SEPTEMBER 29, 1977

**WHY SOVIET TECHNOLOGY IS BEHIND/77**

One-chip multipliers aid signal-processing systems/93

Prototyping method eases breadboard design/104

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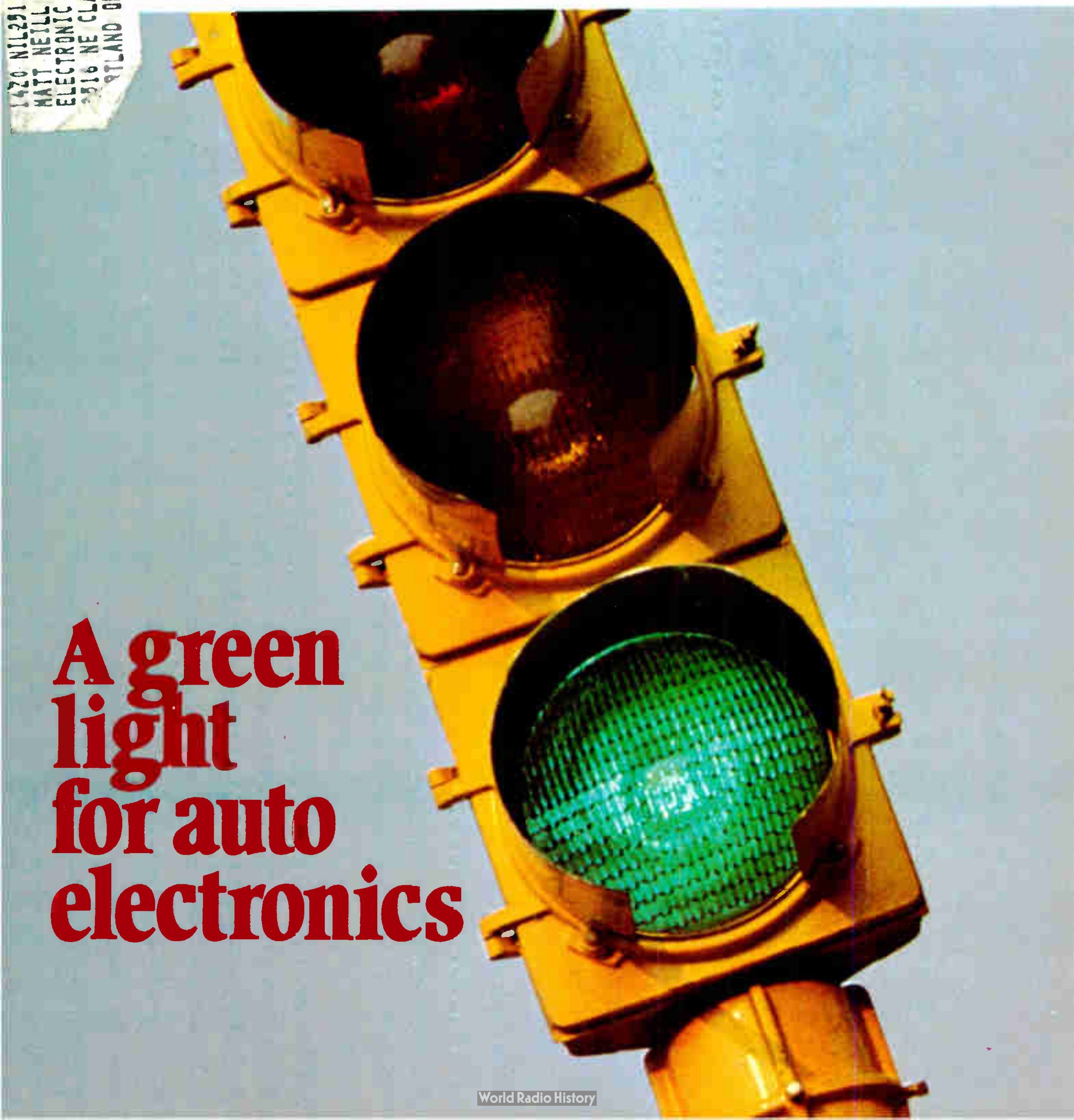
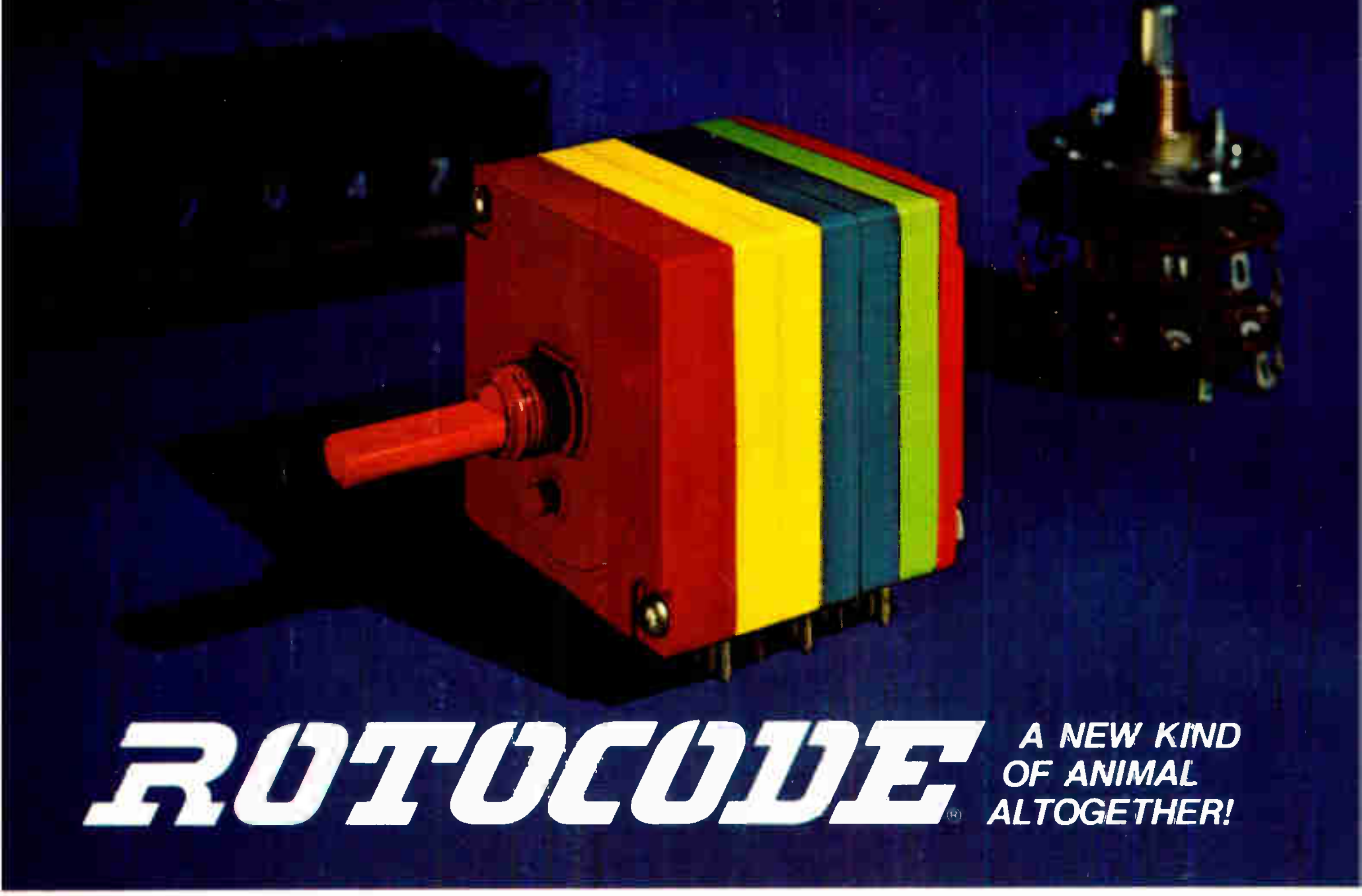
# Electronics®





# A green light for auto electronics

# What would you get if you crossed a rotary switch with a coded thumbwheel switch?

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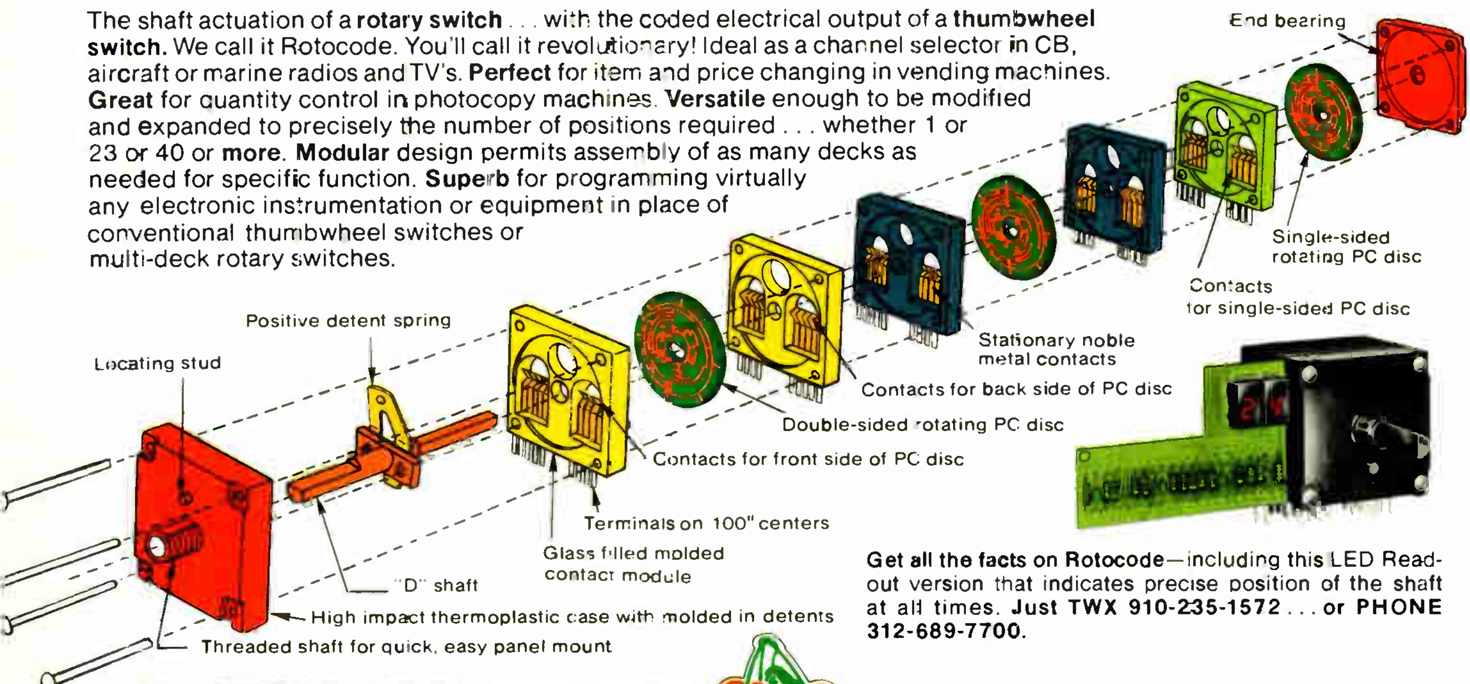


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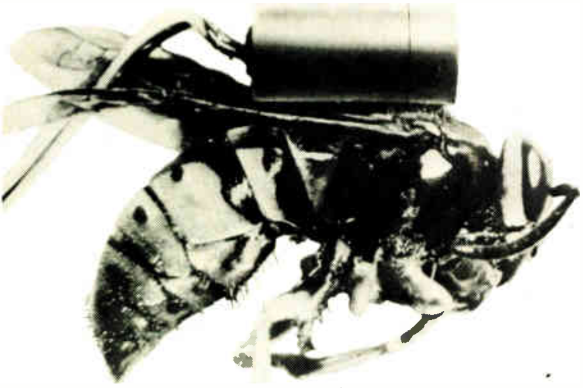

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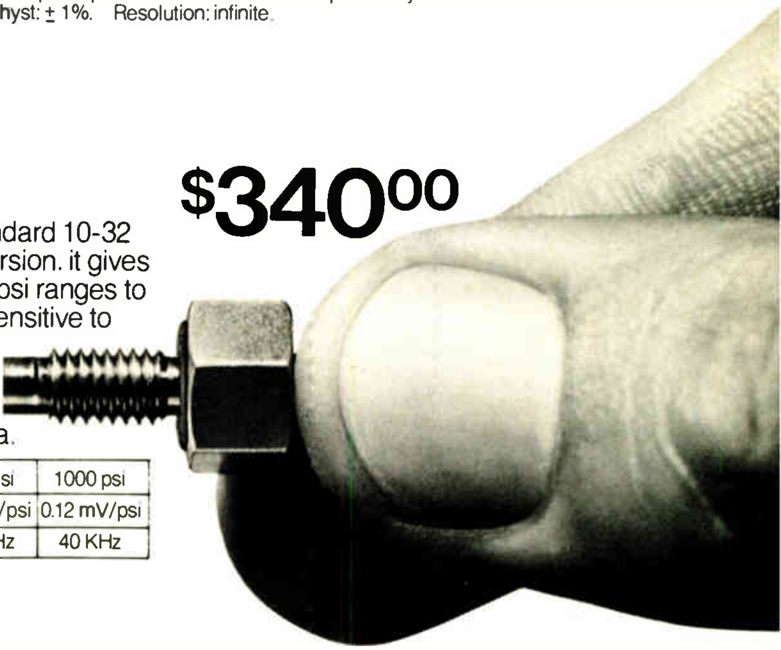
Must not be used in water or corrosive medium.

### Only 0.080 in diameter (that's tiny), EPI-080.

This solid-state pressure transducer is 0.080" in diameter, 0.25" in length and occupies a volume of only 0.0013 cubic inches. Yet it gives accurate static and dynamic pressure readings like the big ones do. Its atomically bonded, diffused diaphragm with leads attached to the non-active area make this device virtually insensitive to acceleration, vibration and shock.

| Typical ranges | 25 psi | 50 psi | 100 psi | 250 psi | 500 psi |
|---|---|---|---|---|---|
| Sensitivity nom. | 3 mV/psi | 1.8 mV/psi | 1.0 mV/psi | 0.4 mV/psi | 0.2 mV/psi |
| Useful frequency nom. | 25 KHz | 30 KHz | 40 KHz | 60 KHz | 80 KHz |

Excitation: 5V. Output impedance: 750 Ω nom. Repeatability: 0.5%.
Non-linear and hyst: ± 1%. Resolution: infinite.



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### Tiny but easy to handle, EPS-1032

This easy to install pressure transducer is built with standard 10-32 UNF thread and is available in an optional M5 metric version. it gives flat pressure readings static and dynamic, in 5 to 5,000 psi ranges to as high as 90KHz. Has infinite resolution and is also insensitive to acceleration, vibration and shock. Made of stainless steel, and with its built-in "O" ring seal can be screwed in just about anywhere. However, for corrosive or water usage, order our "welded" version at $50.00 extra.

| Typical ranges | 5 psi | 50 psi | 100 psi | 250 psi | 1000 psi |
|---|---|---|---|---|---|
| Sensitivity nom. | 3 mV/psi | 2 mV/psi | 1.2 mV/psi | 0.5 mV/psi | 0.12 mV/psi |
| Useful frequency nom. | 9 KHz | 15 KHz | 15 KHz | 20 KHz | 40 KHz |

Combined non-linear and hyst: ± 1% below 100psi, ½% 100 psi or above.
Excitation: 6V. Output impedance: 250 Ω nom.
Repeatability: 0.25%. Thread length: 7/16".

# Entran Pressure Transducers.

**(Today, miniature makes sense.)**

# Electronics

**The International Magazine of Electronics Technology**

**Vol. 50, No. 20 • September 29, 1977**



## Highlights

**Cover: The electronic auto is here (almost), 83**

Electronic engine controls are a must to meet U. S. antipollution and fuel-economy requirements, but they are only part of Detroit's plans. Other evolving electronic systems include multiplexed setups for integrating the various sensing, control, and display subsystems and—eventually—radar-controlled cars.

Cover photograph is by Joe Ruskin.

**ITT units cooperate on digital switch, 72**

The new pulse-code-modulated electronic switching system from ITT-Europe is the product of centralized development by the firm's various national units. A contender for use in the digital-switching phone networks expected to predominate worldwide, System 12 will be produced cooperatively.

**Digital multiplexer speeds signal processing, 93**

Real-time signal processing, long the fiefdom of analog methods, is falling under the sway of digital techniques. The impetus: new devices such as the multiplier chips that speed the complex operations needed for the digital treatment.

**Anyone can play, 104**

Assembling a complex breadboard can be easy with a methodical approach that accounts for parts layout and power distribution. The key is an updated version of the bus bar called the power distribution element.

**In the next issue . . .**

Designing with mechanical filters . . . an update on computer-aided design . . . delta modulation is ready for the big time.

# Publisher's letter

The Soviet Union, most Moscow watchers agree, is quite a way behind the United States in applying electronics to national needs. There is no question, indeed, about the consumer electronics sector, where annual production of color television sets, for instance, accounts for only 1 million out of a total of 8 million TV sets, none of which boasts integrated circuits. In telephones, too, the Soviet Union is lagging, and it is just beginning to modernize its skimpy, decades-old system with electronic exchanges—but the first ones have had to be imported, from Britain.

The military area, to be sure, is where the Russians are doing their lion's share of electronics spending. They are not, however, telling the world much about their technological successes—and nothing about their failures, if any.

It was not an easy task, therefore, that we handed to Peter Hann, Moscow bureau chief for McGraw-Hill World News, when we asked him to report and write a profile of the Soviet Union's electronics efforts. For a view, then, of how Russian electronics endeavors are faring, turn to page 77. You'll find details on the Soviet-sponsored Comecon computer development program and some news about the country's communications satellite plans, among other things. One thing you won't find, though, is a feeling that the Soviet Union is about to close the technology gap. Indeed, reading between the lines, one might conclude that the gap is widening.

Breadboarding a new circuit almost always starts out one way and, after all the changes and second thoughts, ends up as quite a complex assemblage of parts and interconnections. Then comes another headache: converting the prototype into production-line boards. One answer to these design hurdles is the bus-bar concept detailed in the article that begins on page 104.

Bernard Carey, author of the article, has been developing an undergraduate laboratory course in computer system design for the last two years. He was interested in finding a low-cost method for breadboarding microcomputer-based systems. Along with low cost, he wanted a physically and electronically reliable system that untrained students could easily apply. In the course of his investigation, Carey tried all the commercial breadboarding types and found them wanting.

Then, Carey was asked by Rogers Corp., Rogers, Conn., to analyze a Mostek dynamic memory board that used the company's printed-circuit bus bars as power distribution elements. As he analyzed the electrical characteristics of the Mini-Bus, Carey realized its potential for breadboarding microprocessor circuitry.

A group of graduate students, including co-author Harry Grossman, built the first low-cost breadboards based on the bus bars and Vector boards and compiled the data discussed in the article. Now this method is in regular use in the computer lab at the University of Connecticut.

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## Readers' comments

### No ground

**To the Editor:** A potentially troublesome error appears in my schematic (Fig. 1) ["Wideband preamp and LSI pair form high-quality counter," Sept. 1, p. 108]. The left side of $S_2$ should not be connected to ground. The ICM 7207 contains an internal pulldown, and closing $S_2$, would short the power supply.

I have also noted that some of the ICM 7207s tested require a resistor of 1 to 5 kilohms from pin 12 to $V^+$ in order to scan the display.

James A. Mears
Dallas, Texas

### Maintaining balance

**To the Editor:** For Mr. Nissink's bias-current network ["Bias-current network improves sample-and-hold response," Sept. 1, p. 111] to be effective, the LM307 would have to be individually selected to have nearly equal bias currents. The bias offset of this op amp is 50 nA maximum, with no minimum specified bias current. This means that the bias current in one input could, for example, be 1 nA while that in the other input is 51 nA, in which case Mr. Nissink's circuit wouldn't help much to minimize drift. Nevertheless, his idea is deucedly clever.

D. Hileman
Woodland Hills, Calif.

■ *According to Bruno Walmsley, applications engineer at RCA, bias currents at the inputs of the LM307 are almost always balanced to within 5%. The condition cited by reader Hileman would be extremely unlikely.*

### Association vs union

**To the Editor:** Perhaps I am misinterpreting Mr. Pereda in Readers' Comments [Sept. 1, p. 6], but he appears to advocate unions for the protection of mediocrity in engineering. . . .

I don't know anything about the activities of the American Medical Association and I doubt that they are a union in the sense that most of us think of unions. Perhaps a similar organization for engineers would be very beneficial. . . .

Craig West
San Jose, Calif.

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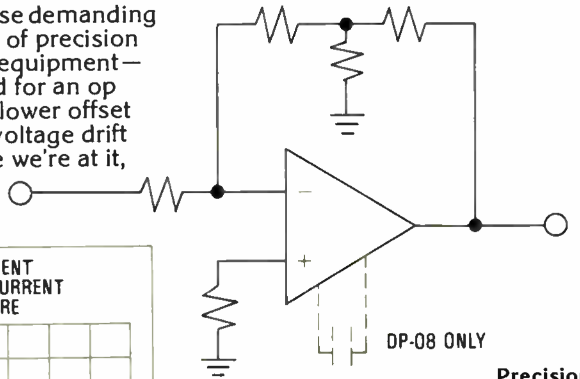


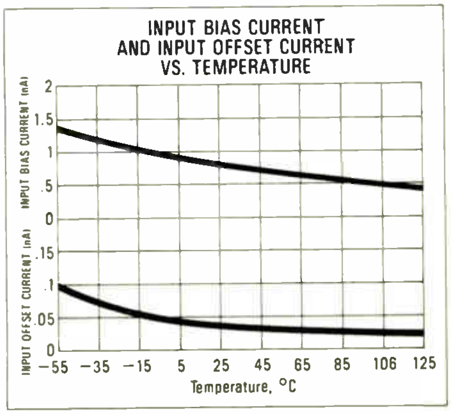


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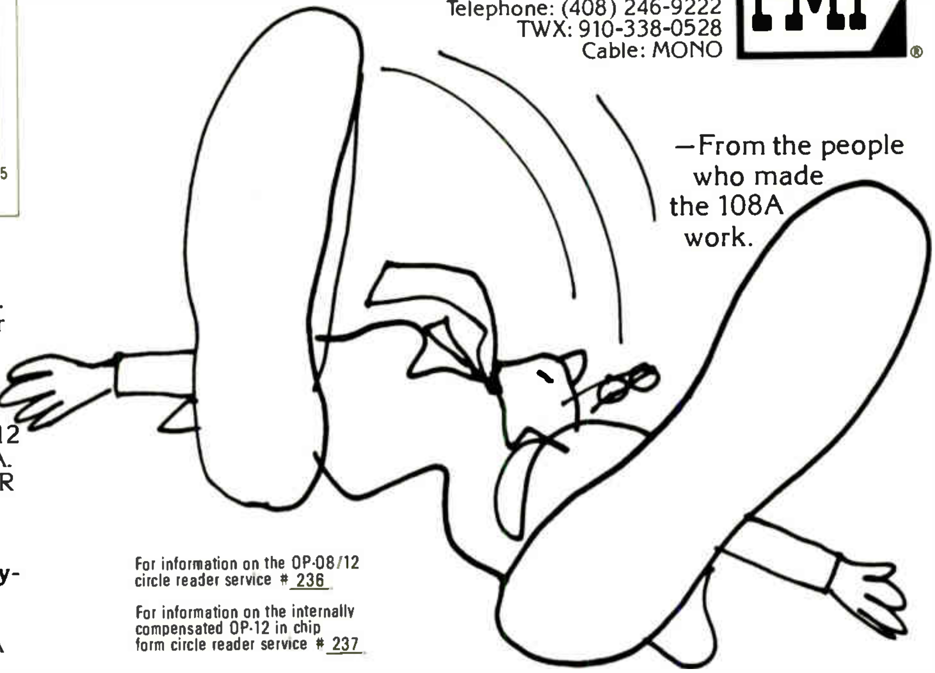

—From the people who made the 108A work.

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 $V_S$ = ±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

## News update

Gas-discharge display terminals have taken a giant step toward direct competition with cathode-ray-tube types in military computer peripherals. This comes with first deliveries this month of "second-generation" gas-discharge, or plasma, terminals from Interstate Electronics Corp. of Anaheim, Calif. [*Electronics*, Feb. 17, p. 91]. The PD 2000 terminals are for Systems Development Corp. in nearby Santa Monica and will be integrated into a telemetry information processing system for the Air Force's Space and Missile Test Center at Vandenberg Air Force Base, Calif.

The plasma display has been the leading candidate to succeed the CRT ever since the first commercial gas-discharge panel was introduced in 1971. Yet terminal manufacturers were slow to adopt it, largely because the discrete circuitry needed to drive the display was too complex and expensive. But now that Interstate has incorporated microprocessors and other ICs in its designs, the picture for plasma terminals looks much brighter.

The ruggedized PD 2000 and a commercial-grade PD 1000, both available now and selling for $10,000 and $8,900 respectively, "are priced at a level competitive with CRT-based terminals of like performance," claims Sid Wing, Interstate's computer products marketing manager.

Weighing less than 50 pounds and occupying less than two cubic feet, both models have a maximum writing speed of 8,333 characters/second for a 5-by-7 character. They come with such standard features as dual-font, upper- and lower-case alphanumerics, full graphics capability, interface keyboard, and control command functions for over 70 different commands.

In addition to the SDC contract for 26 PD 2000s at a cost of over $300,000, Interstate has orders for several other PD 1000s and 2000s. However, it has orders approaching 400 units for a new fully militarized model that can be mounted in a half-rack, the PD 3000, to enter full production after Jan. 1, 1978.

**Bruce LeBoss**

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**A new source for the C106.** This popular 4A general purpose SCR and corresponding sensitive-gate triac are now available from RCA. In the economical, easily mounted 3-lead Versatab package.

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| Family | $V_{DROM}$ (V) | $I_T$ (A) | $I_{GT}$ (mA) | Description | Pkg. |
|---|---|---|---|---|---|
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| G4000 | 50-400 | 15 | 3 | Gate Turn-off SCR | TO-220 |
| S860 | 50-600 | 100 | 200 | Gen. purpose SCR | ½" stud |
| S5800 | 100-600 | 5 | 50 | Fast switching SCR | TO-220 |
| C106 | 15-600 | 4.0 | 0.200 | 4 amp gen. purp. SCR | TO-202 |
| T2320 | 50-400 | 2.5 | 3-40 | Sensitive-gate triac | TO-202 |
| T6000 | 50-600 | 15 | 10-50 | Gen. purpose triac | TO-220 |

**A new source for circuit ideas.** "Power Options from the Powerhouse" is a new designer's guide to the selection of optimum RCA solid-state devices for power circuits. It's arranged by application, with over 40 circuits shown. This makes it easy for you to choose the type best suited to the job.

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Circle 10 on reader service card

# Editorial

## Gearing up for the auto market

Semiconductor makers have long looked wistfully at the automobile industry as a huge untapped mass market for their products. And no wonder. Take 10 million vehicles and multiply that figure by dozens of integrated circuits—now including microprocessors, their necessary add-on memory, and custom input/output chips. Then do that multiplication every year, inserting the relevant cost per device, and you come up with one of the most enticing long-term markets ever created. What's more, the fast-paced history of semiconductor development is full of cases where the technological progress achieved in meeting one market's needs has led to widespread growth in many other fields as well.

It is hardly a surprise, then, that the semiconductor makers are eager for Detroit—to say nothing of the other auto capitals of the world—to make the big jump to electronic controls. For years, they have been tempted by all sorts of talk about antiskid braking, ignition spark-timing controls, and indeed, by a whole new world of microprocessor-based vehicle-control systems.

It is no surprise, either, that they—the pacesetters in electronics technology—have been impatient with the auto industry's tradition of slow, if not quite glacial, movement toward change. Where five months might be the lead time to develop an important new electronic device, five years is more likely to be quoted when an auto executive is asked how soon some major change is likely to show up in cars.

The Federally mandated gas-economy and emission-control regulations, however, are forcing Detroit into a higher gear. Yet, with a track littered with advanced-technology failures and ahead-of-their-time nonstarters, the auto industry has every reason to be cautious in how fast it applies technological advances from other fields.

Over the long run, too, semiconductor manufacturers may end up appreciating Detroit's step-by-step approach to letting integrated circuitry transform the car as we know it today. After all, it would be hard to recover from the black eye caused by the failure of premature, hastily designed electronic controls. Then, too, electronic controls might work just fine right now, but suffer a setback with the public if, say, sensing elements were not yet up to the job.

Functionally, electronic controls are up to the job. Yet to be resolved, however, are some problems peculiar to the automobile itself. One big need, of course, is for a fail-soft or limp-home capability so that motorists can drive, however slowly or inefficiently, to a repair shop. After all, even with 40,000-mile tires, the spare is still there in the trunk. Another important consideration, too, is the retraining of mechanics so that they can service cars that are going to be more dependent on electronics every year.

The real challenge to the electronics companies that hope to cash in on the automobile market is not producing the devices. The challenge is making them work so reliably that they are virtually invisible to drivers.

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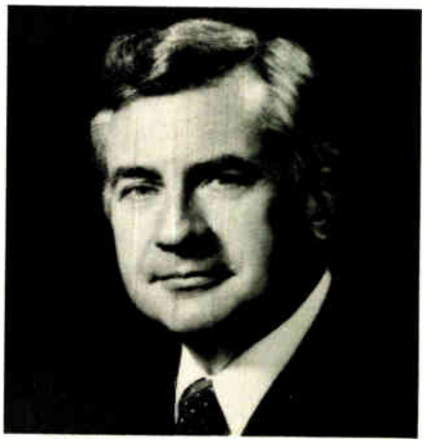
**While others are talking, we're doing it.**



Circle 13 on reader service card

## People

### Questions of organization face new EIA chief McCloskey



**Priority.** McCloskey hopes to restore EIA as the leading semiconductor association.

Even before Peter F. McCloskey takes over as president of the Electronic Industries Association on Oct. 1, the 42-year-old lawyer is looking for answers to some important questions. What kind of structure is most viable and most sensible for the Washington-based association of electronics manufacturers is the leading one.

Right now, EIA's eight divisions reflect the interests of many different businesses, ranging from citizens' band radios to electronic warfare. The issue of whether the varied and often unrelated interests of member companies might be more effectively served by a looser federation giving the divisions greater autonomy is one of long standing.

**Participation.** In addition, McCloskey is asking how the EIA can get more of its 280 member companies to participate at sufficiently high management levels so that, as he puts it, "policies are shaped by the policies of the companies and not the personalities of the people." Finally, he wonders whether the association can "pump some life into its Solid State Products division," which began to collapse when Texas Instruments Inc. quit the association in the summer of 1972.

McCloskey, who had been president since 1973 of the Washington-based Computer and Business Equipment Manufacturers Association, says he is assigning a high priority to restoring the association's role as the leading semiconductor manufacturers' association. Could this lead to a merger with the young Semiconductor Industry Association recently formed in California [*Electronics*, April 14, p. 50]? Too early to say, McCloskey responds, adding, "something like that might develop further down the road."

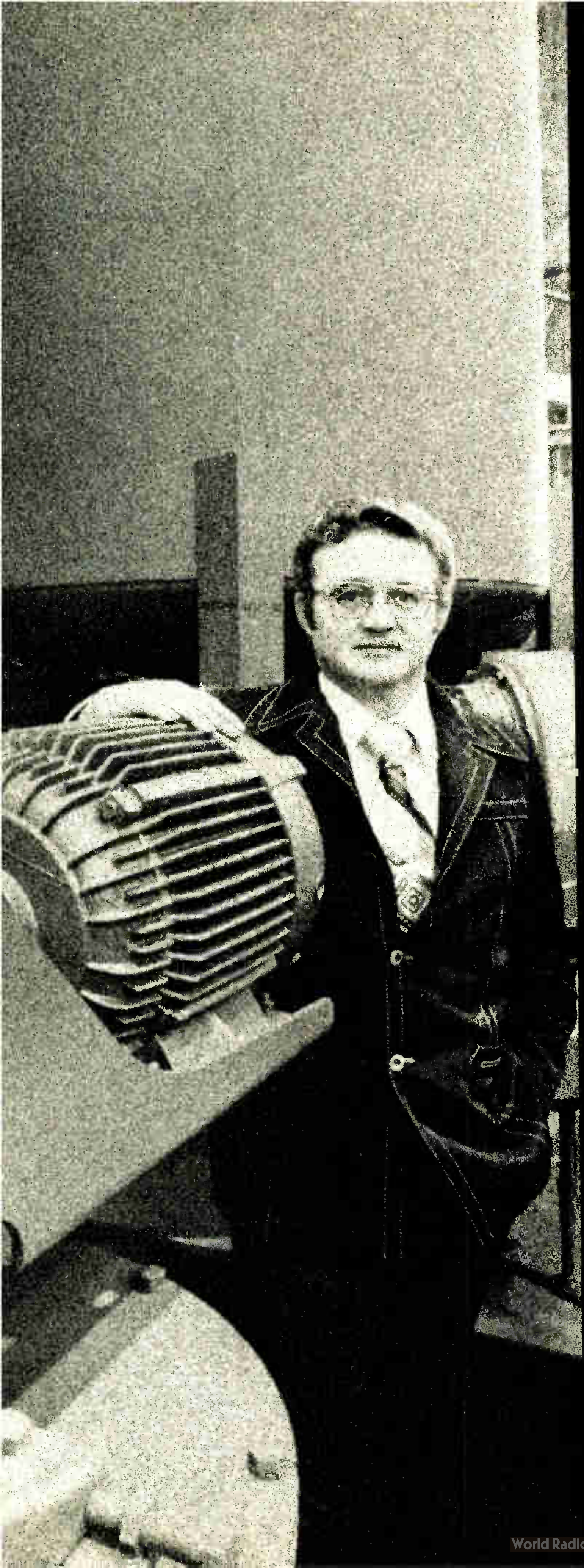
Relaxed and tanned, Pete McCloskey speaks with the soft reasonableness common to Washington lobbyists, a quality that should help him within the EIA as well as on Capitol Hill. He is a believer in the general need to recognize and respond to change. An association, he says, can be viewed "as almost a living organism that has to adjust or adapt" to changing conditions in society if it is to survive, much less succeed.

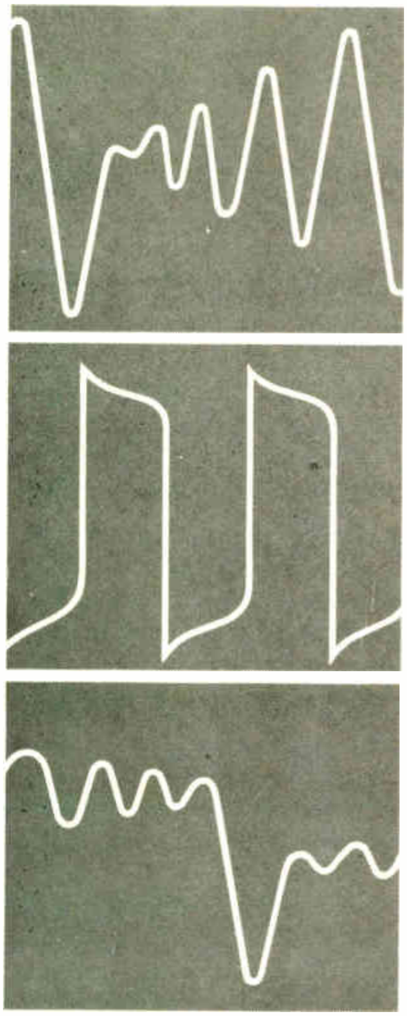
**More contacts.** On the issue of increasing high-level corporate participation, he will begin by increasing contacts with members "to ensure that they are getting a perceived value" for their dues dollars. But, he adds, companies must recognize "that this is a two-way street, and that their representatives [at the association's meetings] must be in communication with the top management of the company" if the EIA is to be effective.

### Seligman guides Data General to the small-business users

No single company dominates the market for small-business computer systems, says Lawrence Seligman, recently named director of the new Small Business Systems Development Group of Data General Corp., Westboro, Mass. That fact makes the 35-year-old former design engineer sanguine about the prospects for the minicomputer maker, with net sales last year above $160 million, to capture a goodly chunk of the huge business market.

Of course, there are other reasons too. "We have the basic hardware







and software we'll need already in the Data General product line," he says. "It's my job now to plan our product mix and to adapt our equipment to the needs of the business market."

The first move has already been made. As head of the Systems Products organization, Seligman, who joined Data General in 1969, helped bring to market the CS/40 business system priced in the $30,000 to $80,000 range (*Electronics*, May 26, p. 52). "But we have to go after a wider market," he says, although he declines to talk specifics. "Conceivably we'll be adapting our small microNova microcomputer and our large Eclipse line to small-business applications."

**Cobol.** A strong selling point for his firm, according to the articulate Seligman, will be the interactive Cobol language introduced with the CS/40. He points out that Cobol is the most widely used language in business data processing, but the interactive version has been available only on much more expensive systems. Its appeal is that it allows real-time transactions, such as order entry, instead of depending on batch processing to do the job. "An interactive computer cuts down on the busy work of card punching and other nonproductive steps required for batch operations."

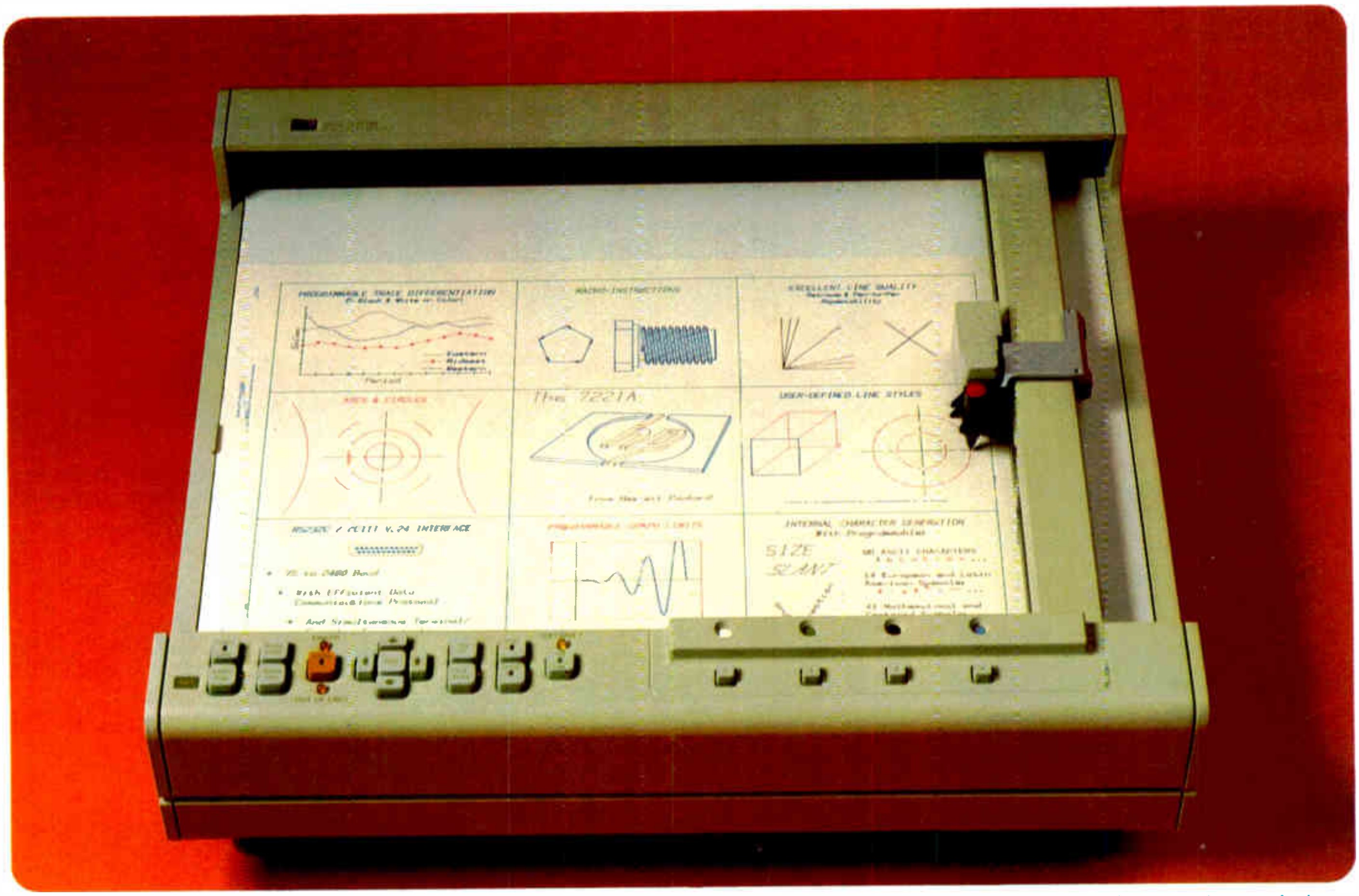
Seligman feels that the human engineering applied to the Data General hardware to adapt it for the commercial market will be crucial to his group's success. This work is much more than just dressing up the equipment in a new package. "For the CS/40, for example, we needed a cathode-ray tube terminal more suited to the operator," he says. "So we came up with one that both swivels and tilts."

But his group will concentrate on adapting the company's general-purpose products to make them easier for small business customers to use. "We don't want to reinvent the wheel," he says, "and we don't want to disrupt the factory" to produce substantially different products from those the company already has.

hp MEASUREMENT COMPUTATION news

product advances from Hewlett-Packard

SEPTEMBER 1977



Multicolor plots are especially useful in engineering modeling, plots of more than one measurement, manufacturing production control, numerical control verification, and in wide areas of mathematics, physics, and chemistry.

## New buffered plotter presents data in 4 colors, remotely

This new, programmable, microprocessor-based 7221A Graphic Plotter from Hewlett-Packard produces low cost, multicolor and high quality graphic plots from remote processing facilities.

Convenient and flexible operation of the terminal plotter is achieved through high-level commands designed to reduce the cost of data communications.

A built-in buffer allows the 7221A to store approximately 1150 eight-bit data bytes and can be expanded to 3080 bytes as an option. This saves time share computer and transmission costs since the computer no longer has to wait for the plotter to execute instructions. Portions of the buffer storage can also be reallocated to store up to 64 user-defined macro-instructions. These can be frequently used shapes, such as a logo-type, and can be invoked at any time by a single command.

Six resident character sets, including three European and Latin American sets, and miscellaneous mathematical and centered symbols with program control of

*(continued on third page)*

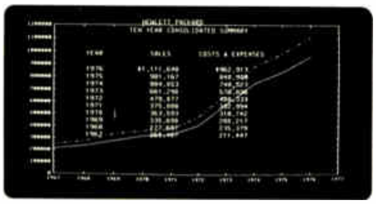
# New graphics terminal has interactive alphanumeric capabilities, too

The latest in microprocessor and raster scan technology are combined in Hewlett-Packard's new 2648A Graphics Terminal to produce a high performance, low-cost and bright display terminal that aids the user in many graphic application areas.

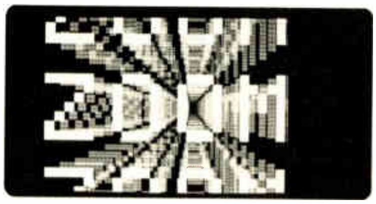
Easy-to-use and flexible, the 2648A allows the user to explore new concepts and try out new ideas in two or three dimensional picture representations. The terminal's many advanced features make these representations easy to achieve. For example: the display-refresh technology enables users to erase and modify the display selectively, without having to redraw the entire image. This feature minimizes user's waiting time and CPU overhead, while reducing communications costs when working with a computer network.

Raster scan technology gives the terminal a continually bright display that is easy to read even in well lit work areas.

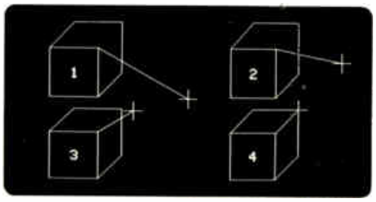
Not only can the terminal generate sophisticated graphics, it also has those characteristics of HP's data entry and communications terminals that make programming so much easier. And, dual mini cartridges provide mass storage capability.



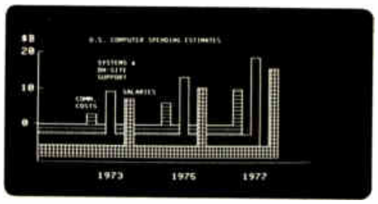
Even with little or no programming knowledge, you can Auto-Plot tabular data automatically. Enter your data parameters on the keyboard; a single keystroke plots the data instantly.



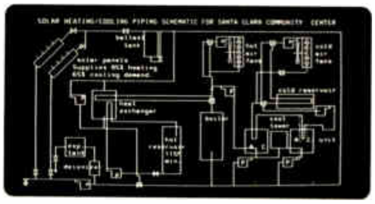
Hardware Zoom and Pan allows any portion of the graphics memory to be magnified up to 16 times. Concurrently, users may pan any portion of the magnified display not in the viewing window.




With the Rubber Band Line, trial graphics can be performed without CPU intervention. The user can draw a line to any length in any direction between a selected point and the cursor.




Added visual dimension to graphics is achieved through Rectangular Area Shading which enhances the shading of parts and assemblies, and facilitates differentiation of similar bar graphs.



Graphic Text Composition allows the user to select a character size, direction and slant within the graphics memory. This can be especially useful for labeling axes and adding notes or comments to the picture before it is committed to a hard copy device.

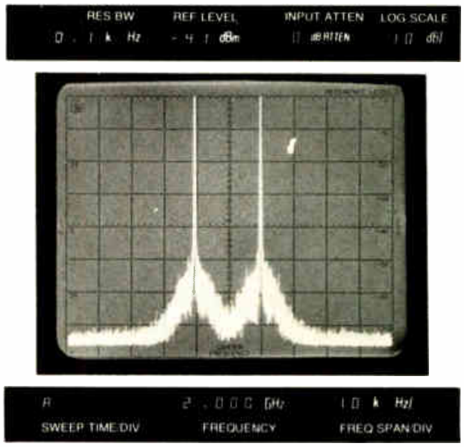
*For more details, check G on the HP Reply Card.*

# Spectrum analysis with 100 or 300 Hz resolution with new option

For high resolution in microwave signal analysis, the HP 8565A Spectrum Analyzer (10 MHz—22 GHz) is offered with 100 Hz and 300 Hz resolution bandwidths as a new option. These are in addition to the instrument's 1 kHz to 3 MHz bandwidths. The 100 Hz resolution performance is specified to 8.5 GHz and usable to 12.9 GHz. Measurements at 22 GHz can be made with 300 Hz resolution.

Higher resolution results in 10 dB more sensitivity, giving the 8565A analyzer an amplitude range of −120 to +30 dBm, 70 dB dynamic range, and internal preselection from 1.7 to 22 GHz. And it's easy to use—most measurements use just three controls, and there are LED displays in the CRT bezel presenting all pertinent control settings.

*For technical data, check O on the HP Reply Card.*




The HP 8565A spectrum analyzer's stability and low noise sidebands ensure full use of 100 Hz resolution, as shown in this two-tone intermodulation test.

# New financial calculator evaluates and prints investment alternatives


Whether you're printing amortization and depreciation schedules, or listing all the cash flows in an Internal Rate of Return problem, the HP-92 Investor gives you that indispensable hard copy for instant analysis or later perusal.

The new Hewlett-Packard HP-92 is a briefcase-sized, financial calculator,—with printer and display. It offers time savings with its preprogrammed functions for institutional investors, financial consultants, and other professionals examining investment alternatives.

The HP-92 Investor solves problems involving time and money. Compound interest. Annuities. Balloons. Internal rate of return for 30 uneven cash flows. Net present value. Bonds and notes. Three kinds of depreciation.

The printer on the HP-92 gives you the answers quickly and quietly—with descriptive labels.

The HP-92 will fit into a standard briefcase and can operate from the rechargeable batteries inside its case. Instant financial analyses are available whether you're at your desk, in a boardroom, even traveling across the country.

The HP-92 Investor solves complicated "real world" problems: time and money calculations; discounted cash flow analysis; percent functions; amortization and depreciation schedules; bonds and notes computation; and statistical functions.

*For more details, check B on the HP Reply Card.*

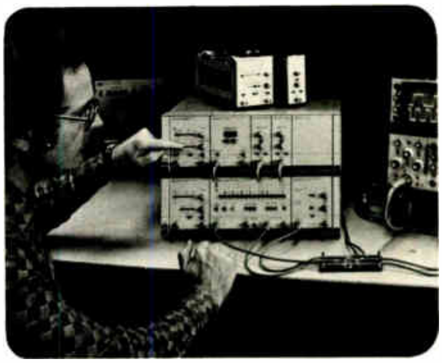
# GHz pulser system for advanced digital design meets your growing needs

Hewlett-Packard's new 8080 system produces precision 300 ps pulses with repetition rates from dc to 1000 MHz. This flexible system is also a digital data generator, producing 16, 32, or 64-bit serial words at up to 300 megabit rates. The 8080 gives you the stimulus capabilities you need for multi-hundred megahertz research and development—in integrated circuits and digital system development, telecommunications research, and fiber optic design.

The system is modular; you choose just the functions you need from a range of pulse and word generating modules. Should testing requirements change, you can easily expand or reconfigure your system to keep it tailored to your application.

