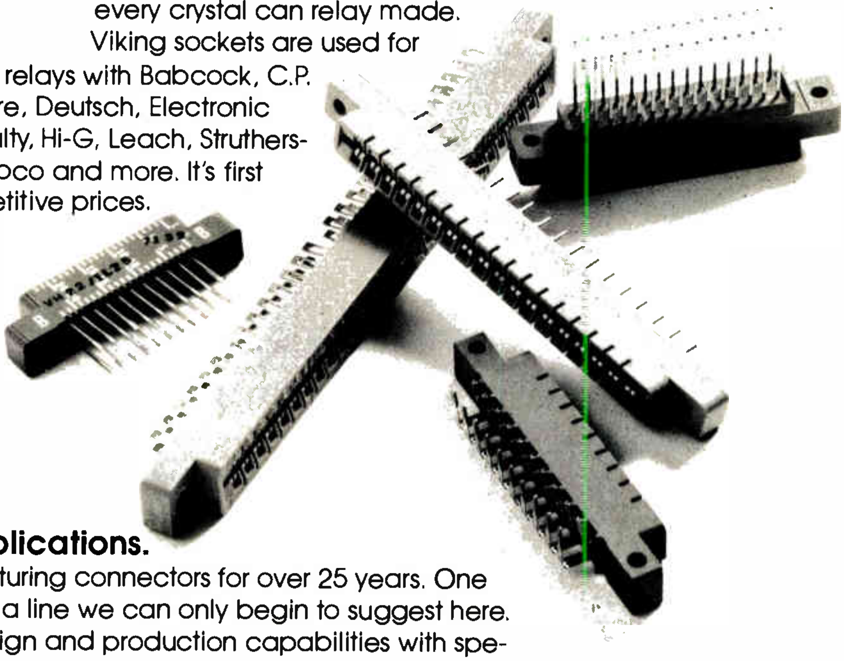

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Circle 239 on reader service card

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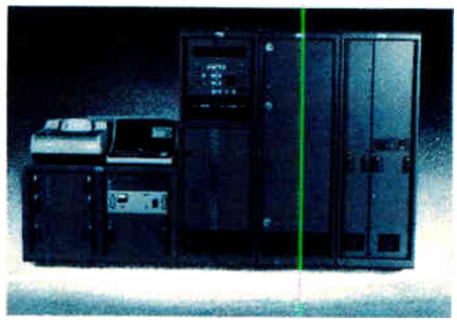

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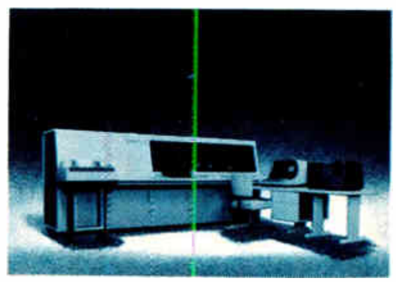

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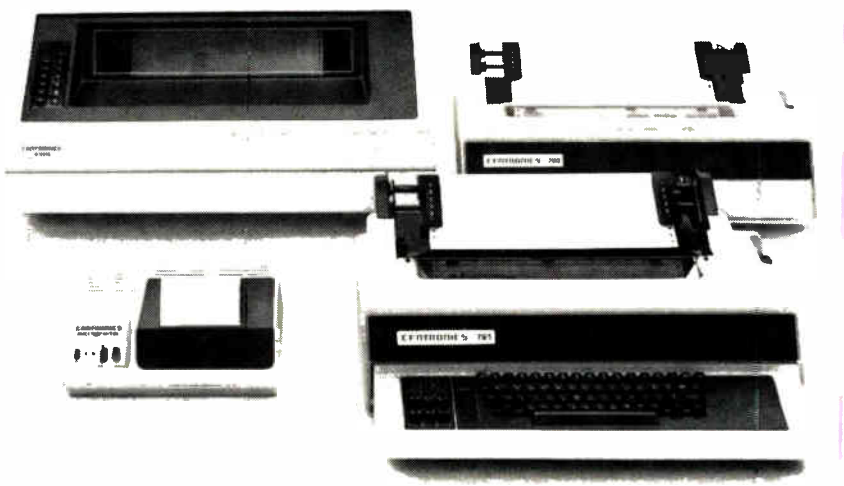
Centronics has more. Competitive prices. The largest worldwide service organization of any printer company. Financial stability with a record of growth and strength unmatched in the business. And a track record of superior product reliability and customer support—whether OEM or end-user.

You know the advantages of a single source supply. You know the breadth of Centronics' line. And now you know why Centronics is the better printer company. Write or call today for the complete details of Centronics' full printer line. Centronics Data Computer (U.K.) Ltd., Petersham House, Harrington Road, London. Tel: 01-581 1011. Telex 8951373. Offices in Frankfurt, Paris and Milan.