Starting simply, for example, with a repetition rate generator and output amplifier, you have a GHz clocking source for subnanosecond logic systems. 300 ps transition times, ECL pulse levels, external triggering, and synchronous gating guarantee high performance and wide applicability. Later a delay generator/frequency divider and a second output amplifier can be added.

*For details on this versatile new stimulus system, check N on the HP Reply Card.*



The HP 8080 series is a powerful new 1 GHz pulse and word generator system for subnanosecond rise-time applications. Because of modular capability, you can configure a pulse stimulus system to exactly match your high frequency testing requirements.

# New remote terminal plotter

(continued from first page)

size, slant and direction, combine to provide flexibility and application throughout the world.

Automatic selection of any four colored pens, through program command or front panel control, permits multi-color plotting which proves extremely useful in applications where traces are hard to distinguish or interpret.

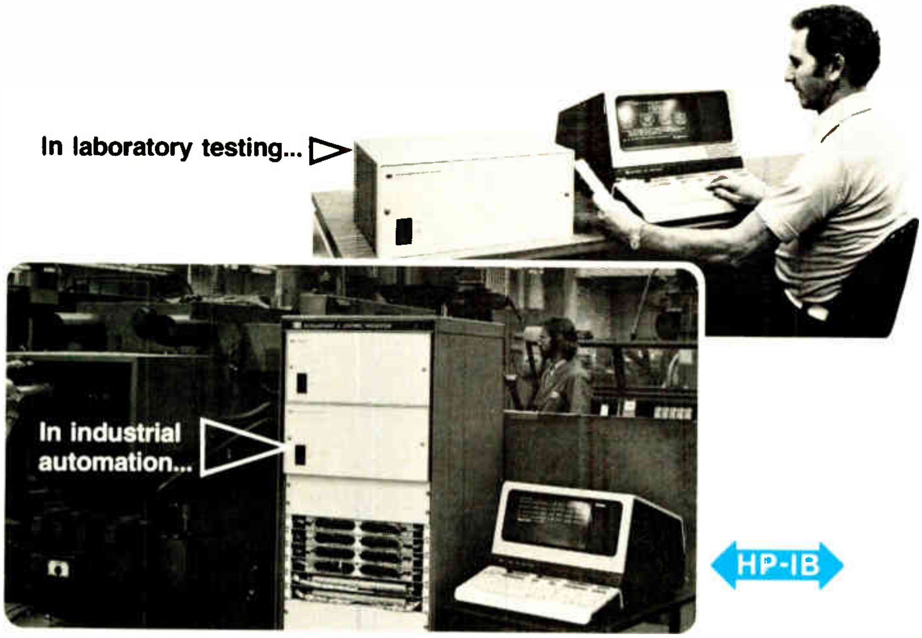
Over forty different instructions, including automatic pen selectability, are built in to simplify programming and increase communications efficiency. Point digitizing, labeling, character sizing, programmable graph limits, rotation, and single command arc and circle plotting are some of the standard instructions.

PLOT/21 user level software support is available for a number of systems and timeshare services. Interface is RS-232C/CCITT V.24 asynchronous serial ASCII, with eight switch selectable baud rates from 75 to 2400 baud.

Excellent line quality and repeatability is retained at all 36 pen speeds, from 1 to 36 cm/s. This results in precise, easy-to-read graphic plots suitable for reports and presentations as well as your more mundane data and graphic needs.

*To see more examples of four-color plots, check M on the HP Reply Card.*

# "Smart" instrument/computer interface uses HP's new SOS microprocessor




New intelligent analog/digital subsystem simplifies product test, monitoring, and control.

Incorporating HP's new silicon-on-sapphire LSI technology, this microprocessor-based analog/digital subsystem is designed to simplify product testing and real-time monitoring and control. Powerful commands are sent to the HP 2240A with simple FORTRAN, BASIC, or HPL programming statements. It performs measurement and control tasks that your computer previously had to handle, freeing it for other uses and reducing program timing constraints.

The HP 2240A in conjunction with the HP Interface Bus (HP-IB) simplifies task communications and programming. It decouples automation tasks from the computer through its microprocessor intelligence: timing, scanning, event synchronizing, formatting, and interrupt tasks can now be delegated to the HP 2240. And an advanced level of self testing allows you to speed your installation and lower your service costs.

The 16-bit silicon-on-sapphire (SOS) microprocessor, tailored for controller applications, operates at the high speed required for real-time applications, and consumes just half the power of comparable systems. This built-in intelligence, and an industry-standard interface (HP-IB), let you implement measurement and control solutions in three easy steps:

- **Connect to the computer of your choice.** The HP 2240 operates with any HP-IB compatible computer. With the HP 2240, the HP 1000 and 21MX series computers and HP 9800 series desk-top computers become powerful tools for the acquisition of data and the control of physical and electrical processes.
- **Connect to your measurement and control application.** The HP 2240 accepts both analog/digital inputs and outputs, and several interrupt-driven inputs. Simplify interfacing with industrial sensors common in real-time processes.
- **Give simplified instructions to the HP 2240.** The powerful command set of the HP 2240 is easy to use. When you delegate real-time tasks from the computer, the HP 2240 holds the task instructions in memory and executes them in sequence without further computer interaction—freeing the computer for other operations.

*For more information on building your own laboratory data acquisition system, check F on the HP Reply Card.*

## New complete DC power supply catalog from HP

Choosing the right power supply for your application is easy with HP's new *DC Power Supply Catalog*. This 128-page catalog contains product descriptions, photographs, outline drawings, specification, and prices for HP's complete line of power supplies covering the range from 10 watts to 11 kW. Products include:

- General-purpose lab and system power supplies
- Precision voltage and current sources
- Digitally programmable power sources

Included is a section detailing several methods to control DC power supplies using the HP Interface Bus. In addition, another section covers power supply ac and load connections.

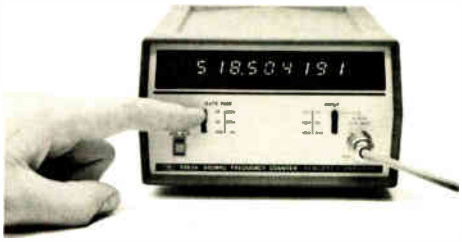
*For your free copy, check Q on the HP Reply Card.*

## HP reduces prices on 2 popular counters

HP's highly popular lower priced counters are now more affordable than ever before with a recent 20% price reduction. The counters are the 8-digit 225 MHz Model 5382A and the 9-digit 520 MHz Model 5383A. Their benefits include:

- Direct counting and direct readout to 1 Hz in 1 sec makes it easy to monitor or adjust frequencies to a precise value much faster than by analog techniques or with a low frequency counter and prescaler.
- High sensitivity (25 to 50 mV)
- Stable time base (aging rate <0.3 ppm/mo.) TCXO optional.
- Three position input attenuator
- Rugged metal case, with rack mounting hardware optional
- In the 5383A, input is fused and switchable (50Ω/1 MΩ).

*For more details, check K on the HP Reply Card.*



## New 70 dB step attenuators for equipment designs to 26.5 GHz

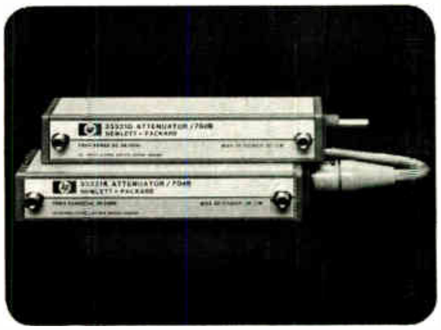
Two new coaxial step attenuators are available for designers of equipment and systems requiring 26.5 GHz operation.

Both models offer 70 dB range in 10 dB steps. Model 33321D is manual and model 33321K is electrically-actuated. The attenuators use the new APC-3.5 connector to achieve operation dc-26.5 GHz, mode-free, and with high repeatability. (Typically 0.05 dB after 1 million steps.) Typical accuracy is 4% of dB reading at 26.5 GHz where SWR is <2.2.

For equipment designs, the small size will be appreciated. Both models fit a 168 x 52 x 43 mm envelope (6.6 x 2.1 x 1.7 inches). For the programmable version, the 24V, 3 watt solenoids are automatically disconnected after a 20 ms switching time. The manual version uses a cam-actuated design that exhibits a low torque action with a particularly smooth "feel", ideal for front panel use on quality instrumentation.

*For additional information, check H on the HP Reply Card.*

HP 33321D/K attenuators provide 0—70 dB in 10 dB steps to 26.5 GHz.



## New systems ROM gives communication capability to 9825A desktop computer

HP-IB

The new System Programming ROM for the HP 9825A desktop computer enhances its capabilities. Among the capabilities provided by the 98224A ROM are the following:

- Read from a busy input buffer.
- Operate the 9825A via a remote keyboard.
- Simplified access to the R4 registers on the 98036A Interface.
- Dynamically store and modify program lines while a program is running.
- Use the 9825A keyboard as an external peripheral using interrupt.

The 98224A ROM will be useful in the following applications:

*Terminal Emulation*—allows the 9825A to go on-line to a large computer which supports asynchronous data communication.

*High Speed Data Logging*—in conjunction with the 9885M Flexible Disk Drive, it is possible to log continuous, periodic data at rates in excess of 1K bytes/sec.

*Redefinition of 9825A Keyboard*—using the keyboard interrupt routines, the keyboard can be treated as an external device with each key being redefined.

*Operation of the 9825A in a Remote Environment*—control the 9825A from a remote keyboard, useful if the 9825A is located in a hostile environment.

The 98224A and the Asynchronous Terminal Emulator software package (09825-10040) allows the 9825A to act as terminal to the HP 3000 or other computers that support timesharing via an asynchronous, full duplex line.

*For more information, check P on the HP Reply Card.*

## HP quartz oscillators are available for "do-it-yourself" needs

This family of three, high performance quartz oscillators helps you optimally meet your needs for precise frequency in instrumentation, communication and navigation systems...electrically and physically. The 10544 A/B/C family offers:

AGING RATE is a low $5 \times 10^{-10}$/day in all models. These are aged under computer surveillance and are never shipped until that rate is met. So you don't need to age them for months and recalibrate frequently.

SPECTRAL PURITY is excellent, so you can multiply the frequency into the microwave region. Signal to phase noise ratio exceeds 150 dB (for 1 kHz offset) and short term stability is $1 \times 10^{-10}$ (1 sec. avg. time).

RUGGEDNESS All models are built to withstand field use, and environmental performance is fully specified. One model has shock mount provisions, too.

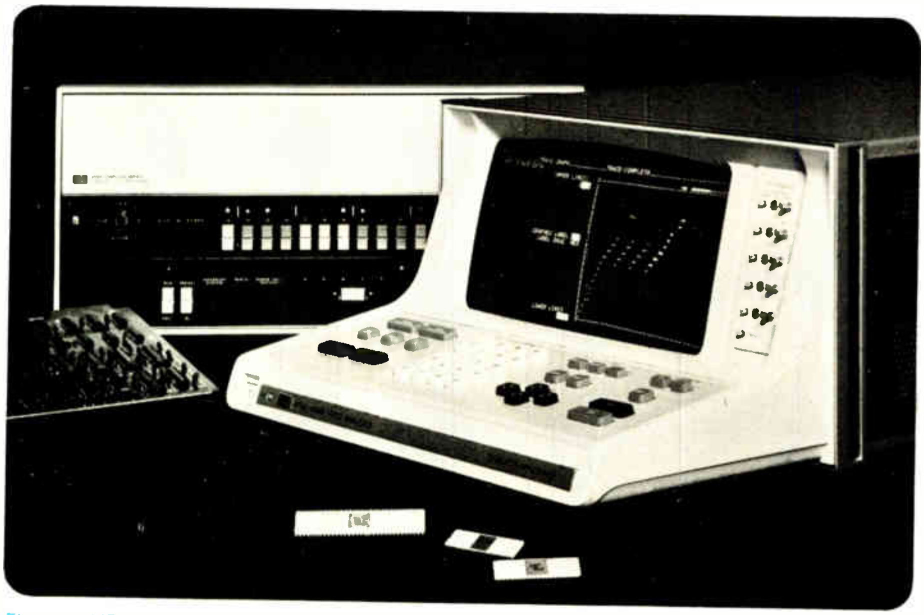
CONNECTORS Models are available with pc board or feed through connectors.

RELIABILITY We produce these oscillators in large quantity both for systems users and for HP's most accurate electronic counters and frequency synthesizers so we have the large data base necessary for accurate reliability figures. And, they're built to HP's high quality standards, of course.

*For more details, check C on the HP Reply Card.*

Compactness (72 × 52 × 62 mm), ruggedness, and high performance are key features in this quartz oscillator family.

# New logic analyzer traces nested loops to 7 levels with state sequences and 'menu' control



The new HP 1610A logic state analyzer is designed to efficiently test digital systems ranging from the simplest logic circuits to microprocessors and computers. Keystroke retrievable testing and display programs offer such test formats as numerical trace listing, data magnitude versus time graphs, and a comparison between current and stored measurements.

The new HP 1610A logic analyzer offers the most extensive triggering available in a logic state analyzer. New measurement capabilities include a greatly expanded trace specification with up to seven levels of sequential state conditions (state values with multiple occurrences); seven choices of trace qualification; and a state count or time interval which can be acquired and displayed in either absolute or relative modes.

With the easy-to-operate 1610A keyboard, the user can trace events in as many as 32 channels at rates up to 10 MHz, selecting only the particular occurrences, coincidences, or logical sequences that are of interest, with results displayed in a well organized format on the CRT screen. A memory 32 bits wide and 64 bits deep can be commanded to capture everything that went on for 63 clock-periods after the trace point of interest, or for 63 periods before; or the trace point may be selected to be in the center of a trace.

A new "menu" concept allows you to select measurement parameters as they are displayed on the screen. Press a key, and the screen presents one of two specification menus: a **format specification**, which defines the relationship between the input channels and the display, or a **trace specification** which defines the conditions under which the test data will be captured.

With state sequences, you can directly locate branched, looped or nested forms (or sections) of state flow. Since you can specify each state condition to "occur" up to 65,536 times, you can locate the nth pass of a loop, beginning at a given state.

Not only can the instrument trace and display logic states, it can also measure absolute or relative time intervals between events, it can count events, it has a graph mode for an overview of all 64 words in memory and produces documentation.

For hard copy records, the 1610A is compatible with HP 9866 thermal printers.

*For additional information, check D on the HP Reply Card.*

# Signature analysis proves effective in HP service programs. Possibly yours too!

The HP 5004A Signature Analyzer detects and displays the unique digital "signatures" associated with data nodes in digital products. By comparing actual signatures to correct ones as shown in the appropriate product manual, a technician can backtrace to a faulty node in a malfunctioning product.

By designing Signature Analysis into appropriate new Hewlett-Packard products, we can provide troubleshooting procedures for component-level repair, without dependence on expensive board exchange programs. The results:

- Decreased costs of ownership for end-users.
- Reduced warranty and service support costs.
- Increased confidence in field repair results.

Can Signature Analysis yield these benefits in *your* service operation? HP and over 50 other companies are finding that the answer is "Yes". Some of the digital products currently benefiting from the technique are:

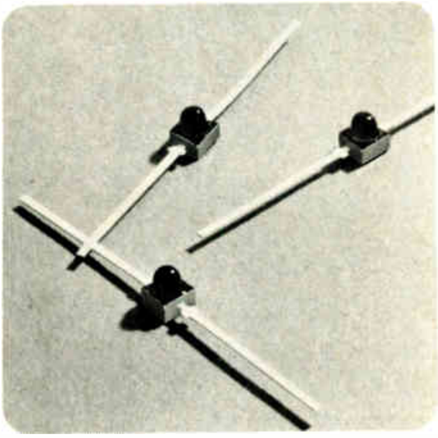
- Computers and peripherals
- Instrumentation
- Communication/navigation equipment
- Industrial and process controls

To learn how signature analysis can make your service operation more efficient, send for the 5004A literature package which includes Application Note 222, *A Designer's Guide to Signature Analysis. Check J on the HP Reply Card.*

Many of HP's new $\mu$P-based instruments and data products utilize the Signature Analysis technique for economical component-level troubleshooting in production and service.

# HEWLETT-PACKARD COMPONENT NEWS

## First subminiature LED lamps with built-in resistors



Because of low current requirements and low size, these lamps will be widely used as gate status indicators with DTL, TTL and low power Schottky TTL gates. Manufacturers will also find them an excellent choice as indicator lamps in cameras and portable electronic equipment.

HP offers the first subminiature light-emitting diode lamps with built-in current limiting resistors.

The red 5-volt HLMP-6600/6620 lamps have a current limiting resistor chip built-in with the LED chip, eliminating the need for an external resistor and giving the digital designer a compact package with which to work.

In addition, the lamps contain a reverse protection diode which allows the user to operate the lamp from a 5-volt source without additional biasing components. The diode offers advantages to designers whose circuits may encounter reverse transients and to customers who drive lamps in the pull-up mode.

The lamps may be mounted on .100 inch centers. The nominal forward current for the HLMP-6600 is 10 milliamperes at 5 volts and provides typically 2.4 millicandelas of axial luminous intensity.

## Broadband mixer features low loss, high isolation

The new HMXR-5001 is designed for low conversion loss and high isolation across the full 2 to 12.4 GHz RF/LO band, while retaining a wideband IF of 0.01 to 1.0 GHz. Conversion loss is typically 7.5 dB from 1-8 GHz and 8.5 dB from 8-12.4 GHz. LO to RF isolation is typically 30 dB. With only a slight sacrifice in performance the HMXR-5001 can be used up to 18 GHz.

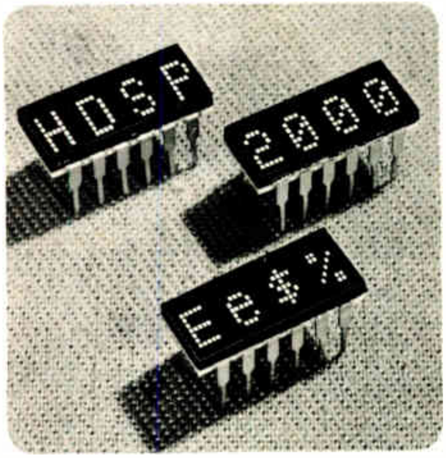
The HMXR-5001 contains hermetically packaged Schottky beam lead quads instead of the chip diodes used in most microwave mixers. For applications where high reliability testing is required, the user can order mixers with screened Schottky diodes. The mixer also uses small semi-rigid cables for transmission lines instead of the stripline configurations found in other mixers.

The combination of sealed diode packages and semi-rigid transmission lines confines the high frequency signal within these components for improved isolation. In addition, this combination allows the use of an epoxy foam to fill the mixer package void and greatly increase mechanical ruggedness.

*For more details, check I on the HP Reply Card.*


New double balanced mixer is intended for frequency conversion use in electronic surveillance systems, instrumentation and test bench set-ups.

## HP lowers price on alphanumeric displays




Display the full ASCII character set, upper and lower-case letters, punctuation, mathematical symbols, and numerals with displays now available at reduced prices.

HDSP-2000 alphanumeric, solid-state displays have been decreased in price up to 30%.

The HDSP-2000 is a compact, 5×7 dot matrix display with on-board electronics. By including shift registers and constant-current drivers within the display package, the user can reduce external parts count for a typical 32-character system by a factor of 36 to 1. These low-voltage displays are TTL or CMOS compatible and are readily microprocessor controlled.

Because of their small package size (3.8 mm) and on-board circuitry, HDSP displays are used in applications including interactive point-of-sale devices, hand-held devices, compact mobile communication sets, 'smart' microprocessor-based systems, medical instruments, and portable terminals.

These displays are available immediately through HP's franchised distributors.

*For more technical information, check E on the HP Reply Card.*

# Two new scientific programmables that won't forget. One prints; one doesn't

Both the new HP-19C and HP-29C handheld calculators have Continuous Memory capability so the programs you store are saved, ready for use, until you clear or overwrite them.

As a result, you can program frequently-needed calculations once, and then perform them as often as necessary—hour after hour, day after day—without the bother or lost time caused by reentering your program.

The Continuous Memory not only retains programs, it also retains the data stored in 16 of the 30 addressable registers plus the display register.

You can merge up to four keystrokes in each of the 98 program steps. Thus you can typically store programs of 175 keystrokes or more for those complex calculation problems you face daily.

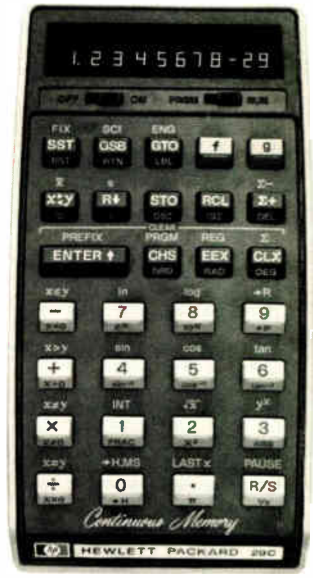
The high-powered HP-19C and HP-29C easily handle today's sophisticated calculations with advanced programming features including:

- Branching
- Three levels of subroutines
- 8 Conditional tests
- Indirect addressing
- Relative addressing
- Indirect control of data register operations
- Decrement or increment for looping
- Pause function
- Ten labels for programs and subroutines

And, editing is fast and easy. You can step through your program a step at a time verifying the listing. Operations can be inserted or deleted and all subsequent steps are automatically "bumped" down or moved upward.

With the HP-19C you have the additional advantage of a quiet thermal printer to help you with your editing. You can list your programs or trace executing programs and easily check them for mistakes.

*For more information, check A on the HP Reply Card.*


On or off, your programs and data are always ready for instant reuse in two new advanced programmable calculators.

---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**South**-P.O. Box 10505, Atlanta, GA 30348, Ph. (404) 434-4000.

**Midwest**-5201 Tollview Dr., Rolling Meadows, IL 60008, Ph. (312) 255-9800.

**West**-3939 Lankershim Blvd., North Hollywood, CA 91604, Ph. (213) 877-1282.

**Europe**-Central Mailing Depot., P.O. Box 529, Amstelveen-1134, Netherlands, Ph. (020) 47 20 21

**Japan**-Yokogawa-Hewlett-Packard Ltd., Ohashi Bldg., 1-59-1 Yoyogi, Shibuya-ku, Tokyo 151, Ph. 03-370-2281/92.


HEWLETT PACKARD


MEASUREMENT COMPUTATION news

product advances from Hewlett-Packard

September/October 1977

New product information from

HEWLETT-PACKARD

**Editor: Iona M. Smith**

**Editorial Offices:**
1507 Page Mill Road
Palo Alto, California, 94304 U.S.A.


00785

## MIL-SSR UPDATE

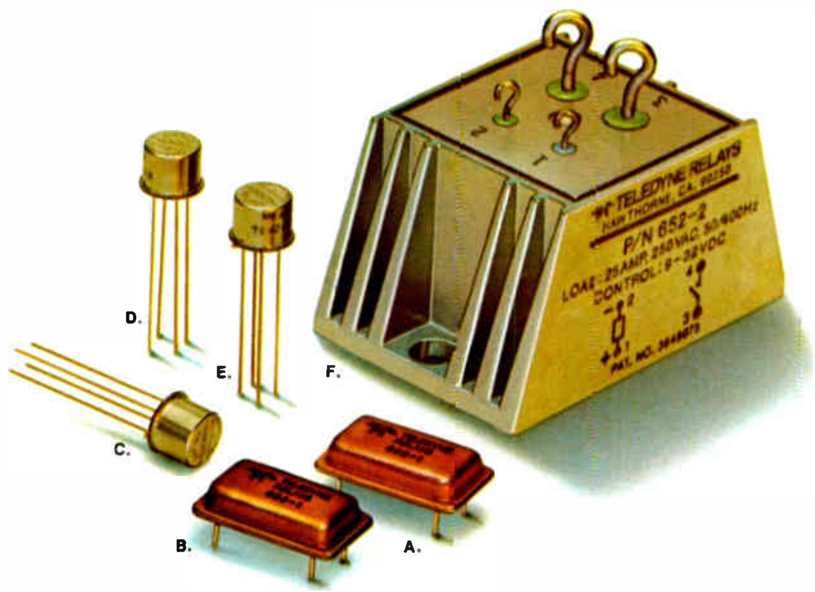
# Another SSR first from Teledyne!


Experience, design know-how, and advanced solid state relay technology bring you another industry milestone with Teledyne's M640 Series — **the first solid state relays to receive QPL approval to MIL-R-28750:**

M28750/5 (Teledyne P/N M640-1W)
M28750/6 (Teledyne P/N M643-1W)
M28750/7 (Teledyne P/N M643-2W)

These SSRs have already established a high reliability record that spans a broad spectrum of switching applications for both airborne and ground support equipment. Our M640 Series features all-solid-state circuitry utilizing hybrid microcircuit techniques in a hermetically sealed TO-5 package. And they're available with bipolar output for AC or DC loads up to 60mA/40V and DC outputs for loads up to 300mA/40VDC or 100mA/250VDC.

For complete specification data, contact your nearest Teledyne Relays sales office listed in EEM, Gold Book or Electronics Buyers' Guide. You'll find we have the experience, products, and technical support to meet all your SSR needs — including a quick reaction capability to design SSRs specifically for your application.




**TELEDYNE'S MILITARY SSRs**

A. **P/N 683-1 DC SSR**
DIP package, with output rated at 600mA/50VDC

B. **P/N 682-1 AC SSR**
DIP package, with output rated at 1A/250VAC

C. **P/N M640-1W Bi-polar SSR**
Mil P/N M28750/5. TO-5 package, with bi-polar (AC/DC) output rated at 60mA/40V

D. **P/N M643-1W DC SSR**
Mil P/N M28750/6. TO-5 package, with output rated at 300mA/40VDC

E. **P/N M643-2W DC SSR**
Mil P/N M28750/7, TO-5 package, with ouput rated at 100mA/250VDC

F. **652 Series AC Power SSR**
Output rated at 25A/250VRMS

## TELEDYNE RELAYS

3155 West El Segundo Boulevard, Hawthorne, California 90250
Telephone (213) 973-4545



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Now AMP's most versatile
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Top performance in a tiny space. AMPMODU posts, receptacles and headers make your packaging designs as tight as necessary.

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Pins are fully protected. Headers are polarized and have self-retention locking latches. Headers fit everywhere on a board, including board center.

Ten basic header styles offer several thousand possible variations. You can approach mass termination with AMPMODU headers. Up to 80 positions.

These headers now complement the AMPMODU interconnection system, which features dual cantilever spring beams in the receptacle, five basic contact types and board to board or board to wire versatility. The forgiving nature of the receptacle design also ensures a uniform, positive electrical contact with the mating posts, everytime.

At AMP our application, service and sales engineers are located throughout the world, and are ready to help you with prototyping as well as providing a complete after-sale service.

For more facts about AMPMODU headers, write or call Customer Service. (717) 564-0100. AMP Incorporated, Harrisburg, PA 17105.

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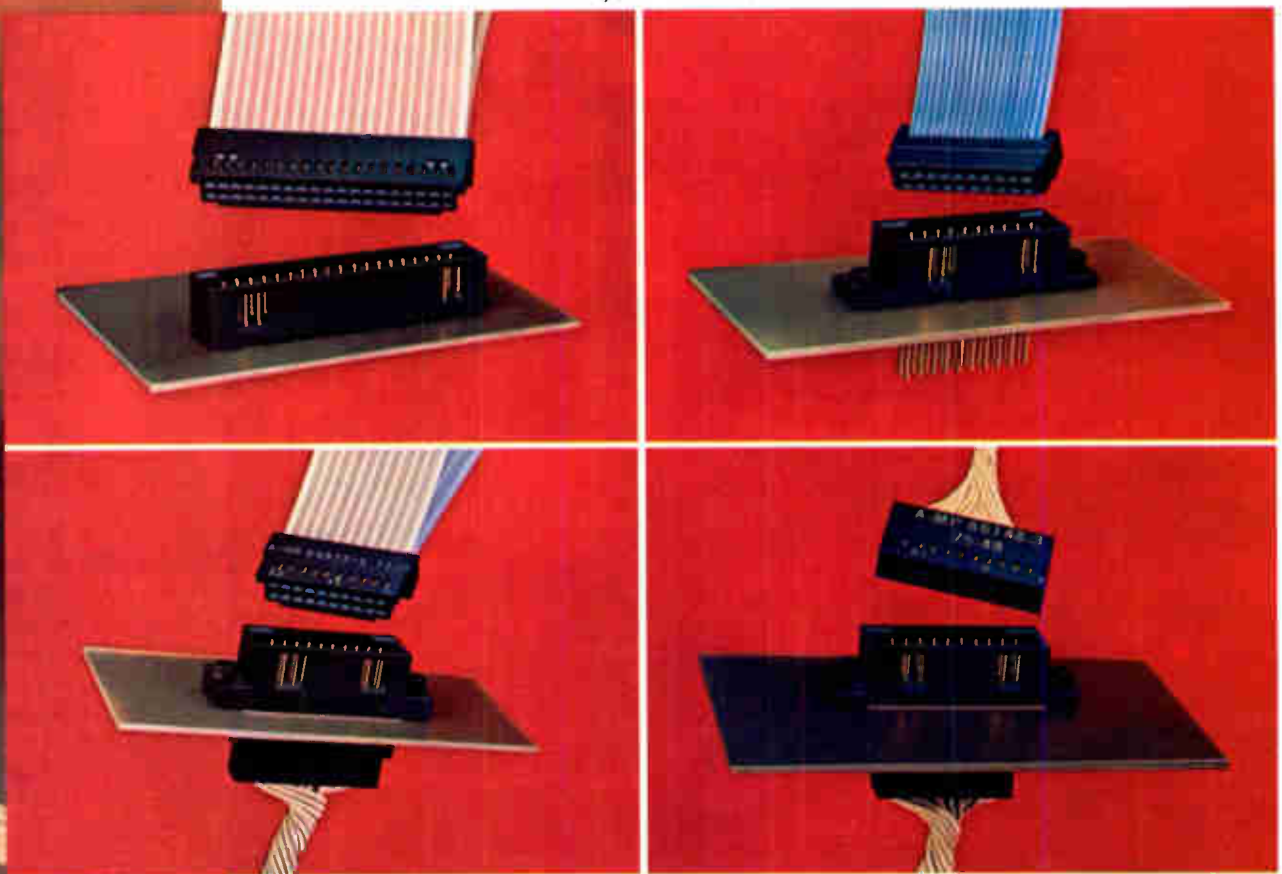

Circle 29 on reader service card

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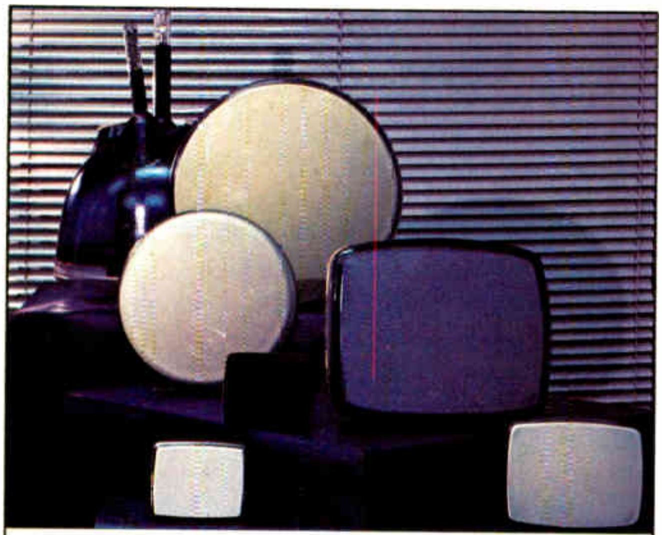




## Meetings

**Tenth Annual Connector Symposium,** Electronic Connector Study Group Inc. (Camden, N. J.), Hyatt House, Cherry Hill, N. J., Oct. 19–20.

**Third Workshop on Reliability Technology for Cardiac Pacemakers,** National Bureau of Standards, Gaithersburg, Md., Oct. 19–20.

**1977 Design Automation Workshop,** IEEE, Michigan State University, East Lansing, Mich., Oct. 19–21.

**Nuclear Science and Nuclear Power Systems Symposia,** IEEE, Sheraton Palace Hotel, San Francisco, Oct. 19–21.

**ISHM 77,** International Society for Hybrid Microelectronics (Montgomery, Ala.), Baltimore Hilton Hotel and Civic Center, Baltimore, Oct. 24–26.

**International Conference on Energy Use Management,** University of Arizona (Tucson), Marriott Hotel, Tucson, Ariz., Oct. 24–28.

**1977 Fall Symposium—PC Boards for the 80s,** California Circuits Association (Palo Alto, Calif.), Airporter Inn, Irvine, Calif., Oct. 25–26.

**Electro-Optics/Laser 77,** Industrial & Scientific Conference Management Inc. (Chicago), Anaheim Convention Center, Anaheim, Calif., Oct. 25–27.

**1977 Annual Semiconductor Test Symposium,** IEEE, Cherry Hill Hyatt House, Cherry Hill, N. J., Oct. 25–27.

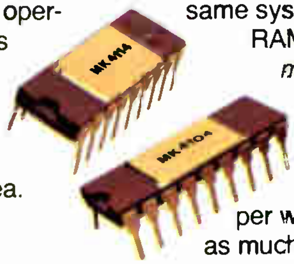
**Ultrasonics Symposium,** IEEE, Del Webb's Town House, Phoenix, Oct. 26–28.

**Midwest Personal Computing Show,** Personal Computing Magazine (Albuquerque, N. M.), O'Hare Holiday Inn, Chicago, Oct. 27–29.

**1977 SID One-Day Technical Conference,** Society for Information Display (Los Angeles), Sheraton Inn-Airport, San Diego, Calif., Oct. 28.


# Lower system power with Mostek's Edge-Activated™ static RAMs.

Higher density, lower power, and simplified system design are the important advantages of Mostek's new Edge-Activated™ series of static RAMs. Implemented with a new Edge-Activated™ circuit design concept, the +5V-only family operates at faster speeds than traditional static circuits, but with much lower power dissipation and smaller chip area.




**Lower Power Means Lower Costs.**

A 16K × 9-bit storage matrix designed with Edge-Activated™ 4104's (4K × 1) or 4114's (1K × 4) dissipates less than 1 watt in the memory array. The same system with static-interface RAMs would dissipate *more than 18 watts.* This means that power sub-system costs, which range from $1.00 to $1.50 per watt, can be reduced by as much as $24.00 in a single storage matrix.

A battery back-up mode, where data retention is maintained at less than 0.3 $\mu$W per bit (typ.), offers even greater reduction of standby power.

**Mostek High Performance RAMs**

MK 4104-3*/ MK 4114-3*

| | |
|---|---|
| Access Time | 200 ns (max) |
| Cycle Time | 310 ns (max) |
| Standby Power Dissipation | 28 MW |
| Active Power Dissipation | <120 MW |
| Power Supply | +5V (± 10% tolerance) |
| Pin Configuration | Industry Standard 18 Pin |

*Available in several speed/power ratings.

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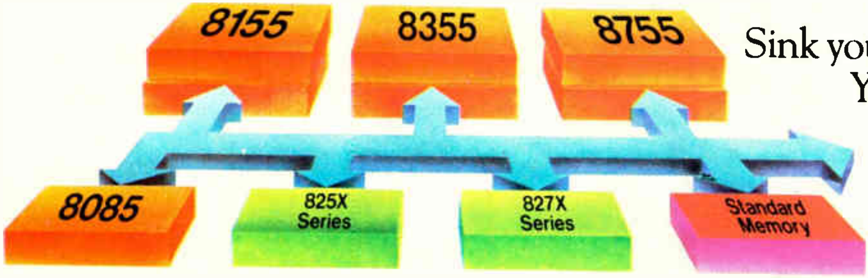
Circle 31 on reader service card

# Intel delivers the 8085, designers just

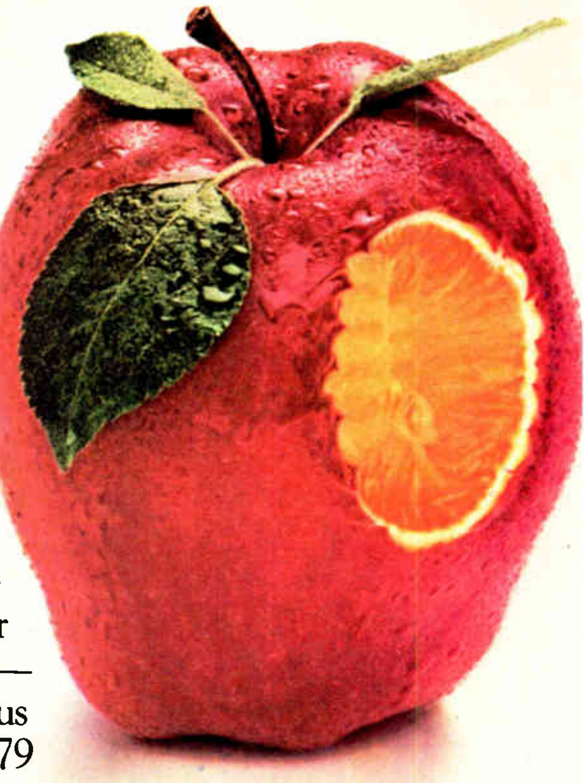



Sink your teeth into Intel's new 8085. You'll find it's the only microcomputer that combines the performance, economic advantages and total support it takes to be recognized as the new industry standard. So it's no surprise that there are already four announced sources for the 8085. In fact, the deeper you go, the better the 8085 gets.

The 8085, even more than the 8080 it succeeds, is a total design solution, not just a component. It delivers higher performance, for capabilities far beyond the 8080's. It has a higher level of integration, so you can design your products with fewer components, making them more competitive and more profitable. And to help you get those products to market quicker we've given the 8085 the industry's broadest base of system and development support.

Yet the 8085 is fully compatible with the 8080. So your investment in existing designs is protected, and implementing new designs is simplified by the wealth of 8080 software and peripherals at your disposal.

It all adds up to a design solution you won't be able to resist. That's true for a broad range of applications. The 8085 can be designed in as an economical stand-alone three-chip system using the 8085 CPU, the 8155 256-byte RAM with I/O and timer, and the 8755 2K-byte EPROM with I/O or its interchangeable 8355 ROM with I/O.



You can expand this basic system for larger applications using additional RAM, ROM, EPROM and Intel's complete family of first and second generation peripheral controllers, including our four new programmable peripheral controller chips—the 8271* Floppy Disc Controller, 8273* Synchronous Data Link Controller, 8275 CRT Controller and 8279 Keyboard/Display Interface. All these components including 8755 EPROM operate from a single +5V supply.

*Available 4th Quarter 1977

# the new microcomputer can't resist.

A multiplexed data/address bus permits integration of many auxiliary system functions—such as clock generation, system control and multiple interrupts—onto the 8085 chip while maintaining 8080 compatibility and the same 40-pin package. And forward-thinking engineers will realize that it is also a link to Intel's future generation microcomputer products.

No microcomputer can match the 8085 as a total design solution because no microcomputer can come close to the 8085's support base. Support for the 8085 includes the Intellec® microcomputer development system with resident PL/M, the high level programming language that can cut months off your software development time. Intellec is the only development system with ICE-85,™ providing in-*system* emulation for faster system development and debugging. Then there's application assistance, training classes and seminars worldwide. And a comprehensive development software library at your disposal.

The quickest way to get a taste of the 8085's power and versatility is with the SDK-85 System Design Kit. It's available now for only $250. You can order SDK-85 and all MCS-85™ components directly from your nearest Intel distributor: Almac/Stroum, Components Specialties, Cramer, Hamilton/Avnet, Harvey Electronics, Industrial Components, Pioneer, Sheridan, L.A. Varah, Wyle Liberty/Elmar or Zentronics.

Or, for more information on the 8085 and SDK-85, use the reader service card or write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051. Telephone: (408) 246-7501.

**MCS-85™ Microcomputer System Components Family**

**8085 CPU** with system bus control, system clock generator, serial I/O and 4-level interrupt control.

**8155/8156 RAM, I/O & Timer.** 256-byte static RAM, 22 I/O lines, 14-bit programmable interval timer/event counter.

**8355 ROM & I/O.** 2048-byte masked ROM, 16 I/O lines. Interchangeable with 8755.

**8755 Erasable PROM & I/O.** 2048-byte UV erasable and electrically reprogrammable EPROM. Interchangeable with 8355.

**Compatible MCS-80™/MCS-85™ Peripheral Components**

*General Purpose*

**8251 Programmable Communications Interface**
**8253 Programmable Interval Timer**
**8255 Programmable Peripheral Interface**
**8257 Programmable DMA Controller**
**8259 Programmable Interrupt Controller**
**8205 High Speed 1 out of 8 Binary Decoder**
**8212 8-bit Input/Output Port** (Latch/Buffer)
**8216/8226 4-bit Parallel Bidirectional Bus Driver**

*Dedicated Function*

**8271 Programmable Floppy Disk Controller**
**8273 SDLC Protocol Controller**
**8275 Programmable CRT Controller**
**8279 Programmable Keyboard/Display Interface**

**Performance Matched Standard Memory**

*Static RAM*

**2114** 1024x4-bit, 450 nsec, 18 pin
**2142** 1024x4-bit, 450 nsec, 20 pin
**8101A-4** 256x4-bit, 450 nsec, separate I/O
**8102A-4** 1024x1-bit, 450 nsec, separate I/O
**8111A-4** 256x4-bit, 450 nsec, common I/O

*ROM/EPROM*

**2716** 2048x8-bit Erasable PROM, 450 nsec
**2708** 1024x8-bit Erasable PROM, 450 nsec
**2316E** 2048x8-bit Masked ROM, 450 nsec
**8308** 1024x8-bit Masked ROM, 450 nsec

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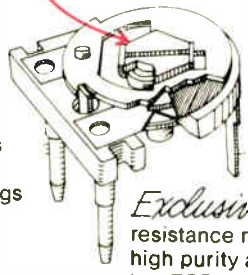
Accept nothing less than Allen-Bradley quality in trimmers, especially when it doesn't cost you any more. The real decision is whether to use our Type 90 or Type D. Both are cermet, single-turn with a choice of top, side or through-the-board adjustment. We have what you need; our distributors have it when your need is now. Ask for Publication 5242 (Type 90) and 5240 (Type D).

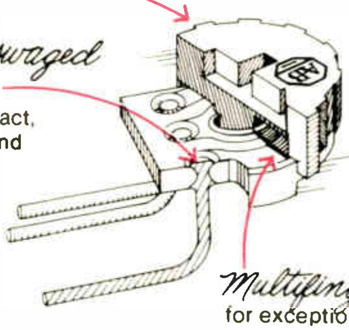
*Front or Rear Adjust* with rugged dust cover (Type D), metal actuator (Type 90).

*Type 90*
7/16" dia.
$.55 ea/1000
2 terminal options
0.5 Watts at 70°C
100 ohms to 2 megs



*Specially swaged leads* offer redundant contact, high strength and excellent solderability.

*Exclusive* resistance material on high purity alumina for low TCR and CRV. Typical TCR for Type D is less than ±35 PPM/°C.



*Type D*
3/8" dia.
$.37 ea/1000
8 terminal options
0.5 Watts at 70°C
10 ohms to 2.5 megs

*Multifinger* contacts for exceptionally low CRV.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# Electronics newsletter

**SOS is used in HP's first medium-speed printer**

Hewlett-Packard Co. is using its silicon-on-sapphire technology—17 chips in all—to break into the market for medium-speed printers. **Its 2631A, a serial dot-matrix type, has among its SOS chips a microprocessor, random-access and read-only memories, and buffers.** The 2631A, from HP's Boise, Idaho, division, will sell for $3,150 and prints 180 characters a second, but is efficient because its processor controls high-speed slewing and bidirectional printing. It also offers three modes—normal, compressed, and expanded font—in its 128-character ASCII set.

**Static RAM cells help overcome faults in ROM**

By adding static random-access-memory cells to its electrically-alterable read-only memory, General Instrument Corp. has overcome some of the memory's shortcomings, including the limit on the number of erase/write cycles and of read accesses between write cycles. **The new device will be sampled in a 1,024-bit configuration by year-end.** It is similar to the TMM142C developed by Japan's Toshiba. The electrically alterable ROM cell takes over only when the system is powered down or turned off. Working with NCR Corp., the Hicksville, N. Y., Microelectronics division of GI puts a two-transistor electrically alterable ROM cell, along with two control transistors, into the load circuit is a standard six-transistor static RAM cell. The p-channel device has a cycle time is about 1 microsecond, a dramatic improvement on the electrically alterable ROM's several-millisecond read-erase-write cycle.

**Sample-and-hold amp chip designed for 12-bit jobs**

Look for Precision Monolithics Inc. to announce soon a monolithic sample-and-hold amplifier with performance that is good enough to meet the accuracy demands of 12-bit applications. **The SMP-81 takes only 3.5 microseconds to acquire a signal and has a droop rate of only 500 microvolts per millisecond,** yet it will be price-competitive with existing monolithic units, selling for about $3.50. To get the performance, PMI is ion-implanting super-beta transistors at the front end and employing a transconductance amplifier as a supercharger to speed up the charging time of the external hold capacitor.

**Cobra Judy radar ready for contract definition**

In November, the Air Force will probably select one or more companies for the contract definition phase of its Cobra Judy program. The aim of the program is a shipboard system somewhat similar to the Cobra Dane radar in the Aleutian Islands [*Electronics*, Aug. 7, 1975, p. 44], which monitors the flights of Soviet ballistic missiles. **There could be as many as three contract-definition phase awards,** with Hughes Aircraft Co., General Electric Co.'s Communications division, RCA Corp., and Raytheon Co. rumored as contenders to build the $50 million radar.

**Detector combines GaAs FET, waveguide on one substrate**

By combining on a single substrate a microwave gallium-arsenide field-effect transistor and an optical waveguide, researchers at Cornell University's Electrical Engineering department have developed a novel monolithic optical detector. The waveguide consists of a gallium-aluminum-arsenide core sandwiched between two layers of cladding materials that have lower indices of refraction: **One layer is the GaAs material that is part of the FET's gate structure.** Where no gate exists on the substrate, air acts as the cladding material. The FET acts as a light detector, and the light absorbed under its gate structure, which creates additional charge, modulates the gate potential and gives extra gain.

**Deposition system provides hermetic seal for wafers**

LFE Corp. has begun to deliver its System 8000, a low-temperature silicon-nitride deposition system for semiconductor wafers that hermetically seals the chips [*Electronics*, March 4, 1976, p. 40]. The system was publicly shown for the first time at the Semicon East show in Boston, close to the Waltham, Mass., headquarters of LFE. Company officials say the automated, microprocessor-controlled passivation system **permits the protected chip to be packaged in plastic.** The System 8000 will sell for about $75,000, and delivery is 20 weeks.

**Zenith may sell off entire research groups**

Electronics companies may benefit from layoffs at Zenith Radio Corp.'s now-disbanded research department as the company tries to place intact research groups with other firms, with hopes of retaining first-right-of-refusal for any development that may turn up from the activities it is abandoning. While some teams are being folded into other Zenith departments, insiders report—but Zenith will not confirm—that the cuts may total several hundred engineers, and include flat-panel display and light-emitting-diode efforts. **The firm is resorting to the research cuts to pare costs in the face of declining earnings;** it has also shaved television prices 3% to 5% in an attempt to maintain its market share.

Zenith has developed 2½-inch-thick gas-discharge displays in 35- to 50-in.-diagonal screen sizes. Three-color resolution is reportedly comparable to that of a standard 25-in. TV receiver, and has as many as 100 elements/in. for one-color displays. The firm's LED group is working with zinc-sulfur-selenide systems for greater display efficiency and a broader spectrum of colors.

**$100 body heat detector uses IR to douse lights**

Adcom Systems Corp. of New York has developed a passive infrared body-heat detector to turn lights on or off when people enter or leave a room. **The IR optics package, which will sell for under $100 per detector, fits into a 4-inch octagonal box that looks much like a wall outlet.** The sensor has a field area or pick-up angle of 90°, which Adcom hopes to improve to 130° by the time the detectors become available in November, and a user-programmable adjustable time delay from 30 seconds to 30 minutes to prevent unwanted cyclings.

**HP microwave counter uses microprocesor**

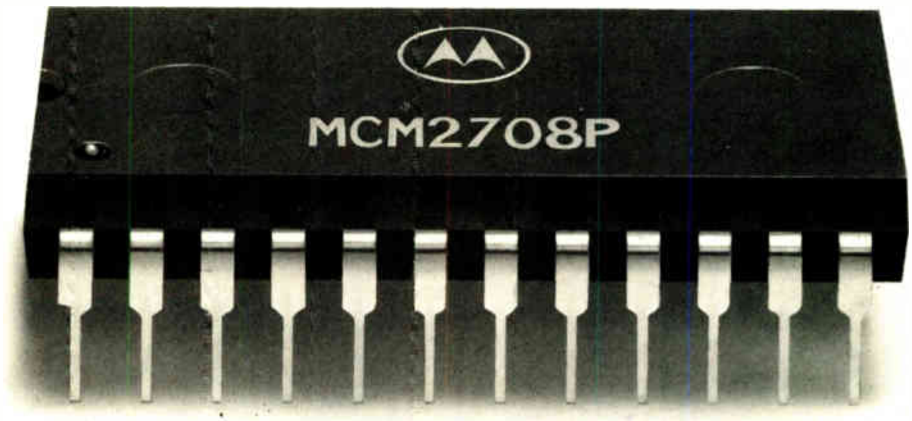
Hewlett-Packard Co.'s Santa Clara, Calif., division has initiated pilot production on a microwave counter to be priced considerably less than comparable units—among them HP's own $6,200 model 5340. The basic model 5342A covers the frequencies up to 18 gigahertz, expandable to 23 GHz. The new counters' base price will be about $4,500. **Unlike the 5340, the 5342A uses one—rather than two—samples to provide its frequency coverage.** To be available late this year or early 1978, the 5342A will use an HP-developed microprocessor for self-test and calibration functions.

# You like our EPROM.

# You'll love this new PROM.

It's our new MCM2708P, the first inexpensive 2708-type PROM. It's inexpensive because it's the first ever in a plastic package.

Use the one-time programmable MCM2708P. It's exactly plug-in compatible with 2708 EPROMs. Program it just as you would program the EPROM, and save dollars by the handsful.




## You'll love our new EPROM/PROM prices, too.

Get your MCM2708P data sheet from Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036, or circle the reader service number.

| Device Number | Function | 100-999 Price |
|---|---|---|
| MCM2708P | 8K PROM | $14.20* |
| MCM2708L | 8K EPROM | $21.00 |

*Under $10.00 in higher quantity

Contact your authorized Motorola distributor or any Motorola sales office for the MCM2708L and the new MCM2708P.

**MOTOROLA Semiconductors**

*The mind to imagine... the skill to do.*



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# A little knowledge about computers can be expensive. A lot can be free.

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Reader Service #202

3. The secret of having computer power where your business needs it. Our book on CS/40 SMALL BUSINESS SYSTEMS tells.
Reader Service #203

4. Describes seven important SUPPORT SERVICES that get systems up and running, then keep them there.
Reader Service #204


5. Find out how our Real-Time Disc Operating System SOFTWARE can get you on-line fast, and keep you there.
Reader Service #205


6. IT'S SMART BUSINESS to know how our way of doing business benefits our customers.
Reader Service #206


7. How OEM's solve the dilemma of keeping their system costs down with our NOVA 3 COMPUTER FAMILY.
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12. NOVA 3 systems, software and support let you customize a system to your application.

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13. A wealth of information about how our computers are being used in actual APPLICATIONS.

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14. Wonder what sets the benchmark for big performance computer systems? Wonder no more, it's ECLIPSE S/230.

Reader Service #214

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16. What's the most you can expect to get from a mid-range mini today? What you get with an ECLIPSE S/130 — the standard setter.

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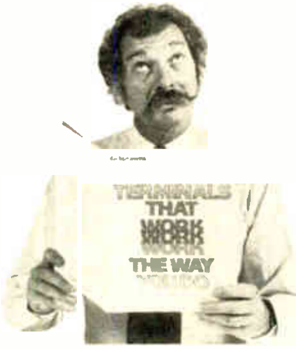


17. You want terminals that work the same way you do? You want the facts on our DASHER TERMINALS.

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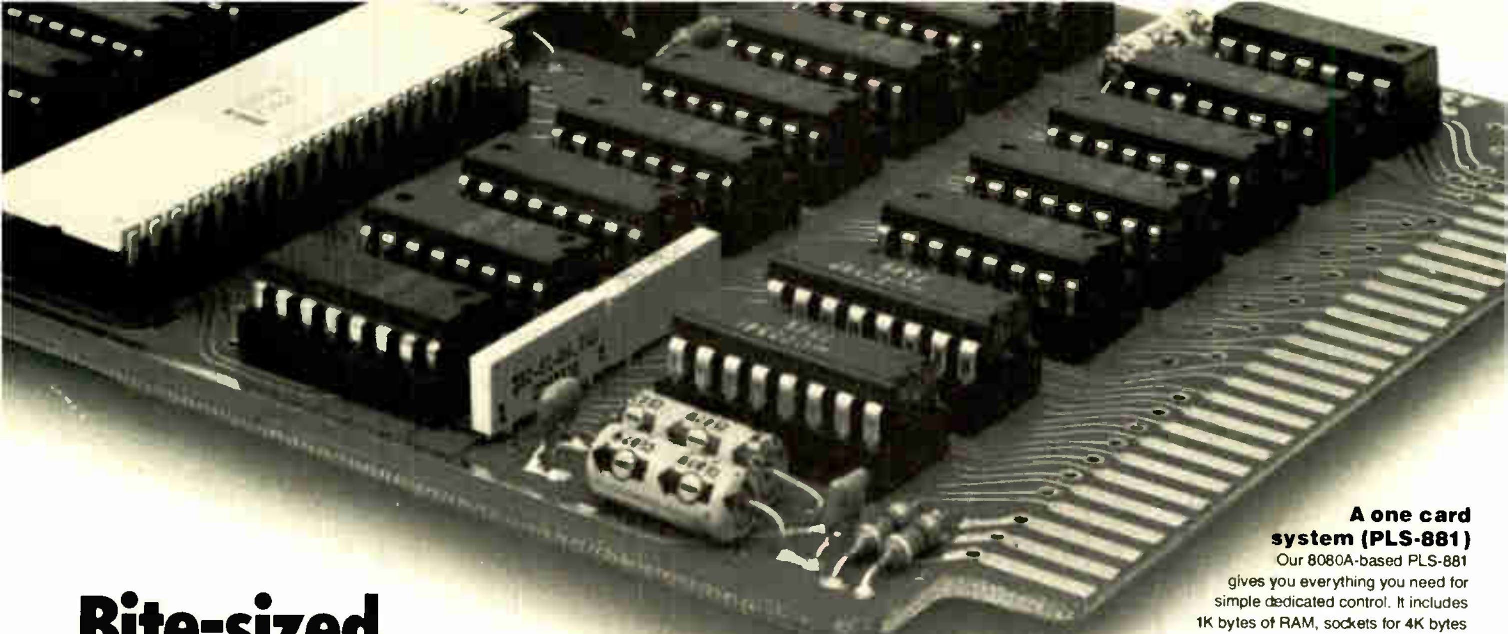

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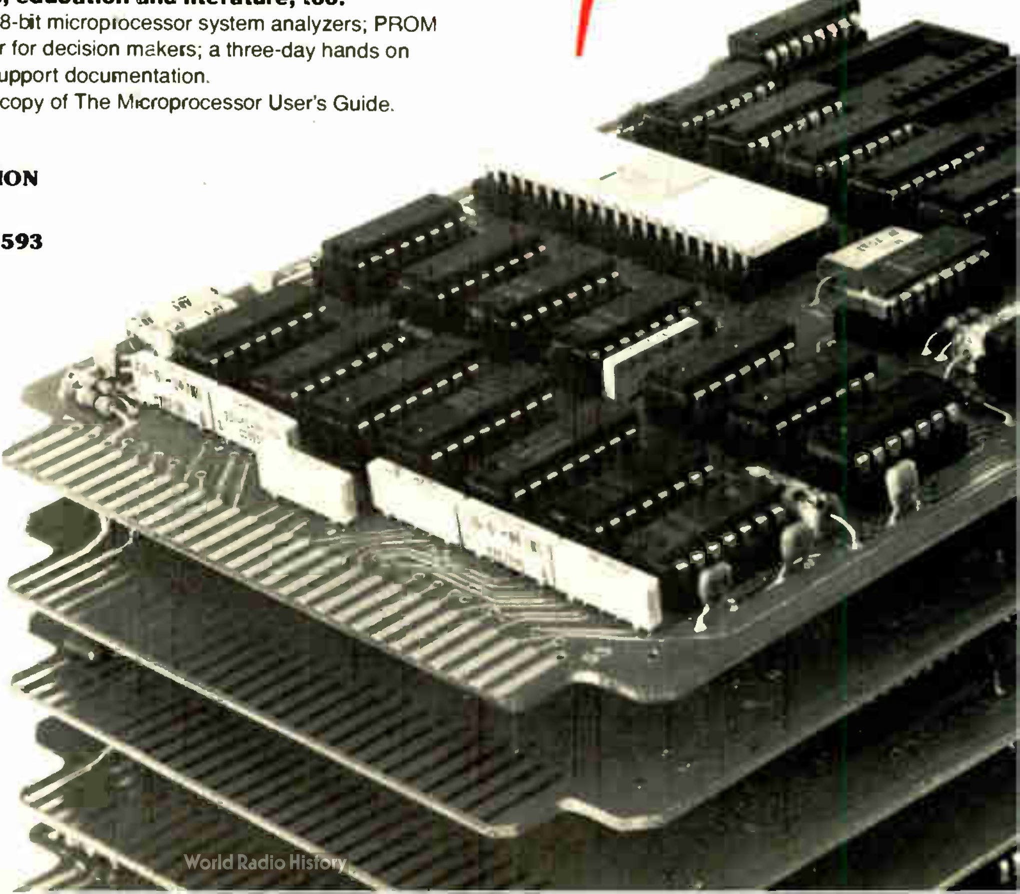

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# Hologram, LCD are the keys to head-up display

U.S. Air Force OKs development of system using holographic lens plus liquid-crystal chips

**The U. S. Air** Force has decided that it looks feasible to design a head-up display—which allows a pilot to see critical cockpit instruments while looking straight ahead through the windscreen—with liquid crystals on silicon chips and a holographic lens, components untried for this purpose in an aircraft. Accordingly, the Air Force Avionics Laboratory has given Hughes Aircraft Co. the green light to develop a flyable brassboard by next August. Eventually, the unit might fit into the service's new fighters, such as the F-16, and attack aircraft.

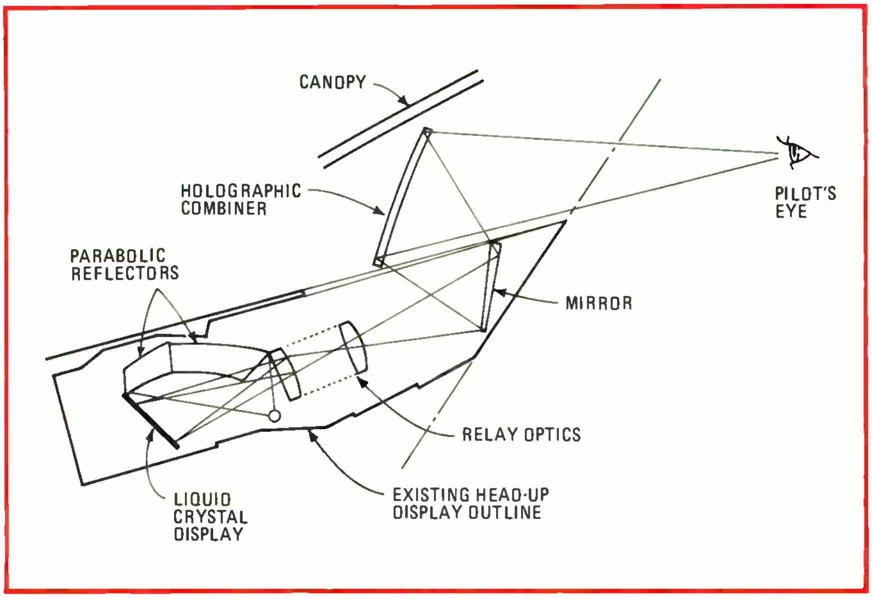
"Though both technologies are state-of-the-art, we have confidence they'll do what we expect of them," says John Coonrod, the project manager at the laboratory at Wright-Patterson Air Force Base, Dayton, Ohio. His confidence comes after seeing mock-ups of the system together with thermal, mechanical, and electrical designs, as well as a display made up of four 1-inch-square liquid-crystal chips, each on its own silicon substrate and butted into an array [*Electronics*, Feb. 19, 1976, p. 29], as well as larger display chips 1.75 in. square. The silicon contains the metal-oxide semiconductor excitation circuitry for the liquid-crystal material and also acts as the display's light reflector.

Hughes' new system will have a larger display than the one reported earlier—using four of the bigger LCD chips plus a 5-in.-diameter holographic lens. Coonrod points out that the capability of the lens was recently demonstrated on head-up displays configured by Hughes for the Swedish air force's Viggen attack plane.

**Better images.** Compared with a cathode-ray tube, the new system should have a threefold improvement in symbol brightness and much better contrast—about a 60% improvement when viewed in bright sunlight, says Michael Ernstoff, a Hughes project engineer. In addition, the entire system will be smaller, weigh less, and fit more easily into an aircraft's cramped cockpit than the conventional displays that incorporate bulky optics to focus the CRT's image. Coonrod estimates, for example, that the new optics should weigh 8 pounds, compared with the 20 lb of optics contained in the F-16 fighter.

Moreover, he notes, "current head-up design stresses the CRT and its circuitry up to and beyond the limits of reliable design, imposing high support costs." To make the CRT image as bright as possible, 20,000-volt power supplies are used. "The development of these supplies to meet environmental specs is often difficult and expensive," Coonrod says. "They're a high-maintenance item." The LCDs should operate in the 10s-of-volts range.

Conventionally, the CRT symbols are reflected off a mirror and through a bulky collimating lens that projects the image onto a partially silvered combining glass. When the




**Smaller.** Hughes' head-up display, with its holographic lens and flat, liquid-crystal elements, takes up less space than usual CRT approach. Brassboard, to fit into F-16 with a wider field of view than present display, is to be ready by next August.

symbols reach the combining glass, directly in front of the windshield, they appear on the glass as virtual images and are melded with the actual scene before the pilot. The combiner then reflects the collimated image into the pilot's eyes. Thus the pilot can look out of the cockpit at targets and see the CRT's flight and weapon-delivery information without his having to refocus his eyes to see both target and data.

**Replacement.** The holographic lens takes the place of the bulky collimating optics. It is made by depositing a thin film of dichromated gelatin directly on the glass combiner and then using laser light to record in the gel a diffraction pattern that depends upon the geometry of the head-up display, including the position of the LCD and the combining glass.

As shown in the drawing, monochromatic light from a thallium-iodide arc lamp shines on the liquid-crystal display, then is reflected onto a mirror, and from there is projected through small relay optics onto the combining glass. The diffraction pattern reacts with the wavefront from the liquid-crystal elements to produce an image that appears to the pilot to be at infinity. □

## Audio

# Japan readying ultrahigh-fidelity stereo system built around PCM disk

Don't look now, but even as Japanese-designed video-tape recorders start their market climb, the next big-ticket consumer electronics item is already in sight. This time it is for the audiophile—ultrahigh-fidelity digital stereo phonographs.

The systems will use plastic disks of the kind familiar from ordinary sound recording, but the audio signals will be pulse-code-modulated. For playback the Japanese are proposing to use a laser, much as in a video-disk recorder.

In early September, Mitsubishi Electric Corp. in partnership with two other firms demonstrated the first experimental system. Mitsubishi announced that it expects to be able to build a commercial player within perhaps two or three years. Such a system would include pickup of information from the disk, decoding, and the low-level audio output stage; a power amplifier would not be included. The disks are said to be not much harder to stamp out than ordinary phonograph records. One 300 millimeters in diameter, about 12 inches across, would hold a half-hour of music and would sell for $11 to $15.

Moreover, since the bandwidth required for this kind of recording is almost 4 megahertz—about the same as for recording television images—the units may be fitted with options to make them convertible to either ultrahigh-fidelity audio or television.

Not to be outdone by Mitsubishi, Sony Corp. soon after announced a similar experimental system that it claims has a potentially longer playing time. But this one-upmanship is largely a bargaining ploy. Sony president Kazuo Iwama says that compatibility between different manufacturers is essential because the product, like the ordinary phonograph, will depend for its success on the availability of prerecorded disks. Iwama contrasted this dependence with the capacity of the video-tape recorder to record its own program material—which makes it a viable product even though there are two basic systems at present.

Hitachi Ltd. has also shown an experimental system. It also points out that in 1972 its subsidiary, Nippon Columbia Co., pioneered Japan's use of PCM for making master tapes, so that by now there is a large supply of the highest-fidelity program material available.

**Stereo.** Circuits inside audio disk system built by Sony are on breadboards, so that shift to production boards could shrink the cabinet. Laser senses PCM pattern recorded on plastic disk, resulting in frequency response that is flat out to 20,000 hertz.

The fidelity of the PCM systems is all anyone could ask for. A sampling frequency of about 44 kilohertz gives them a frequency response that is flat within a fraction of a decibel from direct current to 20 kHz. Harmonic distortion is typically 0.03%. Wow and flutter are kept below measurable levels. No noise is picked up by the systems, and dynamic range is set by the quantization to more than 85 dB for the Sony system and even higher for Mitsubishi's. (About 66 dB is considered extremely good for an analog system.) Crosstalk between channels is zero—compared with the 20 to 30 dB for an analog system.

Disks resemble those used in video players from Philips and MCA Inc. They have a pitch of 1.6 to 1.7 micrometers between the spiral "tracks" and spin at 1,800 revolutions per minute. The audio pickup is handled by the reflection of a laser beam positioned by a three-axis servo system. Mitsubishi and Sony use helium-neon gas lasers, Hitachi uses the so-called channel substrate planar semiconductor laser.

The systems employ redundancy of about 50% extra bits in PCM coding to correct for errors from dropouts. Where the systems part company is in the method of recording information on the disk. Mitsubishi frequency-shift-modulates individual bits, with two frequencies for 0 and 1 and a third frequency for formatting. Sony employs direct nonreturn-to-zero recording of 0s and 1s in the delay modulation scheme used for computer tapes.

Sony claims that its scheme permits higher recording density, and that by increasing density and slowing down motor speed it can obtain an hour or more of recording time. This longer recording time would not affect the performance of a dual-mode audio-video player, because the direct motor drive of the turntable would derive its frequency from a quartz crystal. An extra divider stage could then provide half frequency for half speed or a phase-locked-loop integrated circuit could allow generation of a frequency of any conceivable ratio. □

## Trade

# Japanese ICs take larger U. S. share

Is Japan's next target the U. S. integrated-circuit market? At least one Government analyst of electronics thinks so, on the basis of new import statistics showing Japanese first-half IC shipments up 77% from last year.

The $15.2 million share is not large, a mere 3.3% of the $463.1 million total most of which was earned by the "valued-added" imports of U. S. producers. Under U. S. Tariff Code sections 806 and 807, American firms can import products previously exported in an unfinished state for completion abroad and pay duty only on the value that was added offshore.

Nevertheless, Japan's share of IC imports is climbing steadily, even though total IC imports are also rising. The first-half imports total, for example, is 25% higher than a year ago, when Japan captured only 2.2% of a $370 million total. Moreover, when value-added ICs are removed from the import total, the analyst explains, "Japan's share of the true trade [with foreign companies] is larger than the figures show, particularly when you add the imports from plants Japanese companies have in places like Korea, Taiwan, and Hong Kong."

First-half IC imports from those three countries (which have U. S. producers, too) totaled $78.5 million, $40.6 million, and $18.9 million, respectively. How much of these totals represent value-added production will not be known until breakouts become available in about six months from now. Separating value-added ICs imported from Singapore, Malaysia, and the Philippines is easier. "You can figure about 99% of those shipments are in the value-added category," says a Commerce Department specialist. In the first half, those three countries increased shipments, respectively, to $11 million, $108 million, and $29.9 million, making up more than half the import total.

**Other factors.** Federal analysts see another element in America's first-half deficit of $293 million in IC trade, a 35% increase from 1976. Beyond Japan—which for the first time, with 18% of the trade, moved into the lead as largest foreign supplier of all components—the foreign share of work on U. S. products is rising steadily. The value-added

### Imports of consumer electronics set record

Import records were also set by audio and video consumer electronics products in 1977's first half, according to figures for imports released by the Commerce Department. Japan is accounting for nearly two thirds of the $1.8 billion. That total was 23.5% more than last year's first-half figure, which had also set a record.

Imports of color television receivers rose one third to $246 million. Eighty-five percent of the 1.28 million units brought in came from Japan, whose three-year "orderly marketing agreement" with the U. S. did not take effect until July 1. Under that arrangement, Japan will limit color TV shipments to the U. S. to 1.75 million units per year.

However, industry representatives in Washington are impressed by the doubling of color TV imports from Korea and Taiwan, even though those imports still represent less than 2% of the total. They believe the increase already reflects a shift in production strategy by major importers hoping to offset the constraints on suppliers in Japan.

Two other categories of consumer products also showed significant import increases in the half. Color video cassette recorders, almost exclusively from Japan, soared to nearly 46,000 units—up from the 32,000 brought in during all of 1976. Citizens' band radios, primarily 40-channel units, accounted for nearly 85% of the 9.8 million transceivers imported, reflecting a 14% rise from last year.

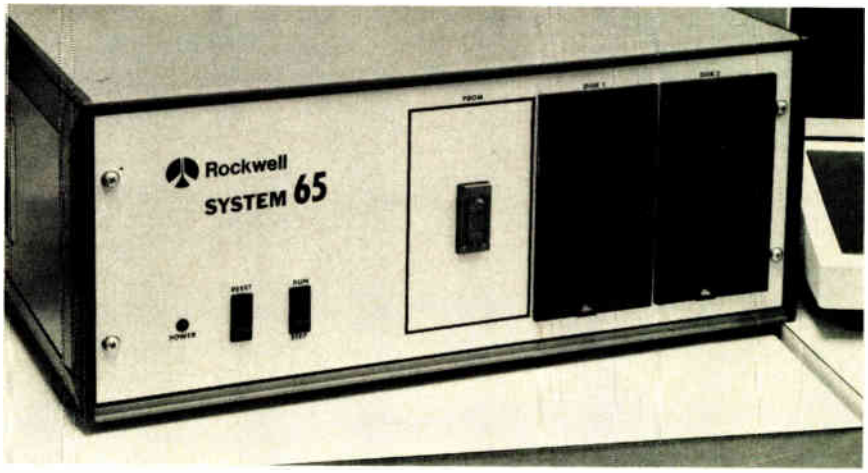
percentage "has been going up about 1% a year for some time," an official notes. "Now it averages about 56% of a circuit's value; it will probably reach about 60% before long." Of the seven IC categories tracked by Commerce, imports are led by monolithic bipolar types, with metal-oxide-semiconductor circuits totaling $170 million in the first half. Transistor-transistor-logic circuits accounted for $130 million in the same period.

Overall, America' long-standing advantage in components trade of all types appears to be eroding. The first half's trade surplus of $380.4 million is down 25% from the 1976 level. The nation's trade deficit with Japan was $100 million in the period as that country increased shipments by 41% to $164 million, while American exports there fell 5%.

Also causing the trade balance to decline were sharp increases in capacitor and resistor imports, which are producing mounting deficits in these categories. The figures show that capacitor imports, worth $83 million in the first half, were up a third from last year, increasing the negative trade balance to $32 million, or 40% more than in 1976. First-half resistor imports of $52.8 million represented an ever sharper increase in that category's U. S. deficit—some $19 million, or more than four times the $4.3 million of the year before. □

## Microprocessors

# $4,800 buys 6500 development system




**Desk topper.** Rockwell microprocessor development system relies for storage on 5¼-in.-diameter floppy disks, which plug into the right side of the unit.

To establish quickly its 6500 microprocessor family which it recently acquired, Rockwell International's Microelectronic Devices is betting on a low-priced microcomputer development system. Called System 65, it relies on a miniature floppy disk that Rockwell says is much simpler to use than present paper-tape storage.

Selling for $4,800, it is much cheaper than units supplied by Intel Corp. and Motorola Semiconductor. Anticipating possible knocks by competitors that System 65 is a loss leader for the 6500 family or a bare-bones unit that offers less, Rockwell says it expects the system to be profitable itself, as a complete tool for the customer.

The disk-based approach simplifies things because it stores programs under development in 13 kilobytes of resident read-only memory chips, says H. R. Anderson, manager of product planning for the Anaheim, Calif., Rockwell operation. "The big advantage is getting away from the rat's nest of paper tape that has to be loaded and handled to run other systems," he says. About 50 units will be completed by month's end, Anderson estimates, with the unit first demonstrated at the Wescon show in San Francisco.

Among important subprograms that are ROM-encoded and permanently resident are those for assembly, monitoring, text editing, file management, peripherals interface, and debugging. Not having to sort, load, unload, and file paper tape can save up to nine tenths of the time required to write, assemble, and edit a typical program, he estimates. Another improvement claimed for System 65 is that the entire user-oriented memory is dedicated to user programs. Some development systems crib part of user memory for operating routines, he says.

For the $4,800, a buyer gets a complete development system, according to Anderson. Included are cabinet, dual 78-kilobyte mini-floppy disk systems and four cards: 6500 central processor unit, input/output controller, 16-kilobyte static random-access memory, and monitor/debug routines. In-circuit emulation, which permits much more precise and extensive debugging, will be an option card available for $1,000 to $1,100. Both Intel and Motorola supply in-circuit emulation options at additional cost—$1,000 to $2,700 and $995, respectively.

**Comments.** Commenting on the Rockwell system, Intel and Motorola officials do not question its ability to perform adequately despite its low price. Both note, however, that the systems are not price-sensitive, at least as yet. "I don't recall anyone yet complaining about price," says the Motorola manager of the firm's Exorcisor, which sells for $7,665 in a comparable configuration. "A few thousand dollars' difference is not significant for a customer whose development program runs to a quarter million dollars," adds his Intel counterpart. An Intellec with performance similar to System 65 is priced at $8,275.

Where System 65 might not match the Exorcisor or Intellec, they speculate, is in three areas. The 78-kilobyte mini-floppy disks may not have enough memory capacity, against their 1-million-byte full disks; high-level computer languages

are increasingly demanded; and a system must be expandable to handle more than one processor chip.

Anderson has answers for all three. "The mini-floppy capacity was picked after a survey," he responds. The system initially has a Focal-65 user-developed language, and others can be added. As for expansion, it has space for four or five extra cards, including "personality cards" to allow the system's use for other microprocessors such as Motorola's 6800 family. □

## Consumer

# Microcomputer tunes and holds frequencies

When Quasar Electronics Co. starts shipping television receivers with what it calls Compu-Matic tuning next month, the firm will be one of the first to offer sets that rely on a frequency synthesizer both to acquire the television channel and to keep that channel tuned to its exact frequency. General Electric Co. has taken a similar approach to the TV-tuning system it has introduced, but other manufacturers that use frequency synthesis revert back to automatic frequency control once the channel has been tuned.

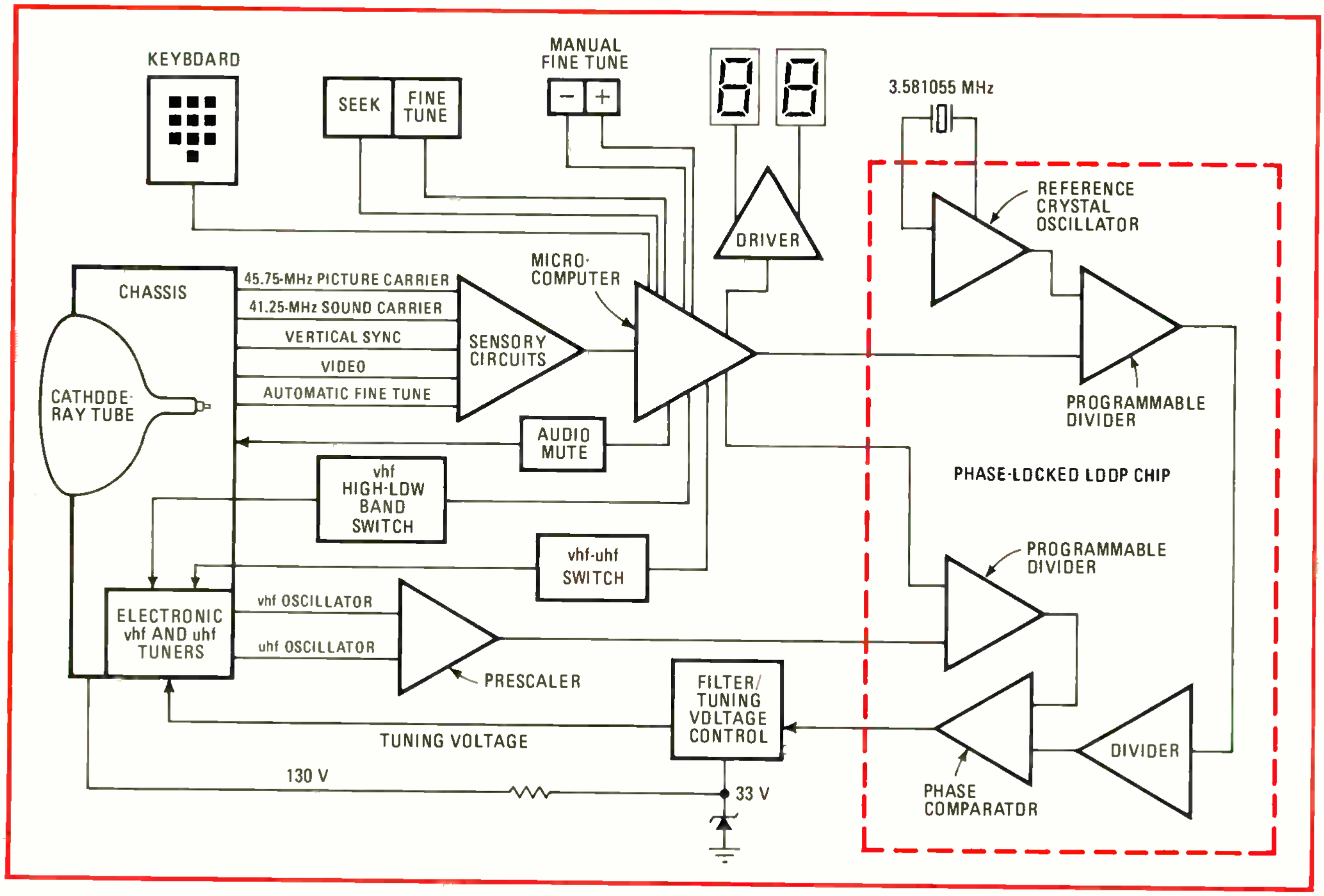
For Quasar, the new models represent a late entry into all-electronic tuning, now commonplace on most manufacturers' top-of-the-line sets. But the firm has not copied other set makers' custom logic implementations; instead, it has put its tuning system under the control of a single-chip microcomputer. Unlike West Germany's Blaupunkt-Werke GmbH, which requires a three-chip processor to handle such extra features as pre-programming [*Electronics*, Sept. 1, p. 36], the Quasar system performs only traditional channel select and tuning chores.

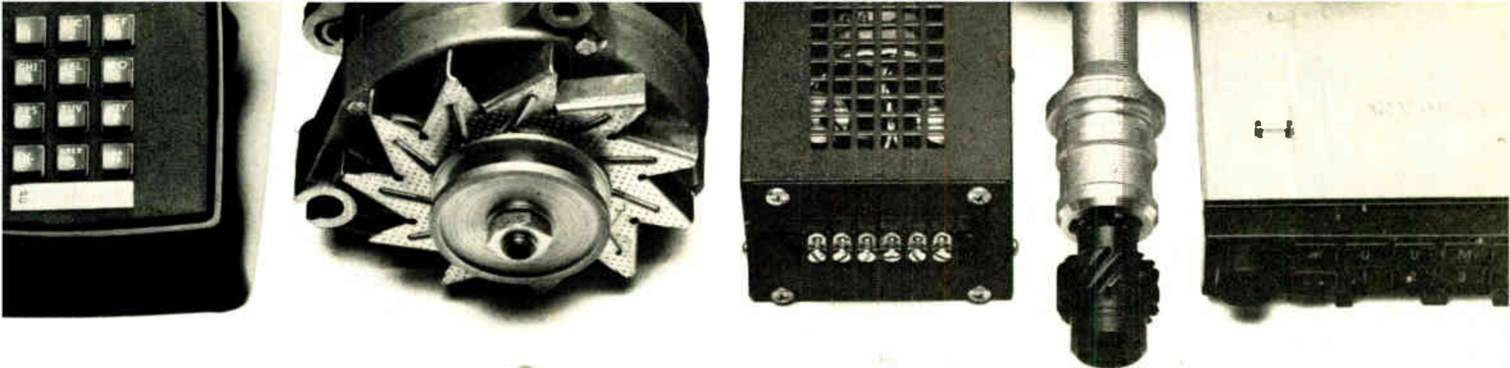
"We considered going the custom route, but when we started optimizing our custom circuit, it began to look like a microcomputer," says Ted Rzeszewski, manager of advanced development engineering at the Franklin Park, Ill., firm. So Quasar turned to a sister subsidiary of Japan's giant Matsushita Electrical Industrial Co.: Matsushita Electronics Corp.

**Microcomputer.** The Kyoto subsidiary spun off a special version of its recently introduced MN1400 4-bit microcomputer for the Quasar tuning application. The Japanese component maker also designed and built a custom phase-locked-loop circuit for the Compu-Matic.

Though the microcomputer is necessary for decision making and control, the key to the system's ability to select channels and maintain their stability is the phase-locked-loop chip, shown in the diagram. It develops a precise refer-

**Tuner.** Quasar's entry into electronic tuning of TV receivers relies on phased-locked loop under 4-bit microcomputer control to select and hold the channel frequencies.





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ence frequency from a standard 3.58-megahertz crystal and compares it with the divided-down tuner oscillator signal. If there is a difference in frequency between the two, an output voltage automatically adjusts the tuner oscillator frequency until the comparator inputs coincide.

"The PLL does the job normally done by automatic-frequency-control circuitry, but it does it an order of magnitude better," Rzeszewski says. The frequency-division chain from the tuner oscillator includes a programmable divider on the PLL chip. The microcomputer programs the divider to divide by the oscillator frequency of the channel selected, ensuring a signal that matches the crystal reference.

While forcing crystal-controlled stability onto the tuner oscillators (which are prone to drift), Quasar has also allowed the user a couple of ways to move off the precise tuning frequencies. "We wanted to retain a manual fine-tuning feature so the customer could tune out noise on very weak stations, at the sacrifice of some picture crispness," Rzeszewski says. "Or he may want to deliberately mis-tune to minimize disturbing signals."

So the user can command the microprocessor to change the reference oscillator signal, which it does by continuously changing the number in the reference's programmable divider as long as the fine-tune buttons are depressed. Also, there is an automatic fine-tune mode for use in cable and master-antenna installations where carriers are often offset from the correct frequencies. In such setups, the Quasar system will search for the carrier frequency as far as 2 MHz away from where it is supposed to be.

**Station choice.** The microcomputer also gives the user a choice of two ways to find the station—either searching for the next active channel higher or lower with seek buttons or tuning directly to the channel by entering two digits on the set's keyboard. Invalid keyboard entries and inactive channel numbers are tuned to the next higher active channel, although the user can defeat the seek feature with a switch, allowing inactive channels to be used for such purposes as video games or videotape playback.

"We use five sensors in the chassis to tell the microcomputer if a valid signal is present and, if so, how accurately it is tuned," Rzeszewski says. A pair of quad comparators look at the five signals—vertical synchroni-

## News briefs

### Charles Ferris to head the FCC; Brown also nominated

Charles D. Ferris, counsel to House speaker Thomas P. "Tip" O'Neill, has been named by President Carter to head the Federal Communications Commission, confirming an earlier report [*Electronics*, Sept. 15, p. 55]. Ferris will succeed Richard E. Wiley, who is resigning.

Carter also nominated Washington lawyer Tyrone E. Brown to the FCC's so-called "minority seat," vacant since Benjamin L. Hooks left to become director of the National Association for the Advancement of Colored People. Ferris' term will expire June 30, 1984. Brown will complete Hooks' term and in 1979 is expected to be renominated for a full seven years.

### U. S. tactical ground and ship radar outlays seen rising

Tactical ground and shipboard radars will constitute the bulk of an estimated $10.6 billion U. S. military radar market in the six years ending in 1982, says a study by Frost & Sullivan Inc. of New York. Annual outlays are projected to rise about 5% annually from $1.6 billion in the Federal fiscal 1977 year just ended to nearly $1.9 billion in fiscal 1982, with a surge to just over $2 billion in fiscal 1979. While tactical ground radars and shipboard radars are forecast to account for $4.5 billion and $4 billion in outlays over the six years, F&S says spending for large surface-based surveillance systems will remain flat at $2.1 billion, as more of their functions are taken over by satellite systems. Offsetting this will be increased spending on hostile weapons locators, search radars, and tactical fire control systems.

### Tektronix expands its microprocessor development lab

Tektronix is enhancing the general-purpose nature of its model 8001 microprocessor development lab, adding in-circuit emulation of the Z-80, TMS 9900, and 8085 devices, as well as the 8080 and 6800, the two devices covered when the system was first announced [*Electronics*, March 31, p. 122]. The company is the first and only major instrument manufacturer to offer a microprocessor development system.

### Distributed network architecture for HP 1000

Hewlett Packard Co. has committed itself to a distributed network architecture that permits HP 1000 and HP 3000 computing systems to be tied together. Comprising software and a read-only-memory subsystem, DS/1000 follows up HP's DS/3000, which initiated a high-level network protocol for the top-end 3000s alone. DS/1000 now goes a step further since it permits both systems to be hooked up, transparent to the operating systems in each. The network can be arranged in any configuration—star, ring, string, or combinations—with the best path set up automatically for high-speed communications between machines.

### Perkin-Elmer introduces thermal printer

The Terminals division of Perkin-Elmer Data Systems Inc. has introduced a $795 thermal printer. The 75-quantity price includes interfacing electronics for RS-232C standard input, making the 100-character-per-second model 650 one of the lowest-priced printers available.

The 650 prints sideways on 8½-by-11-inch dye-impregnated paper, depositing an entire column of dots at one go. A stationary thick-film print head with an array of 288 resistive elements spans the length of the carriage, and the 9-by-12-dot arrangement for each character allows the printer to handle the entire 96-character ASCII set. A 6800 microprocessor controls the 650, which has buffer memory for storing a single page.

zation, automatic-fine-tuning voltage, composite video, 45.75-MHz picture carrier, and 41.25-MHz sound carrier. The customer can adjust the composite video threshold so that he can skip over weak signals. □

## Distributors

# Schweber takes on Data General micros

Microcomputers are widely available from semiconductor distributors, so the announcement that Schweber Electronics Corp. has added a new line might normally be greeted with a big yawn. But the fact that it is the microNova line from Data General Corp. should cause a stir in distributor, minicomputer, and semiconductor circles.

The agreement gives Schweber Data General's line of 16-bit microprocessor products—chips, boards, packaged computers, peripheral equipment, and software. It is believed to be the most important such agreement to date between a leading computer manufacturer and a major distributor, and Data General president Edson de Castro says it is just the beginning. The Westboro, Mass., company will be lining up other distributors for the microNova line as well.

"We feel the market for small computers, particularly for microcomputers, is much too broad for us to sell into directly," de Castro says. "Local, off-the-shelf delivery is becoming very important." Schweber, a Westbury, N. Y., based distributor, has 16 U. S. locations, and approximately 100 salesmen. "A distributor salesman can afford to make a call on prospective microcomputer users in conjunction with other component products he sells," de Castro reasons. In addition, Data General field service contracts will be made available to users as part of the agreement.

For his part, Seymour Schweber, president of Schweber, says the agreement will open the doors of more than 500,000 potential customers "who have been virtually ignored by computer manufacturers. These people have been orphans in a storm, because the computer manufacturer didn't even return their phone calls." Salesmen selling systems at $100,000 or more did not want to take the time to follow up an inquiry about microcomputers, he says.

Data General's list prices for the microNova line range from $225 for a chip set to $1,995 for a boxed system and as much as $11,000 for a system including a diskette and printer. The full range will be offered by Schweber.

The only other minicomputer manufacturer offering microcomputers through distributors is the Digital Systems division of Texas Instruments Inc. Three distributors offer the TI 990/4 microcomputer and the division's advanced microprocessor prototyping lab. □

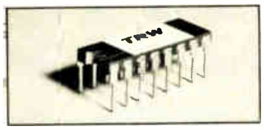
## Instruments

# 3½-digit DMM hits low of $49.95

How low in price can a 3½-digit digital multimeter go? At least to $49.95, says Sinclair Radionics Ltd., the British firm near Huntingdon, in Cambridgeshire, which pioneered low-priced calculators and claims to be Europe's largest manufacturer of digital multimeters.

For this price, Sinclair does not include the ability to make ac current measurements. But the model PDM35's accuracy—to within 1% of reading—is better than the 2% of full scale typical of analog multimeters, with their d'Arsonval-type movements. Also, the meter's input impedance is the standard 10 megohms of a DMM, compared with the much lower 20,000 ohms per volt of analog voltohmmeters.

Until now, digital multimeters have been almost twice the price of the new unit, which is aimed directly at the low-cost analog multimeter field. In that field, the familiar Simpson model 260 now sells for about $75, whereas a miniature

# The biggest, fastest little  shift registers you can buy.

**TRW's new TDC-1006J 256-bit serial shift register is unmatched for speed and power.**

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**TRW LSI PRODUCTS**

***...from a company called TRW***

Circle 51 on reader service card

VOM, such as the Triplett model 310, now sells for about $50. Sinclair also says it will introduce a 4½-digit multimeter for $199 early next year.

Nevertheless, the firm admits there will always remain applications where the moving-needle analog display will be preferred to monitor input changes. And there always will be people who plainly prefer to look at a meter needle.

**Market.** John T. Nicholls, head of Sinclair's Instrument division, estimates the total world market for analog multimeters at about 1 million units per year, selling for an average price of $40. Sinclair hopes to sell somewhere between 50,000 and 100,000 PDM35 units the first year, he says. Already, preliminary showings to dealers have resulted in firm orders for about 20,000 units.

The 3½-digit model is packaged in a modified version of a Sinclair calculator case, has a 0.150-inch light-emitting-diode readout, and runs off a standard 9-v transistor battery. It has automatic polarity indication and uses a simple slide switch for range changing.

According to Nicholls, the low price comes from using bipolar field-effect-transistor circuits for the analog input circuits and a digital large-scale integrated circuit for counting

**Meter.** Sinclair's DMM has accuracy to within 1% of reading, no ac measurements.

pulses and driving the LEDs. The precision input voltage divider employs thick-film technology. The LSI chip is the one in the company's 3½-digit $99 model DM2 multimeter of which more than 25,000 units have been sold. The chip is built by both General Instrument Corp. in Scotland and by Plessey Co. and comes in a 16-pin low-cost package.

The unit uses a single-slope technique for analog-to-digital conversion. In this technique, a ramp is internally generated, and the count from an internal 10-kilohertz clock is accumulated until a comparator senses coincidence between the ramp and the unknown input signal.

**Accuracy.** The meter's accuracy depends on the stability of the clock frequency; therefore Sinclair uses a temperature-compensated oscillator. It says the accuracy of within 1% holds over a temperature range of 19°C to 23°C. Although calibration is guaranteed for only three months, Nicholls says it should hold for about a year. As to the absence of an ac-current range, Nicholls points out that the few users who require such capability usually need up to 20 amperes full scale, which would be beyond the capability of a low-cost digital instrument anyway.

The meter measures dc voltages in four ranges with full-scale values from 2 v (actually 1,999 v) to 1,000 v; ac voltage in four ranges from 2 v to 500 v full scale; dc current in six ranges from 200 microamperes to 200 milliamperes full scale; and resistance in five ranges from 20 Ω to 20 MΩ full scale. □

### LSI-11 helped plot *Courageous'* course

Engineers at Digital Equipment Corp.'s Components Group joined Skipper Ted Turner's *Courageous* crew—at least in spirit—in celebrating the 12-meter yacht's successful defense of the America's Cup Sept. 18 off Newport, R. I. DEC's LSI-11 helped *Courageous* navigator Bill Jorch (pronounced "george") compute his position and such other critical data as wind speed and direction [*Electronics*, June 23, p. 34] as the U. S. entry swept to four straight wins over Australia. In the system's automatic mode, the boat's instruments were multiplexed to the LSI-11, which computed and displayed data, including distance to marks along the course.

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Now you can have RAM and EPROM on the same board and buy as much or as little memory as you need. And because our memories use 16 pin memory element sockets you can change your memory when you change your mind.

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Compare these features with our much improved read, write and refresh cycle times and you'll choose MSC first.

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Up to 16K × 8 of RAM and up to 8K × 8 of EPROM on the same board.

RAM expandable in 4K × 8 increments and EPROM expandable in 1K × 8 or 2K × 8 increments.

On-board DIP switches to select any of 16 address start locations for RAM and 16 address start locations for EPROM.

Cycle times:
Read, 350 nsec.
Write, 500 nsec.
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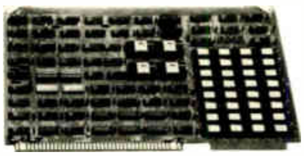
Totally SBC 80 and Intellec MDS hardware and software compatible.

Limited one year warranty on parts and labor.

Delivery 30 days ARO.



*MSC 4502*

### 64K RAM Version

Up to 64K × 8 of RAM and up to 8K × 8 of EPROM on the same board.

RAM expandable in 16K × 8 increments and EPROM expandable in 1K × 8 or 2K × 8 increments.

On-board DIP switches to select any of 16 address start locations for RAM and 16 address start locations for EPROM.

Cycle times:
Read, 350 nsec.
Write, 500 nsec.
Refresh, 500 nsec.

Totally SBC 80 and Intellec MDS hardware and software compatible.

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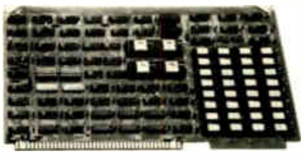

*MSC 4602*

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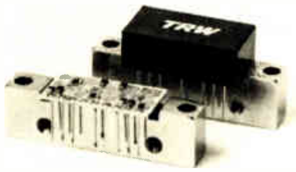


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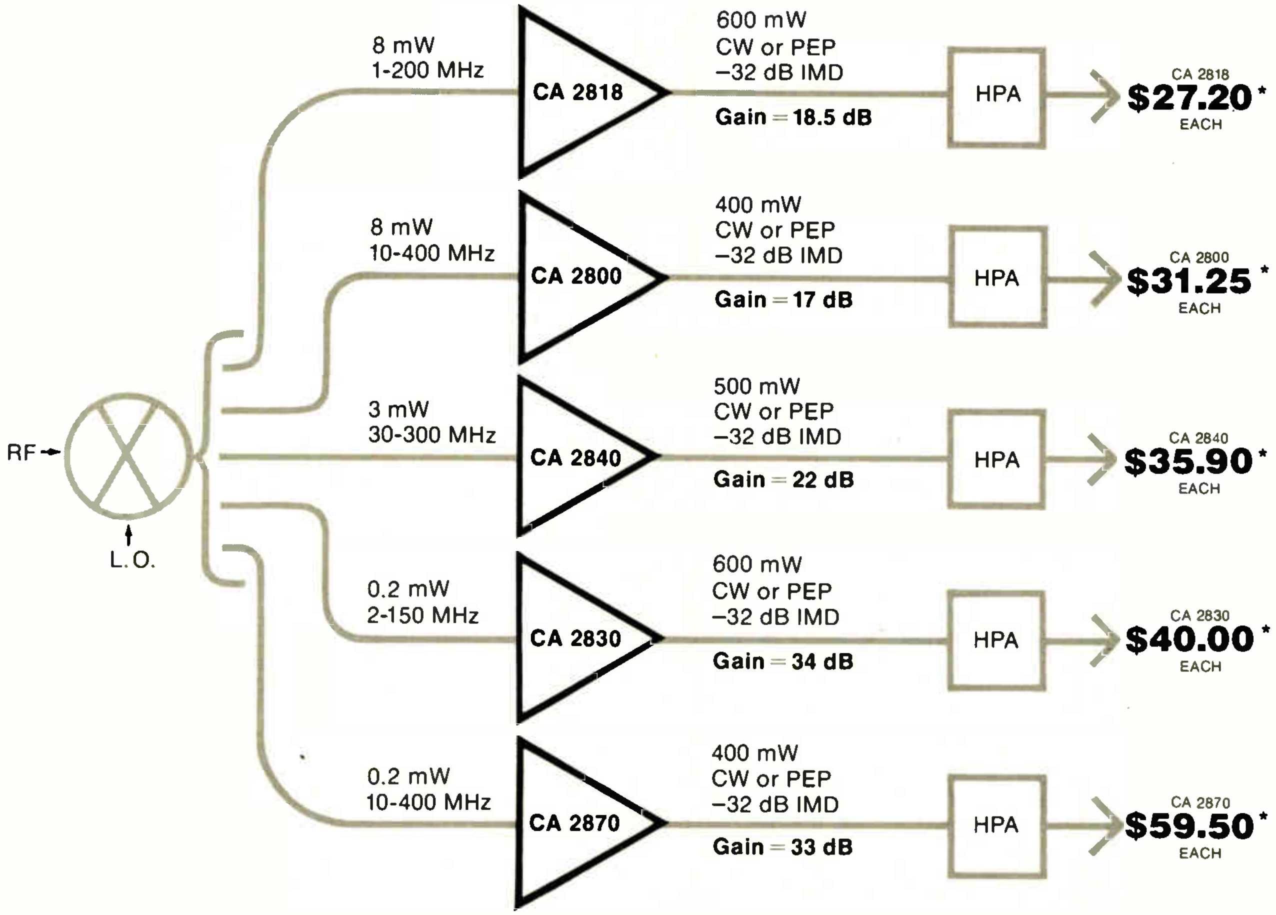

# RECEIVER APPLICATIONS:

40 MHz to 100 MHz IF amplifier.

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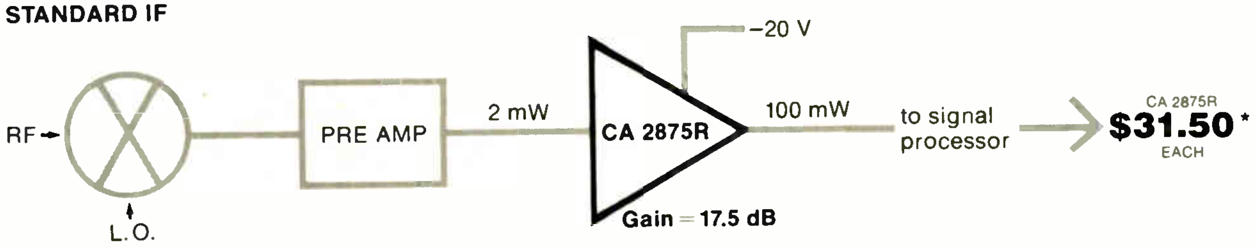
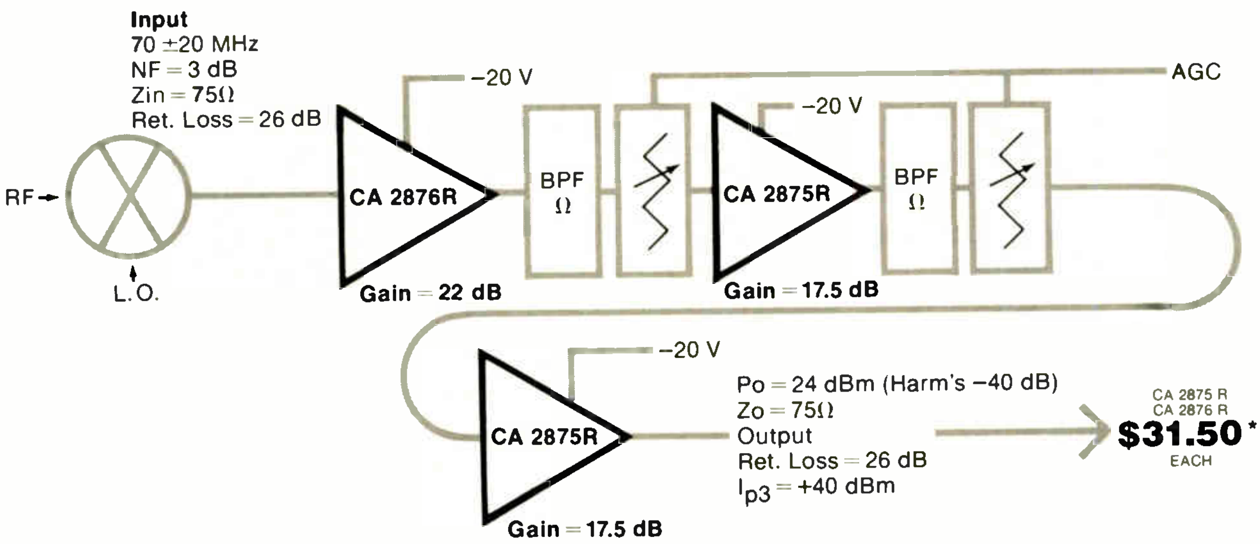
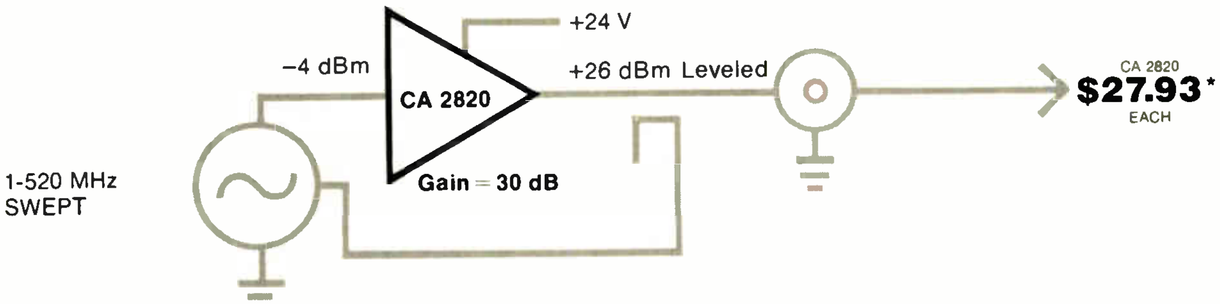



### HIGH PERFORMANCE IF




# INSTRUMENTATION APPLICATIONS:

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# New Sinclair Cambridge Programmable. An astonishing $29.95!