CENTRONICS® PRINTERS
Simply Better

Solid State
D.C. To Synchro Converte

PROVIDES A THREE WIRE AC OUTPUT PROPORTIONAL TO A DC VOLTAGE INPUT

FEATURES:

- Developes a fully isolated 3-wire AC output proportional to a DC signal
- Maintains accuracy with tracking speeds as high as 720°/SEC
- Isolated reference input
- Accuracy is not affected by reference voltage or power supply variations
- Provides 0.5 VA output drive
- Three wire AC output developed with 15 minute accuracy
- Hermetically sealed metal package
- Package size and terminal configuration may be altered at no extra cost
- Units can be altered to meet your exact voltage and frequency requirements—in most cases at no extra cost
- Output remains constant for ± 10% reference voltage variations
- Low output distortion (<0.5%)
- Infinite resolution

SPECIFICATIONS: MAC 1562-1

- **Input signal** — 0 to ± 10V DC
- **Input signal resistance** — 10K minimum
- **Reference input** — 26V RMS ± 10%
- **Operating frequency** — 400 HZ ± 10%
- **DC power** — ± 15V ± 1%
  ± 50MA no load
  ± 100 MA full load (139Ω L-L)
- **Full scale output** — 11.8V AC line to line ± 2%
- **Power output** — 0.5VA max.
- **Transfer function**

$$S1\text{-}S3 = 11.8V \times \sin\left(\pi \times \frac{EIN}{10\ V}\right)$$

$$S2\text{-}S3 = 11.8V \times \sin\left(\pi \times \frac{EIN}{10\ V} + 120^\circ\right)$$

$$S2\text{-}S1 = 11.8V \times \sin\left(\pi \times \frac{EIN}{10\ V} + 240^\circ\right)$$

- **Accuracy***
  15 minutes of ARC (Max) at 20°C ± 10°C
  30 minutes of ARC (Max) over the operating temp. range

*Accuracy is based on the following equation:

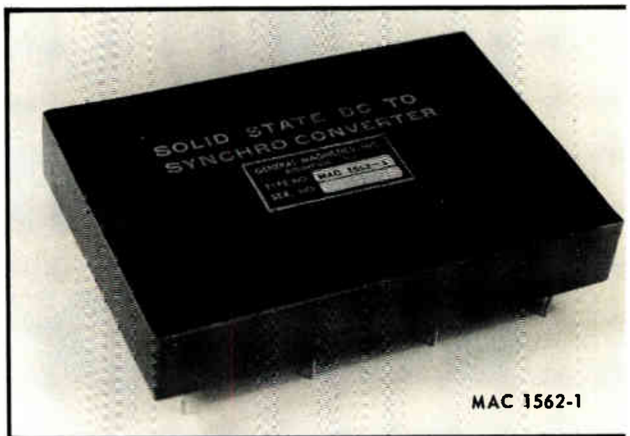
$$\theta = \tan^{-1}\left[\sqrt{3}\ \frac{(1-K)}{(1+K)}\right]$$

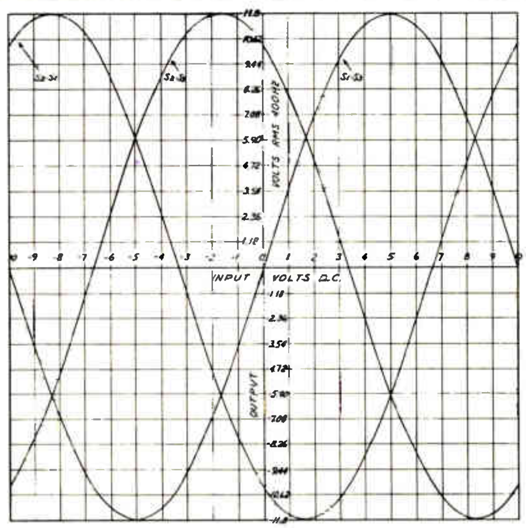
Where K is the measured ratio (S3-S2)/(S1-S2)

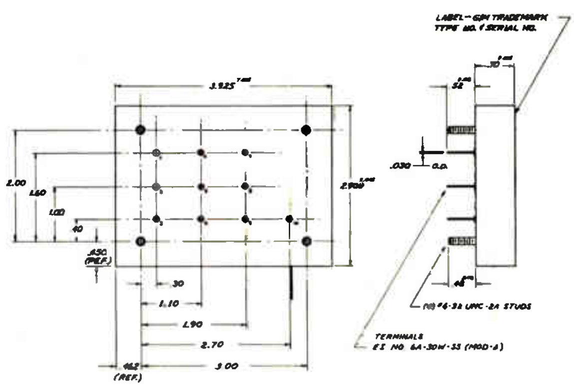
- **Tracking speed** — 720°/SEC
- **Operating temperature range** 0°C to 70°C
- **Distortion** 0.5% max.

For units to meet wider temperature range and other specifications please consult the factory.

Circle 192 on reader service card







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Electronics
Reader Service

If the cards below have already been used, you may obtain the needed information by writing directly to the manufacturer, or by sending your name and address, plus the Reader Service number and issue date, to Electronics Reader Service Department, P.O. Box No. 2530, Clinton, Iowa 52734, U.S.A.

Place correct airmail postage here ... for faster service.

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