**How pocket calculators grew up**

A couple of years ago, calculators took a step forward. Programmability transformed the slick slide-rule calculator into an advanced scientific machine.

Sadly, it also transformed a cheap little calculating aid into a piece of capital investment.

*Now the all-new Sinclair Cambridge Programmable puts programmability where it belongs: in the palm of your hand, for less than $30.*

**The features of the Sinclair Cambridge Programmable**

The Cambridge Programmable is genuinely pocketable. A mere 4½" x 2", it weighs about 2oz.

Yet there is absolutely no compromise in the package of functions it offers.

Because the Cambridge Programmable is both *a scientific calculator* with memory, algebraic logic and brackets (which means you enter a calculation exactly as you write it), and a *programmable calculator* which offers simple, flexible through-the-keyboard program entry and operation.

The Cambridge Programmable has a 36-step program memory, and features conditional and unconditional branch instructions (*go to* and *go if negative*).

There is also a step facility, which allows you to step through the program to check that it has been entered correctly. If there is any programming error, the learn key allows you to correct single steps without destroying any of the remainder of the program.

To achieve this, each program key-stroke has an identifying code, or 'check symbol'. (The symbols for the digit keys are the digits themselves, while the symbols for the operator keys are letters printed beside the keys.)

The check symbol for ⊟, for example, is F. So if, as you step through the program, the display shows

check symbol    step number


it means that ⊟ is programmed as step 26. If step 26 should have been ⊞, all you have to do is press

[▲/▼] [RUN] [+]
learn

**puts machine into 'learn' mode.** **the correct step**

It's as simple as that!

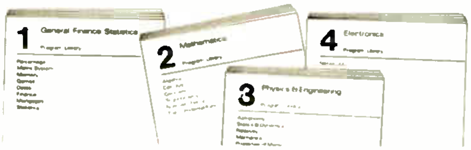
These facilities make the Cambridge Programmable exceptionally powerful, whether it's running programs you devise for yourself or the programs in the Program Library.

**Use the 294-program library to tailor the machine to your own specialty**

Like a full-size computer – and *unlike* far more expensive specialist calculators – the Sinclair Cambridge Programmable can be programmed to handle calculations concerned with *any* specialty.

And of course, whatever it's doing the Programmable is error-free – in fact, once it's programmed, it can even be given to an operator who doesn't understand the program!

To save you time, and to help inexperienced programmers, Sinclair have produced a library of 294 programs ready to be entered straight into the calculator.




Using these standard programs, the Cambridge Programmable solves problems from quadratic equations (where the program gives both real and imaginary roots) to twin-T filter design, and from linear regression to bond yields. It even plays a lunar landing game! To realise the full power of the Cambridge Programmable, the Program Library is a must.

(The calculator is supplied with 12 sample programs, and full instructions for entering your own program. The four books in the program library are available at $4 each, or $10 for the complete set.)

**Why the Cambridge Programmable costs so little**

The Sinclair Cambridge Programmable uses the Sinclair talent for miniaturisation to the full – as you'd expect from the company that pioneered the truly pocketable pocket calculator, and recently introduced the world's first pocket TV.

Chip and circuitry design are unique to Sinclair, and the Cambridge Programmable is assembled by Sinclair's own staff at their headquarters plant. Shipped direct, and sold to you direct, the Cambridge Programmable accumulates no middleman's profits on the way.

The result is a pocket programmable calculator of advanced design, sold by the manufacturer with the manufacturer's own 1-year comprehensive guarantee, at a price unmatched by any comparable calculator.

## 10-day no-obligation offer

There's a lot more to this remarkable calculator than a brief written description can cover.

You need to see it and handle it... to program it yourself in a few seconds to save you hours... to check its performance against tables and graphs... to test the full range of programs available... to evaluate, perhaps, its use as an educational aid in developing a student's computer understanding.

So we're offering a 10-day trial. Send your check or money order with the order form below, and you'll receive a calculator direct. Use it for 10 days, and if you don't feel it's the finest $29.95 you've ever invested, send it back. We'll refund your money without question.

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Signature ______

**Army names Boeing, Vought to compete for GSRS missile**

Development of the General Support Rocket System, a highly mobile, surface-to-surface missile, has been started by the Army with the award of competitive contracts of more than $34 million each to Boeing Co. of Seattle and Vought Corp. of Dallas. **The 29-month validation program by the Army Missile Research and Development Command, Huntsville, Ala., calls for a competitive shootoff prior to a production decision.** The GSRS, with a range of more than 18 miles, will include six factory-sealed and maintenance-free rockets in a disposable, rectangular launching pod. Modular design, the Army says, will permit interchange of rockets, pods, and launchers with those of U. S. allies.

**Telecommunications technology in China gaining, says EIA . . .**

Telecommunications technology in the People's Republic of China "is more advanced than anyone thought," says the Electronic Industries Association's John Sodolski, following the return from that country of an EIA delegation of seven member companies [*Electronics*, Aug. 4, p. 49]. The firms' representatives, specializing in satellite communications, were impressed by a Chinese-built, 10-meter earth station and a telecommunications switching center. **"No one knew they had the earth stations, but they said they had a number of them,"** Sodolski said, adding that "the quality of the switching center was impressive—better than anyone anticipated."

**. . . But Peking trade potential seen hurt by new study**

As a People's Republic of China telecommunications delegation visits European space facilities (see International Newsletter), efforts by U. S. satellite communications companies to cultivate a Chinese market received a severe setback. It came in the form of a Library of Congress study assessing the China space program as almost completely oriented to military uses. The study, which evaluated space programs of 148 nations, says the last five of the seven Chinese satellites orbited since 1970 **appear to have been either reconnaissance or electronic eavesdropping satellites.** The report, made public Sept. 20 by the House Committee on Science and Technology, is regarded by electronics company representatives as offsetting the encourgement they derived earlier in the month from the technology export policy statement by Defense Secretary Harold Brown.

**FCC spells out uhf/vhf antenna rules for TV sets**

Television receiver makers who want to attach a common ultra- and very-high-frequency antenna to their products have been told by the Federal Communications Commission that they must meet one of two conditions. **Their measurement data must show that the common antenna's uhf reception is comparable to that of the uhf loop antenna now provided, and it must come complete with a description of the test procedures and equipment used to derive the data.** Alternatively, the common antenna request must show that receivers incorporate a built-in splitter circuit to couple uhf signals to the uhf tuner in a way that tests show yields acceptable reception.

The FCC ruling came after set makers sought clarification of an order requiring all receivers produced after July 15, 1978, to have a uhf antenna attached, not merely provided, if the vhf antenna is also attached. "Merely connecting the built-in vhf antenna to the uhf terminals" is not acceptable, the FCC said in response to industry queries.

## Promises and problems in ERDA's push for solar electric power

Solar electric power advocates are being told there is "good news" in the Energy Research and Development Administration's plans to accelerate its photovoltaics program [*Electronics*, Aug. 4, p. 33]. The word comes from Henry H. Marvin, ERDA's solar energy division director, who in mid-September detailed the agency's proposals before the House Committee on Science and Technology.

Back from a tour of U.S. industry and Government laboratories involved in photovoltaic development, Marvin found that solar cell prices in the range of $1 to $2 per peak watt might be achieved by 1978–79, "two years earlier than ERDA's current projected milestone," and move the market "into a very rapid growth stage in the 1980–85 time frame."

By 1986 this could lead to the development of commercial plants capable of an annual production of 500 megawatts of modules "at a market price of less than 50 cents per peak watt," expanding by the year 2000 to "50 gigawatts of solar array modules at a market price of 10 to 30 cents per peak watt." Should that happen, ERDA believes some 20 gigawatts of electricity—3% of estimated U.S. demand—could be generated by photovoltaic conversion. That figure beats ERDA's previous 1.5% estimate.

### Thorns in the roses

Nevertheless, there are some sharp thorns on ERDA's rosebush, as Marvin is quick to point out. "The major factor we see holding back this price reduction is the very large investment in manufacturing facilities required to implement cost-reducing technologies."

To stimulate this investment, ERDA's proposed new plan would accelerate solar cell buys through a series of "pull-through" experiments and applications in load centers of 25-to-500-kilowatt size, contracted for in 8 to 12 solicitation cycles over a 10-year period. Marvin adds that "smaller-scale applications, such as residences, become an option in the early 1980s."

ERDA's draft plan thus represents a switch from its existing program, for it opts to emphasize solar-cell technology and applications instead of pushing the development of equipment for large-scale manufacturing.

A good part of ERDA's decision to stress photovoltaic technology in its new proposal to the Congress is based on what Marvin calls "the very sizable technical problems to be resolved." These range from the need to double the efficiency of solar arrays to 15% to 20% from the present 8% to 10% level to development of a low-cost, highly transparent, and noncontaminating array encapsulant to replace glass, plus "a very strong need to improve the capability of electric energy storage" derived from arrays.

As with any new technology, ERDA's draft plan has critics as well as advocates. Rep. Mike McCormack (D., Wash.), chairman of the Science and Technology subcommittee on advanced energy technologies, told one reporter, "There is no way to legislate a technology into being." Others who have seen ERDA's draft revisions have more particular criticisms.

Of the 30 responses analyzed by ERDA thus far, Marvin says, "some feel that the goal of $1 to $2 per watt in 1980 is too ambitious, particularly for flat-plate silicon." But half of ERDA's fiscal 1977 technology funds are devoted to silicon array cost reductions, and photovoltaic specialists want a better R&D balance between silicon and materials like cadmium sulfide, gallium arsenide, and cadmium telluride.

While there is general agreement in industry with ERDA's concept of a demand-pull strategy to spur the market through larger array buys and experimental applications, the responses also raise the question whether a market that is wholly dependent on Government stimulus can attract the necessary private investment in plant and equipment. "The underlying issue," Marvin contends, "is whether an intermediate market which will be growing and self-sustaining exists as we approach the $1 to $2 per peak watt goal." Clearly, industry is uneasy about that prospect.

### Persuading Congress

The fact that ERDA's new proposal is generating as much debate as it already has—much of it outside the industry—is encouraging to some industry optimists. "At least there is someone else in church besides the choir," says one. As for those who say ERDA's revised goals are too ambitious, the same person recalls that "no one believed we could meet the timetable for a lunar landing either." He dismisses Congressman McCormack's observations quickly. "He wouldn't be saying that if he hailed from Arizona, Texas, or Utah. Washington is always cloudy—except when it's raining." But McCormack, a sponsor of solar heating and cooling as well as electric vehicles, is widely regarded as a realist and a force to be reckoned with on energy issues. If ERDA is to succeed with its program, it must muster its fellow optimists to convince the Congress that its goals are in fact achievable.

**Ray Connolly**

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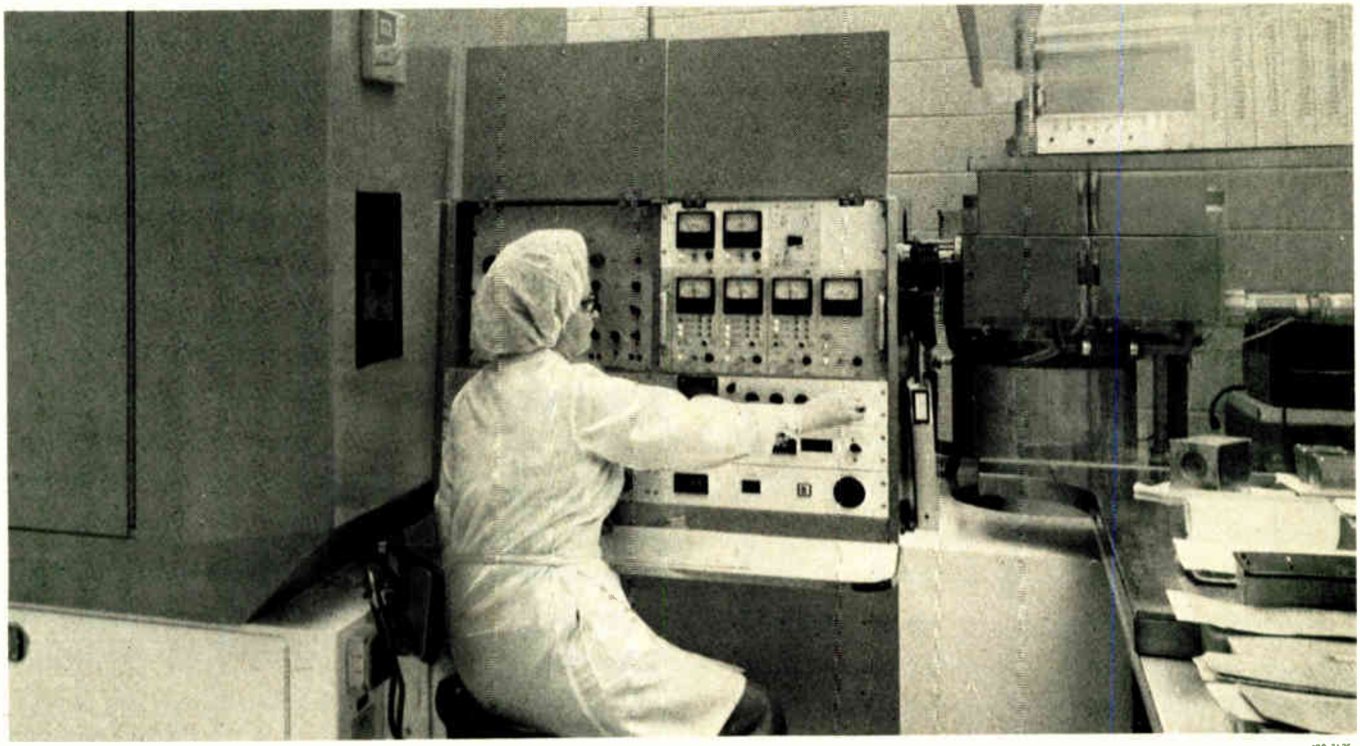
Write or call George Tully or Bob Milewski to arrange a visit. You can reach them at the Semiconductor Division, Sprague Electric Co., 115 Northeast Cutoff, Worcester, Mass. 01606. Tel. 617/853-5000.



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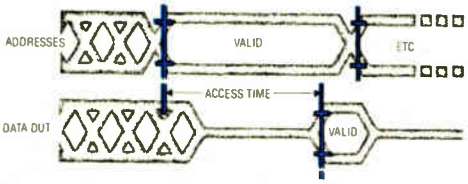
| **NO CLOCKS. NO TIMING STROBES.**   | ✓ | ✓ | No clocking needed for TI's fully static 4K RAMs. No edges. Just present an address to the selected device and data can be read at access time. That's it. |

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| **HIGH SPEED.** | | ✓ | TI's new 4K static RAMs take up where the 2102 left off. Offering a wide choice of speeds from 150 ns to 450 ns maximum access/minimum cycle. Plenty of performance to match today's and tomorrow's CPUs. |
| **LOW POWER.** | | ✓ | Compare the power savings of the new 4K statics to the low power 21L02. For equivalent speed, the new TMS 4044 uses 63% less power. For super low standby-power/battery-backup operation, use the pin-compatible 20-pin TMS 4046/47 Series. Data is retained down to 10 mW. |
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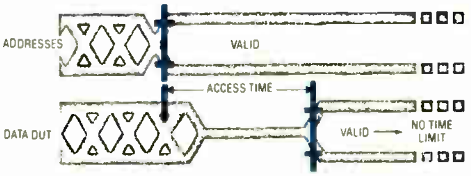
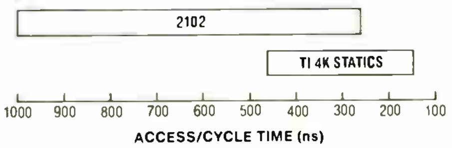
**DATA VALID— NO TIME LIMIT.**




**HIGH SPEED.**

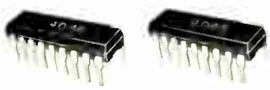



| Max Access | 4K x 1 | 1K x 4 |
|---|---|---|
| 150 ns | TMS 4044-15 | TMS 4045-15 |
| 200 ns | TMS 4044-20 | TMS 4045-20 |
| 250 ns | TMS 4044-25 | TMS 4045-25 |
| 300 ns | TMS 4044-30 | TMS 4045-30 |
| 450 ns | TMS 4044-45 | TMS 4045-45 |

**LOW POWER.**

| Parameter | Four Low Power 1K Static RAMs (2102AL-2) | One TI 4K Static RAM (TMS 4044-25) |
|---|---|---|
| Max. Access Min. Cycle | 250 ns | 250 ns |
| Operating Power (Max.) | 1368 mW | 500 mW |
| Package(s) | 4 x 16 pin | 1 x 18 pin |
| Board Area Ratio | 3.7 | 1.0 |

**HIGH DENSITY 18-PIN PACKAGE.**



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93192

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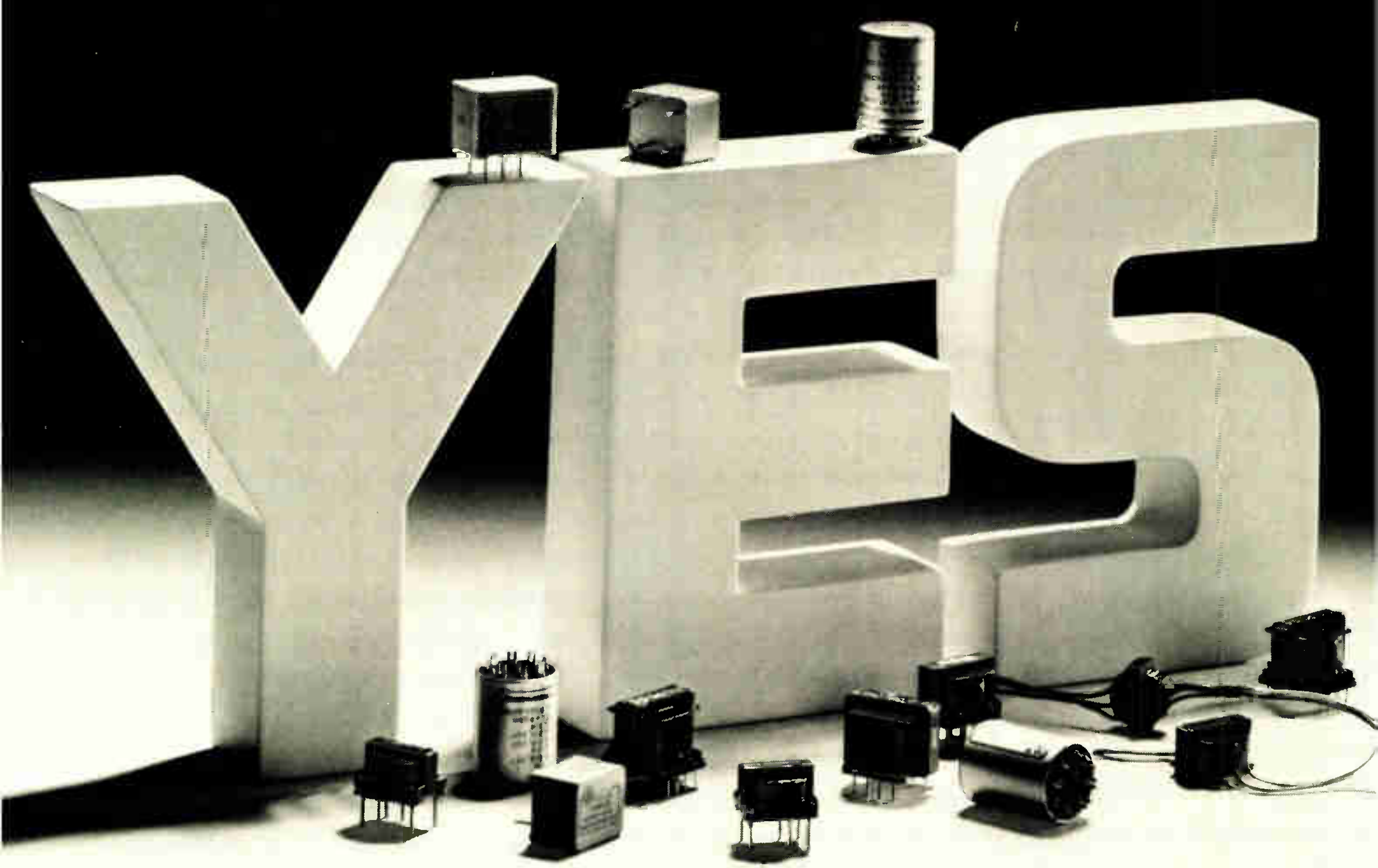


TRW/UTC has a line of miniature industrial audio or signal transformers that come in three wattage ratings. And, they're available in four different configurations.

To find the unit you need, check the table below.

| | Ouncer | Subouncer | Sub-Subouncer |
|---|---|---|---|
| P.C. Board Mounting | PC-O Series | PC-SO Series | PC-SSO Series |
| Flexible Leads | | SO Series | SSO Series |
| Molded | | SO#P Series | SSO#P Series |
| Alarm Housing | O Series | | |

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**TRW UTC TRANSFORMERS**

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Circle 62 on reader service card

**A third firm shows audio-tape systems based on VTRs**

Japanese manufacturers of consumer electronic products are positioning themselves to move into what they see as a promising new market segment: audio-tape ultrahigh-fidelity systems that use pulse-code modulation and are based on video-tape recorders. The latest firm to show possible offerings is Mitsubishi Electric Corp., with two experimental systems based on the video-home-system technology for VTRS. **One is based on an adapter for VTRS, making it similar in concept to systems earlier announced by Sony and Matsushita** [*Electronics*, Sept. 15, p. 64]. The other, for hi-fi buffs, is a special-purpose audio deck built around a VHS tape drive. It has electronic circuits for recording and playback of PCM audio—all video functions have been omitted. Japanese firms are also pushing development of disk-based ultrahi-fi systems (p. 42). The Osaka firm hopes to negotiate a standard format with other VHS makers in order to facilitate sales of prerecorded tapes.

**U.S.-Japanese firm plans to join video-disk market**

In a move that will step up the competition in the burgeoning market for video-disk players, the U. S. entertainment giant MCA Inc. and the Japanese hi-fi component maker Pioneer Electronic Corp. have formed a joint company. Universal Pioneer Corp. will begin production of industrial data-retrieval systems in October 1978, at a rate of about 1,000 systems a month. **The player will include a microprocessor and will retrieve information from 5,400 individual television frames on a disk.** About a year later, the company expects to start production of consumer units.

**Chinese delegation views European Satcom facilities**

The People's Republic of China, anxious to expand its satellite telecommunications capabilities (see p. 57), has sent nine specialists to six Western European countries on a six weeks' tour, says the European Space Agency. The delegation from the Chinese Electronics Society, headed by Lei Hung, will conclude its trip on Oct. 20 after visiting national space facilities and companies **for briefings on high-power broadcast satellites, transmission techniques, fixed and mobile earth stations, plus new technological developments and satellite applications.** The visit will cover France, the Federal Republic of Germany, the Netherlands, Italy, the United Kingdom, and Sweden. (See Washington Newsletter, p. 54).

**2 British firms target audio cassettes for TV game memories**

Believing that cassettes based on programmable read-only memories are too limited for the TV game market, EMI Ltd. and General Instrument Microelectronics of Great Britain plan to introduce early next year hardware for a microprocessor-based game set that uses standard audio-tape cassettes. EMI, the world's largest producer of records and tape cassettes, claims to have developed a high-density recording technique that protects program integrity. **Thus, a standard programmed $5 cassette can hold 2 megabits of program, including voice and sound effects, versus only 16,000 bits for the typical mute $20 PROM.** General Instrument is basing its approximately $150 chip set around a CP 1610 16-bit microprocessor, a standard TV interface chip, a custom-designed n-channel MOS character-generator chip, and various memory circuits. Both firms are talking with U. S. and continental TV makers about building the scheme into sets due in late 1978 because "the add-on market for TV games is dead," surmises a General Instrument executive.

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Circle 64 on reader service card

# Multilevel bit storage in CCD memory gives higher packing density

**If CCD memories** are to make it as replacements for disks and tapes in low-cost storage systems, they must be cheap. That means they must be dense—much denser than random-access memories, which have high speed as their selling point. So increased packing density is the goal of Mitsubishi Electric Corp.'s new technique of stacking two levels of storage one on top of the other, thereby packing 2 bits of memory into each storage site.

Using this approach, they have produced an experimental 131,072-bit charge-coupled-device memory that achieves its high packing density with the same geometry as in 65,536-bit CCD chips. Their chip measures 8.9 by 7.9 millimeters, but it has large margins as a precaution. The cell area per bit is 208 square micrometers.

The memory is organized as 256 randomly addressable shift registers of 512 bits each for application as a 131-k-by-1-word device. Each register is composed of four parallel registers, each containing 64 cells that can store levels of zero charge, a third of the full charge, two thirds, and full charge.

**Input stage.** To store 2 bits in one cell requires two write cycles and an input stage with two input cells, one of which (S in the figure) is twice the size of the other (I in the figure). The first bit is sampled and stored in S as 1 or 0. The second bit is sampled and stored in I, which is electrically separated by M from the bigger input cell.

Next, the two charge packets are mixed by lowering M. If both bits are 0 or 1, then the charge to be transferred to the shift register's first serial storage cell is, respectively, 0 or 1. If the first bit is 0 and the second is 1, then the charge to be transferred is a third of the full charge because I is only a third of the combined input cells; if the first is 1 and the second is 0, then the charge is two thirds because S makes up two thirds of the combined cells.

For read and refresh operations in each register, an associated high-performance cross-coupled amplifier is used with two reference levels to detect the 2 bits of stored data. In effect, it compares the value of the output signal with values that are midway between the output's possible values.

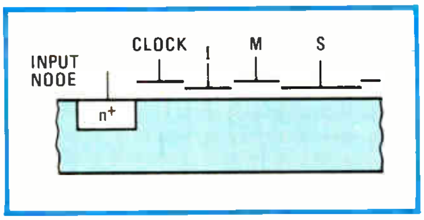
For the first bit, the sense amp compares the output signal with a half-level signal from a dummy register. If the output signal is zero or one third—less than the half-level signal—the sense amp generates a 0 for the first bit and resets the dummy register's signal at one sixth. If the shift register's output is zero—less than the dummy register's new signal—then the sense amp generates a 0 for the second bit. However, if the shift register's output is one third, the sense amp generates a 1.

If the shift register's output is two thirds or one, compared with the dummy register's half level, then the sense amp generates a 1 for the first bit and resets the dummy at five sixths. Then if the shift register's output is one, the sense amp generates a 1 for the second bit. However, if the shift output is two thirds—less than five sixths—the sense amp generates a 0.

The CCD array employs a double-level polysilicon gate structure that is an extension of the conventional n-channel silicon-gate technology. The device is compatible with transistor-transistor logic and operates from conventional metal-oxide-semiconductor supplies of 12, 5, and −5 v. The register desired can be selected by address input. Clocks—including data-transfer, read-and-write control, chip-select, and column-address-strobe clocks—are common to all 256 registers.

Researchers at Mitsubishi's laboratory at Kitaitami, near Osaka International Airport, say the transfer efficiency of charges down the serial cell array of their 131-k memory is not 100%. Moreover, a 64-cell length for each register is the maximum possible, given the state of the art in MOS fabrication. In fact, there is some question if the transfer efficiency can be maintained at a high enough value to give good yield in production. A company spokesman says fabrication technology will soon improve sufficiently to make this question academic. □

**Two for one.** Configuration of input stage permits one CCD cell to hold 2 bits.




## Great Britain

# 6800 broadens range of process controller

Much process-control hardware has been tailor-made by systems houses, but standard units suitable for a wide range of jobs can be built with microprocessors. So believes The Solartron Electronic Group Ltd., which is announcing a process-control computer built around a Motorola 6800 8-bit microprocessor. The unit is intended for applications in hydrocarbon processing.

"Thanks to the microprocessor, we're providing an off-the-shelf standard product that does not have to be tailored to accept a variety of inputs from gas or fluid measurements," says John Emmerson, marketing manager for the firm's transducer group. The 7900/01 is designed for such applications as petrochemical pipelines, where it can monitor a pipeline used to transfer different products, one after the other, he says.

Emmerson forecasts a good market for the $3,000 unit. "I don't see any major European competition," he says. He expects to ship half his products to the U.S. market to compete against units that measure only gases or only liquids.

**Applications.** Other uses include monitoring the energy used by the system being controlled and measuring the energy content of oil or gas. The instrument can compute volume, mass, and energy flow from as many as 10 inputs, including density, static and differential pressure, temperature, specific gravity, fluid flow rate, and calorific value.

The Farnborough, Hants., firm chose the 6800 because it has a better instruction set and better backup than its competition, according to Emmerson. For density measurement, the 7900 needs only 4,096 bits of electrically programmable read-only memory and 384 bits of random-access memory, of which 265 bits are provided with a battery backup. The 7901 has an additional computer board so that it can also measure flow.

The portable controller is designed so that "it can be used in the field by a process engineer who is not a software expert," he says. With a simple control-word program based on a table of 100 numbers broken down into groups representing the various parts of a system, the user can enter data from the transducers or other sources. This programmability means that the unit may be moved without having to be taken back to home base for reconfiguration.

Another selling point is that "we've paid more attention to integrity," Emmerson says. By that, he means the firm aimed for a well-thought-out design that yields consistent, highly accurate results. For example, the primary transducer inputs of flow and density are duplexed so that the controller can compare for any mismatch. □

## Around the world

### Saddle yoke, reuse of flyback energy cut color TV power

Coming on the market next month is a Blaupunkt GmbH 20-inch TV set that dissipates 75 watts, as much as 100 W less than comparable sets. The Hildesheim, West Germany, firm is stressing the improved set life that comes as a result of the low power use. Its new model compares favorably with the most thrifty of the Japanese 20-in. sets and with the Xtended Life line from RCA Corp., which has a 19-in. set (corresponding in viewing area to the foreign 20-in. models) with an 86-W consumption.

The German set combines first-stage developments that reduced power to 95 W with a saddle yoke used for power deflection instead of the usual toroid to achieve the drop to 75 W. With its greater number of windings, the saddle yoke has a higher impedance—thus halving current use, which means less power consumption and less heat.

The chief energy saver is a first-stage development: a vertical deflection circuit that uses the horizontal-flyback pulse energy, which usually goes to waste once it has traced the scan lines for one frame of the TV picture. The circuit includes a modulator that produces a pulse-modulated rectangular signal fed by two synchronously switched low-voltage thyristors to the vertical-deflection stage. The thyristors are configured as a class AB amplifier, which has an efficiency of about 70% when driven with the rectangular signal, compared with about 12% for the more common class B amps. So energy needed for vertical deflection is 7 or 8 W, about 17 W less.

Also helping to drop power to 95 W are special transistors in place of thyristors in the horizontal-deflection stage, and a red-green-blue-driver designed as a push-pull circuit using less power than class A or B amps.

### CCD-MOS chip promises high-performing correlator

In the breadboard stage at the University of Edinburgh, Scotland, is an analog correlator that combines MOS devices and CCD circuitry. Researchers at the Wolfson microelectronics liaison unit say the monolithic correlator will practically fit onto one chip while promising significantly better performance than other approaches.

They think the unit will be a cheap way to pluck weak signals from background noise for pulse-compression filters or to build programmable filters for other signal-processing jobs. Moreover, it promises to be an attractive alternative to costly and complex digital hardware and to nonprogrammable analog charge-coupled-device circuits, they say.

So far, their chip combines a 32-stage CCD register that serves as a delay line and a MOS multiplier of 32 matched transistor pairs. Soon to be tested are chips that also include a three-phase CCD clock, a sample-and-hold circuit for storing the reference, and a 32-way array of complementary-MOS switches for clocking in the reference. Off chip will be only five operational amplifiers and a counter. The correlator is programmable because the reference signal may be changed and even refreshed either synchronously or asynchronously with the CCD clock. The prototype operates at 8,000 samples per second, although higher speeds look obtainable.

### Audio sales booming in West Germany

Audio-equipment sales in West Germany are expanding vigorously and are running neck and neck with television receiver sales, says Philips GmbH, the Hamburg-based affiliate of the Dutch company. For the first time, the audio market will match the combined sales of color and monochrome TV sets: nearly $2 billion this year, says the firm.

Because they tend to be highly accurate, Philips' predictions are taken seriously by market watchers. Moreover, the West German economy is considered the pacesetter in Europe. For example, what consumers there snap up now are likely to be the next hot items in other countries.

The segments performing the best are car radios and high-fidelity systems for the home, says the Hamburg firm. Both are expected to do well in coming years; in fact, prospects for audio sales in general through 1980 are bright despite the relatively high penetration figures for some products.

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Circle 67 on reader service card

# One-chip micros spur new race

Intel, Mostek, and TI are bunched up front; basic question is whether devices should be compatible with multichips

| 8-BIT MICROCOMPUTERS | | | | | | |
|---|---|---|---|---|---|---|
| | Intel | Fairchild | Mostek | Motorola | Rockwell | Texas Instruments |
| Computer | 8048/8748 | 3859 | MK3870 | MC6801 | unnamed (1-chip 6500) | TMS9940 |
| Technology | n-channel | n-channel | n-channel | n-channel | n-channel | n-channel |
| ROM size (bytes) | 1,024 | 1,024 | 2,048 | 2,048 | 2,048 | 2,048 |
| RAM size (bytes) | 64 | 64 | 64 | 128 | 64 | 128 |
| Instructions | 96 | 70 | 70 | 72 | 53 | 58 |
| Input/output bits | 32 | 32 | 32 | 30 | 34 | 32 |
| Power supply (V) | +5 | +5 | +5 | +5 | +5 | +5 |
| Availability | now | now | now | 1978, 2nd quarter | 1978, 1st quarter | 1978, with EPROM, 1st quarter, with ROM, 2nd quarter |
| Alternate sources | AMD Signetics | – | Fairchild Motorola | – | MOS Technology Synertek | – |

**The most volatile** segment of the microcomputer market, byte-oriented one-chip devices, has reached flashpoint: three designs introduced during the past year are fighting for supremacy. At stake is a market that should grow to more than $100 million in the next 12 months.

The microcomputers are:

- Intel Corp.'s 8048, an 8-bit microcomputer that comes with 1,024 bytes of program read-only memory, 64 bytes of scratch-pad random-access memory, and three 8-bit input/output ports. The 8048 family, which includes the 8748, the industry's only user-erasable programmable ROM, is upwardly expandable, with matched ROM I/O and RAM I/O chips for adding the extra memory that more powerful control applications need. It is not, however, software-compatible with the general-purpose 8080/8085 family, but can be used with the peripherals. Other suppliers are Advanced Micro Devices Inc., Signetics Corp., and Nippon Electric Corp.
- Mostek Corp.'s 3870, an 8-bit device that is software-compatible with the multichip F8 and is one of the most powerful one-chippers available. It has 2,048 bytes of program ROM, 64 bytes of RAM, and 32 bits of I/O ports. It is not upwardly expandable in program capacity or I/O capability. Other suppliers are Fairchild Camera and Instrument Corp. and Motorola Semiconductor.
- Texas Instruments Inc.'s 9940, which is software-compatible with TI's family of 9900 16-bit microcomputers. Like the 3870, it has 2,048 bytes of program ROM, but its 128 bytes of RAM gives it twice the scratch-pad capacity of the Intel or Mostek entries. Like the 3870, it has 32 general-purpose lines, but like the 8048, it is expandable (to a full 256 bits) and will be supplied in a user-programmable model, the 9940E. Another supplier is American Microsystems Inc.

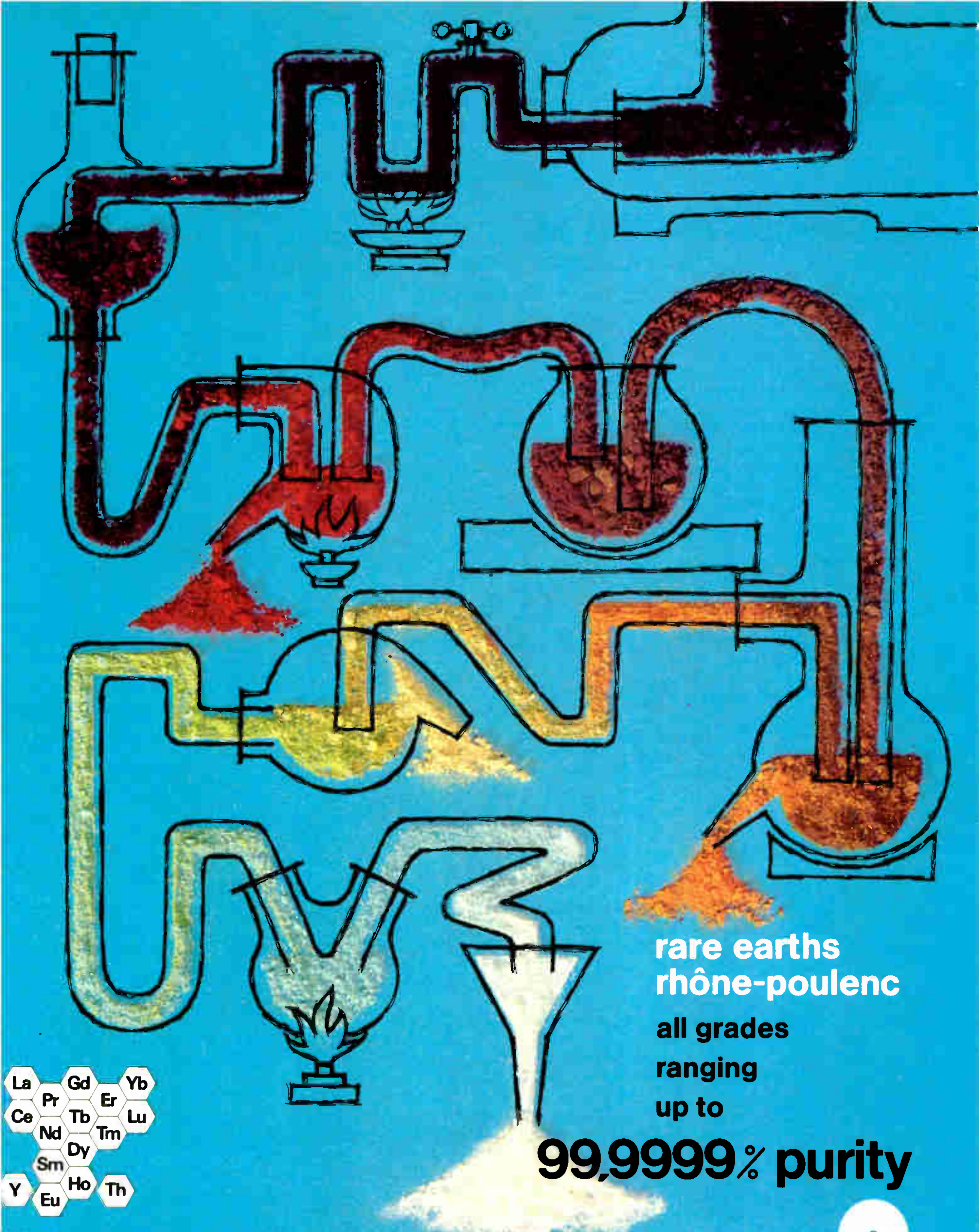
While there are some differences in the processing power and program size of these chips, the three suppliers diverge sharply on the question of whether to make a single-chip microcomputer compatible with established multichip families of devices.

Intel adopted the view that it was better to surrender the compatibility with 8080 software in order to optimize its design around the most efficient software for one-chip configurations. TI, on the other hand, chose to make its 9940 software-compatible with its more powerful multichip 9900 family, so as to minimize its software investment, but at the expense of a slightly less elegant design. Mostek's philosophy stands somewhere between the two. It was able to optimize its one-chip 3870 and still make the devices software-compatible with the multichip F8, thanks to the ease with which the original two-chip F8 design proved capable of being redesigned into a one-chip format.

**Design concepts.** According to George Adams, product marketing manager for low-end microcomputers at Intel, the strategy the Santa Clara, Calif., firm is taking is to build a full family of single-chip devices, all with the same instruction set and the same basic architecture but with different mixes of ROM, RAM and I/O for different price and performance levels.

The software, he says, is used to tailor the particular device in its family of one-chip microcomputers to a specific application. Intel's family of one-chippers is dedicated, in the sense that each is tailored to meet the needs of various segments of the one-chip marketplace.

"Our strategy is to bracket the 8048/8748, above and below," says Adams. At the low end, competitive with 4-bit devices is the 28-pin 8021,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Pr Er
Ce Tb Lu
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with 1 kilobyte of ROM or erasable PROM, 64 by 8 bits of RAM, 21 I/O lines, and a 10-microsecond instruction cycle time. Above it is the 8049, with 2 kilobytes of ROM or erasable PROM, 128 by 8 bits of RAM, 271 I/O lines, and a 2.5-microsecond instruction execution time.

Again, the software and instruction sets of the one-chip devices are not compatible with those of the higher-performance multichip systems. "That would defeat the whole purpose of the one-chip family," he says. "The idea is a family of microcomputers complete on one chip and with software designed specifically for control applications. If there were a one-chip controller with a multichip microcomputer's instruction set, it would be worse than useless."

Quite the contrary, asserts Edwin S. Huber, marketing manager at TI's microprocessor department in Houston. "By making the 9940 compatible with all 9900 devices, we will allow designers who have been using multichip systems with limited amounts of memory to look at single-chip microcomputers for cost reduction and performance improvement," he says. "In the near term, the emphasis at TI is going to be hardware and software compatibility wherever possible."

Mostek poised its part at the juncture between the 4-bit p-channel microcomputers and other firms' single-chip 8-bit entries, optimizing it as a high-volume, low-cost computer for stand-alone applications. That is why, unlike the TI and Intel approaches, Mostek's MK3870 is not expandable but can address 2,048 bytes of program ROM. Users that require more could turn to multiprocessor systems or to the multichip F8 microprocessor from which the 3870 derives its instruction set. Memory for variable data can also be added.

Because the 3870 lacks any inherent program expandability, software compatibility with the F8 was almost a necessity. "We were concerned that 3870 users might have to re-engineer their software in order to expand," comments Robert F. Schweitzer, microcomputer marketing manager for the Carrollton, Texas, firm. "And compatibility is important because it provides a scheme for emulating the device in RAM or PROM before the program is committed to on-chip ROM."

**The pack.** Making a lively situation even livelier are a host of entries from three other manufacturers, some of which will be self-contained families, while others will be subsets of larger series. The latter approach is being taken by Rockwell International Corp. Adding to the wide assortment of one-chip 4-bit devices that make up its PPS/4 series will be a software-compatible, 2-megahertz 8-bit member of Rockwell's newly acquired 6500 multichip family, a system the firm supplies with MOS Technology Inc.

Nowhere is the push toward one-chip parts more evident than at Motorola Semiconductor. Besides getting on Mostek's 3870 bandwagon, the firm's Austin, Texas, MOS operation will also be supplying a device that will be part of and software-compatible with its MC6800 family. The MC6801, due in the second quarter of 1978, will be as powerful as any one-chip model available, with 2 kilowords of ROM, 128 words of RAM, an instruction repertory of 72, and 30 I/O bits.

The firm is also developing single-chip parts that will stand alone. The first is the MC67000, with 2,048 by 10 bits of ROM and 128 by 8 bits of RAM and a serial I/O configuration useful for real-time control applications. The device, in two-chip form, is now sold only to Motorola's Automotive Products division for use on Ford Motor Co. programs. Motorola hopes the experience it gets with the auto part will give it a pricing edge on its standard devices.

Like their counterparts at Intel, the designers at Fairchild, who invented the original F8 microcomputer, are supplying a series of one-chip parts that will be software-compatible with each other and with the original F8 instruction set. The first chip, called the MicroMachine 1, has 1 kilobyte of ROM, 64 bytes of RAM, and 32 I/O lines. Fairchild also will supply the 2-k 3870 Mostek version and will consider offering Motorola's 6801 as well. □

Communications

# New ITT unit has eye on the 1980s

European firm crosses national lines with development of System 12, a PCM system aimed at electronic switching market

*by James Smith, McGraw-Hill World News*

**Electronic switching will** open the next billion-dollar telephone equipment market for the public-telephone business. No one is more aware of this than ITT-Europe, which has already leapfrogged over many of its European competitors in nailing down its position in the field. Through a special Europe-wide center for systems design and manufacturing development set up last fall, ITT is currently completing systems development for a pulse-code-modulation exchange that will be its workhorse for the next decade—much the way the semielectronic Metaconta was for the 1970s.

The vehicle for developing System 12, as the new PCM system is called, is the Brussels-based International Telecommunications Center. ITC now has an engineering and marketing staff of about 100 and is scheduled to go to 130 next year. In addition, it draws heavily for inputs on national design centers in Antwerp, Paris, Stuttgart, and Salerno. An independent company, its stock is held by International Standard Electric Co., the ITT worldwide holding company, and 10 ITT manufacturing affiliates in West Germany, Austria, France, Great Britain, Norway, Spain, Italy, Belgium, the Netherlands, and Switzerland. Officials of the national houses make up the board of directors, with E. A. Van Dyck, senior vice president of ITT-Europe and head of its Telecommunications Group, as chairman and H. O. Nordsieck, vice president of ITT-Europe, managing director.

While Metaconta was the product of a relatively loose cooperation between national houses of ITT, developing the next generation of electronic equipment requires such heavy investment and coordination of production and testing that probably none of ITT's big national manufacturing units could tackle the job alone. System 12, like Metaconta, is intended to be ITT's contender for the public switching business of European countries that do not have their own national switching development programs and for export to Third World countries.

**Test run.** ITT has installed its PCM exchange in Charleroi, Belgium, for a trial. Called System 12, it is being developed by a newly organized Europe-wide center.

To move hard on a standardized PCM system, ITT-Europe officials had to overcome doubts of national houses that feared their participation in ITC might upset delicate relationships with their respective postal and telephone authorities (PTTs). The question was especially sensitive for ITT affiliates already cooperating with national telephone authorities on national development programs.

This was true for ITT's British subsidiary, Standard Telephone Co., which is already engaged in a three-year effort with Plessey Co. and British General Electric Co. to develop System X, a top-secret electronic system for the British Post Office. ITC is required to keep strict separation of technical crews working on System 12 and System X, which is why it has no design center in Britain. The same is true for Switzerland, another country developing its own electronic system. In fact, some of the national systems may eventually compete with System 12 for export business.

**Rivals.** Despite the problems, ITT seems to have a lead in digital switching over its European competitors. Both L M Ericsson and Philips Gloeilampenfabrieken appear to be concentrating on semielectronic exchanges. France's CIT, probably ITT's most advanced European competitor, has reportedly run into cost problems on its E-10 and is thought to be changing its design concept for the larger E-12 system. But the main competition is from North America, where technical developments are monitored for ITC by ITT's affiliate, Telecommunications Technical Center, Stamford, Conn. Some of the pressure is coming from smaller U. S. firms such as Vidar Corp. and Stromberg-Carlson Corp.

But ITT has also been carefully watching efforts of Northern Telecom Ltd., a subsidiary of Bell Canada, which has been selling all-electronic systems to independent telephone companies in the U. S. and is making efforts abroad, mainly in the Far East. ITT is also following efforts by the Bell System to set up an international advisory group.

One of the most complicated problems facing ITT's engineers has been to design a system for both low- and high-capacity exchanges so that purchasers will not have to buy two systems. The main drawback for small switchers has been the cost of control computers, but rapid growth of microprocessing techniques points a way over this hurdle. "The microprocessor," says Nordsieck, "is decentralizing switching control—giving greater flexibility for telephone authorities to start with smaller exchanges."

Size is also a key consideration for developing countries, many of which may move directly to electronic systems. Such countries often install equipment first in large population centers, requiring large exchanges. Some, such as Indonesia and Malaysia, have completed installation of initial systems and are expected to shift to smaller equipment.

To reach the Third World market, ITC incorporated national specifications of key European systems—British, French, Swiss, and West German—even though these countries have national programs that may lock System 12 out of their domestic markets. The objective, however, is to reach export markets whose specifications are still based on those of European countries.

ITC is now producing hardware to meet the 1980 deadline for its first PCM exchange in Jutland. This means it needs its prototype by 1979 and models in 1978. It has completed the first round of circuit design and is putting models together for tests. □

Military electronics

# Navy merges San Diego labs

Electronics center is now part of Naval Ocean Systems Center, the better to develop tactical information systems

*by Larry Waller, Los Angeles bureau manager*

**Narrower goals.** Howard L. Blood, technical director of center, says that before it was revamped it was too spread out.

**If the electronics** industries have heard little of late from the Navy's Electronics Laboratory Center, which normally seeks visibility for its state-of-the-art work, there is a good reason: the San Diego lab no longer exists as a separate entity. Ever since March, it has been part of the new Naval Ocean Systems Center, along with the former Naval Undersea Center.

Why did the Navy submerge its electronics lab into another organization when the lab is renowned for its accomplishments? Since its formation in 1945, its contributions have included the Naval Tactical Data System and, most recently, a worldwide lead position in fiber-optics research.

The official Navy line is: "The consolidation recognizes the increasing importance of tactical information systems integration for the benefit of Naval command." To this end, the new center becomes the principal research arm for the technologies that support this mission and will also develop surveillance and undersea weapons. Furthermore, the elimination of officers' jobs and more than 300 civilian posts is expected to save $1.33 million a year. As of October, the center will have no more than 3,000 personnel—still enough for it to remain a major facility.

But funding pressure itself evidently is not a major reason for consolidation. The tentative 1978 budget for the new center calls for approximately $200 million, compared with $85 million for the former electronics lab and $100 million for the undersea center in fiscal 1977.

**A better focus.** With internal shifts still under way, things are confused. But conditions will start improving when results of an outside study surface next month, believes Howard L. Blood, technical director of the center. "We hope to identify specific areas on which to focus our funding and structure [our operation] accordingly," he says.

Blood believes that such a move will help to correct a condition that was becoming apparent before the consolidation. "We were too broadly spread out and simply couldn't do everything for everybody," he states.

Another goal for the center is to establish a stronger identity in the Navy hierarchy. Most other labs are what Blood calls "platform-oriented," meaning they have a clearly defined mission to serve specific carrier, submarine, or aircraft needs. Instead, "we're inter-platform integrators" whose efforts are somewhat diffused into most Navy programs, Blood says.

**Looking ahead.** He expects electro-optical technology to be perhaps the most eye-catching part of future electronics work, since up to 150 people are already involved in fiber optics and related jobs. Traditionally strong capabilities in electromagnetic-wave propagation and acoustics, both vital in Navy surface and undersea communications, also are slated for heavy emphasis, Blood predicts. At the same time, the electronics-system content of undersea weaponry has grown to the point that a closer association of the two formerly separate centers can be expected to help future developments. Whatever form the structure takes, management continuity is intact. Blood retains the post in the new center that he had in the undersea operation, and Capt. Robert R. Gavazzi, who was commander of the Naval Electronics Laboratory Center, now directs the entire Naval Ocean Systems Center.

The current estimate of how long it will take for new roles to be defined, further changes to be made, and conditions to be smoothed out is a "realistic 12 to 18 months." In the meantime, the center will keep a low profile, meeting its commitments, but not undertaking new ones. □

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Electronics abroad

# The Soviets struggle to catch up

Most resources are reserved for military programs, with little fallout allotted for civilian sectors

*by Peter Hann, McGraw-Hill World News*

**In the Soviet** Union, the electronics industries are like an iceberg. Under water is the military area: it is much bigger than the civilian sector and gets top priority in both money and manpower. It is never publicly discussed by the Russians and is virtually impenetrable as far as foreign experts or businessmen are concerned.

The smaller, visible tip is the civilian segment: it absorbs much less in the way of resources but is still extremely hard to quantify. This difficulty is largely due to the Soviets' sense of secrecy, but it is partly because some electronics—airport radar and space hardware are examples—obviously have quasi-military significance. One feature of the Soviet system is that scientists, engineers, and other experts, who in the West would move freely between defense and civilian work, never do so in the Soviet Union. This restriction limits cross-fertilization of experience and ideas, and it means that the advantages that the Soviet military programs enjoy do not result in the kind of spin-off that the U.S. space programs, for instance, have brought to U.S. consumer electronics.

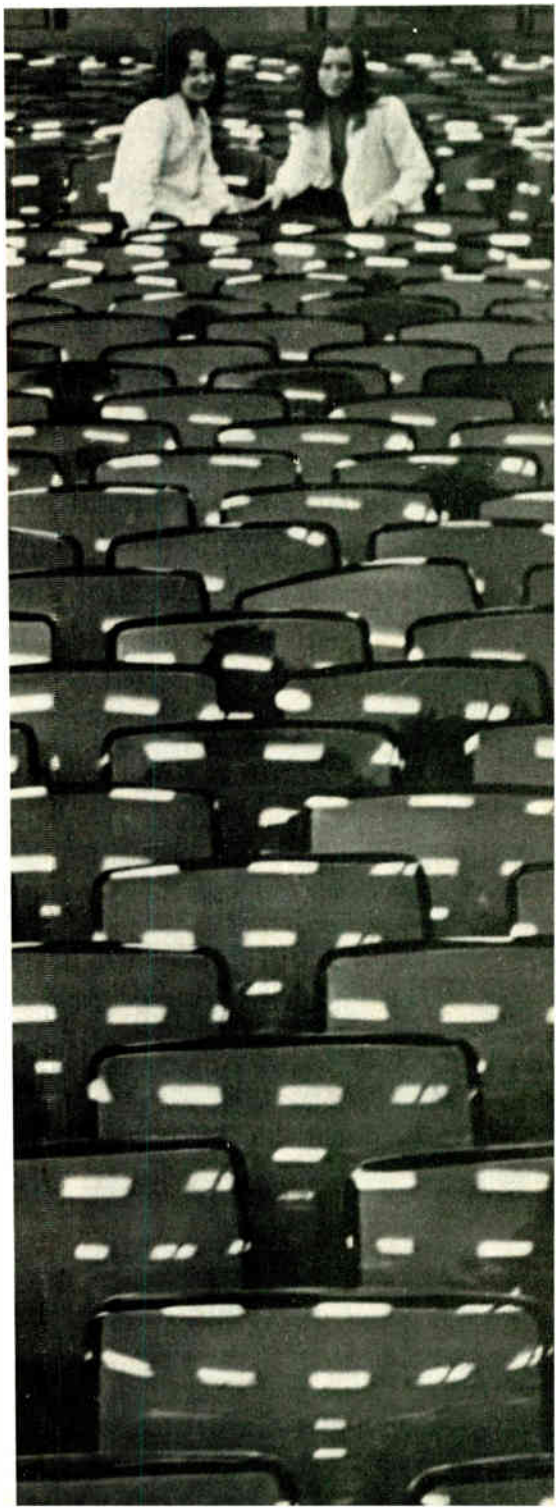
The development of electronics is of prime importance to the Russians, who are faced with a labor shortage that demands the introduction of more automation into industry. Electronics is also a key element in the energy field, which is enormously important to the Soviet economy, but trying to pin down Russia's exact intentions is difficult.

This article is the sixth in a series that examines the electronics industries of the Eastern European Bloc, or Comecon.

The current five-year plan, which runs from 1976 through 1980, offers mainly generalizations. It says, for instance, that the aim is "to increase the output of instruments and means of automation 1.6 to 1.7 times and of computer facilities 1.8 times" during the period. But there are no specific figures to establish exactly what these increases will mean.

The Russians' objectives and progress become clearer, however, from a study of their dealings with some of the Western and Japanese companies trying to do business with them. The general conclusion to be drawn is that the Soviets are well behind the West in almost all areas of electronics. Their research is often as good as that of their Western colleagues, with whose work they are usually familiar. But the equipment used in research is sometimes inferior; more important, when a good idea emerges, it invariably gets bogged down in the production process. The problem of turning ideas into products plagues Soviet industry as a whole but is particularly noticeable in electronics, where technology is moving so fast.

**One generation behind.** In computers, the Soviets are considered to be from five to seven years behind the West. In hardware terms, this means about one generation and reflects Russian failure to master the technology and manufacture of advanced integrated circuits. Some Western sources estimate Soviet output at less than 1,000 computers a year, so that the Soviets appear to have



**Parade.** TV tubes made in Lithuania are exported to Italy, France, Finland, Yugoslavia, and other countries.

## Probing the news

**Getting the picture.** Scientists in Kharkov use graphics terminal to design air- and water-purification systems for the region.

perhaps 5,000 to 7,000 computers at work in the civilian sector today.

Nevertheless, the Russians have a computer industry that is growing. Its main emphasis is cooperation with five other members of the Council for Mutual Economic Cooperation (Comecon), each of which collaborates in making machines or computers under the unified system of Electronic Computers of Socialist Countries (ES for short), previously called the RJAD program.

The smallest are the ES1020, with a speed of 20,000 operations per second, which is made jointly by the Soviet Union and Bulgaria; the ES1021, a 40,000-operation/s machine made in Czechoslovakia that is designed for management and economics work; and the ES1030, a Soviet-made computer capable of 80,000 operations/s.

The group is also producing larger machines. The ES1040, made in East Germany, can handle 300,000 operations/s and is intended for high-level scientific work, according to Soviet literature. The ES1050, capable of 500,000 operations/s, has just gone into production in the Soviet Union. The Soviets also claim that by November they will have assembled their first fourth-generation machine, the ES1060, which will handle 1.5 million operations/s, with a random-access storage of 256 to 2,048 kilobytes.

To date, the Russians appear to have sold about 400 small- and medium-sized computers, the vast majority to their Comecon partners. This year, the Soviets have also begun to push exports of the ES1033, which they say is 2.5 times faster than the ES1030. Specifications published by Electronorgtechnica, which handles computer exports, say it can solve up to 15 problems simultaneously and has a storage capacity of up to 512 kilobytes. The organization claims to have orders for 40 ES1033s.

Despite this record, the Russians are plainly interested in buying Western computers whenever their own conditions and those outside permit. The potential size of the Soviet market is hard to pin down. "There are about 6 to 10 big opportunities every year," says Gary Lehr, Moscow representative for Honeywell Inc. He says these are worth anything from $2 million to $15 million each, which means a total of perhaps $100 million a year.

**Lightning.** In the broad area of communications, the Soviets are making tremendous efforts to span their huge country, which has 11 time zones. They have a well-established network of communications satellites and ground stations that they plan to expand before 1980. The basic system comprises the Molniya (Lightning) satellite, the latest of which, the Molniya-3, has an on-board computer, three complete transceiver systems, and a sun sensor that powers a solar-cell propulsion system. It is being used to relay color TV programs.

The Molniyas work in conjunction with a series of approximately 60 comparatively simple ground stations called the Orbita network. By 1980 the network will have 70. Three of the existing installations are outside Soviet borders.

The latest development is the introduction of the Statsionar or Raduga (Rainbow) satellites, which sit in stationary orbit over the equator to give continuous coverage of the country. These satellites relay both TV programs in color and black and white and telephone and telegraph messages, and they are shortly to carry computer data also. At least 10 are to be in use by 1980.

**Space wrangling.** For the longer term, the Russians want to set up a system called Intersputnik, which would rival the U. S.'s Intelsat. But the radio frequencies and the positions in space over the equator required by the plan have caused an international dispute with France and West Germany, which are collaborating on the Symphonie series, and with Indonesia.

Telephone communications are also due for a big expansion in the Soviet Union, which is still in the Dark Ages in some respects. Moscow, a city of about 8 million, has only 2 million phones. Breakdowns and interruptions are frequent, and most of the exchanges are about 30 years old. Direct dialing is available to many cities, but the noise level is often high. Britain's Plessey Co. has penetrated this market, having sold two electronic 1,000-line exchanges with multifrequency push-button phones. The company has also been talking about a 7,000-line exchange.

In broadcast equipment, the Soviets are producing both color and black-and-white television sets, but without integrated circuits. In 1975, three out of four Soviet families owned a TV set. Monochrome production will be about 7 million sets this year, and color sets, based on the French Secam system, will total just over 1 million. Earlier this year, Soviet officials were talking about buying the PAL system to produce a two-system set for export. □

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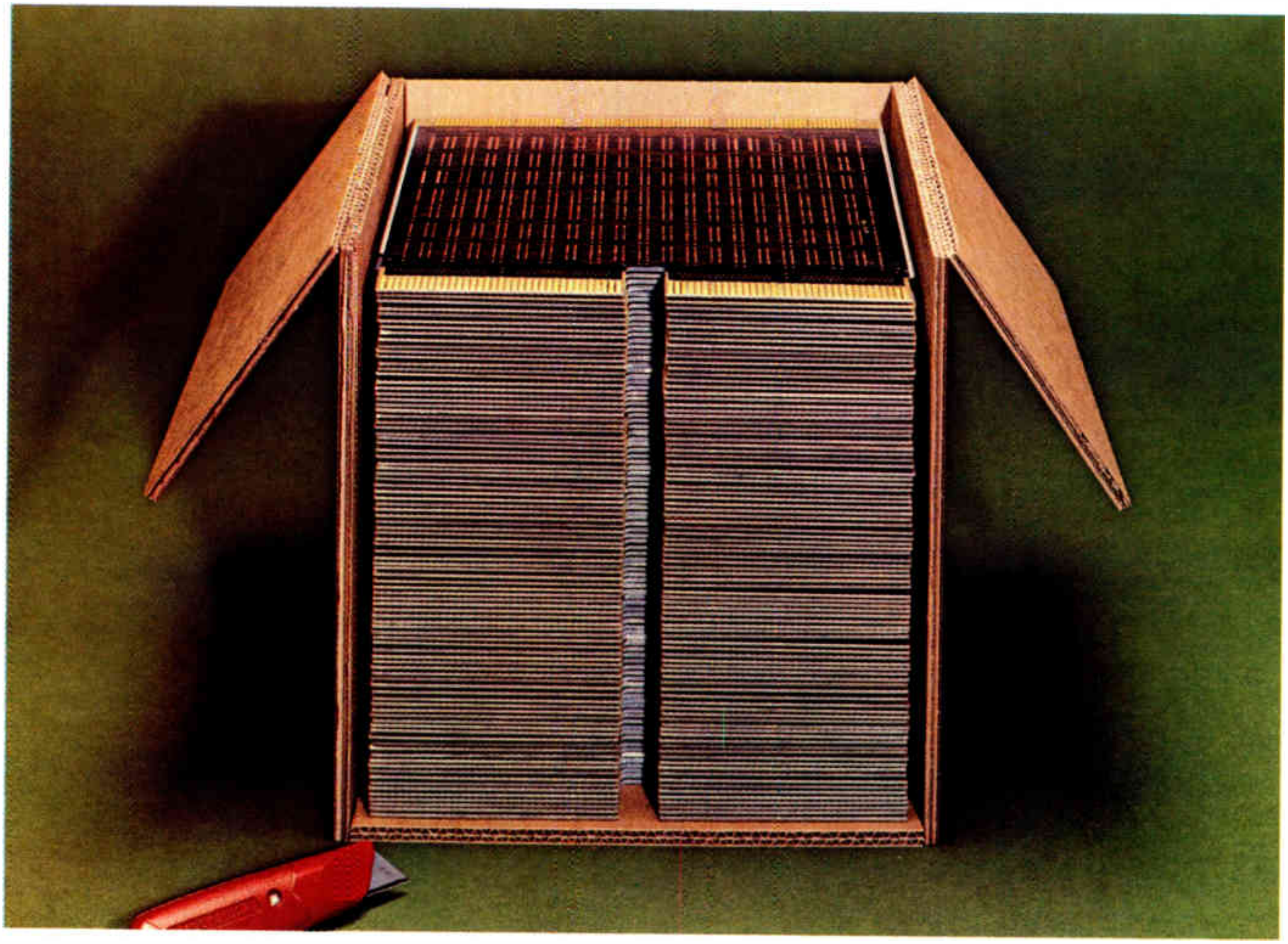

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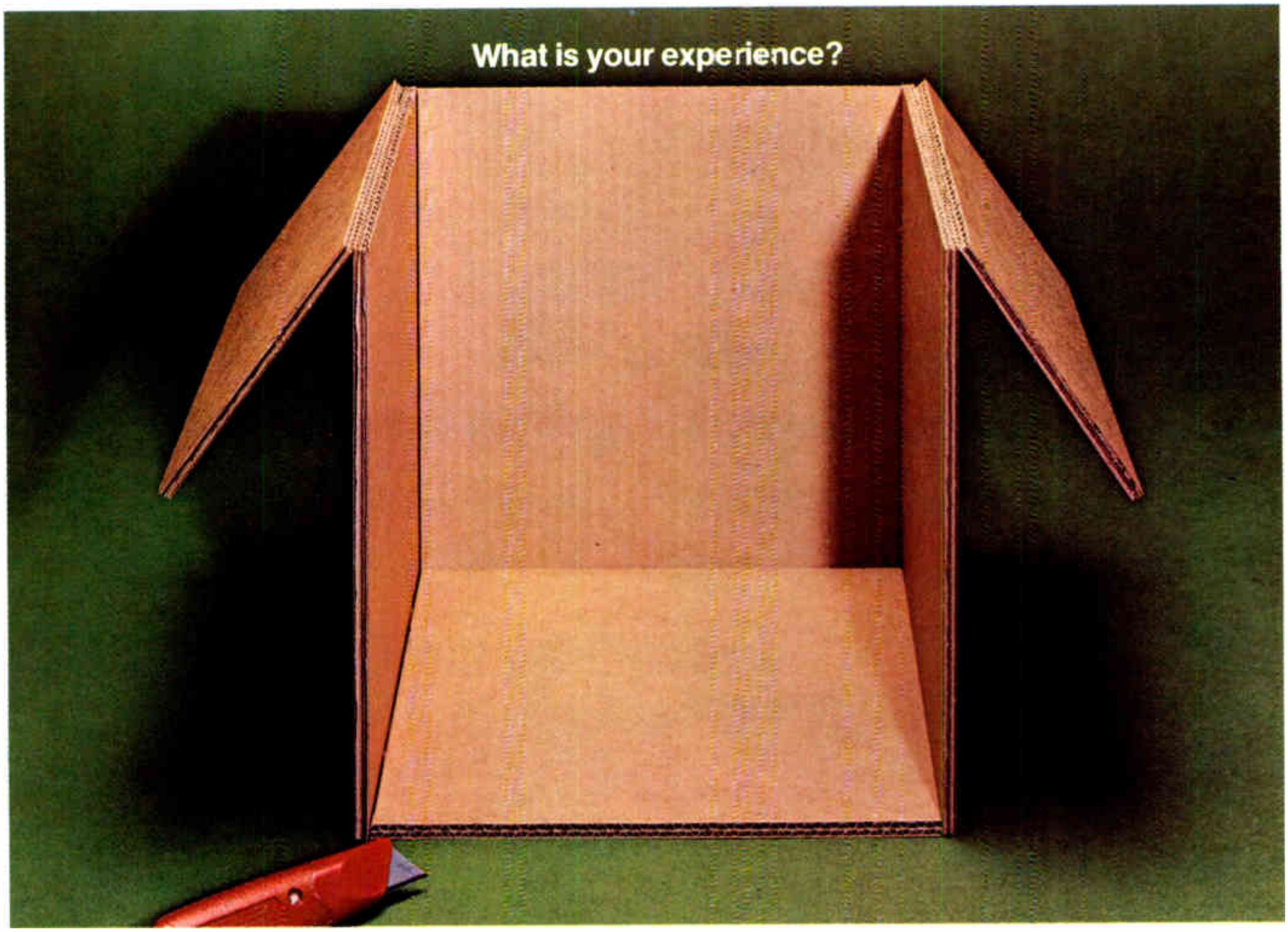


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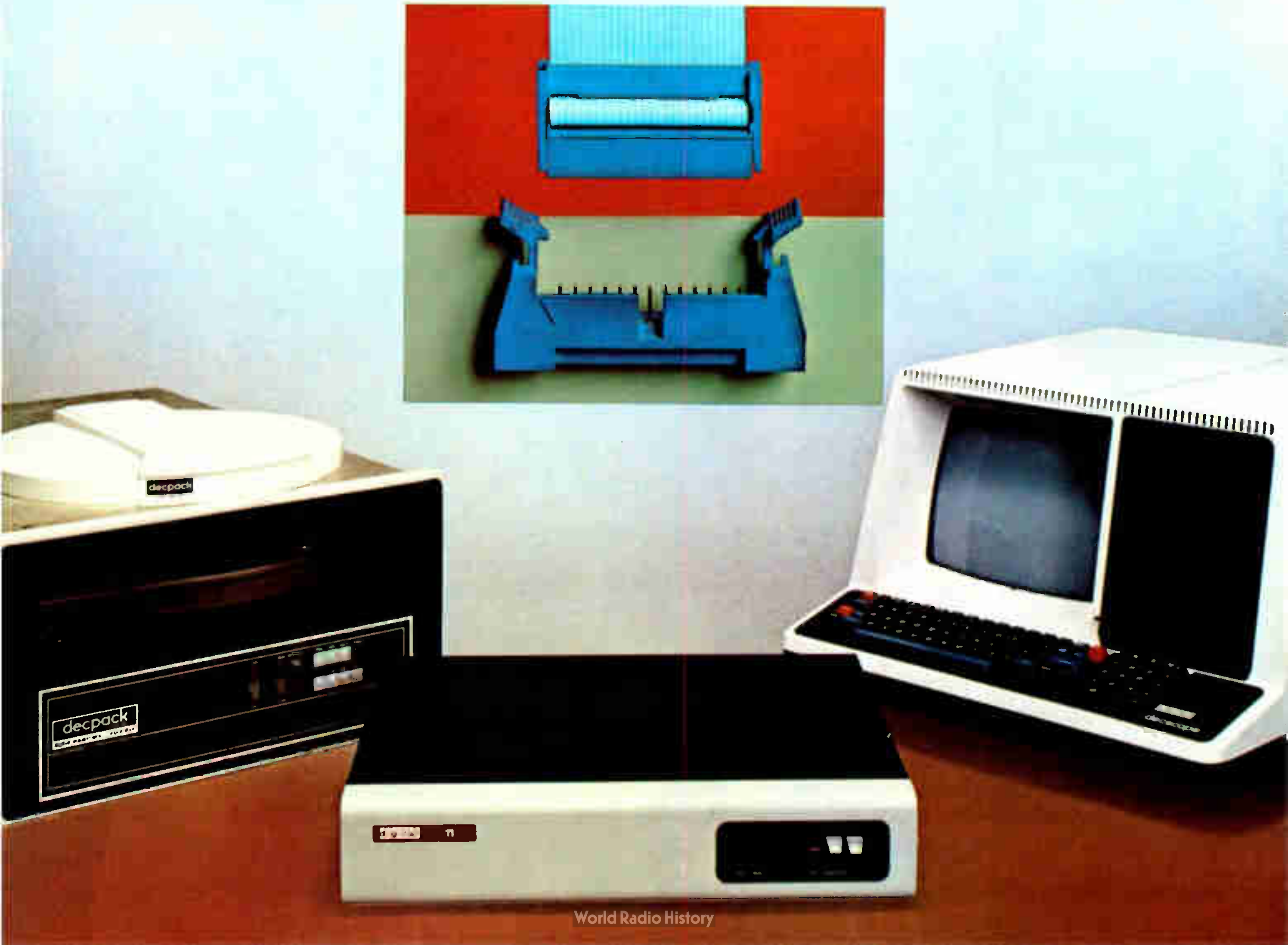


# Technical articles

SPECIAL REPORT

## Automotive electronics gets the green light

by Gerald M. Walker, *Consumer Editor*

☐ Now speeding along after a slow cranking-up period, automotive electronics is bringing the passenger car to a new level of efficiency, convenience, safety—and complexity. The big challenge to the electronics designer these days is that the great traffic cop in Washington, the Federal Government, has mandated both nonpolluting cars and gas-saving engines. As usual, there is much debate over how soon and in what ways its conflicting demands can be met, but on one thing the Big Three are finally agreed—electronic engine controls will be essential.

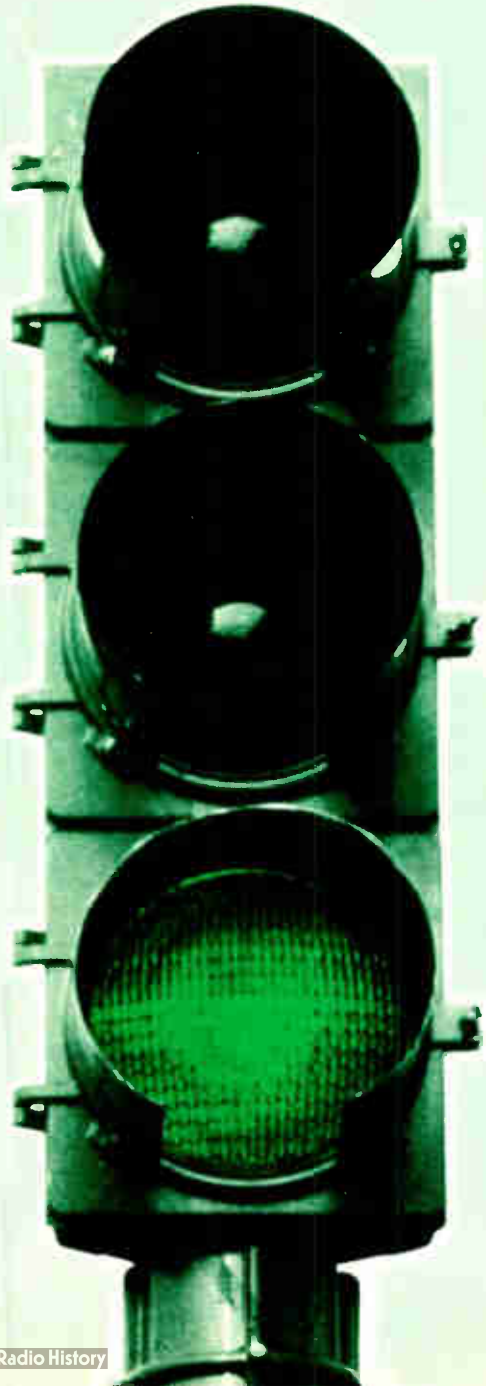
Adding electronic controls to an engine of itself improves fuel economy and limits polluting emissions. Electronic spark advance and electronic fuel metering, separately or in combination, are the two principal approaches here. Digital controllers seem to be winning out over analog systems for spark advance. But the car makers differ on whether to go with a greatly altered but still recognizable carburetor or whether to swing over to electronic fuel injection, as General Motors has done in its Cadillac system. The availability of low-cost sensors is another concern. But the biggest problem concerns the catalytic conversion of exhaust gas wastes, which for efficiency must work with an electronic engine control but which at the same time prevents it from maximizing fuel economy (see "Fuel economy conflicts with cleanliness," p. 85). Still, Government pressure makes this the fastest track in automotive electronics.

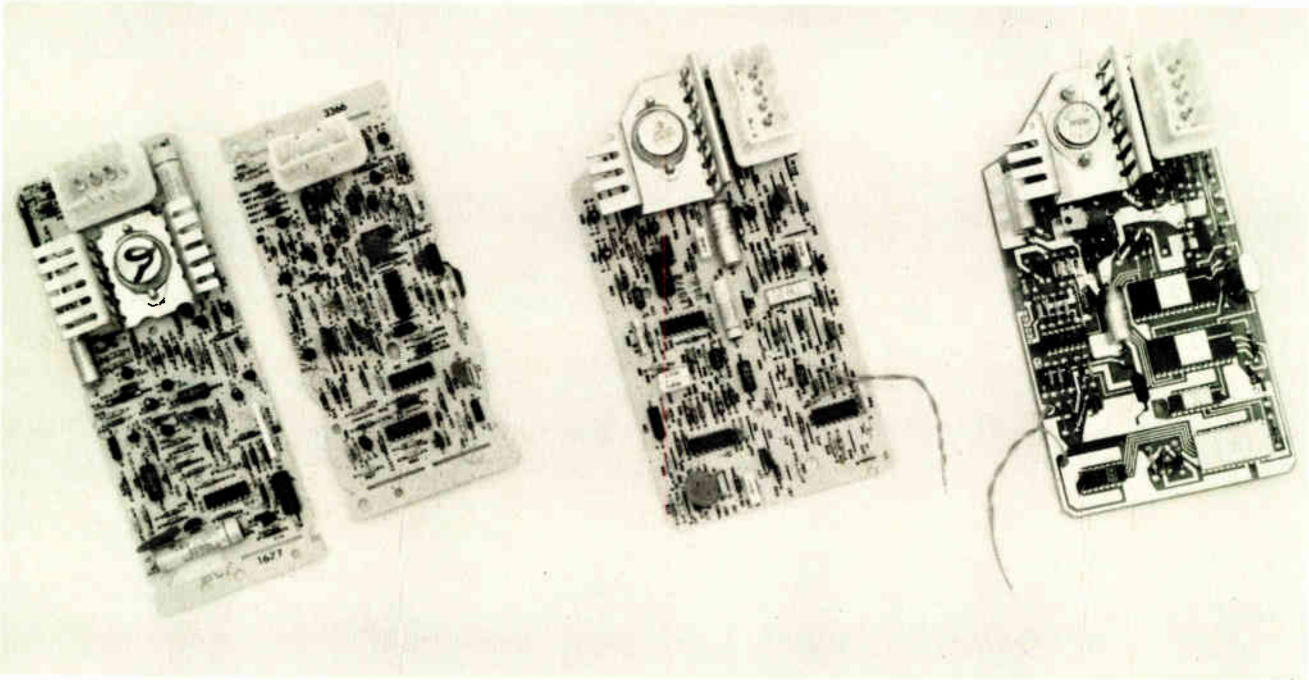
Moving almost as fast, the car's other electronic subsystems are continuing to evolve. Digital displays are perhaps the liveliest issue here. As for circuitry, voltage regulators and electronic ignition systems, two of the first converts to electronics, have already gone into second generations with increased integration. Yet to be settled is whether controls for headlights, intrusion alarms, windshield wipers, hazard flashers, and so on, should use custom large-scale integrated circuits or general-purpose microprocessors. By now, standard microprocessors have fallen far enough in price to compete with custom LSI, which has a high front-end cost, and if designers opt for them, that could mean the use of six to eight microprocessors per car.

### The computerized car

Indeed, car makers are already working toward the day when the automobile's various sensing, control, and display systems can be integrated completely into microcomputer-based systems, though it is not yet clear whether each car will have a central computer or an automotive version of distributed processing. Either way, the automobile of the mid-1980 model years will be a rolling computer center in which multiplexing will have become a necessity.

Still close to the starting line, however, are totally new electronics systems such as radar-controlled braking for increased safety. This effort and others like it (adaptive suspension is an example) are still at the laboratory stage. While they are promising, they face either technical or cost obstacles or both that will delay their





**1. Lean-burn generations.** Since introducing its lean-burn spark-advance system, Chrysler has continued development. The first was an analog two-circuit-board version (left), the second was cut to one pc board, and the third is a digital microprocessor version.

adoption until well into the 1980s. (Actually, it is safe to say that today virtually every conceivable application of electronics is undergoing development or evaluation somewhere within the highly secret confines of the automobile companies' laboratories.)

Finally, the extent of all these electronic applications raises the specter of maintenance and repair. The average car is already straining the capabilities of the trained mechanic, so for fear of selling a machine too complex to maintain, the automobile firms have stepped up their programs for developing automated test and diagnostic systems for repair shops (see "Testing goes microelectronic, too," p. 90). They are also working on an on-board microprocessor-based diagnostic system that would monitor the operation of the engine, the amount of air in the tires, and other vital functions and alert the driver to any problems. But they are leery of providing him with more information than a warning—the highly sophisticated diagnostic systems will be reserved for the mechanic back in the repair shop.

### Focus on engine controls

The engine is what a car is all about, so any system or components that affect its performance are treated by Detroit's designers with the utmost care.

"The most sophisticated large-scale integrated circuits won't impress a motorist much if they cause the car to break down some rainy night in the middle of nowhere," an automotive company electronics development manager points out. "That's why we make sure that every new system has a 'limp home' capability, so that if the electronics fails, the car will run—maybe not very well, but well enough to get the driver home."

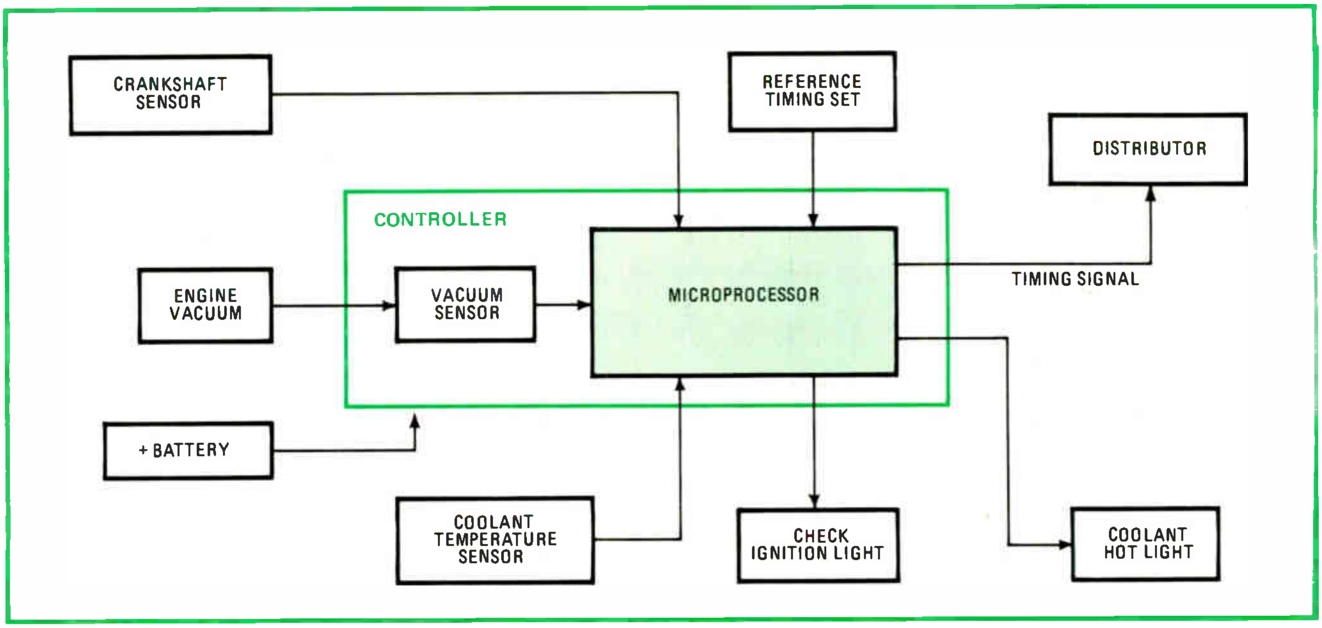
Chrysler Corp. was the first in the field, with an electronic lean-burn spark-advance system intended initially for 400-cubic-inch four-barrel engines. An analog design, it has two printed-circuit boards containing the spark-advance controls and receives four inputs from the throttle position, engine vacuum, and water and inlet air temperature.

Since then, the company has phased in a one-board version for 1978, which uses three custom chips and has reduced component count from 230 to 120. It will go on all V-8s and on the company's new line of four-cylinder subcompacts, the Omni and the Horizon, due to be introduced later in the 1978 model year. Chrysler intends to have the lean-burn system on all its cars and light trucks after 1978, although, because of the carburetor design, the six-cylinder cars will be more difficult to equip with such a system.

The next step—further integration—has already been taken. Chrysler is working on two approaches at present. The first is a digital, microprocessor-based lean-burn system that will undergo a thorough production test run this year (Fig. 1). RCA Corp. is at present supplying the parts—its 40-pin 1801 microcomputer, plus a 1,024-bit read-only memory, a 32-byte random-access memory, and a complementary-metal-oxide-semiconductor input/output device. The second, also a digital, microprocessor-based system, will add electronic fuel metering to the spark-advance computer. RCA Corp. and Texas Instruments Inc. have been signed to compete for its design, which will probably require an extra 1-k ROM and an extra I/O chip. Eventually, either system could be reduced to a single processor and memory chip plus a custom I/O device.

### The Misar system

General Motors Corp. also made its entry into electronic engine controls with a spark-advance system, called Misar (for microprocessed sensing and automatic regulation) and designed by its Delco-Remy division for




**2. Advanced spark advance.** The Delco-Remy Misar system funnels four inputs into a 10-bit custom microprocessor developed by Rockwell. It is a spark-advance system programmed with a "map" of the spark timings appropriate to different engine conditions.

the 1977 Oldsmobile Toronado (Fig. 2). The system permits the engine to be tuned to improve fuel economy and drivability and, according to GM, has cut the Toronado's fuel consumption by approximately 10%.

Basically, the Misar system is a "map" of spark-advance settings stored in memory and accessed in the initial design by a custom 10-bit microprocessor from Rockwell International Corp.'s Microelectronics division. Input signals are crankshaft position, manifold vacuum, coolant temperature, and reference timing. Fed with these four inputs, the microprocessor in effect looks up the spark advance required to match the driving conditions and passes the information to the distributor. The advantage of the microprocessor is that it can be programmed to fit the characteristics of various engines.

In addition, the Misar system can be expanded to take on other engine control functions, such as fuel metering or exhaust-gas recirculation, because of its as-yet unused ROM capacity.

While the 10-bit microprocessor for the Misar program is a custom design, it is not clear yet whether other companies in the GM family will take the same route. The I/O chip will remain a custom design without question, primarily because of the specialized sensors that must be used. For the microprocessor, however, customized versions of the general-purpose machines will

## Fuel economy conflicts with cleanliness

An automobile that always burned up all the gas fueling it would be both economical and nonpolluting. No engine attains this goal, but electronic control can bring it very close—if not close enough to satisfy the Government.

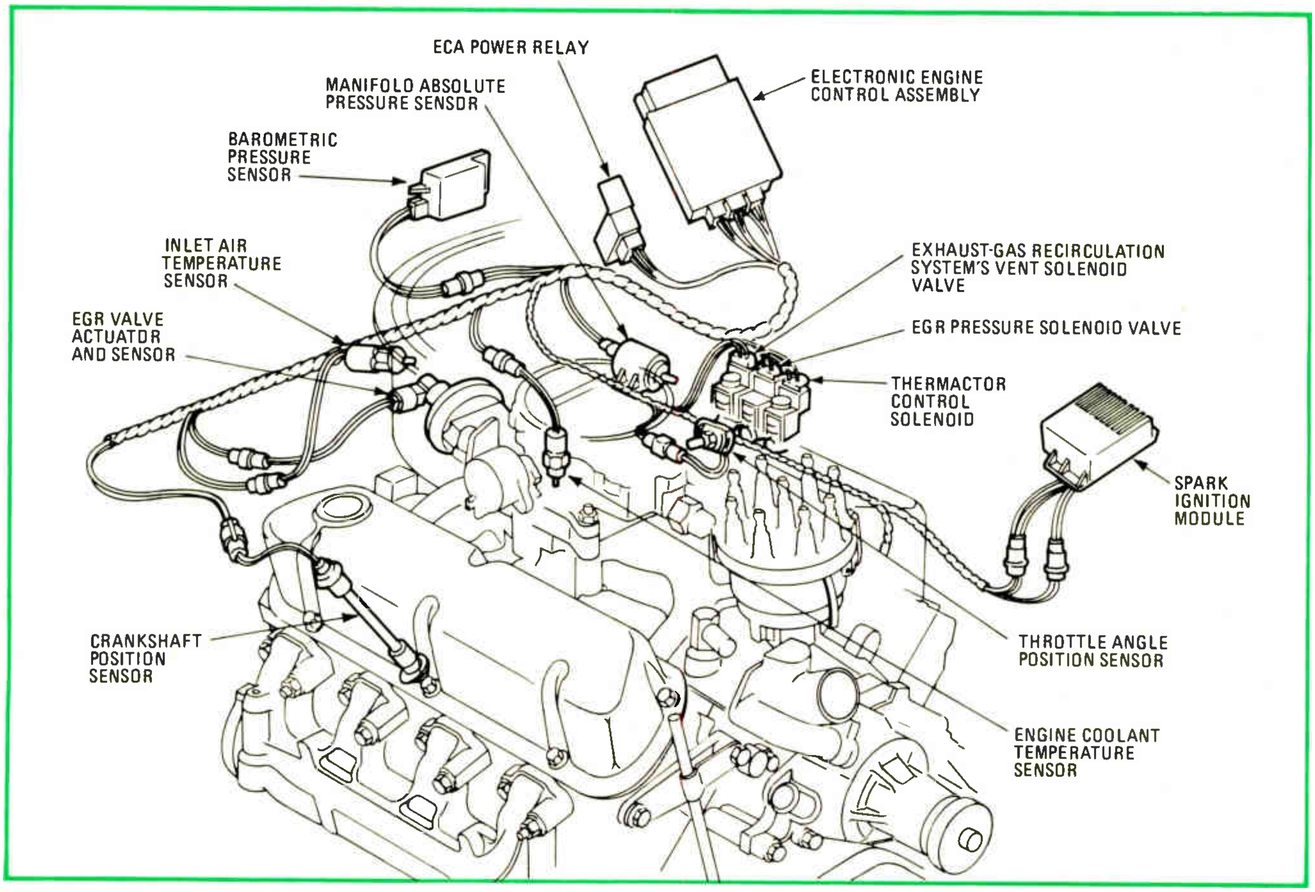
For all the gas to burn, it must be mixed with sufficient air, in at least the chemically correct or stoichiometric air-fuel ratio. At moderate speeds, however, a car runs easily off a much leaner mixture, one containing proportionally more air and less fuel, while to start or go really fast, it needs a richer-than-stoichiometric mixture. Otherwise variations in the mix delivered to the various cylinders may cause stalling or knocking and overheating at high speeds. For instance, a lean mixture tends to retard combustion, hence the usefulness of spark-advance systems.

So far, the goal would seem to be to operate the car at all times off the leanest mixture consistent with drivability. An electronic engine control can do this by using inputs from critical variables—notably engine speed, quantity of air intake, and temperature, whether of air or coolant—to fine-tune some aspect of fuel use by, say, spark timing or fuel metering. This fine tuning also keeps polluting emissions low, but the Environmental Protection Agency wants them kept still lower, causing a design predicament.

The problem is that the only known method of further reducing emission levels—catalytic conversion of exhaust gases into nonpollutants—requires not a lean air-fuel mixture but one controlled precisely at the stoichiometric ratio. It therefore militates against the fuel economy mandated by another set of Federal regulations.

The conflicting requirements are these: on the one hand, the Environmental Protection Agency (as of the time of writing) intends to limit automobile emissions of hydrocarbons, carbon monoxide, and nitrogen oxide to at most 0.41, 3.4, and 0.4 gram per mile, respectively, and it wants these standards met by 1980 (recently moved back from 1978). On the other hand, Public Law 94-163 requires each manufacturer to have a production-weighted average fuel consumption of 18 miles per gallon in 1978, 20 mpg in 1980, and 27.5 mpg in 1985.

Still, any solution involving catalytic conversion has to involve electronic control of the air-fuel ratio. Remember the 1974 model year cars, which limited emissions with the converters alone and as a result suffered from hesitation and slow startup.




**3. Recirculation.** The first electronic engine control from Ford puts both spark timing and exhaust-gas recirculation under the control of a 12-bit microprocessor. It uses seven sensors, and its outputs go to two actuators—the spark-ignition module and the EGR valve actuator.

be used, depending on the engine-control application. Motorola Inc.'s Integrated Circuits division has a contract with GM to supply it with microcomputer devices built around its 8-bit n-channel MOS family and also to furnish design and processing technology to GM's Delco Electronics subsidiary.

## A building-block approach

Ford Motor Co. has announced three distinct systems for engine control, of which two are aimed at emissions control and one at fuel economy. The idea is eventually to combine all three systems.

The first is a microprocessor-based system combining ignition timing and exhaust-gas recirculation (EGR), designed to meet current emission-control regulations, but also intended as a building block for future model years. As diagrammed in Fig. 3,, the 2-bit microprocessor is fed by altogether seven engine-condition sensors and controls two actuators. The seven sensors comprise two pressure, two position, and two temperature, and one exhaust-gas device. One actuator governs the standard ignition module, which produces the high-voltage pulse fed to the appropriate spark plug. The other controls the EGR valve, which diverts unburned fuel from the exhaust back into the intake manifold. The 1978 model version has 12 custom integrated circuits, including a 12-bit microprocessor developed by Tokyo Shibaura Electric Co. (Toshiba) in Japan.

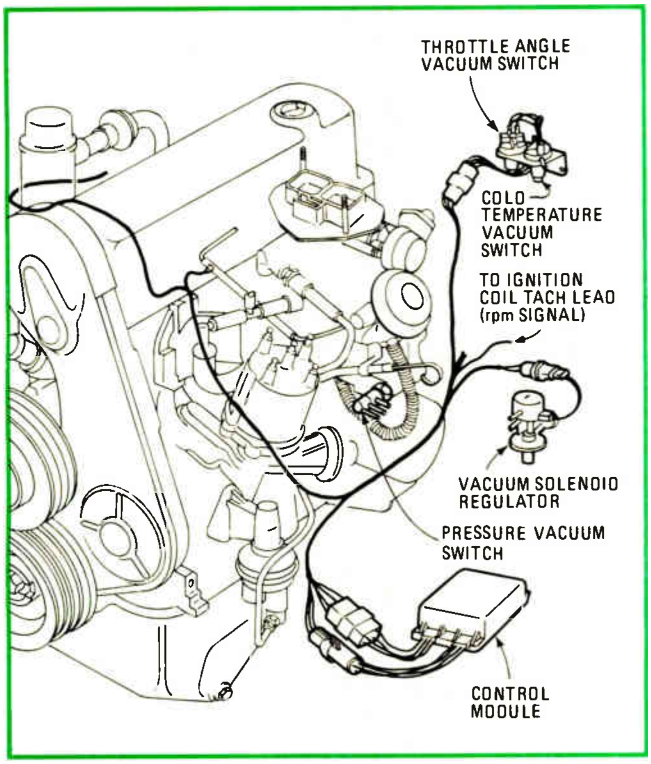
A vital part of the electronic engine-control design is what Ford calls "default logic." The company has determined that redundancy, the hallmark of the aerospace industry, is not the best way to ensure reliability on an automobile, because of cost and space limitations. Instead, to protect the driver against unnecessary towing, the default logic allows the control to ignore a failure and keep the engine firing. There is an easily recognizable loss in operating efficiency, but the car runs well enough to get to a repair station.

The second major system, also intended to be a building block for future combined electronic engine controls, is a feedback carburetor system (Fig. 4). When mated with a three-way catalytic converter, it will help meet future emissions-control requirements.

## Catalytic conversion requirements

The three-way catalyst allows simultaneous conversion of hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen ($NO_x$) into harmless wastes. But for the catalyst to perform satisfactorily, the engine must have a very closely controlled air-fuel ratio. In fact, an offset of 2% from the ideal or stoichiometric air-fuel ratio can result in a 30% reduction in conversion efficiency. A standard carburetor cannot adapt adequately to the variations in engine operation and so will not give the catalyst the quality of input needed.

Instead, a feedback control has been designed for the carburetor (Fig. 5). Whenever the engine is running outside the ideal air-fuel ratio, a sensor placed in the




**4. Electronic carburetor.** Ford's feedback carburetor is designed to work with a three-way catalytic converter to meet emissions control requirements. An exhaust-gas sensor feeds data to the control module, which then adjusts the carburetor's air-fuel ratio.

exhaust manifold sends signals to an electronic module, which then corrects the fuel-metering system, in this case, the carburetor. For example, if the oxygen in the exhaust manifold is running too high, the carburetor is set to a richer air-fuel mixture. To put it another way, the closed-loop system optimizes catalyst performance by keeping the air-fuel ratio in the stoichiometric region.

Besides the exhaust-gas sensor, the system has a couple of special-condition sensors for cutting out the converter when the engine is cold or idling. The only output is the carburetor control.

Probably the most intriguing new control, which Ford will bring out later in the 1978 model year, is the dual-displacement engine (DDE) system, to be introduced as an option on some trucks with 300-cubic-inch, six-cylinder engines. Engines are designed for vehicles to meet peak demand but are not always operated at peak demand, which means a loss in efficiency. In recognition of this, the dual-displacement engine system is designed to tell when the full power of the engine is not needed and turn off three cylinders, thus saving fuel. On the basis of tests covering both city and highway driving, Ford expects its DDE system to increase fuel economy by 10% on average.

In the DDE system (Fig. 6), there are sensors for engine load, temperature—the DDE system will not operate when the engine is cold—throttle position, and engine speed. There is only one output: signals to three solenoids that are directly mounted in the valve train. Energizing these solenoids stops valve motion, sealing off those three cylinders. For the driver's convenience, there is an indicator light, to tell him when the cylinders have been deactivated, and a toggle switch for overriding the control system and returning the vehicle to six-cylinder operation.

After the 1978 model year, if no major problems arise, Ford will likely extend the DDE concept to eight-cylinder vehicles and passenger cars. At the same time, it plans to mix and match all three control systems.

In fact, it has also taken steps to combine the first two, as evidenced by its recent announcement that Motorola Semiconductor has won the design award for the engine controls to go into the 1980 model cars. Until this point, the spark-timing and EGR system has been supplied by Toshiba, the Essex group of United Technologies Corp., and Ford's own Electrical and Electronics division (EED), which is supplied by Texas Instruments Inc. and Intel Corp. The carburetor controls have come from Motorola's Automotive Products division and EED.

Now spark timing, exhaust-gas recirculation, and fuel management will all be handled by Motorola's two-chip system, which mates an n-channel MOS microprocessor with an injection-logic I/O and analog-to-digital converter chip. The other suppliers will have to copy Motorola's customized approach.

Ford expects to ship just 30,000 cars equipped with the 1978-model-year spark-timing and EGR system. For the 1979 model year, Ford expects to ship some 100,000 to 150,000 of these systems, using a repartitioned module that will reduce the nine custom ICs to six. This module will be used until the two-chip combination system can be phased into production.

Application of sophisticated electronic controls to the engine raises the ticklish problem of where to locate the control modules. So far, the Big Three have split over whether to put the engine controls in the engine compartment or in the passenger compartment.

### The best place

The tradeoffs are almost equally balanced. On the one hand, auto designers like to put engine components in the engine compartment, where they are accessible and easy to connect to the portion of the engine they control; but the temperature there reaches 105°C and dictates insulation for electronic modules. On the other hand, the passenger compartment has a more congenial climate for electronics, but requires connective wiring through the fire wall, which auto engineers do not like.

To date, Chrysler has opted to mount the control module in the engine compartment. Comments Earl Meyer, its chief engineer for engine electrical engineering: "We tried heavy insulation of the type used for batteries, but found it too costly. The solution was to mount the spark-advance computer at the air intake point, close to the engine. Mounting it away from the engine, you face wiring and harness problems that probably double the possibilities of failure."

For its electronic engine controls—the Misar spark-advance and also the Cadillac analog electronic fuel-injection system—General Motors has chosen the passenger compartment. John T. Auman, executive engineer of advance products engineering at the General Motors Technical Center, points out that the engine

## What about air bags?

Another recent Federal regulation requires passive restraints to be installed in all new automobiles by the 1984 model year. The air bag controls, of course, would be electronic.

The announcement took the auto companies by surprise, since the Government had appeared to be favoring a study period before making a decision. In fact, General Motors Corp. had signed a contract with the Department of Transportation for a Government subsidy to install air bags in 150,000 intermediate-sized cars for the 1980 and 1981 model years and then sell the cars to consumers at no extra cost. The goal was to discover how acceptable air bags would be to the public and to track how they performed.

Now, seemingly regardless of the results of this project, the auto companies will have to install air bags in large cars from the 1982 model year on, intermediate-sized cars from 1983 on, and small cars from 1984 on. At present, the car makers are "studying" the impact of these installations, so that the actual design work has yet to begin.

Use of air bags is bound to increase the amount of electronics in the automobile, adding acceleration-deceleration sensors, control modules, and on-board recorders that will monitor air bag performance. But neither the auto companies nor their electronics suppliers appear overly enthusiastic about the prospect. They have been down this road before with the seat-belt interlock systems: a year after the belts became mandatory, Congress wiped out the regulation because consumers were complaining about the inconvenience. Now the auto producers all fear they will be forced to gear up for air-bag installation only for the requirement to be eliminated after the fact.

compartment environment may affect the peripheral components more than the microprocessor. Particularly sensitive are driver circuits with high duty cycles operating at high currents and temperatures.

Ford is in both camps. Two of its three engine-control systems are in the engine compartment—the carburetor feedback and the dual-displacement engine modules. The microprocessor-based spark-timing and exhaust-gas recirculation module is in the passenger compartment. "We have no long-term position on location," remarks Robert S. Oswald, manager of electronic engine controls for Ford's engine engineering department. "You can create an 80°C environment in the engine compartment with proper insulation and shielding, but you've got to pay for it. You get that environment automatically when you go into the passenger compartment. But accessibility of components and length of harness both strongly favor the engine compartment.

"If the semiconductor manufacturers can get the technology to a point where temperature capability is available without a significant increase in cost, then there's no decision—it will all be in the engine compartment. The perfect engine control would be mounted on the engine where you can assemble and test the system as an entity," he concludes.

Auto companies in Europe, which have often led Detroit in introducing design innovations, have been somewhat slower in applying microelectronics, particularly microprocessors, to engine controls. The Japanese car makers, Nissan and Toyota, are being even more cautious, apparently waiting to see what the Americans do. Cost of electronics, particularly as it affects the price-sensitive small imports, is the major roadblock for microprocessors overseas.

### Overseas producers proceeding with caution

Nevertheless, some companies are working on engine-control systems, realizing that ever-tightening requirements for fuel economy and pollution abatement enforce the use of electronics. As in the U. S., the auto systems suppliers and their semiconductor suppliers are pushing the development of automotive electronics in pace with the auto makers.

For example, at Robert Bosch GmbH, the big German automotive-accessory maker, microprocessors are currently undergoing vehicle tests as controls for two engine functions—ignition and fuel metering. (Later on, processors will also be tested in electronic transmissions and for anti-skid control.)

Microprocessor-based ignition systems with digital spark advance will probably be employed on a broad basis by 1979-1980, according to Bosch. In this area, Bosch is working on two systems. They process the signals differently, use memories differently, and employ different sensors. One system is based on a special-purpose microprocessor chip with on-chip read-only memory. Somewhat like GM's Misar system, the ROM stores spark-timing characteristics in relation to vehicle speed and load.

The other system is also based on a special-purpose microprocessor, but has an external data memory that is also accessible to other digital controls in the car, such as electronic fuel injection, electronic transmission, or anti-skid. This second system is especially suited for the central electronic optimization system (EOS) that Bosch is developing for future centralized computer controls.

### Sensors: a sensitive area?

Ever since the development of the first automotive electronic controls, a major problem has been mating the memory and logic portions with the sensing points. It has been tough to find low-cost sensors and transducers that are both sensitive enough and reliable enough.

Most of today's electronic engine-control systems use inputs from atmospheric and/or manifold pressure (vacuum), engine speed and/or throttle position, and coolant and/or air temperature. In addition, fuel metering or carburetor feedback aimed at maintaining precise air-fuel ratios requires exhaust-gas sensors. Bendix Corp. has estimated that there are 55 different sensor configurations for cars that could be used in 8,000 possible system designs.

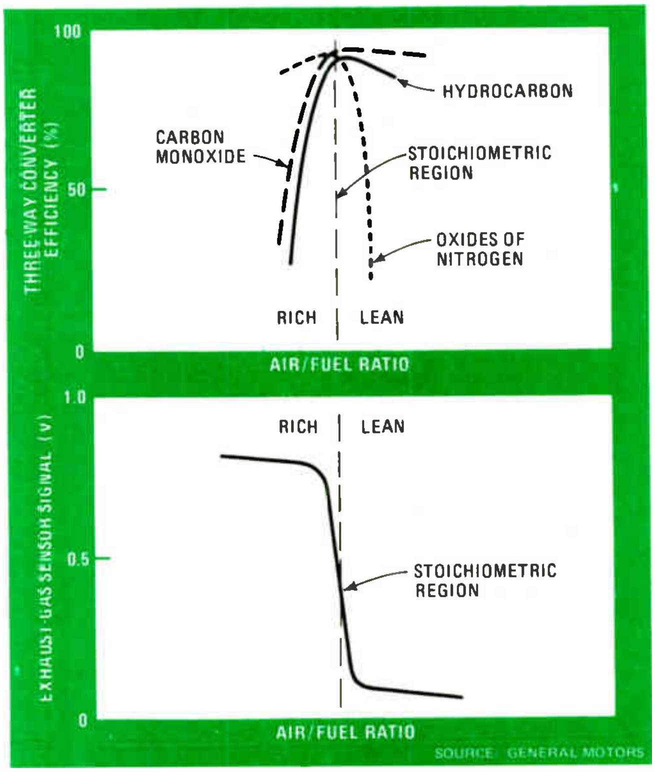
The manifold-pressure sensor provides an electric signal indicating the intake manifold absolute pressure. The amount of air taken in by a cylinder is directly dependent on the pressure in the manifold, so this sensor has to be extremely accurate. There are at least four transducer types: LVDT (linear variable differential transformer), piezoelectric, variable capacitor, and strain gage.

To compute engine speed, sensors are placed to measure crankshaft position. The favored sensor for this application has been a variable-reluctance magnetic type that reacts to flux changes produced by holes or gear teeth on the rotating shaft.

As for throttle-position sensors, which provide inputs representing the torque desired by the driver, the primary approach has been with linear potentiometer types. Solutions have been found to problems arising from wear of sliding contacts, so that performance of over a million full cycles is possible.

To cope with sudden changes in air temperature, particularly likely in exhaust-gas recirculation systems, temperature sensors need a very fast response. One coolant temperature sensor consists of 99% pure nickel wire wound on a bobbin inside a brass housing.

There are two exhaust-gas sensors for closed-loop exhaust-gas recirculation systems: zirconium oxygen and the titanium oxygen types. They also are required to respond to abrupt changes. The zirconium oxygen sensor is an electrochemical device that gives an electrical voltage output as a function of engine exhaust condition. Bosch has developed a special lambda sensor for this application. It exhibits a step voltage change at the stoichiometric air-fuel ratio, independent of changes and drifts in the engine (Fig. 7).




**5. Cleaning up.** The three-way catalytic converter operates most efficiently when the engine's air intake is just enough for all the fuel to burn. Keeping the air-fuel ratio in this stoichiometric region (top) requires a sensor responsive to any air or fuel excess (bottom).

## Changing displays

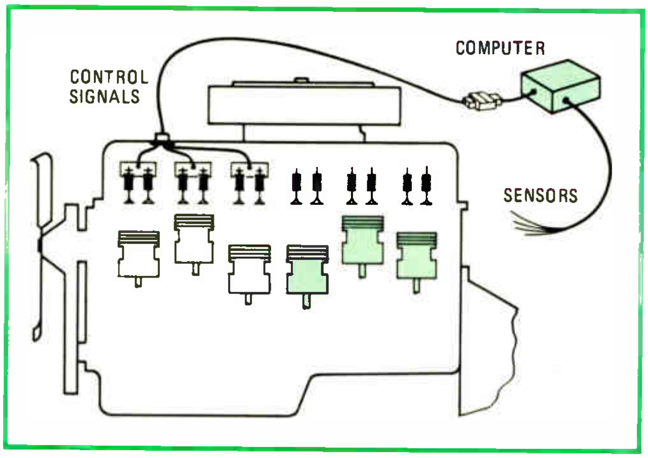
Digital displays run into cost obstacles and also present a problem to auto designers raised on analog indicators. So far only clocks and radios have offered openings for electronic digital displays. But the auto makers are planning major changes in dashboard display, in which they want to include digital "message centers" showing drivers pre-programmed reminders or trip computers showing distance traveled, gas mileage, and the like. Another incentive, reports Smiths Industries Ltd. in England, is that a conventional dashboard using analog instrumentation contains more than 400 parts, whereas a solid-state version can be manufactured with only 35 parts.

Chrysler, which has introduced a digital clock with a vacuum fluorescent display, has put light-emitting diodes on its new electronically tuned radios and combination radios and citizens' band transceivers. However, the company will probably go with vacuum fluorescent displays in its new generation of dashboards because of their visibility under all ambient conditions and their appearance. One drawback of LEDS in cars, explains John Webster, manager of electronic product development at Chrysler's Huntsville division, is that they wash out in bright sunlight. Another is their color—red in a car is reserved for important warnings and using yellow and green LEDS imposes a cost premium, he says. As for liquid-crystal displays, Webster says that it is too soon to predict whether they will be successful in an automobile, because of problems at low temperatures and their long response time.

GM researchers, however, have installed and tested in a 1975 Chevrolet an instrument panel cluster consisting of five twisted nematic liquid-crystal displays. They included warning indicators, a speedometer, fuel gauge, clock-odometer, fuel gauge, and automatic transmission indicator. The warning indicators were tried in four different formats: transmissive, color transmissive, reflective, and color transreflective. The rest operated in the reflective mode only. The reflective and color transreflective warning indicators were deemed the best for clarity under all operating conditions.

Reporting for the Society of Automotive Engineers on the results of the trials, the GM researchers concluded: "LCDS have a number of very positive attributes for automotive use: low voltage and power requirements, excellent visibility in bright sun, flexibility of design, color capability, and reduced bulk. Additional work is still required to increase their temperature range without use of heaters and shorten their response times."

In Great Britain, Smiths Industries has also experimented with dashboards using LCDS as well as dc electroluminescent, gas-discharge panels, LEDS, and electrochromic displays. For cost, appearance, temperature range, and ease of manufacture, Smiths likes the dc electroluminescent type best. Its advantage for vehicle display is visual appeal and the possibility of a wide range of colors (see table). The basic bright-yellow phosphor color may be filtered externally to provide green and red displays, and the viewing angle, also important in a car, is over 160°. The disadvantages are poor brightness and contrast in sunlight and short life expectancy




6. 6 — 3 Ford's new dual-displacement engine option will go on six-cylinder engines for light trucks. Sensors measure temperature, transmission gear, engine load and speed, and throttle position, and the control module shuts down three of the six cylinders.

under very bright conditions, according to Smiths.

The size and complexity of the automotive electrical system increases every model year. With more and more electronic control systems in the offing, the amount of wiring to accommodate it all is going to escalate.

According to one General Motors estimate, there are already some 17 electronic subsystems being designed for the automobile, with more to come. A typical American car may be equipped with more than 400 meters of cable, 83 switches, 14 electric motors, and 69 lamps. There may also be up to 27 sensors and 27 fuses and breakers to protect circuits that are tied together with something like 100 connectors.

In addition, copper is going up in cost, making autc harnesses more expensive. Removing some of it by multiplexing would both cut costs and lighten the load, thus aiding fuel economy. Clearly, the automobile represents a prime target for a multiplexed electrical system, not only to reduce the parts count, but potentially to improve reliability by reducing the number of connections.

### The way is clear for multiplexing

Multiplexing in a car would mean replacing the direct copper wire links between switches and motor lights with a system that would convert and transmit commands to activate or deactivate the motors or lights along a single network. These coded signals could be sent along either two or three copper wires or an optical-fiber light pipe. Chances are the first place auto companies would look to multiplex would be the steering column, which now conceals a mass of copper wires. The second place might be in the left front door, which also holds a lot of wire for window, seat, and door-lock controls.

Right now the cost of a multiplexed car is still higher than the copper wire, say auto engineers. However, multiplexing might buy some additional features that would make it worthwhile. For instance, given the right transducers, an on-board diagnostic system would be easier to install with a multiplexed hookup. Alternatively, if fiber optics takes off as predicted, the cost of multipexing could become competitive even sooner.

All the auto companies are working on multiplexing, but their estimates of when it will be a reality range from a couple of years to 10 years. Whenever it comes, it will certainly increase the use of power transistors, Darlington devices, and the new gate turn-off silicon controlled rectifiers, which unlike conventional SCRs can be shut down as well as turned on by having a voltage

## Testing goes microelectronic, too

The automobile companies are also applying microelectronics to the test equipment that will keep their dealer repair stations abreast of the new electronic engine controls.

For instance, a Motorola MC6800 microprocessor is basic to the electronic engine performance analyzer to which Chrysler Corp.'s Huntsville division recently put the final touches. When attached to special test points on the engine's electrical system, this unit checks out its starting, primary and secondary ignition, and no-load operation, and diagnoses any problems.

The advantage of the microprocessor is that it eliminates the need to replace the entire tester as new car models come out. Instead, the system can be reprogrammed to handle each new engine electrical system. The variable information, such as the size of the alternator and number of cylinders, is entered via a keyboard.

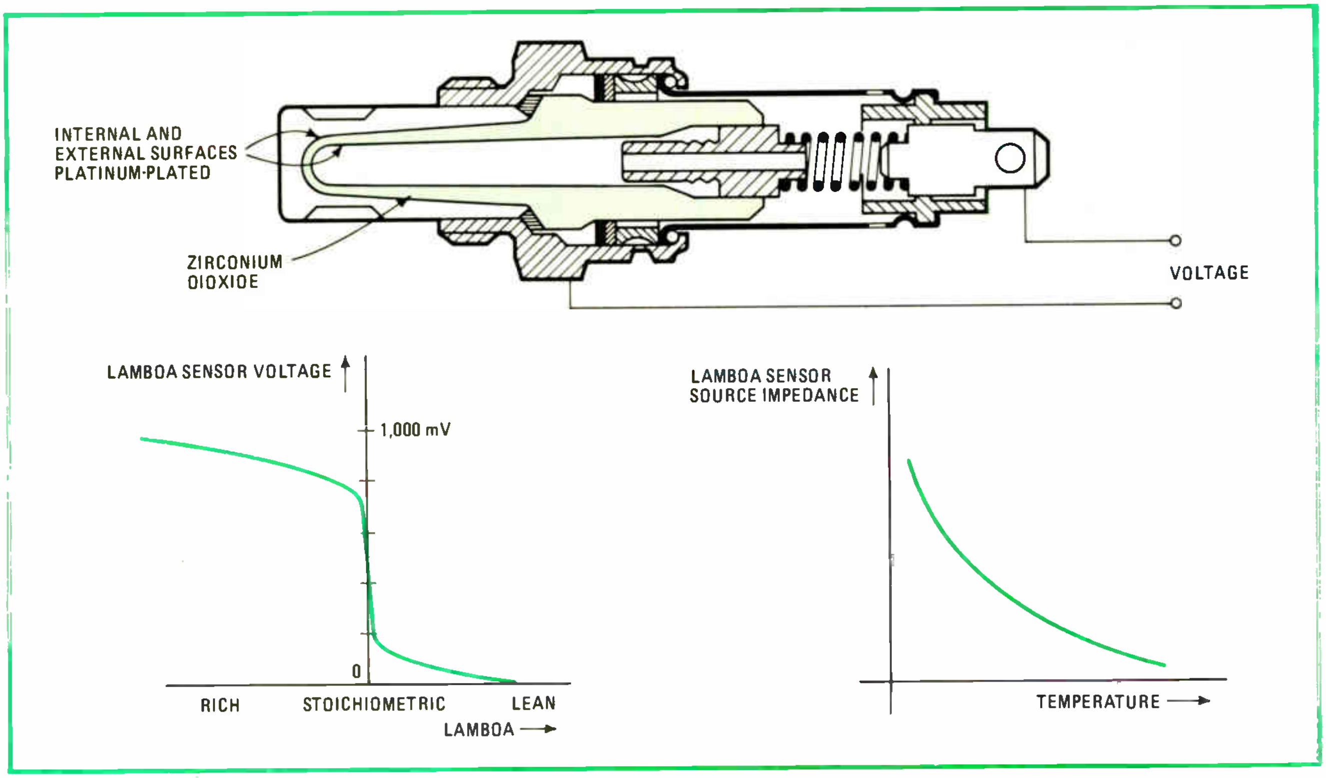
The unit performs some 70 or 90 tests in four to five minutes, displaying the results on a five-line Burroughs Panaplex gas-discharge display and an optional cathode-ray-tube display. The Burroughs character display presents a statement of the condition or fault found, with results and/or corrective action to be taken. The cathode-ray tube displays ignition and other waveforms.

The tester also makes a cylinder-to-cylinder compression check, allowing the mechanic to determine which cylinders are contributing to engine power and which are not. In addition, it spot-checks the Chrysler lean-burn spark computer to see if it is functioning. However, if a problem is indicated, the mechanic then makes a more thorough examination using the stand-alone lean-burn test instrument developed earlier by the company.

Down the road, say the Chrysler designers, the service shop diagnostic computer will link up to a diagnostic microprocessor in the car. At this point it will be possible to program the tester very quickly to fit each model car, because the on-board microprocessor will carry a "signature program" for that model.

Ford has taken a different tack. In support of its 1978 program, the company has developed a system consisting of a "core" tester—a digital volt-ohmmeter with some special signal-conditioning circuits and logic—plus an adapter box or boxes with harness. A dealer who is selling only one of Ford's three basic engine-control systems would acquire the core tester and one of the boxes. The core will be constant from year to year, and only the adapter boxes will be changed with the new models.

Eventually, for those dealers who want greater speed and sophistication, Ford plans to introduce a more elaborate, microprocessor-based diagnostic tester.




**7. Sensored.** The zirconium lambda sensor designed by Robert Bosch is meant for use in a closed-loop electronic fuel injection system. The sensor responds to deviations from the stoichiometric air-fuel mix by signaling a control module to adjust the quantity of fuel injected.

applied to the gate. It is predicted that a fully multiplexed automobile could require 20 such devices.

In the U.S., General Motors is probably furthest along in this area. It has developed a multiplexed control system with a single fiber-optic cable to replace the multiwire harness, connectors, and printed-circuit boards required to interconnect steering column switching functions with power actuators and lights.

An encoder module located at the top of the steering column digitally multiplexes switching signals for windshield wipers, turn signals, hazard flashers, key reminder, horn, headlights, and cruise control. It transmits these signals as light pulses through an optical-fiber cable to a decoder module at the base of the steering column. This module decodes the signals and routes them to the appropriate power actuators.

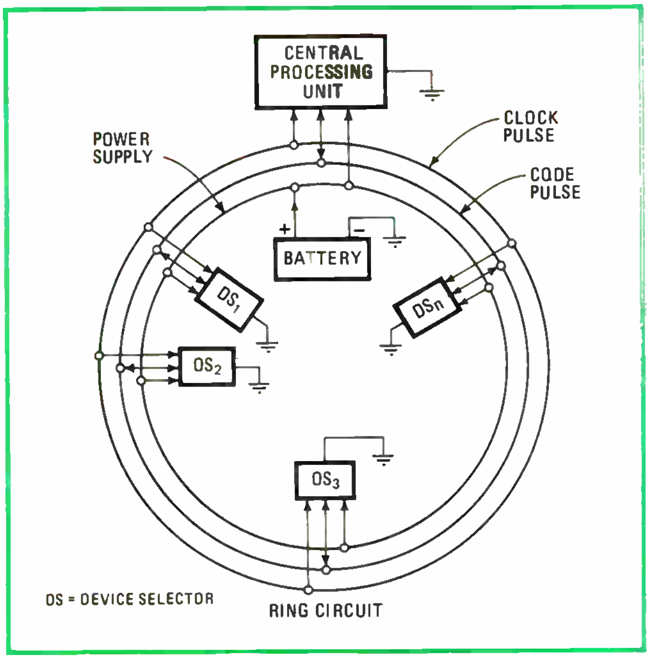
A light-emitting diode on the encoder converts the 32-bit digital words to light pulses to be transmitted down the optical-fiber cable. A photodiode on the receiving end reconverts the light pulses to electrical signals for the decoders to route.

## Test results

Installed in a 1975 Buick Electra, this multiplexed system handled signal chores and proved that small switches could replace the larger, high-current switches used at present. One problem this test program underscored was the need for a low-cost solid-state switch capable of taking the low-current signals from the decoder module and converting them into high-current power drive signals.

In Germany, Robert Bosch is developing a number of microprocessor-based multiplexed wiring systems to replace harnesses in trucks and buses. One system can supply, control, and monitor up to 128 loads on the vehicle by way of only three conductors. The loads can be switches, sensors, and all the electrical functions.

The three-conductor multiplexed ring system, as Bosch calls it, uses a 150-kilohertz generator to produce




**8. Multiplexing.** The Bosch three-wire multiplexed system is in the form of a ring, with a microprocessor handling signals. The first wire carries a 150-kHz clock pulse. Coded data words from the processor go along the second. The third supplies battery power.

**SOLID-STATE DISPLAY TECHNOLOGIES FOR AUTOMOTIVE USE**

**Technologies available**

Light-emitting diodes (LED):
small dots or digits used in calculators and some watches; semiconductor process.

Liquid-crystal displays (LCD):
electrically controlled liquid; switches from clear to blocking as a shutter.

Gas-discharge (plasma) panels (GAS):
excited gas in tiny pockets emitting light as a neon tube does.

Dc electroluminescence (DCEL):
large-area light-emitting phosphor silk-screening type manufacturing process.

Electrochromic (EC):
reflecting symbols by coloring of electrodes as a reversible electro-coating.

**Criteria for instrument display**

| | Most suitable | Satisfactory | Poor |
|---|---|---|---|
| System cost | DCEL | | others |
| Appearance | DCEL | LED<br>EC<br>LC<br>GAS | |
| Life | LED | DCEL<br>LC<br>GAS | EC |
| System reliability | LED | DCEL<br>LC<br>GAS | EC |
| Temperature range | DCEL | LED<br>EC<br>GAS | LC |
| Overall choice | DCEL | EC<br>LC<br>GAS | LED |

SOURCE: SMITHS INDUSTRIES LIMITED

clock pulses carried over one of the three wires as illustrated in Fig. 8. Coded data words selected by the appropriate data switch are generated in the microprocessor and transmitted along the second conductor. The third conductor supplies the battery power. The three conductors link 16 selector substations, which in turn serve 8 loads each for a total of 128 loads.

Coded data words comprise 22 bits in a sequence of binary pulses for synchronization control functions and commands. Pulses at the end of the signal train are sent back to the central processor to confirm the execution of the command or to report a condition such as headlights dimmed, brights on, etc. The two-way data exchange can also be used to monitor operating conditions such as water temperature, oil level, and the like.

## A radar car for the future

As a way of making cars safer, air bags may be much in the news (see "What about air bags?" p. 88). But for some years now, auto companies and some of their systems suppliers have been trying a much more radical approach—the development of a cost-effective, radar-controlled braking system that would help prevent accidents caused by inattentive or alcohol-impaired drivers. The technical and cost problems have been so intractable that the projects have not left the laboratory, but the Government's interest continues and could move radar safety systems to the front burner.

The biggest technical obstacle to an automatic radar braking system has been target discrimination—how to distinguish between a nonhazardous object off the road and a hazardous object ahead. Fewer false targets would be picked up if the maximum detection range were restricted and a highly directive antenna were used. A recent study made by the U. S. Department of Transportation of a car with radar-controlled braking developed by Bendix Corp. determined that a detection range of 150 feet and a beam width of 2.5° were acceptable for this 22.125-gigahertz system. The agency also recommended changing to a radar transmitter frequency of 35 to 36 GHz, on the basis of antenna beam width and total size, but found either pulse or diplex-interrupted continuous-wave modulation acceptable. Finally, DOT concluded that transmitter power should be at least 20 milliwatts or better to detect targets right out to maximum operating range.

The use of microprocessors to process the radar signals may hasten a solution to the problem of false alarms. One such system using two microprocessors in an experimental car has been developed by RCA. One microprocessor controls dashboard warning displays. The other operates in conjunction with a forward-pointing frequency-modulated continuous-wave radar.

With the microcomputer program the radar unit can perform three functions. First, during highway driving under cruise control, the radar monitors the lanes ahead, and if the vehicle comes too close to another car, the computer cuts out the cruise control and the radar system automatically maintains a safe distance thereafter. Second, the radar system can be set to sound an audible warning of obstacles or other cars up to 30 meters ahead when there is fog or impaired visibility. Third, the radar system automatically applies the brakes in situations in which the computer deems a serious collision to be unavoidable. The driver can override this last function if necessary.

Although reducing the distance and beam width of the transmission and using a microprocessor to evaluate radar target data have not completely done away with false alarms, the present systems could reduce highway accidents, say some researchers. But that still leaves the cost barrier to be overcome. □

# Real-time processing gains ground with fast digital multiplier

## Refinements in algorithm and hardware cut speed-power product of one-chip device, promising new applications

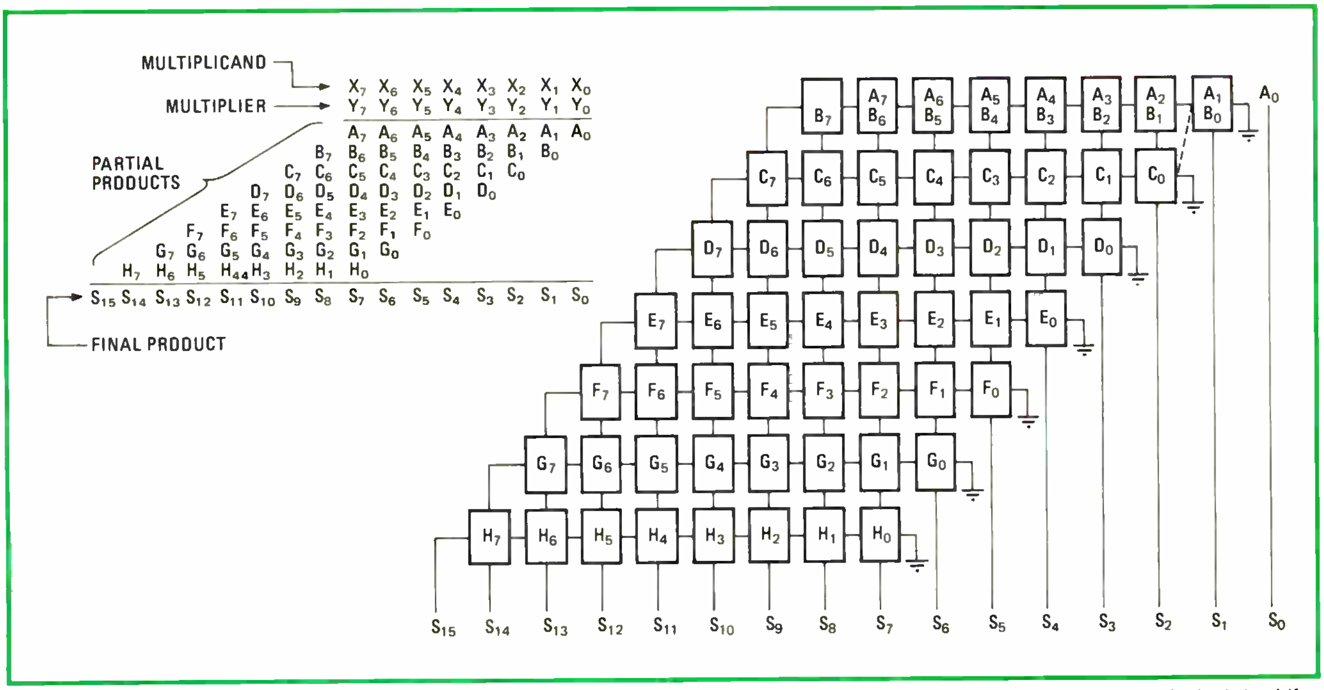
by Shlomo Waser, *Monolithic Memories Inc., Sunnyvale, Calif.*,
and Allen Peterson, *Stanford University, Palo Alto, Calif.*

☐ In real-time signal processing, analog methods have held sway despite the advances in digital techniques. But now, fast multiplier chips are helping turn the tide. These chips can speed the complex operations needed for digital treatment, which previously could only be carried out off line using large computers. Functions like autocorrelation and fast Fourier transforms necessary for digital filtering and compression, for example, can now be done in real time by the multipliers and the new, fast analog-to-digital converters. As a result, performance in such fields as telephony, television, and sound reproduction will be greatly enhanced, and digital signal processing will assume the dominance in these areas once held by analog techniques.

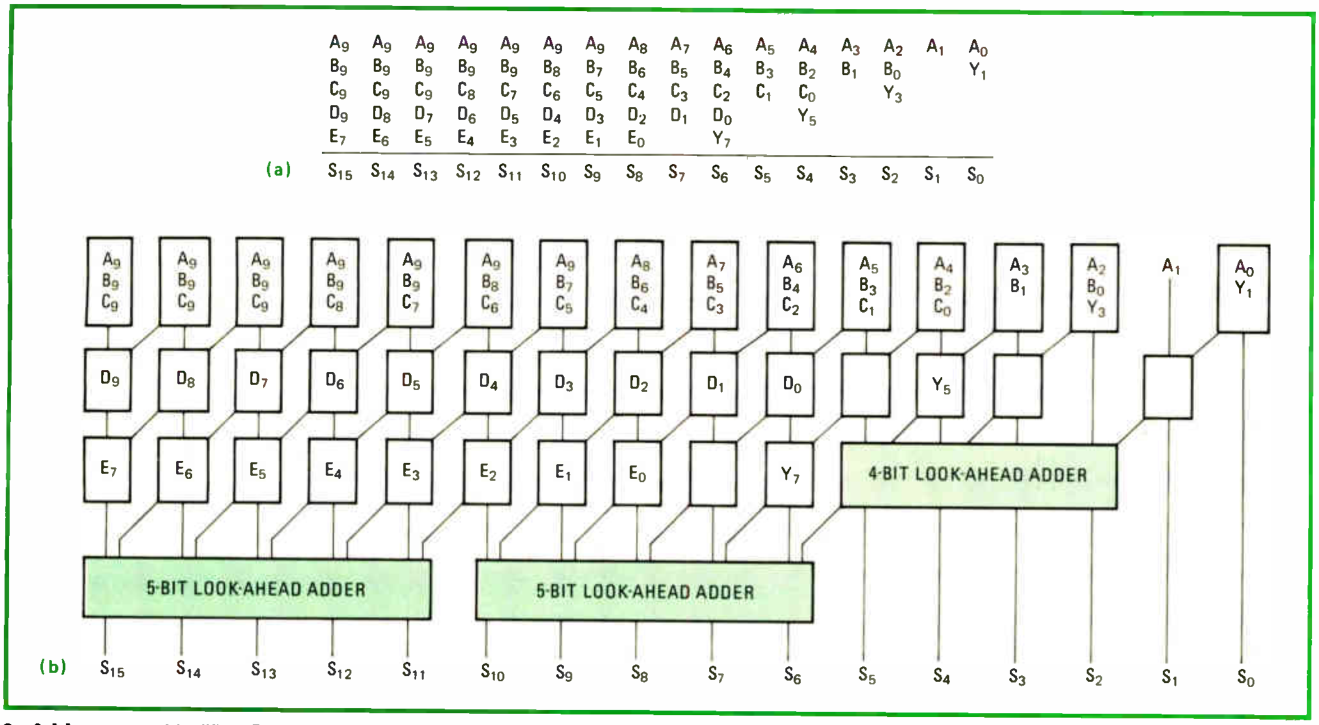
The single-chip MMI67558 can multiply two 8-bit numbers in 100 nanoseconds, yet it dissipates only 1 watt. These figures represent a significant breakthrough in speed-power product. The combined attributes of high speed, small size, and low power dissipation destine the 67558 for new roles in signal processing. The classic example of a notch filter 1 hertz wide and 100 decibels deep, which would be pointless to design using tuned circuits, now becomes practical with digital techniques. And spectral analysis, the process of breaking down complex signals into their single-frequency components, is done most accurately using the fast Fourier transform which requires extremely fast multiplication.

The reduction in cost and size of complex digital components translates into dramatic savings on the system level. The low-power 67558, besides costing far less than the functionally equivalent hard-wired logic, has a smaller power supply requirement, occupies far less circuit board area, and needs no forced-air cooling or heat sinking. Moreover, the reduction in circuit interconnections means an inherently more reliable design.

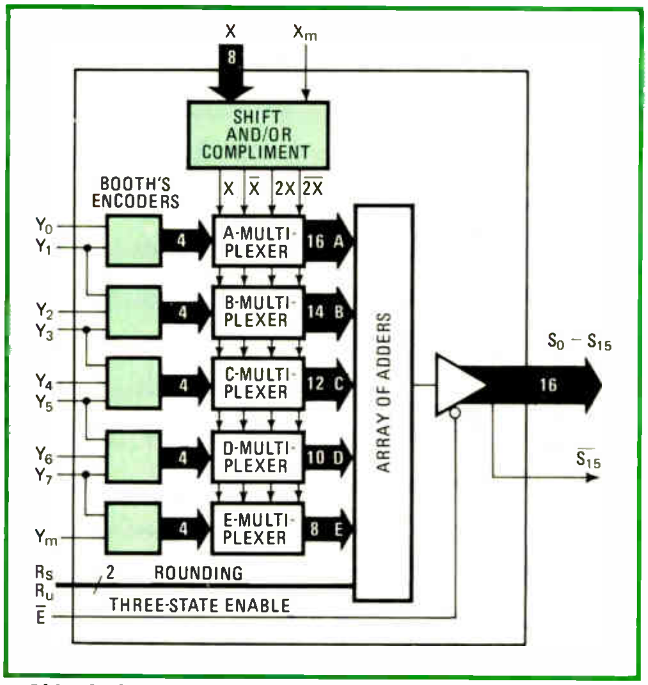
The 67558 not only has guaranteed entry into the conventional areas of digital signal processing, such as radar and sonar, but it has clear access to a host of




**1. Combinatorial multiplier.** The double-length product is formed by adding together the eight partial products, each of which is shifted according to the weight of the corresponding multiplier bit. In the scheme at the right, the operation is carried out by 56 binary full adders, and the speed of multiplication is governed by the ripple carry from $A_1$ through $B_7$ and on down to $S_{15}$.




**2. Adder array.** Modified Booth's algorithm reduces the number of partial products (a), which are sign-extended to accommodate two's-complement operations. The adder array (b) is arranged in a modified Wallace tree, requiring fewer carry-save adders to sum the partials.




**3. Chip design.** The MMI67558 breaks up the Y operand into five parts, each of which is encoded to four select lines. Only one select line is active at a time; it chooses the value of the partial product to be ±X or ±2X. If no select line is active, the partial product is zero.

relatively new areas, such as medical electronics, for electrocardiography and brain and body scanning; sound processing, for voice synthesis or speech scrambling and musical recording applications like compression and expansion; and video enhancement, for facsimile transmission, satellite relay of weather photographs, and compression of digital television signals.

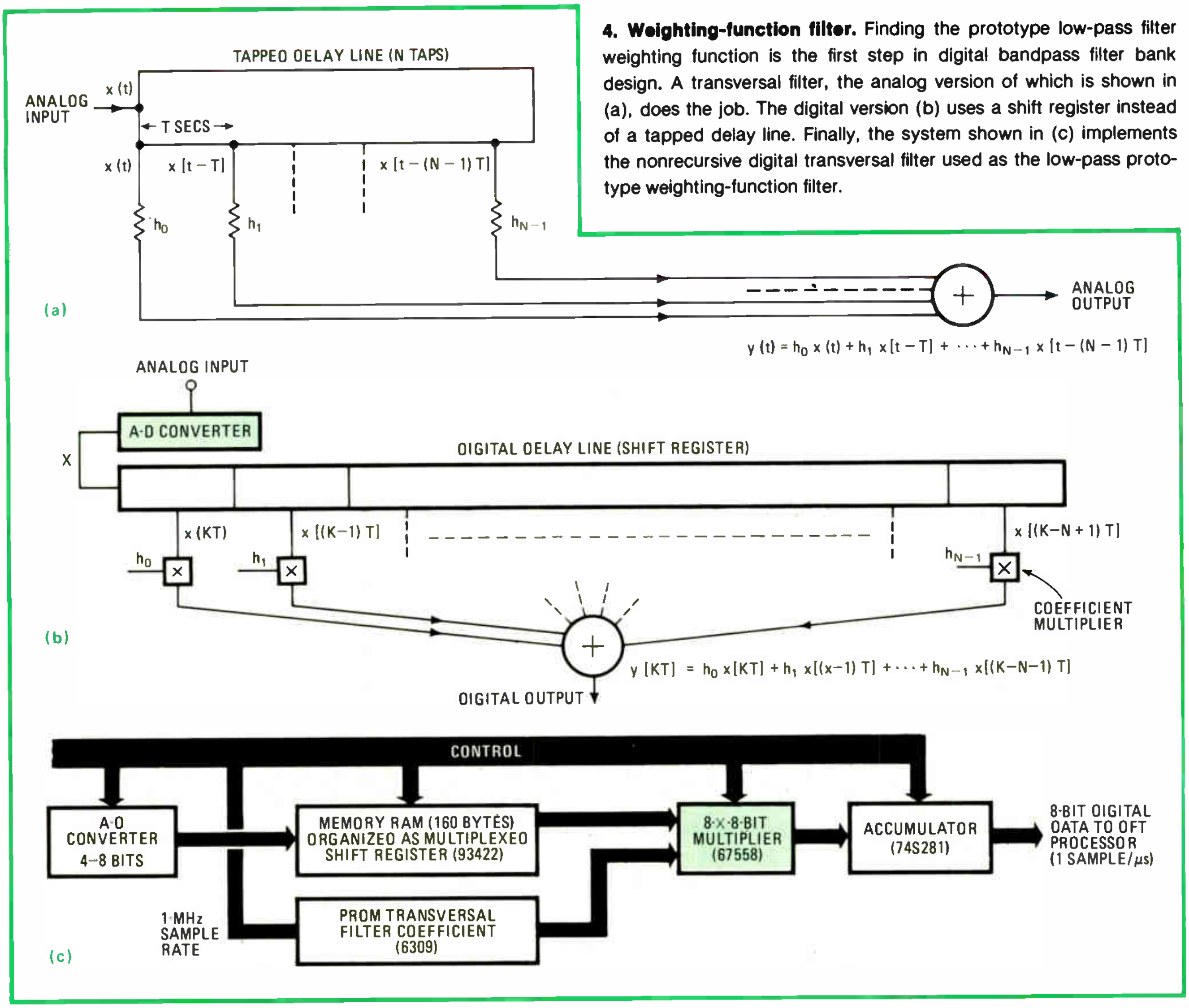
Although it seems like an oversimplification, it is fair to say that the bandwidth in digital signal processing is limited by the speed of multiplication. In the final analysis, all computation reduces to addition and multiplication; and multiplication is traditionally performed by successive addition, such that the calculation of the product of two n-bit numbers requires at least $n-1$ additions. Thus, if the signal is quantized into 8 bits and a computation consisting of an addition and a multiplication is required, the latter consumes almost 90% of the processing time. If, however, the multiplication speed were to match that of the addition, the bandwidth of the signal processor would be 4½ times larger.

## Modified algorithm

Speed enhancement in the 67558 begins with modification of the multiplication algorithm. The add-and-shift algorithm is the simplest way to perform multiplication, the operation being carried out in a manner analogous to the way one multiplies numbers using pencil and paper. For example, in multiplying two binary numbers, each bit of the multiplier requires a corresponding add-and-shift operation:

| | | |
|---|---|---|
| multiplicand | 110 | (5) |
| multiplier | × 101 | (6) |
| | 110 | $(6 \times 2^0)$ |
| partial products | 000 | $(0 \times 2^1)$ |
| | 110 | $(6 \times 2^2)$ |
| final product | 11110 | (30) |

Even though computers can add and shift in the same instruction cycle, n bits of multiplier require at least n such operations. This method, known as sequential multiplication, is performed with adders and shift regis-




**4. Weighting-function filter.** Finding the prototype low-pass filter weighting function is the first step in digital bandpass filter bank design. A transversal filter, the analog version of which is shown in (a), does the job. The digital version (b) uses a shift register instead of a tapped delay line. Finally, the system shown in (c) implements the nonrecursive digital transversal filter used as the low-pass prototype weighting-function filter.

ters and is adequate for low-speed multiplication.

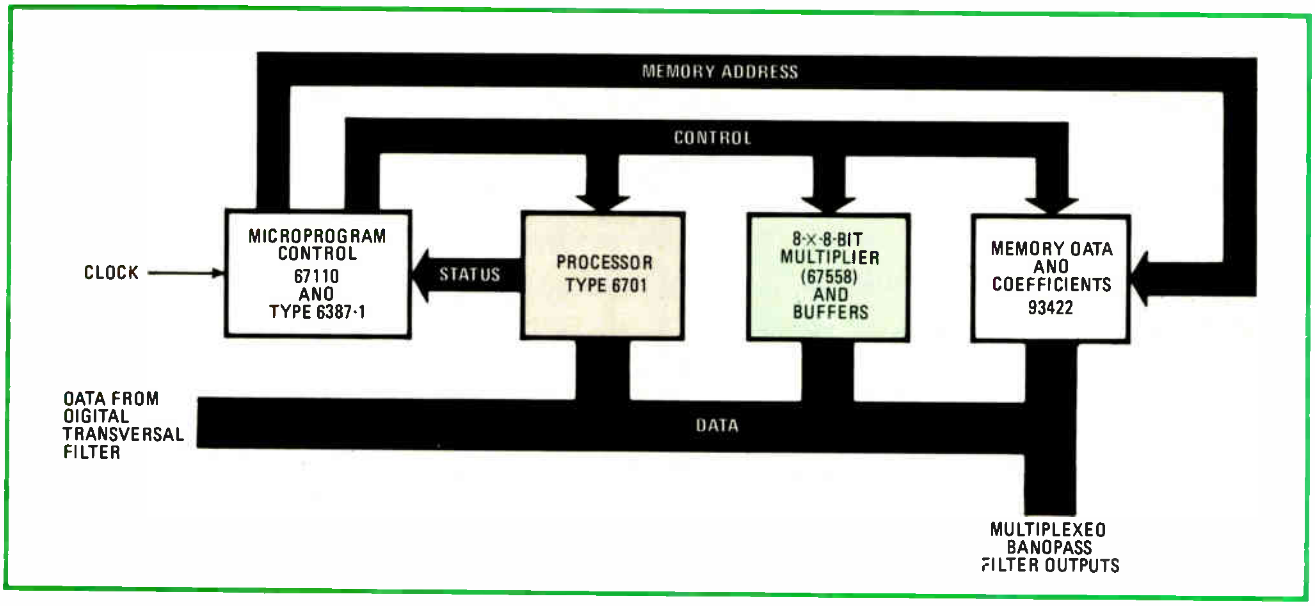
High-speed multiplication calls for a combinatorial approach. In this approach, the partial products are formed simultaneously and then added in one operation. Each successive bit in the partial product is determined by an AND operation of successive multiplicand bits with a single multiplier bit. This procedure is related to the add-and-shift algorithm, since a 0 multiplier produces a zero partial product and a 1 multiplier simply duplicates the multiplicand in the partial product. The actual shifting is performed by the interconnections of the adders used to sum the partials, as shown in Fig. 1.

For the sake of simplicity, the speed of multiplication is best expressed as a function of logic-gate propagation delays, while the power dissipation is directly related to the total number of gates. Referring to Fig. 1, the speed of multiplication is governed by the delays from $A_1$ to $B_7$ to $S_{15}$. This path consists of 14 adder stages, each of which has 4 gate delays; with another gate delay for the generation of partial products, the total is 57. The gate count results from 64 AND gates that generate the partial products and from the 56 binary adders. Since each adder contains 10 gates, total count for the combinatorial multiplier described is $64 + (56 \times 10) = 624$ gates.

**INSTRUCTIONS FOR CARRYING OUT MODIFIED BOOTH'S ALGORITHM**

| Bit $2^1$ $Y_{i+1}$ | Bit $2^0$ $Y_i$ | Bit $2^{-1}$ $Y_{i-1}$ | Operation |
|---|---|---|---|
| 0 | 0 | 0 | add zero (no string) |
| 0 | 0 | 1 | add multiplicand (end of string) |
| 0 | 1 | 0 | add multiplicand (a string) |
| 0 | 1 | 1 | add twice the multiplicand (end of string) |
| 1 | 0 | 0 | subtract twice the multiplicand (beginning of string) |
| 1 | 0 | 1 | subtract the multiplicand (−2X or +X) |
| 1 | 1 | 0 | subtract the multiplicand (beginning of string) |
| 1 | 1 | 1 | subtract zero (center of string) |

The combinatorial multiplier, though significantly faster than the sequential type, has room for improvement. The carry bits that are passed among the adders slow down the operation, and a technique known as carry-look-ahead, which keeps track of carry bits while not adding them, is often used to reduce the carry-




**5. Digital bandpass filter system.** Once the low-pass weighting-function filter is built, a discrete Fourier transform (DFT) of the weighted data stream is used to transform the prototype filter into a bank of bandpass filters, each with a center frequency that corresponds to one of the DFT components. Transformation is best performed under bit-slice processor control.

propagation delay, but with the penalty of a much higher gate count.

But the 67558, instead of waiting for the carry bit to ripple through, adds them at a later time. Postponement of the addition of carries is applied to all the adder stages except the last one. The carries from the last stage essentially form an n-bit operand to be added to the n-bit sum, and this operation requires look-ahead adders.

Another side benefit of postponing addition of the carries to a later stage is that the first stage can be made up of carry-save adders, each having three inputs, with the result that the total number of adder stages is reduced from seven to six. This entire scheme is a modified Wallace tree.

The tree reduces both the number of gate delays and the gate count. Contributors to the propagation delay include 1 gate that generates partial products, 6 carry-save-adder delays of 4 gates each, and 2 stages of carry-look-ahead with 3 gates each, for a total of 31 gate delays. The gate count is made of 64 + 48 carry-save adders + 2 carry-look-aheads. Each of the latter has 30 gates, giving a total count of $64 + (48 \times 10) + (2 \times 30) = 604$ gates.

One other technique is used to increase speed. The approach, the modified Booth's algorithm (first used in the IBM 360), reduces the number of partial products by half; consequently, the number of carry-save-adder stages, and hence the gate count, are also reduced. Basically, Booth's algorithm allows the multiplication operation to skip over any contiguous string of all 1s and all 0s, rather than form a partial product for each bit. Skipping a string of 0s is straightforward, but in skipping over a string of 1s, the following property is put to use: a string of 1s can be evaluated by subtracting the weight of the right-most 1 from the modulus. (The modulus of an n-bit word is $2^n$, and the weight of any nth bit is $2^{n-1}$, counting from the right.) For example, the value of the binary string 11100 computes to $2^5 - 2^2 = 28$.

In the actual hardware implementation of the algorithm, each multiplier is divided into substrings of 3 bits, with adjacent groups sharing a common bit. However, Booth's algorithm works only with two's-complement numbers—the most significant bit of which has a weight of $-(2^{n-1})$—and requires that the multiplier be padded with a 0 to the right to form four complete groups of 3 bits each. To work with unsigned numbers, the multiplier must also be padded with two 0s to the left, one so that the multiplier will not be treated as a negative number and the second so that the fifth group will be complete. Thus the modified Booth's algorithm is a multiplier-encoding scheme that involves a constant shift of 2 bits at a time while examining 3 multiplier bits, and it produces five partial products rather than eight—the fifth partial product being a consequence of the fact that Booth's algorithm only handles two's-complement numbers. All the possible permutations, as shown in the table, form instructions that prevent unnecessary computation for zero partial products.

The hitch in the modified algorithm is that, as shown in the table, a subtractor is required. The subtraction is implemented by adding the two's complement of the number to be subtracted. In taking the two's complement, the number is first complemented and 1 is then added to the least significant bit.

From the table, it can be seen that the $Y_{i+1}$ can simply be added to the LSB of the partial product. If bit $Y_{i+1}$ = 0, no subtraction is called for and adding 0 changes nothing. On the other hand, if bit $Y_{i+1} = 1$, then the proper two's complement is performed by adding 1 to the LSB. Of course, in the two's complement, the sign bit must be extended to the full width of the final result, as shown by the repetitive adders in Fig. 2a.

The scheme of the modified algorithm is shown in Fig. 2b. The gate delay is made up of 2 gates decoding the 3-bit multiplier instruction, 2 gates for selecting shift or double shift, and 2 carry-save-adder stages and 3 stages of carry-look-ahead, yielding a total of 21 gate delays. The gate count is made up of 5 encoders, 32 multiplexers, 40 carry-save adders, and 3 carry-look-aheads for a total of $(5\times5)+(32\times5)+(40\times10)+(3\times30) = 675$ gates. Thus, for a small penalty in gate count, the speed multiplication is improved, and the output data is also available either signed or unsigned.

### Hardware implementation

In implementing the multiplication algorithm, several techniques contribute to the reduced power dissipation in the 67558. First, computer-aided circuit design was used to determine noncritical signal paths—those with lower speed requirements—slowing down the gates in these paths lowers the power dissipation.

Second, the number of devices required for AND-OR-invert gates in the multiplexer section of the circuit was minimized: the logical equation $\overline{C}=\overline{A}\cdot B$ is realized by a single transistor, where C is the collector, B is the base, and A is the emitter. With fewer transistors, each multiplexer dissipates less power.

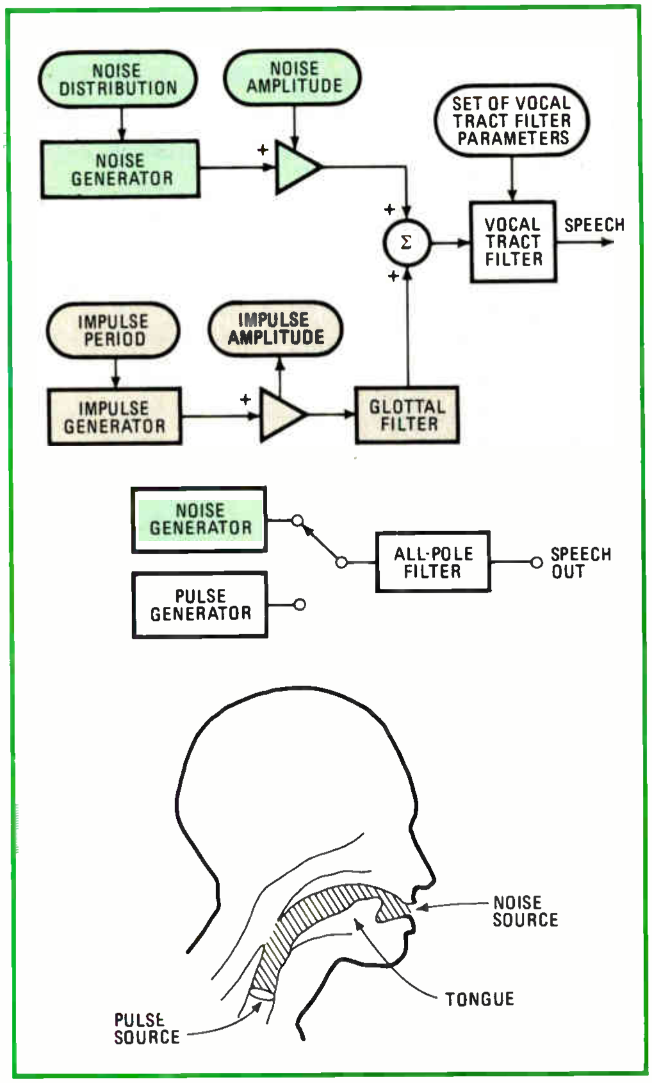
Finally, power is reduced in the implementation of exclusive-OR gates. Although transistor-transistor logic is most suitable for NAND gates, they build an inordinately extensive exclusive-OR circuit. Typically, the problem is circumvented with a circuit that resembles an AND followed by an OR; but this approach produces output voltages that are too high, and level translators must then be used to readjust thresholds. The 67558, however, does not use level translators—instead, the input threshold voltages of subsequent stages are matched to the exclusive-OR outputs. The final design of the 67558 is diagrammed in Fig. 3.

### Digital signal processing

In determining the bandwidth limits in the digital processing of analog signals, the first rule is that the sampling rate must be at least twice that of the highest frequency component of the analyzed waveform. In speech processing, for example, since the highest pitch generated by the vocal chords is about 4 kilohertz, a sampling rate of 8 kHz is required. Therefore a sample must be taken at least as often as every 125 microseconds to fulfill the requirement.

A figure for the computational speed of real-time voice processing can be arrived at depending on the operation to be performed. To compute the autocorrelation function for 256 samples of a speech waveform, for example, each sample value is multiplied by 256 other samples. Therefore, in a period of 125 μs, 256 multiplications are required, and thus each multiplication must be peformed in less than 500 ns.

The number of bits of resolution in signal processing is of concern at the time of analog-to-digital conversion and during computations. When an analog signal is converted to a digital word, the signal-to-noise ratio is critical. A poor ratio can result in clipping of the waveform, which, when converted, introduces phantom frequency components. For example, if a waveform at one point has a level of 160 millivolts and each quantizing level is 10 mv, 4-bit resolution is sufficient for the a-d conversion. If the resolution of the system is



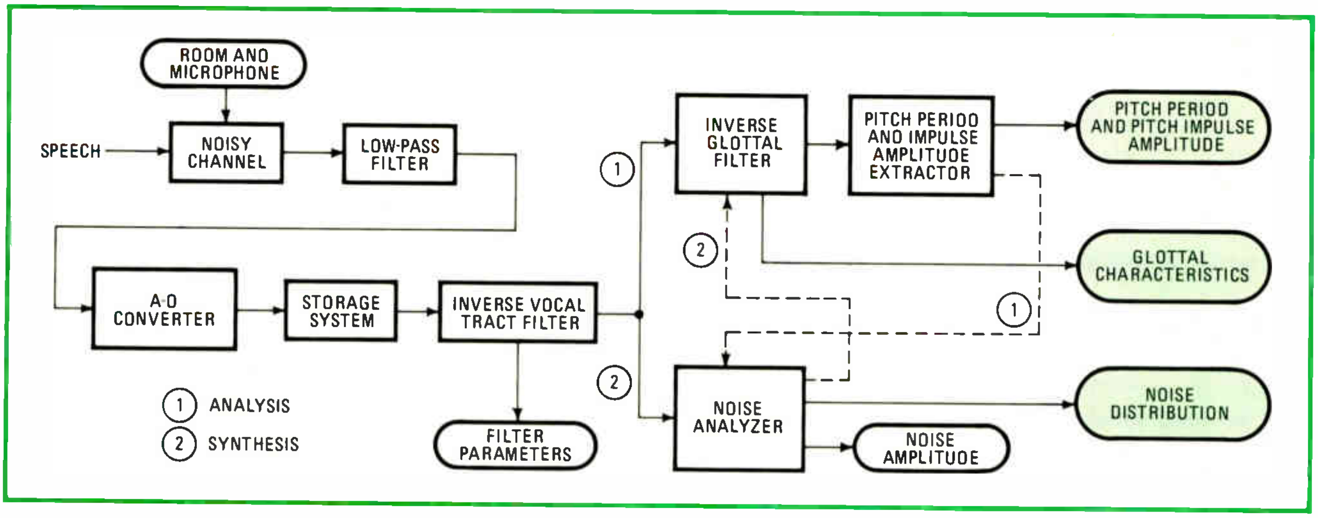

**6. Speech mechanism.** Understanding the mechanism of speech is key to voice processing. In speech synthesis, the vocal tract becomes a time-varying digital filter excited by pitch impulses (to simulate voiced sounds) or random noise (unvoiced sounds).

extended to 8 bits, a maximum noise level or interfering signal of $2^8\times10$ mv = 2.56 volts can be tolerated.

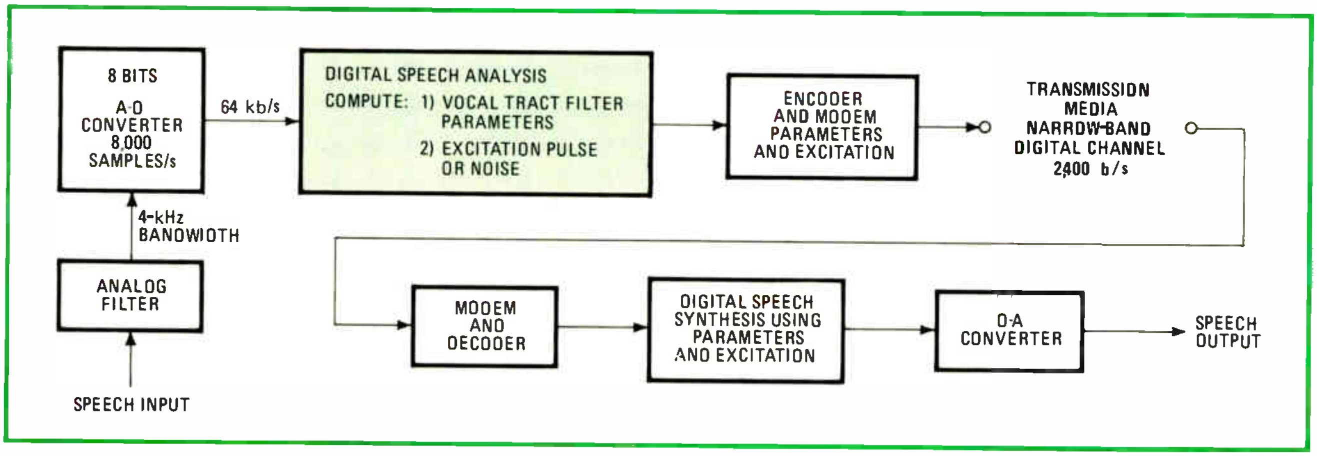
The second place that the number of bits is significant is during the computation. In discrete time analysis, infinite precision of the filter coefficients is usually assumed. In carrying out arithmetic operations, however, the number of bits grows as the calculation proceeds—multiplication may double the word length of the operands, and products must therefore be rounded. Using fixed-point arithmetic with real-time hardware requires careful analysis of operations: too many bits adds to expense and may convey a false sense of accuracy, whereas too few bits results in erroneous analysis.

For full precision in multiplication, each time the product is used as an operand, the number of required bits is doubled. Multiplication of two 8-bit numbers requires 16 bits for full precision, and operating on the result requires a 16-bit multiplier, which in turn generates a 32-bit product.

When using fractional numbers, the full precision is




**7. Speech analysis model.** Speech is digitized and stored, and vocal-tract filter coefficients are then computed. Next, pitch period is determined for voiced signals and noise excitation is determined for unvoiced signals.




**8. Compression.** Narrow-band digital voice communication system shows the advantages of digital over analog processing. Digitized speech, converted to a data rate of 64,000 b/s, is compressed to a rate of 2,400 b/s to reduce the cost of transmission.

not always needed. Instead, a rounding scheme provides the best 8-bit fractional number from the full 16-bit product. Rounding in the binary number system is similar to the scheme used with decimal numbers whereby 0.5 is added to the part to be discarded and the number is then truncated.

## Bandpass filter

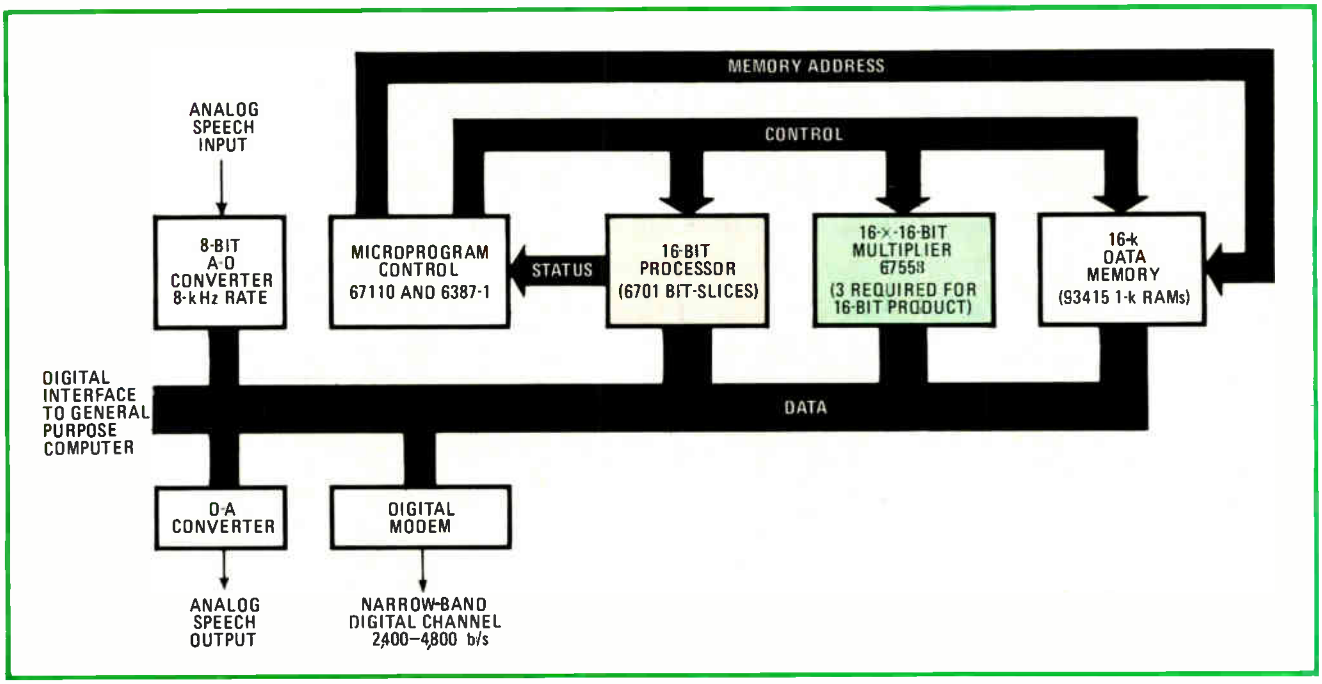
Digital processing techniques can be applied directly to the real-time domain. Bandpass filters, for example, can be assembled efficiently using finite impulse response filters and fast Fourier transform computers. Basically, the design of banks of such filters starts with a low-pass prototype digital filter that derives a weighting function. A discrete Fourier transform of the weighted data stream then transforms the low-pass prototype into a bank of bandpass filters. Each of these filters has a center frequency that corresponds to one of the transform frequency components.

The prototype is a digital version of an analog transversal filter. A standard configuration for the latter consists of a tapped delay line, a set of weighting resistors, and a summer, as shown in Fig. 4a. The output signal is formed by summing the delayed and weighted input signals, according to the equation shown.

To make a digital version, the input signal is first sampled and quantized into a digital form as shown in Fig. 4b. An n-stage digital delay line—or shift register—holds successive numbers (usually in binary format) generated by the a-d converter and shifts the sequence by one state when a clock pulse is applied every T seconds.

The digital filter is nonrecursive, since each output number depends only on the input sequence. Weighted sums of the output sequences are not involved, as they are in the recursive digital filter. Figure 4c gives a system configuration for the transversal filter operations that yields the low-pass prototype.

To complete the design of the multichannel bandpass filter, the n-point discrete Fourier transform of the digital output samples from the transversal filter must be computed. While this computation can be built up with hard-wired medium-scale integrated building blocks, a more flexible system uses a microprocessor. Only minor changes in architecture need then be made to accompany a different number of channels in the bank. Bipolar 4-bit slices such as the 6701 or 2901, together with program controllers like the 67110 or 2911, work well and are




**9. Real-time microprogrammed speech processor.** Full-blown speech processing is carried out by this system, which uses bit-slice processors, fast RAM, and 67558 multipliers. Analog output, narrow-band digital output, and interface with a computer are provided.

relatively simple to arrange, as shown in Fig. 5.

The filtering and processing techniques thus developed can be applied to the area of speech analysis and synthesis. Research in this area has led to the introduction of voice encoding and other digital techniques into telephone communications, and these techniques can achieve great savings as the cost of digital hardware declines.

Real-time implementation of digital speech analysis and synthesis involves a large number of multiplications and therefore requires a high-speed computational capability. Since the speech model is time-varying, the computations are usually carried out in blocks of about 20 or 30 milliseconds' duration. Speech samples are obtained at rates of 8,000 to 10,000 samples per second, with a typical block length of 256 samples.

While one block of samples is being taken, complicated computations such as autocorrelation and updating of digital-filter coefficients must be carried out. A system is typically limited in its capability by the multiplication rates available, since several million multiplications per second often must be performed.

## The speech process

The 67558 multiplier permits the building of a generalized processor that can carry out the necessary calculations. By applying rules of speech generation and digital filtering techniques, specialized hardware such as the 67558, under fast microprocessor control, now makes possible relatively low-cost real-time speech processing.

Analysis of the actual speech process is the key to its synthesis. It is generally accepted that speech is created by a combination of glottal excitation—the rapid opening and closing of the glottis, or vocal chords—and noise excitation of the vocal tract produced by the flow of air out of the lungs. The vocal tract is the portion of the windpipe that begins at the glottis and separates into two paths, one of which terminates at the lips and the other at the nostrils. The characteristics of the vocal tract are mainly the cross-sectional area and the resonance coefficients.

In speech processing, it is usually assumed that the source of excitation and the vocal tract system are independent. Accordingly, in speech synthesis the vocal tract is treated as a time-varying digital filter that is excited by pitch impulses to simulate voiced sounds or by random noise to simulate unvoiced sounds. The problem of speech analysis reduces to two parts: computing the numbers that characterize the transfer function of the time-varying digital filter, and determining the position in time of the excitation-pitch pulses (or sometimes only the pitch frequency for periodically occurring excitation pulses).

## Speech parameters

Whether impulses or noise should be used as the excitation for the speech-synthesis filter is determined by the voicing. Voiced sounds generate pulses, while unvoiced sounds produce only noise. A model of speech generation is shown in Fig. 6.

Figure 7 is a configuration for digital analysis of speech in order to obtain excitation and filter transfer-function parameters appropriate to a given sample of speech. The parameters are then used to recreate speech in a digital analysis-synthesis communication system. One advantage of digital speech processing is clearly shown by Fig. 8, which illustrates the compression of 64,000 bits per second of encoded speech into a bandwidth of only 2,400 b/s.

A generalized digital processor capable of carrying out calculations for real-time analysis and synthesis of speech either for communication or for research is shown in Fig. 9. □

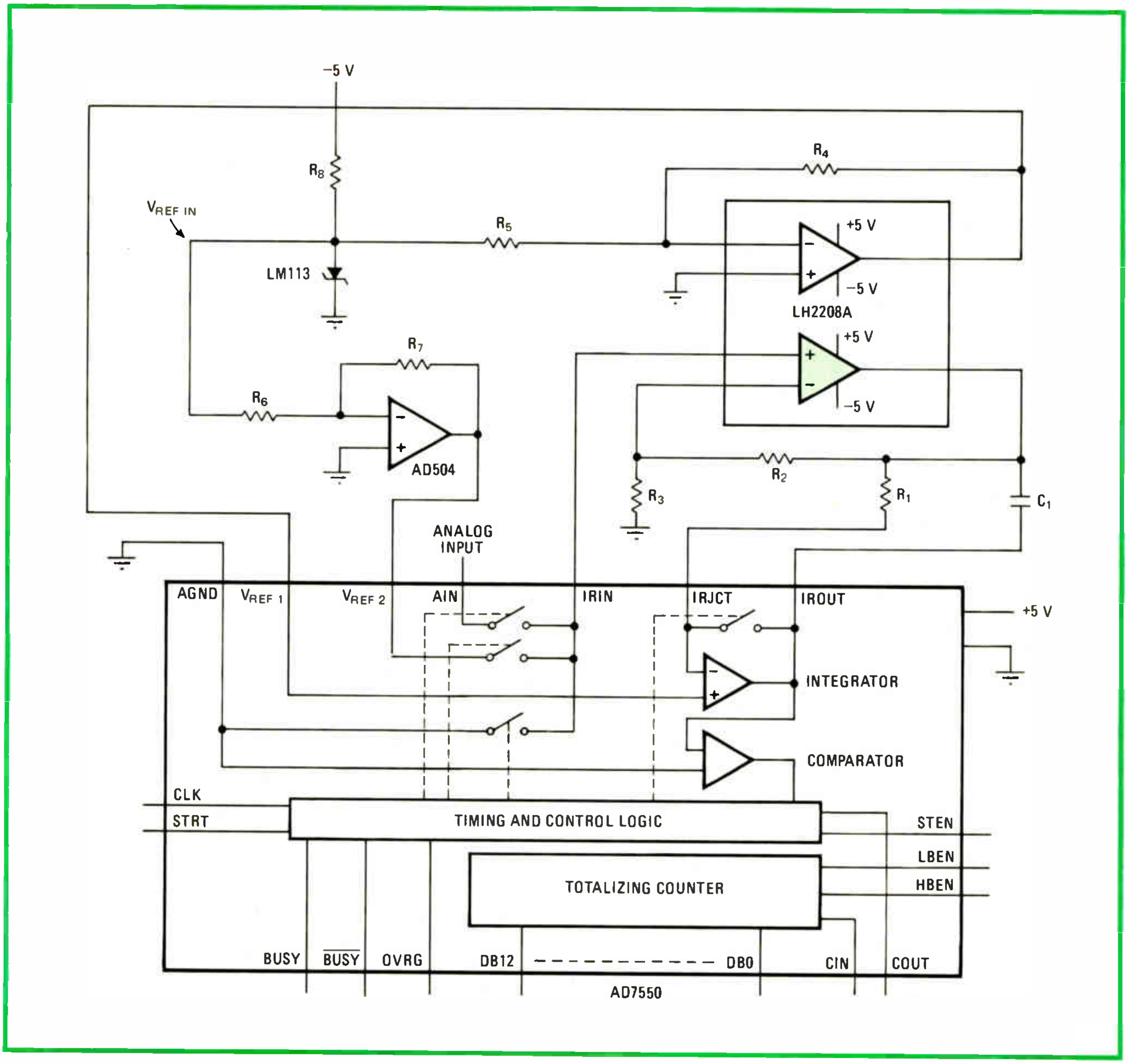
## Buffer improves converter's small-signal performance

by Will Ritmanich
*Precision Monolithics Inc., Santa Clara, Calif.*

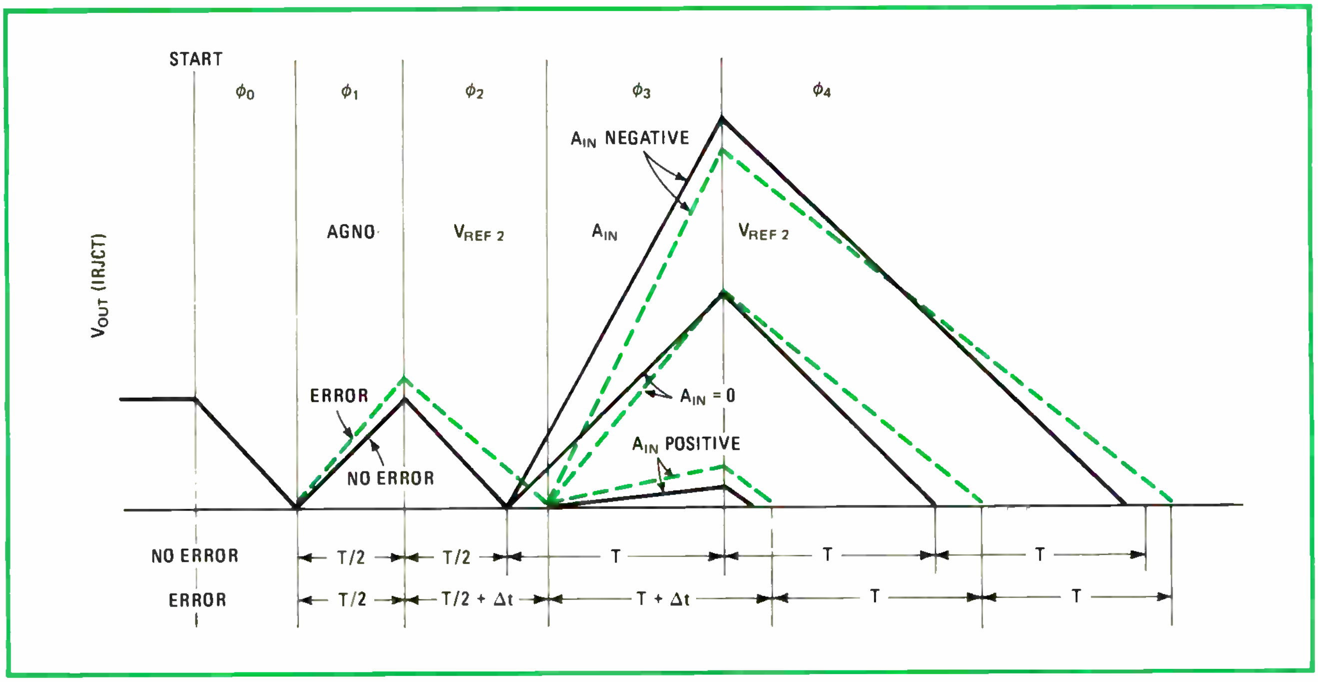
If an operational amplifier is placed in the integration and error compensation loop of the popular AD7550 analog-to-digital converter, the converter can measure microvolt-level signals without errors being introduced by its own or the op amp's offset-voltage drifts. Adding this buffer also increases the impedance of the signal (input) port of the converter, allowing it to be driven from high source impedances.

To understand why an external buffer can improve converter performance, it is necessary to know how the converter processes the input signal. The AD7550 uses the quad-slope integrating method, an improved version of the often-used dual-slope method.

A shortcoming of the dual-slope type is that errors at the input of the integrator due to noise or comparator




**1. Improved performance.** AD7550 accurately measures even microvolt-level analog voltages if op-amp buffer is placed in converter's integrator and error compensation loop. Converter views offsets as just another error that has been introduced in integrator loop.




**2. Four-phase integration.** AD7550 uses quad-slope method to detect most errors, including op-amp offset voltage drifts. This method eliminates error by measuring comparator trip-time delay, Δt, converting Δt to a voltage and subtracting the voltage at end of cycle.

offset drift show up as errors in the digital output word. The quad-slope method detects all AD7550 offset-voltage errors, converts them to a digital equivalent during the integrating cycle, and subtracts them from the final count at the end of the cycle.

Normally, a ground signal, a reference voltage, or an analog input is connected through the converter's integrator input (IRIN) terminal to the integrator junction (IRJCT) port. As shown in Fig. 1, the buffer is connected between the terminal and the port, in series with integrating resistor $R_1$. The choice of signal is determined by internal logic-controlled switch settings.

Before a four-phase a-d conversion begins, a reference voltage, $V_{REF\ 2}$, is applied to the inverting input of the integrator, resulting in a negative-going ramp at the integrator's output port. The ramp resets the output to zero. When the output voltage is equal to the comparator's trip voltage, phase $\phi_1$ is initiated.

At this time, a digital counter starts and the integrator is connected to input AGND to determine whether the converter's negative supply voltage is at ground potential. If not, an error voltage is generated that is proportional to the difference.

The output of the integrator rises proportionally to the error voltage until the counter stops counting system clock pulses, at fixed interval T/2, (Fig. 2.) Then $\phi_2$ is initiated. The accumulated voltage on the integrating capacitor, $C_1$, is proportional to AGND × T/2.

During $\phi_2$, the integrator is connected to $V_{REF\ 2}$ and any error voltage on this signal. The output of the integrator falls at a rate proportional to the error until the comparator trip point is reached. If there are no errors, the counter stops after time T; otherwise, the trip time is delayed by Δt.

$\phi_3$ then begins, starting a second counter that ultimately displays the digital equivalent of the analog input voltage introduced during the phase. $V_{REF\ 2}$ is again applied during $\phi_4$, and the counter continues to run until the integrator falls below the comparator trip point. $V_{REF\ 2}$ is normally equal to $2V_{REF\ 1}$, and the converter detects any difference.

Because $\phi_1$ through $\phi_3$ occupy a total period of 2T if there are no errors, any errors detected during these phases must show up as a delay in trip time by Δt. Since the charge gained during $\phi_3$ by the integrating capacitor is proportional to $A_{IN\ av} \times T$, and the charge lost will be equal to $V_{REF\ 2} \times \Delta t$ during $\phi_4$, then the number of counts (N) relative to the normalized (full-count) time is equal to:

$$\Delta t/t = A_{IN\ av}/V_{REF\ 2} = N$$

and is displayed directly. Thus any offset error in the buffer will not affect system accuracy, because it will be viewed as an additional (series-introduced) error existing during $\phi_1$ through $\phi_4$. At the same time, the amplifier can still be used to boost small-signal input voltages.

The gain of the amplifier may be determined by resistors $R_2$ and $R_3$ and is equal to:

$$G = \frac{(R_2+R_3)}{R_3}$$

To maintain the proper relationship between $V_{REF\ 1}$ and $V_{REF\ 2}$, resistors $R_2$ through $R_7$ are employed in the circuit and are determined by the equations:

$$V_{REF\ 1} = (R_4/R_5)V_{REF\ in}$$

and:

$$V_{REF\ 2} = \frac{R_7}{R_6}\frac{R_2+R_3}{R_3}V_{REF\ in} = 2V_{REF\ 1}$$

$V_{REF\ 1}$ and $V_{REF\ 2}/2$ should be within 6% of each other at all times. Otherwise, in $\phi_2$ and $\phi_4$, during which time

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$V_{REF\,1}$ is compared with $V_{REF\,2}$, error voltages will be generated that the converter cannot compensate for.

This conversion technique requires a stable reference voltage at the $V_{REF2}$ terminal of the AD7550, and therefore the LM113 zener diode is used with the low-offset AD504 op amp for the greatest accuracy. □

# Timer and converter generate slow ramp for chart recorders

by David Wingate
*London Hospital Medical College, London, England*

A long sweep time increases the effectiveness of an X-Y chart recorder in monitoring slow system changes. An astable multivibrator operating at low frequency and a versatile digital-to-analog converter can be used to generate an extremely linear, low-frequency ramp for the X axis, and at low cost, too. Although many good chart-recorder systems have the ability to hold down the distance the pen traverses to 0.02 centimeter per second, this circuit can limit it even further—in the neighborhood of 1 centimeter per hour, if needed.

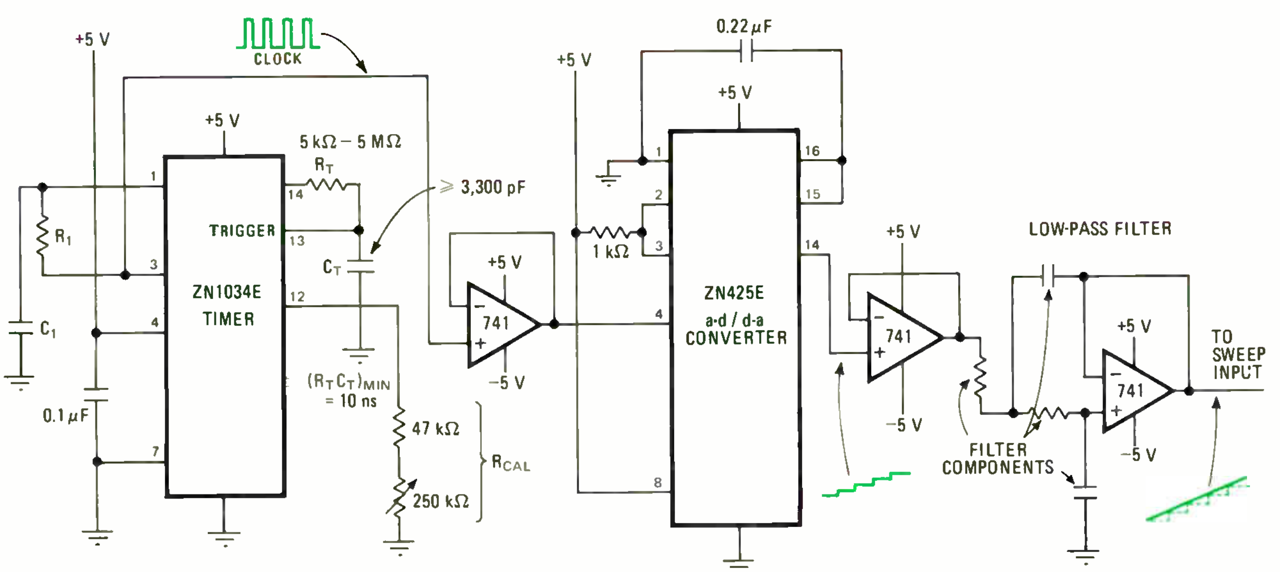
In this circuit, the rate of increase in the ramp voltage produced by the converter is controlled by the frequency of the timer. As shown in the figure, the clock for the circuit is the Ferranti ZN1034E precision timer, operated in the astable mode. This device is somewhat unusual in that the pulse width of the oscillations produced is controlled by $R_1C_1$ but the frequency of oscillation is controlled by combination $R_TC_TR_{cal}$. The second combination is part of the astable network, detecting the fall of the output pulse and retriggering the timer, and thus controlling its basic repetition rate.

$R_T$ and $C_T$ are held constant, with $R_{cal}$ the variable resistor. The table in the figure shows the relation of $R_{cal}$ to the pulse frequency. The pulse width is not critical for timebase applications, but it can be varied if required. The width equals 0.6 $R_1C_1$ seconds, where R is expressed in kilohms and C is expressed in picofarads.

After passing through a buffer stage, the clock drives the binary counter in the Ferranti ZN425E d-a converter, which is wired to serve as a ramp generator. The rate of increase in the magnitude of the ramp voltage is a function of the clock frequency; since the output rises incrementally, a staircase approximation of a ramp is generated. After passing through a buffer, the ripples in the staircase waveform are smoothed by a standard low-pass filter tuned to the clock frequency.

By increasing the capacity of the converter from an 8- to a 12-bit device, it is possible to generate a ramp voltage having even greater resolution. The circuit has served well in an application involving prolonged recording of biomedical and biological data, but, many other nonmeasurement applications are possible. □

*Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.*




| $R_{CAL}$ (kΩ) | CLOCK FREQUENCY (Hz) |
|---|---|
| 100 | 2736 $C_TR_T$ |
| 150 | 4095 $C_TR_T$ |
| 300 | 7500 $C_TR_T$ |

ZN425E, ZN1034E: AVAILABLE FROM FERRANTI ELECTRIC INC., EAST BETHPAGE RD., PLAINVIEW, N.Y.

**Slow time base.** Low ramp frequency for X input of chart recorder, permitting long-period monitoring assignments of various systems, is generated by d-a converter and timer. Slope of ramp voltage with respect to time is determined by clock frequency.

# Assembling a complex breadboard can be as easy as 1, 2, 3

## An updated version of the bus bar helps make parts layout more orderly and power distribution less noisy

by Bernard J. Carey and Harry Grossman, *Department of Electrical Engineering and Computer Sciences, The University of Connecticut, Storrs*

☐ The breadboard for complex digital circuitry often winds up as a system's stumbling block, simply because a designer has failed to account for parts layout and power distribution. Yet a systematic approach to breadboard building, using an updated version of the bus bar known as the power distribution element, can produce easy-to-assemble wire-wrapped breadboards for microcomputer system modules. Moreover, this approach eliminates much of the high-frequency noise generated by the switching action of the high-speed logic of such modules.

This new prototyping method has been used successfully at the University of Connecticut's microprocessor laboratory to construct central processing units and memory and peripheral-interface modules. It is simple enough for untrained workers to complete complex boards quickly and easily.

Of course, the designer must adhere to the guidelines that follow if semiskilled workers are to be able to build microcomputer boards. Breadboards that were built following these guidelines were tested for noise, and the results demonstrate the noise reduction possible with power distribution elements.

The advantages of using the new prototyping method with these bus bars are several:

- The method imposes an orderliness on board layout that facilitates the layout itself and speeds up the process of creating the breadboard (especially when untrained workers do the job).
- It results in electronic assemblies that have a low noise level on power and ground lines because of the inherent noise suppression of the PDEs.
- It provides a lower-cost technique of fashioning breadboards by substantially reducing the number of decoupling capacitors required to reduce system noise.
- It eases the transition from breadboard to printed-circuit board, because the layout used in the breadboard is reasonably efficient and logically organized from the outset (especially where the bus bars are incorporated into the production pc board design).

### Breadboard to pc

This breadboard procedure was designed to exploit the potential of the mechanical and electrical properties of PDEs for realizing a low-noise system. The use of these bars also established an orderly layout.

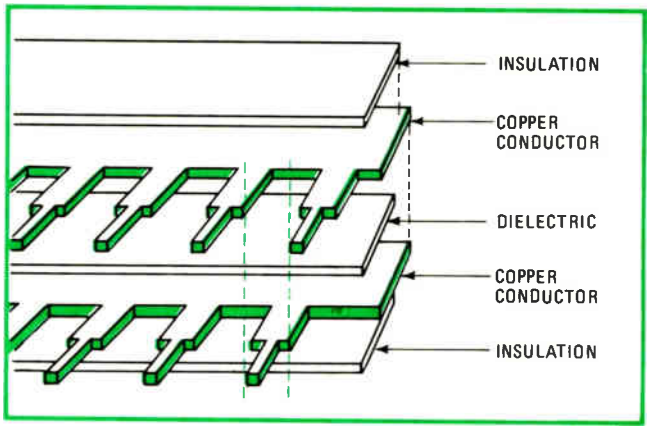
Students at the University of Connecticut who constructed prototypes with this method were able to conceptualize the PDE as a black box with an input/output relationship that could be used to advantage in constructing new digital modules. Thus they saw the construction process as the positioning and interconnection of a group of functionally related digital elements (logic devices and PDEs).

A close similarity may exist between the layout and signal interconnection of a wire-wrapped prototype and those of the final pc board version of the prototype. This relationship is most evident in the memory matrix of a memory board, but it will also hold true in other boards using random logic, microprocessors, and large-scale integrated devices.

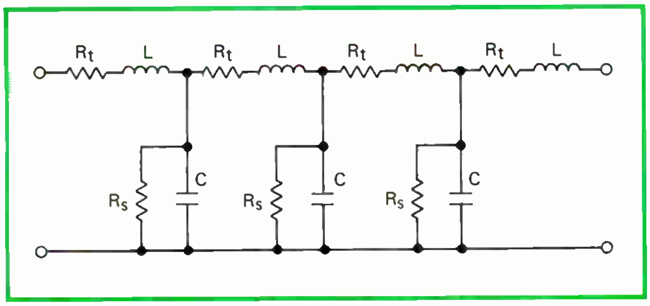
The trend away from random logic to LSI results in a more standard signal interconnection system. That standardization, coupled with the formal organization of the board imposed by PDEs, simplifies layout.

### Bus power

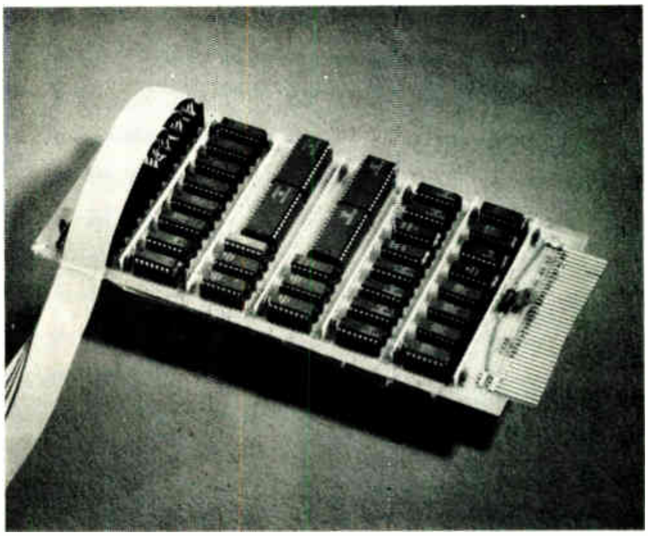
Before looking at the actual construction of prototype boards, it is best to examine the power distribution element itself. A PDE (Fig. 1) is composed of two copper conductors laminated into an integral unit with an interleaved thin dielectric. The exterior is generally covered with a plastic barrier material to prevent accidental shorting. One conductor is the power bus and the other is




**1. Power distributor.** The power distribution element (PDE) is composed of a two-conductor bus bar interleaved with a dielectric. This exploded view shows the components of a vertically mounted configuration. Other PDEs are available in horizontal configurations.




**2. Equivalent circuit.** The circuit equivalent of a PDE resembles a very lossy transmission line. The buses' low impedance and low inductance make them effective elements for suppressing high-frequency noise on power and ground lines.



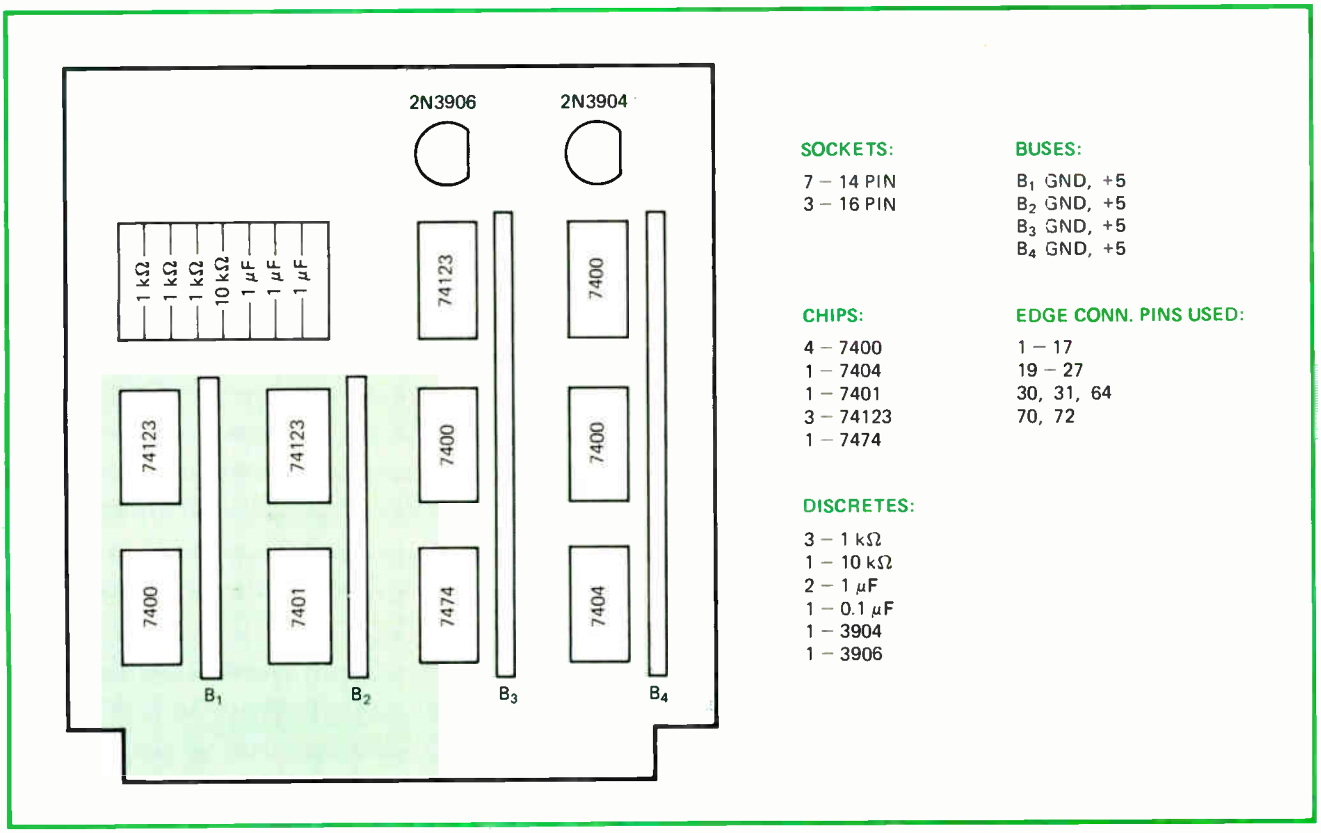
**3. Interface breadboard.** This 8080 interface card is an illustration of a circuit built with the method described. The thin upright components between the rows of DIPs are PDEs. All system wiring is done on the underside of the board by wire-wrapping.

a ground return. Pairs of leads from the two conductors are brought out at regularly spaced intervals for insertion into standard pc-board holes. Power and ground for a particular integrated circuit are connected to a pair of leads, while the pair of leads at either end serve as the bus bar's I/O points.

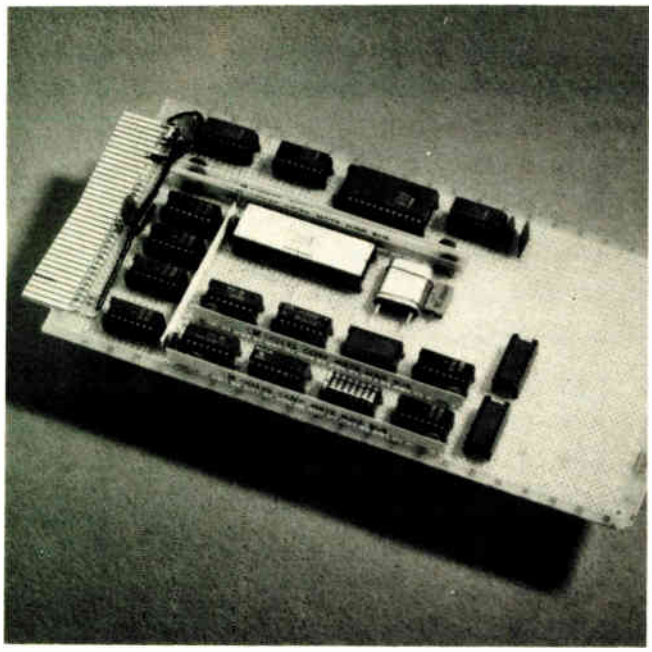
A PDE is equivalent to a very lossy transmission line (Fig. 2) with a low characteristic impedance on the order of several ohms. Because of its low impedance, current transients will produce lower noise voltages than on pc wiring, which has a characteristic impedance as high as 50 ohms. Because a bus bar is quite lossy, it also will attenuate the noise voltage and energy more per unit length than buses printed on the pc board.

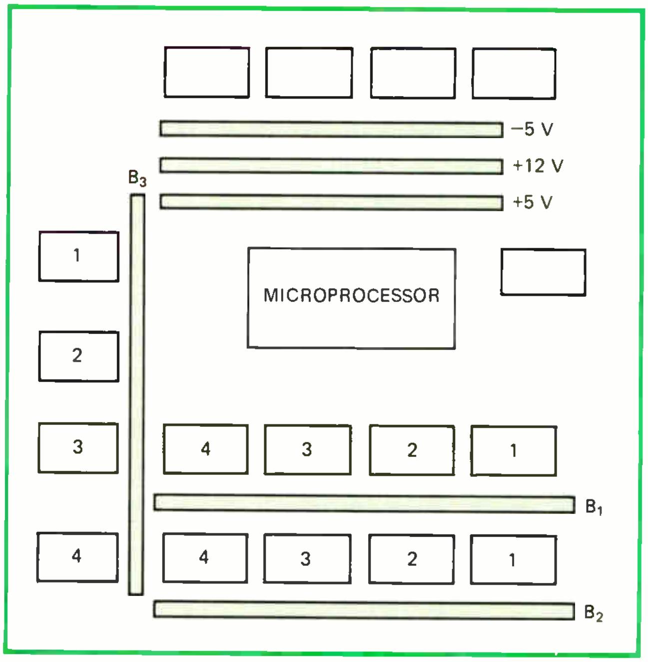
A PDE is more efficient at suppressing high-frequency noise than are decoupling capacitors—in spite of the fact that commercial bus bars usually have much lower capacitances than typical decoupling capacitors. Above 20 megahertz, the inductance of the leads of most decoupling capacitors renders the capacitance ineffective. While the PDE is limited in capacitance (225 to 1,200 picofarads per square inch), it is an extremely low inductance element at noise frequencies above 20 MHz.

PDEs are available from such firms as Rogers Corp.,




**4. Board layout.** In this construction method for breadboards, sockets are arranged in rows or columns, with a PDE for each. Every PDE has its own separate ground and power returns to the edge connector's plated-on ground- and power-connector fingers.






**5. Microprocessor.** This board (left) has an 8080A CPU plus interface circuitry. It has a mix of TTL and MOS circuitry. Layout (right) must account for three power supplies rather than one as in a memory card, and this prevents a symmetrical layout.

Rogers, Conn.; Eldre Components Inc., Rochester, N. Y., and Bussco Engineering Inc., El Segundo, Calif. The units come in vertical configurations, as in Fig. 1, and horizontal configurations with pins at 90° angles to the edge so that the bar will lie flat on the board. The type in the circuits described in this article is the Rogers M-823, a vertically mounted, two-conductor PDE.

### Breadboarding with the PDE

The main component used in the development of the breadboard is a simple glass-epoxy pc board without printed power or ground planes. This inexpensive board has holes predrilled on 0.1-in. centers and 72 edge contacts. It accommodates a mixture of different sizes and families of ICs, in association with discrete components. Standard wire-wrappable sockets ranging in size from 14 to 40 pins are inserted into the board along with standard 9-in.-long PDEs with solder tabs, costing less than $1 each. When combined with discrete components, the result is a breadboard such as the 8080 interface circuit of Fig. 3.

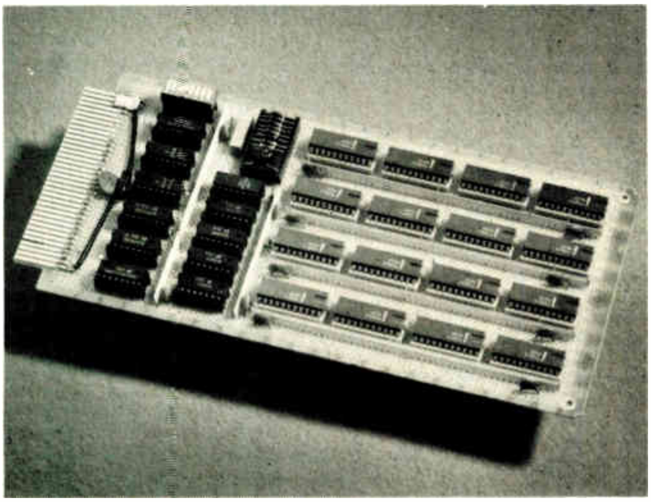
A specific example can best demonstrate the procedures involved in layout of a typical breadboard. But it should be clear that these procedures apply to any circuit design. The goal is to produce a buildable board that is immediately operable (assuming no engineering design errors) in a minimum amount of time, after minimal effort, and at the least possible expense. There are seven specific layout considerations in this procedure. The breadboard builder should:

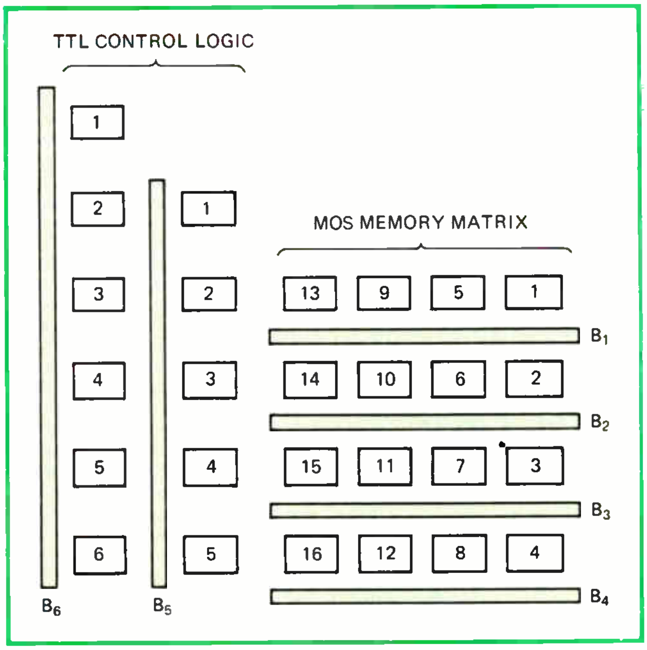
1. Generate a complete parts list from the circuit diagram so that every part that must appear on the breadboard is known.
2. Note any relationships between IC functions that might make wiring easier. For example, consolidate gates electrically interconnected on the circuit diagram into as few packages as possible, and then locate the packages as close to each other as possible.
3. To get a systematic grounding and power-distribution system, arrange sockets in rows or columns, with a separate PDE for each row or column. Segregate all transistor-transistor-logic and metal-oxide-semiconductor devices by family types into these rows and columns.
4. To prevent ground loops, make power and ground connections to each PDE at one end only and as close to the edge contacts as possible.
5. For added filtering, leave room at either end of the bus bars for an hf ceramic disk capacitor with a value of at least 0.01 microfarad.
6. Whenever possible, put discrete components in sockets connected by wire-wrapping terminals. This makes for easier replacement of defective components and keeps the board neater.
7. Keep drivers/receivers as close as possible to the edge contact being serviced, because these devices draw the most current.

With all these precepts in mind, the designer generates a board layout diagram: the means of correlating information on the circuit diagram with the pieces of hardware it describes. The layout diagram (Fig. 4) should be a representative picture of the component side of the board (not necessarily to scale). Essentially, it shows the position of each socket and the type of chip or component in that socket. This information corresponds directly to that recorded on the circuit diagram. Where discrete components are to be mounted, the sockets should also show the position and value of each such component. Moreover, each PDE circuit should be labeled.

A complete parts list should also be shown on the layout diagram to describe everything mounted on the board. This list should include the type and quantity of chips, sockets, and discrete components needed, all PDEs and the voltages they carry, and a list of all edge

**6. Memory.** The memory board (below) is a 2-k-by-8-bit static memory using 16 Intel 2102 MOS random-access memories and TTL control logic. The board is divided into families of logic types (right) each having its own PDE for distributing +5 V and ground.






connection pins required. The board layout diagram, together with the circuit schematic, contains all of the information necessary to generate the signal-path wire-wrapping list.

With the board diagram in hand, even an unskilled worker can construct the breadboard. He or she should take the following steps, in order.

First, position all sockets as shown on the layout diagram and secure them to the board with adhesive. Discrete components not in sockets should be attached to the board with a soluble adhesive for easy removal.

Next, solder wire-wrappable pins in place only at those edge contacts that are to be used. Each edge contact carrying the same supply voltage should be positioned and tied together at the edge connector. To bring a good ground to the board, connect three adjacent edge pins and their opposites. All other power supply connections may be made on one edge pin and its opposite connected together.

To cut noise, decouple each power supply voltage brought on to the board edge contacts. In some cases, this is the only decoupling necessary. The recomended decoupling values are 0.1 $\mu$F for an hf ceramic-disk capacitor paralleling a tantalum capacitor of 20 to 30 $\mu$F.

Then make connections to PDEs. Define one side of the bus bar as ground and the other as a supply voltage. Connect power and ground to the ICs composing the row or column to which the PDE is assigned. Connections are made by soldering a wire to the tabs on the bus bar and by wire-wrapping to appropriate IC sockets. Thirty-gauge wire can be used for wire-wrapped connections. With all the sockets connected to their appropriate bus bars, connect each PDE to its appropriate ground and power supply at the board's input edge contacts.

To avoid couplings between the PDEs, which would increase the noise level, each bus bar should have a separate ground and power connection, with both connected at the same end of and as close to the edge contacts as possible. Minimum wire size for these connections should be 24-gauge multistranded. Of course, the wire gauge should become heavier as the number of devices hung off the PDE increases.

To illustrate the noise-reduction properties of this construction method, a microcomputer system composed of an 8-bit CPU and a 2,048-word-by-8-bit MOS static memory was built. The cards used a mixture of MOS logic, TTL and Schottky-TTL along with various PDE layout configurations. A special test program was designed so that noise would be injected into the power and ground lines of the two-board microcomputer system. The resulting noise signals were monitored at test points on the various bus bars.

## Cutting noise

The microprocessor board (Fig. 5) contains an Intel 8080A CPU, a system clock, and interface circuitry between the processor and other modules in the overall system. A variety of power supplies (+5 volts, −12 v, −5 v) and dual in-line packages (14-, 16-, 22-, and 28-pin) are used, together with a heavy proportion of random logic. Of the 14 packages, 12 are small-scale integration and 2 are LSI. As the source of the control, data, and address variables that activate the memory board, the CPU consists of a mix of MOS and TTL.

The 2-k-by-8 memory board (Fig. 6) has an LSI array of 16 Intel 2102 MOS random-access memories and an address-decoding and control section of SSI 7400 series TTL devices. The memory matrix is a 4-by-4 array and is logically organized so that the lower 2-by-4 array is the first 1,024 8-bit words of system memory, while the upper 2-by-4 array is the next 1-k-by-8-bit portion of system memory.

Each column on the board has its own PDE for distributing +5 v and ground, so switching noise is isolated between columns. In addition, the logic organization of the memory matrix is such that noise behavior for each column is essentially the same. The 8-bit word is distributed across the columns so that exactly two devices per

## TABLE: EXPERIMENTAL TEST DATA

| Instruction | Test point | Decoupling | Noise observed | Explanation and analysis |
|---|---|---|---|---|
| **Noise in MOS memory matrix** | | | | |
| Read / 18 ms | $B_1$, $IC_1$ | None | 860 mV pk/pk | Case (a). No decoupling. Typical noise levels approximately 860 mV pk/pk. |
| Halt | $B_1$, $IC_1$ | None | 68 mV pk/pk | Case (a). No decoupling. Only system clock and some support functions operate. |
| Write / 18 ms | $B_3$, $IC_{15}$ | 0.01 $\mu$F | 460 mV pk/pk | Case (b). Noise at decoupled supply node of PDE. Note noise is reduced by approximately 2 : 1 over case (a). |
| Write / 18 ms | $B_3$, $IC_3$ | 0.01 $\mu$F | 520 mV pk/pk | Case (b). Noise at end of the PDE without decoupling. As expected, noise is less (460 mV) at decoupled node. |
| Write / 18 ms | $B_4$, $IC_{16}$ | 0.1 $\mu$F | 440 mV pk/pk | Case (b). Decoupling values were increased from 0.01 $\mu$F to 0.1 $\mu$F. It was concluded that 0.01 $\mu$F decoupling capacitors were adequate in this breadboard condition. |
| Write / 18 ms | – | 0.01 $\mu$F | 360 mV pk/pk | Case (c). Decoupling of 0.01 $\mu$F at both ends of the PDE reduced noise level to 360 mV pk/pk. |
| **Noise in TTL memory control logic** | | | | |
| Instruction | Test point | Decoupling | Noise observed | Explanation and analysis |
| Write / 18 ms | $B_5$, $IC_2$ | None | 1.2 V pk/pk | Case (a). No decoupling. Typical noise levels were 1.2 V pk/pk. |
| Write / 18 ms | $B_5$, $IC_1$ | 0.01 $\mu$F | 440 mV pk/pk | Case (b). Noise at the decoupled supply node of the PDE. Note noise is reduced by about 3 : 1 over case (a). |
| Write / 18 ms | $B_5$, $IC_5$ | 0.01 $\mu$F | 740 mV pk/pk | Case (b). Noise at end of the PDE without decoupling. Again, noise is greater (740 mV) than at the decoupled end of the PDE (440 mV). |
| Write / 18 ms | $B_5$, $IC_1$ | 0.01 $\mu$F | 300 mV pk/pk | Case (c). With decoupling at both ends of PDE, noise is typically reduced by about 4 : 1 over case (a). |
| **Noise in microprocessor** | | | | |
| Instruction | Test point | Decoupling | Noise observed | Explanation and analysis |
| Write /18 ms | – | None | 940 mV pk/pk | Case (a). No decoupling. |
| Write / 18 ms | – | 0.01 $\mu$F | 400 mV pk/pk | Case (c). With decoupling at both ends of the PDE, noise was reduced typically by 2 : 1 over case (a). |

column will be active at any given time. A maximum of two devices will be switching and injecting noise into the power- and ground-distribution system at any one time.

The layout of this board (Fig. 6b) is much more orderly than the microprocessor layout (Fig. 5b). However, both boards follow the layout rules enunciated earlier, with resulting low noise characteristics for both. Timing of noise appearing in the system will be a function of two variables: the program being executed and system clock rate, which specifies the rate at which a program is sequenced.

## Microcomputer testing

Two instructions, load accumulator and jump, were used in a test program to cause internally generated switching noise to appear on the system's power and ground lines. The program controls the characteristics of the noise to cause generation of worst-case noise. It switches 11 address variables simultaneously, along with almost all of the devices on the memory board—putting maximum hf noise into both power and ground lines of the PDES.

Noise tests on the memory board were divided between the transistor-transistor and MOS logic families, each operating under three power and ground noise-distribution conditions: (a) PDES without decoupling capacitors; (b) PDES with 0.01-$\mu$F decoupling at one end; and (c) PDES with 0.01-$\mu$F decoupling at both ends.

The configuration in (a) provides a basis of comparison for determining the need for and amount of decoupling capacitors. Noise generated in the columns of the matrix and rows of control logic was measured with the CPU exercising the memory through a read/write loop.

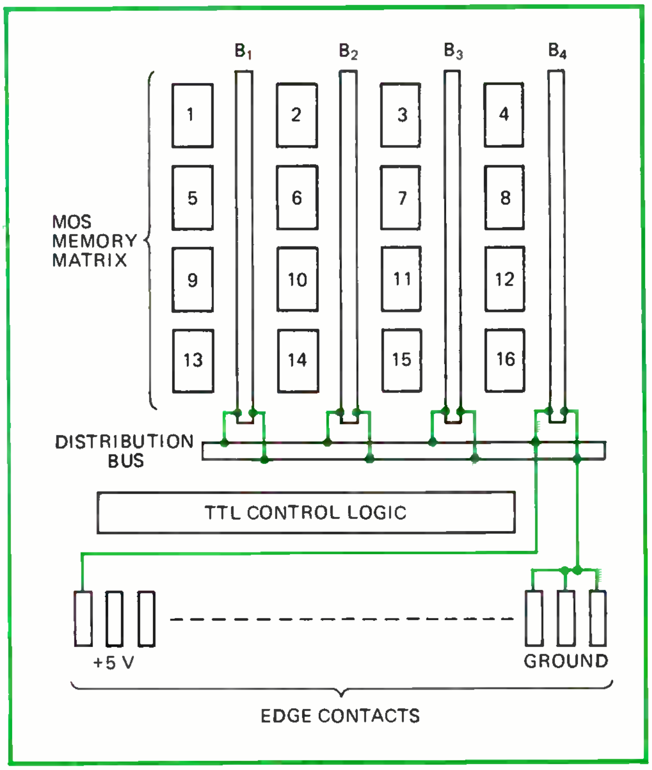
With configuration (b), power and ground from the main power supply were individually connected to the bottom of each PDE. Noise flows toward power supply connections where it is dissipated, since this is the lowest-impedance path back to the main supply. For this reason, 0.01-$\mu$F decoupling capacitors were added to the bottom (connection end) of each PDE, and noise measurements were taken as in configuration (a).

Noise may be generated at any point along a bus bar and is initiated at any PDE/IC node. Since the noise power is dissipated as the spike propagates from its point of origin along the PDE in either direction, decoupling at both ends—configuration (c)—should provide some improvement over decoupling at one end. So noise measurements were obtained as in other two cases.

Noise tests on the microprocessor board were carried very much as they were on the memory board. The table shows the test data obtained on the memory board (for both the MOS memory matrix and the TTL control logic) and on the microprocessor. The tests were performed on + 5-V and ground lines at points referenced in the table by bus and IC numbers.

As the table shows, decoupling both ends of a PDE proved to be the most effective method of noise reduction for both boards. Noise reduction from 2:1 to 4:1 over the configurations without decoupling were obtained. Decoupling only at the supply end gave some improvement, but not as much as with double decoupling.

Finally, a test was performed to determine the effect




**7. Daisy chaining.** It is possible to replace all separate PDE ground and power returns with one distribution bus on the memory board of the microcomputer. However, this approach actually increases system noise levels by introducing extra coupling between PDEs.

of daisy chaining: replacing the individual power and ground connections to each bus bar with one pair of wires. A memory board was configured with a PDE used as a distribution plane supplying all columns in the matrix (Fig. 7).

As predicted, noise in the matrix is greater than in the configuration without daisy chaining, because the coupling between the bus bars is closer and the impedance at the junctions of the distribution bus and the PDES is higher. A comparison of the measured noise voltages with those in the table shows that daisy chaining the power and ground connections increases noise about 33% at the junctions and 60% at the top of the PDES.

To provide a comparison, a commercial wire-wrappable microcomputer board was tested in the same manner as the microcomputer breadboards. The commercial board's arrangement is such that power and ground are distributed on pc wiring, and a 0.01-$\mu$F decoupling capacitor is used with every chip. Signal interconnections are wire wrapped.

Measured noise voltage at power and ground points on this board range from about 350 millivolts peak to peak to 800 mv pk-pk. Of course, there are 25 decoupling capacitors, compared to the 10 when one PDE per column is used on the breadboards. Even with all these added capacitors, the noise characteristics were worse than with the equivalent breadboard. Wire-wrapped boards with PDES appear to offer clear design and cost advantages over commercial wire-wrapped boards with etched power- and ground-distribution systems and "brute force" decoupling. □

# Astable multivibrator measures tolerance of capacitors

by V. Ramprakash
*Electronic Systems Research, Madurai, India*

Knowing the absolute value of a capacitor is sometimes less important than knowing its tolerance, or deviation from a standard value, especially in batch-measuring applications. This circuit uses an astable multivibrator in a simple bridge-type circuit to directly measure the signed value of capacitor tolerance. Once the meter is calibrated, it can be used over a wide range of reference-capacitor values without adjustment, thus combining accuracy and low cost with convenience.

As shown in the figure, the test and reference capacitors ($C_T$ and $C_{ref}$, respectively) are used with resistors R and $R_1$ to control the frequency of oscillation in the astable multivibrator. A center-zero microammeter measures the bidirectional current flowing between the collectors of the transistors during each cycle.

As expected, the duty cycle of the output waveform is normally 50%, occuring when $C_T = C_{ref}$. The magnitude of the current flowing from $Q_1$ during one half of the cycle is equal to that of $Q_2$ flowing in the opposite half; since the currents are opposite in magnitude, the average-responding meter reads zero.

If $C_T$ is greater than $C_{ref}$, then $Q_2$ will be off for a greater time per cycle than $Q_1$, and the meter will show a positive deflection. The deflection is a measure of the difference between $C_T$ and $C_{ref}$, although the relationship between the deflection and the difference is not linear.

The tolerance is defined as $T = \Delta C/C_{ref}$, where $\Delta C$ is equal to $C - C_{ref}$. If $R = R_1$ and we neglect $R_C$, the meter current flowing per cycle is:

$$I_{av} = \frac{0.69R\Delta C}{0.69RC_T + 0.69RC_{ref}} \times I_m \quad (1)$$

or:

$$I_{av} = \frac{\Delta C}{C_{ref} + \Delta C + C_{ref}} \times \frac{V_{cc}}{R_m} \quad (2)$$

Dividing the numerator and denominator of the first term by $C_{ref}$ reduces the equation to:

$$I_{av} = \frac{T}{2+T} \times \frac{V_{cc}}{R_m} \quad (3)$$

This equation is used to make a one-time calibration of the instrument for a given full-scale meter deflection, provided the reference capacitor does not change by a factor greater than 10. Let $C_T = C_{ref} = 1$ microfarad in the astable circuit so that $R_1$ can be adjusted for a zero indication on the meter. Use a 0.2-$\mu$F capacitor for $C_T$ so that there is a 20% difference between $C_T$ and $C_{ref}$ and adjust $R_m$ for a full-scale reading of 100 microamperes. Thus equation (3) becomes:

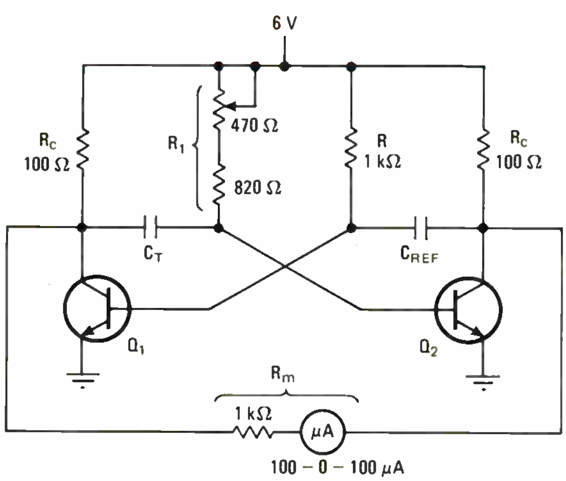
$$100\,(10^{-6}) = \frac{0.2}{2+0.2} \times \frac{V_{cc}}{R_m} \quad (4)$$

from which it is determined that $V_{cc}/R_m = 1{,}100\ \mu A$. Substituting this value in (3) and dividing both the numerator and denominator of the first term by T, the relation of meter deflection (D) to the tolerance for a 100-$\mu$A movement becomes:

$$I_{av} = D = (1 + 2/T)^{-1} \times 1{,}100\ \mu A \quad (5)$$

This equation is easily evaluated in order to calibrate the meter. The results are shown in the table. □

*Engineer's notebook* is a regular feature in *Electronics*. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.




**Tolerance meter.** Test capacitor $C_T$ and reference capacitor $C_{ref}$ control frequency and duty cycle of astable multivibrator. Tolerance rating of $C_T$ is related to change in duty cycle and is found by measuring arithmetic average of the bidirectional current flowing in the collector circuit. Relation of meter's deviation to tolerance rating of $C_T$ is shown in table.

| $C_T$ TOLERANCE (%) | ±20 | ±15 | ±10 | ±5 | ±1 | 0 |
|---|---|---|---|---|---|---|
| METER READING | ±99.99 | ±76.74 | ±52.38 | ±26.82 | ±5.47 | 0 |

# SR-52 solves second-order differential equations

by H. E. Lee
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Transient-analysis or heat-transfer problems often involve a second-order differential equation. But even if the equation is nonlinear, this SR-52 program solves it quickly and accurately. It uses a numerical approximation method based upon the fourth-order Runge-Kutta technique to achieve excellent results.

The program will solve any equation of the form $y'' = f(x,y,y')$, given any set of initial boundary conditions. The second-order equation is reduced to two first-order equations by the program, thus creating a set of 10 linear, interrelated equations that are solved using the well-known method of finite differences.

A simple example demonstrates the usefulness of the program. Consider the resistor-inductor-capacitor circuit shown, where the current is to be found as a function of time. The Kirchoff loop equation may be written:

$$V = L\frac{di}{dt} + Ri + \int \frac{i}{C}dt \qquad (1)$$

This is the well-known integrodifferential equation that characterizes a series RLC circuit. Differentiating with respect to t, and noting that V is a constant 5 volts, the equation becomes:

$$\frac{dV}{dt} = 0 = L\frac{d^2i}{dt^2} + R\frac{di}{dt} + \frac{i}{C} \qquad (2)$$

$$\text{or:} \quad \frac{d^2i}{dt^2} = -\frac{R}{L}\frac{di}{dt} - \frac{1}{LC}i \qquad (3)$$

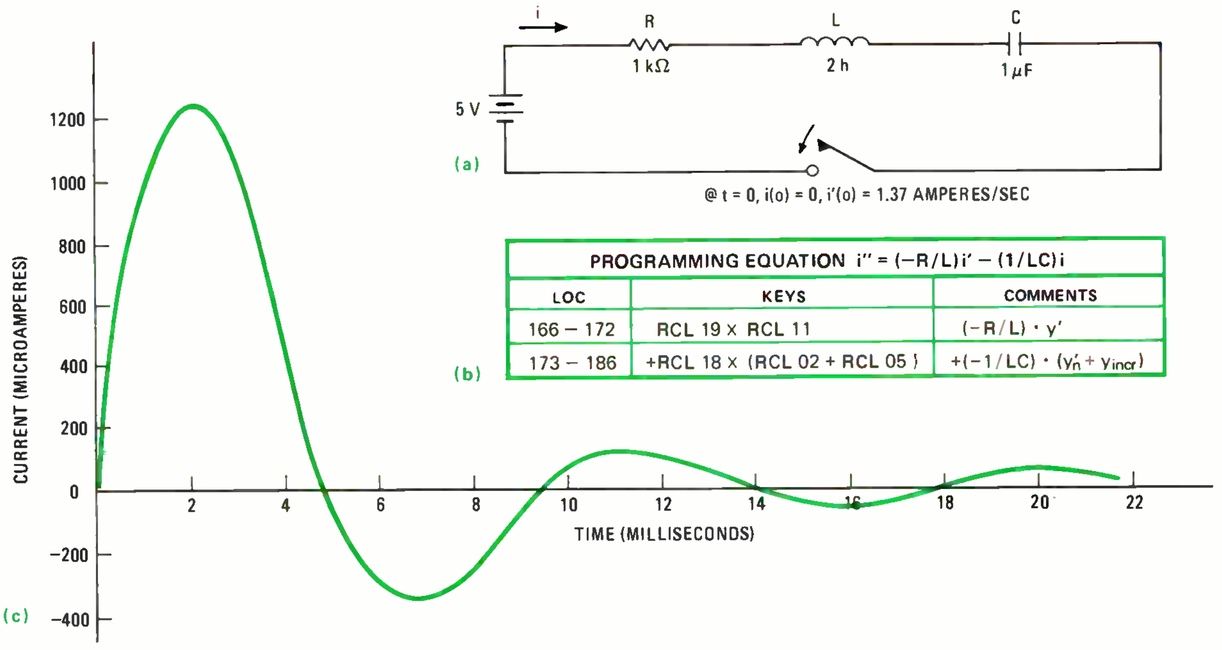
Substituting for R, L, and C, the equation now becomes:

$$\frac{d^2i}{dt^2} = i'' = -500i' - 0.5(10^6)i \qquad (4)$$

This equation is of the desired form for the calculator, where x is the time (t), y is current (i), and $y'$ is $i'$.

The right side of Eq. 4 is entered into the calculator program beginning at location 166; the table in the figure shows how this is done. First, however, we may store the $i'$ coefficient $(-R/L)$ in a spare register, such as $R_{19}$, the i coefficient $(-1/LC)$ in $R_{18}$, and any constant term in $R_{20}$, permitting these values to be easily changed without affecting the stored general equation.

The key code shown in (b) will be easily understood if it is recognized that the coefficient of the y term must always by multiplied by the contents of the $R_{02}$ plus $R_{05}$ registers and that the $y'$ coefficient must be multiplied by $R_{11}$, to ensure that the 10 linear equations are updated properly. If the right side of the equation has an x coefficient, it must always be multiplied by $R_{01}$. The small table shows the coding needed for the equation $y'' = x^2 + 3x + 4 + 4y' - 7y$ as an additional example so that there will be no confusion in programming any general second-order equation. After the equation has been keyed in, all one need do is enter the initial boundary conditions at $R_{01}$ through $R_{03}$ and specify in $R_{04}$ the increment of time over which the internal linear




(b)

| PROGRAMMING EQUATION $i'' = (-R/L)i' - (1/LC)i$ | | |
|---|---|---|
| LOC | KEYS | COMMENTS |
| 166 – 172 | RCL 19 x RCL 11 | $(-R/L) \cdot y'$ |
| 173 – 186 | +RCL 18 x (RCL 02 + RCL 05) | $+(-1/LC) \cdot (y'_n + y_{incr})$ |

**Classical solution** SR-52 solves second-order differential equations, linear or nonlinear. Once the general equation for the typical network shown in (a) is known, it may be presented to the calculator for evaluation (b). Plotted results (c) show expected damped oscillation.

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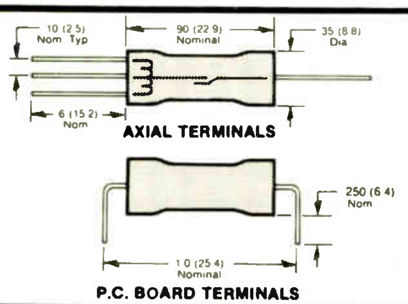
**RELAY INFORMATION** VDC @ 25°C

| Order Info | Rated Coil Voltage (VDC) | Must Operate (VDC) | Must Release (VDC) | Coil Resistance, Ohms (± 10%) | Max Coil Voltage |
|---|---|---|---|---|---|
| LG101-1-5 | 5-12 | 4.0v | 5 | 500 | 25 |
| LG101-1-24 | 24 | 19.0 | 2.0 | 2000 | 50 |

**DIMENSIONS**




### PREMIUM QUALITY SWITCHES

- **Low Contact Resistance** Typically 50 to 90 mΩ
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- **Highest strength glass-to-metal seals available**

### PREMIUM COIL CHARACTERISTICS

- **Low Power Consumption, High Sensitivity (TTL Compatible)** 50 mw nominal
- **High Overvoltage Capacity** Designed for up to 5 times nominal coil voltage
- **Fast Operation** Operations less than 1 m.s.

### PATENTED CONSTRUCTION (Pats. Pend.)

- **Quality Engineering Plastics** High insulation resistance ($10^{12}$ Ω typical), high humidity protection, high chemical resistance
- **Rugged** No exposed parts, withstands physical abuse, can be submerged for cleaning
- **Practical** Low profile size and mounting pattern will retro-fit most industry standards, terminals accessible for in-circuit testing
- **Integral Switch Terminals** No joints

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| THE PROGRAMMING OF $y'' = 4y' - 7y + x^2 + 3x + 4$ | | |
|---|---|---|
| LOC | KEYS | COMMENTS |
| 166 – 170 | 4 · RCL 11 | $4y'$ |
| 171 – 182 | −7 · (RCL 02 + RCL 05) | $-7y$ |
| 183 – 188 | +RCL 01 · $x^2$ | $+x^2$ |
| 189 – 196 | +3 · RCL 01 + 4 | $+3x + 4$ |

equations are stepped in order to determine the current.

A wise choice for the increment (h) is the smallest value possible: typically, 0.001 second or less. Otherwise, the program has difficulty converging to a solution. (A value of 0.0005 s was used for the example discussed.) Press A to find the current after time $t_o + h$; thereafter, pressing RUN n times will yield the current flowing after time $t_o + nh$. □

## *SR-52 SECOND-ORDER DIFFERENTIAL EQUATION PROGRAM

| LOCATIONS | CODES | KEYS | COMMENTS |
|---|---|---|---|
| 000 – 001 | 46 11 | *LBL A | |
| 002 – 005 | 15 43 00 07 | E RCL 07 | |
| 006 – 011 | 42 00 09 55 02 95 | STO 09 ÷ 2 = | $K_1 = h \times f(x, y, z) = h \times f(t, y, y')$ |
| 012 – 017 | 42 00 05 43 00 08 | STO 05 RCL 08 | |
| 018 – 023 | 42 01 00 55 02 95 | STO 10 ÷ 2 = | $L_1 = h \times g(x, y, z)$ |
| 024 – 028 | 42 00 06 12 15 | STO 06 B E | |
| 029 – 034 | 43 00 07 65 02 95 | RCL 07 X 2 = | $2K_2 = 2h \times f(x + h/2, y + K_1/2, z + L_1/2)$ |
| 035 – 040 | 44 00 09 55 04 95 | SUM 09 ÷ 4 = | |
| 041 – 046 | 42 00 05 43 00 08 | STO 05 RCL 08 | $2L_2 = 2h \times g(x + h/2, y + K_1/2, z + L_1/2)$ |
| 047 – 049 | 65 02 95 | X 2 = | |
| 050 – 055 | 44 01 00 55 04 95 | SUM 10 ÷ 4 = | |
| 056 – 060 | 42 00 06 15 12 | STO 06 E B | |
| 061 – 066 | 43 00 07 42 00 05 | RCL 07 STO 05 | $2K_3 = 2h \times f(x + h/2, y + K_2/2, z + L_2/2)$ |
| 067 – 072 | 65 02 95 44 00 09 | X 2 = SUM 09 | |
| 073 – 078 | 43 00 08 42 00 06 | RCL 08 STO 06 | $2L_3 = 2h \times g(x + h/2, y + K_2/2, z + L_2/2)$ |
| 079 – 084 | 65 02 95 44 01 00 | X 2 = SUM 10 | |
| 085 – 088 | 15 44 01 00 | E SUM 10 | evaluate differential changes in K and L in test equation, sum in $R_{10}$ $(L_4)$, in $R_{09}$ $(K_4)$ |
| 089 – 094 | 43 00 07 44 00 09 | RCL 07 SUM 09 | |
| 095 – 099 | 43 00 09 55 06 | RCL 09 ÷ 6 = | $y_{n+1} = y_n + (K_1 + 2K_2 + 2K_3 + K_4)/6$ |
| 100 – 104 | 85 43 00 02 95 | + RCL 02 = | |
| 105 – 108 | 81 42 00 02 | HLT STO 02 | |
| 109 – 114 | 43 01 00 55 06 95 | RCL 10 ÷ 6 = | $z_{n+1} = z_n + (L_1 + 2L_2 + 2L_3 + L_4)/6$ |
| 115 – 118 | 44 00 03 00 | SUM 03 0 | |
| 119 – 124 | 42 00 05 42 00 06 | STO 05 STO 06 | |
| 125 – 128 | 41 11 46 12 | GTO A *LBL B | |
| 129 – 134 | 43 00 04 55 02 95 | RCL 04 ÷ 2 = | decrement h |
| 135 – 138 | 44 00 01 56 | SUM 01 *rtn | |
| 139 – 140 | 46 15 | *LBL E | |
| 141 – 145 | 43 00 04 65 53 | RCL 04 X ( | |
| 146 – 149 | 43 00 03 85 | RCL 03 + | $h \times (y_n + y \text{ increment}) = \text{store in } R_{07} = h \times g$ |
| 150 – 153 | 43 00 06 54 | RCL 06 ) | |
| 154 – 157 | 42 01 01 95 | STO 11 = | |
| 158 – 160 | 42 00 07 | STO 07 | |
| 161 – 217 | 43 00 04 65 53 . . . | RCL 04 X ( . . . . . | $h \times$ test equation entered $= h \times y'' =$ store in $R_{08}$ |
| 218 – 223 | 54 95 42 00 08 56 | ) = STO 08 *rtn | |

### INSTRUCTIONS

- Key in program
- Enter differential equation, excluding $y''$ term, beginning at location 166
  *Form is $y'' = f(t) + A + By' + Cy$. See text.*
- Clear all data memories
  *Press *CMs*
- Enter initial values
  *$(y_0)$, STO 02, $(y_0')$, STO 03, at $(x_0)$, STO 01*
- Enter incremental values of $x$ for which equation steps to find new $y$
  *(h), STO 04*
- Enter equations $y$, $y'$ and constant coefficients
  *(C), STO 18, (B), STO 19, (A), STO 20*
- Press A to find $y_1$
- Press RUN to find $y_2, y_3, \ldots y_n$

  Calculation time for each is about 12 seconds

| REGISTERS | |
|---|---|
| $R_{00}$ | – |
| $R_{01}$ | $x_0 \times n = x_n$ |
| $R_{02}$ | $y_0 \times n = y_n$ |
| $R_{03}$ | $y_0' \times n = y_n'$ |
| $R_{04}$ | $h = \Delta t$ |
| $R_{05}$ | y increment |
| $R_{06}$ | y′ increment |
| $R_{07}$ | $h \times g$ |
| $R_{08}$ | $h \times f$ |
| $R_{09}$ | $K_{sum}$ accumulator |
| $R_{10}$ | $L_{sum}$ accumulator |
| $R_{11}$ | $(y_n' + y'_{increment})$ temporary store |
| $R_{18}$ | y′ term coefficient (optional) |
| $R_{19}$ | y term coefficient (optional) |
| $R_{20}$ | constant term (optional) |

# Engineer's newsletter

### High-level languages are tops for microcomputer systems

Most programs for microcomputers are written directly in assembly language, but you can look for far more extensive use of high-level languages now that the necessary program compilers are becoming available. From the programmer's viewpoint, high-level-language programs are easier to write and much more compact than assembly-language programs. And **since the number of progam errors is largely a function of the number of lines of code, regardless of the language used, errors certainly will be fewer.** Also, the block structure of high-level languages permits easy program modification, and tightening up an assembled program is simple because the code that the compiler generates may be checked over and tweaked up by hand. You may even sidestep assembly language altogether by storing the compiled program in a progammable read-only memory.

### A better way to approximate factorials

Apparently there is a faster and more accurate way of computing an approximation for a factorial than the one given on this page in the Aug. 18 issue. According to F. A. B. Smith of Washington, D. C., it is known as Stirling's equation: $n! = [1+1/(12n-1)](n/e)^n(2\pi n)^{1/2}$. For 13!, **this approximation yields an error on only 0.002%**, dropping to a mere 0.00014% for 50!, notes Smith. What's more, Bob Jewett, who is with Hewlett-Packard in Santa Rosa, Calif., has come up with a streamlined equation: $n! = (2\pi n)^{1/2} \exp[n[ln(n)-1]+1/12n]$, which requires taking a logarithm and only one exponent. With this form, the residual fractional error is approximately $1/360n^3$, Jewett points out. And if integer truncation is used, the worst-case error is still only 0.0003%.

### A simple route to bit-oriented instructions

Microprocessor-based programmable controllers seldom offer **simple bit-oriented instructions, such as set, reset, or test one input/output bit or one flag bit.** But with Texas Instruments' 9900 or 9980 microprocessors, there's a straightforward and inexpensive way to get these instructions without adding logic, notes Horst Huse, who is with Germany's TI Deutschland. You use the three bit instructions (SBO, SBZ, and TB) of the 9900/9980 communications-register-unit interface, along with a 1,024-bit static random-access memory (for 1,024 extra flag bits). Connect the three CRU control lines directly to the RAM (CRUOUT to DATA IN, CRUCLK to $R/\overline{W}$, and CRUIN to DATA OUT), the microprocessor's $A_{5\text{-}14}$ address lines to the RAM's $A_{0\text{-}9}$ inputs, and the $A_{3\text{-}4}$ microprocessor addresses to the RAM's $\overline{CE}$ input through an OR gate. Now, with the proper addresses loaded in WR 12 of the register file, the SBO instruction becomes SET FLAG BIT, SBZ becomes RESET FLAG BIT, and TB becomes TEST FLAG.

### Learn to characterize dielectric materials

Measuring the properties of dielectrics like synthetic films, elastomers, fibrous materials, plastics, and laminates is a complex task. To ease the way, GenRad has put together a helpful application note that explains the procedure and even **describes how to prepare a specimen for characterization.** The 16-page booklet, number EID 11, also includes definitions of pertinent terms and a discussion of the various factors affecting the dielectric properties of materials. For your copy, write to: GenRad, 300 Baker Ave., Concord, Mass. 01742.

**Lucinda Mattera**

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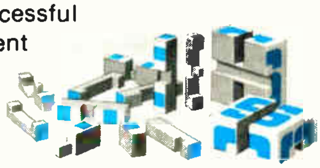

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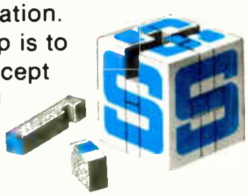

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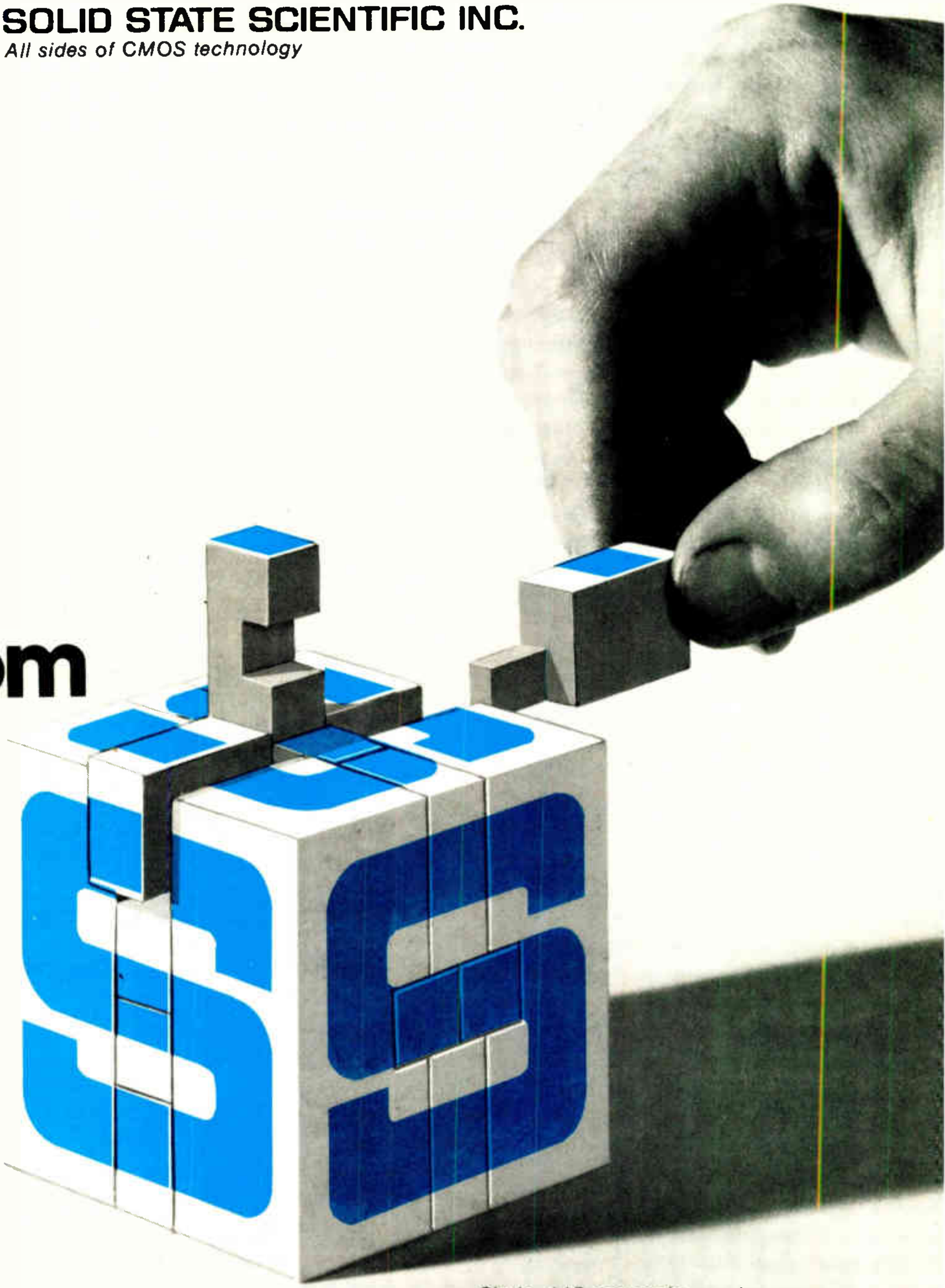

Circle 115 on reader service card

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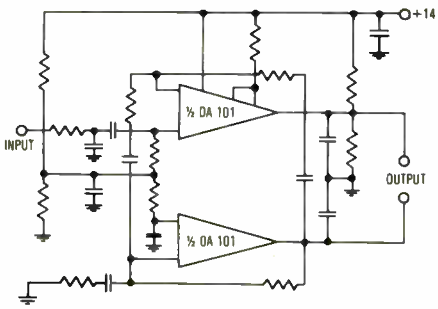
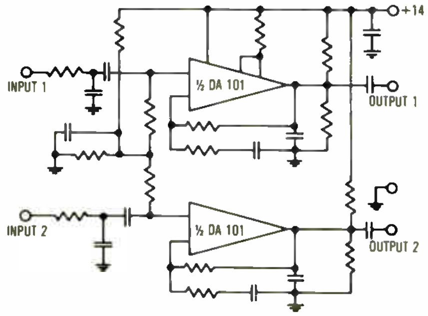
|---|---|
| Supply Voltage | 24V |
| Operating Voltage | 16V |
| Peak Current | 3A |
| Storage Temperature | −55°C to 150°C |
| Power Dissipation | 22W |
| **ELECTRICAL CHARACTERISTICS** | **TYPICAL** |
| $V_{CC}$ = 14V dc | |
| $I_{idle}$, $P_{out}$ = 0W | 40mA |
| Differential Input Bias Current | 0.80 μA |
| Open Loop Gain | 90dB |
| Power Out @ 5% Distortion | |
| 4Ω Bridge | 6W |
| 4Ω Non-bridge | 3.5W |
| **THERMAL CHARACTERISTICS** | |
| Thermal Resistance, $R_{\theta JC}$ (Typical) | 4° C/W |

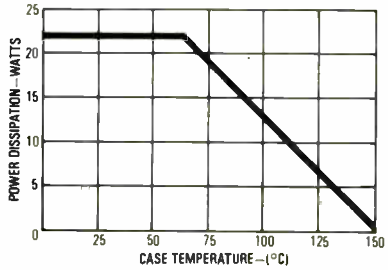
### AUDIO BRIDGE CIRCUIT



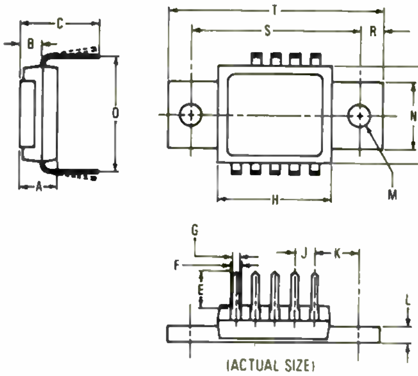

### TWO SEPARATE AMPLIFIERS CIRCUIT




### DERATING CURVE




### DIMENSIONS AND CONNECTIONS




(ACTUAL SIZE)

| SYMBOL | INCHES MIN. | INCHES MAX. | MILLIMETERS MIN. | MILLIMETERS MAX. |
|---|---|---|---|---|
| A | | .220 | | 5 59 |
| B | 127 | 133 | 3 22 | 3 38 |
| C | .423 | 443 | 10 746 | 11 254 |
| D | 628 | 632 | 15 95 | 16 05 |
| E | 215 | .225 | 5 463 | 5.717 |
| F | 044 | 048 | 1 13 | 1 21 |
| G | 015 | 019 | 0 39 | 0 47 |
| H | 644 | .650 | 16 37 | 16 52 |
| J | .095 | 105 | 2 413 | 2 667 |
| K | .275 | .285 | 6 983 | 7 237 |
| L | .086 | 096 | 2 183 | 2.437 |
| M | 1220 | 1280 | 3 100 | 3 250 |
| N | 369 | .379 | 9 373 | 9 627 |
| P | 539 | 549 | 13 693 | 13.947 |
| R | 120 | 130 | 3 053 | 3.307 |
| S | .955 | .965 | 24.253 | 24.507 |
| T | 1 199 | 1 219 | 30 446 | 30.954 |

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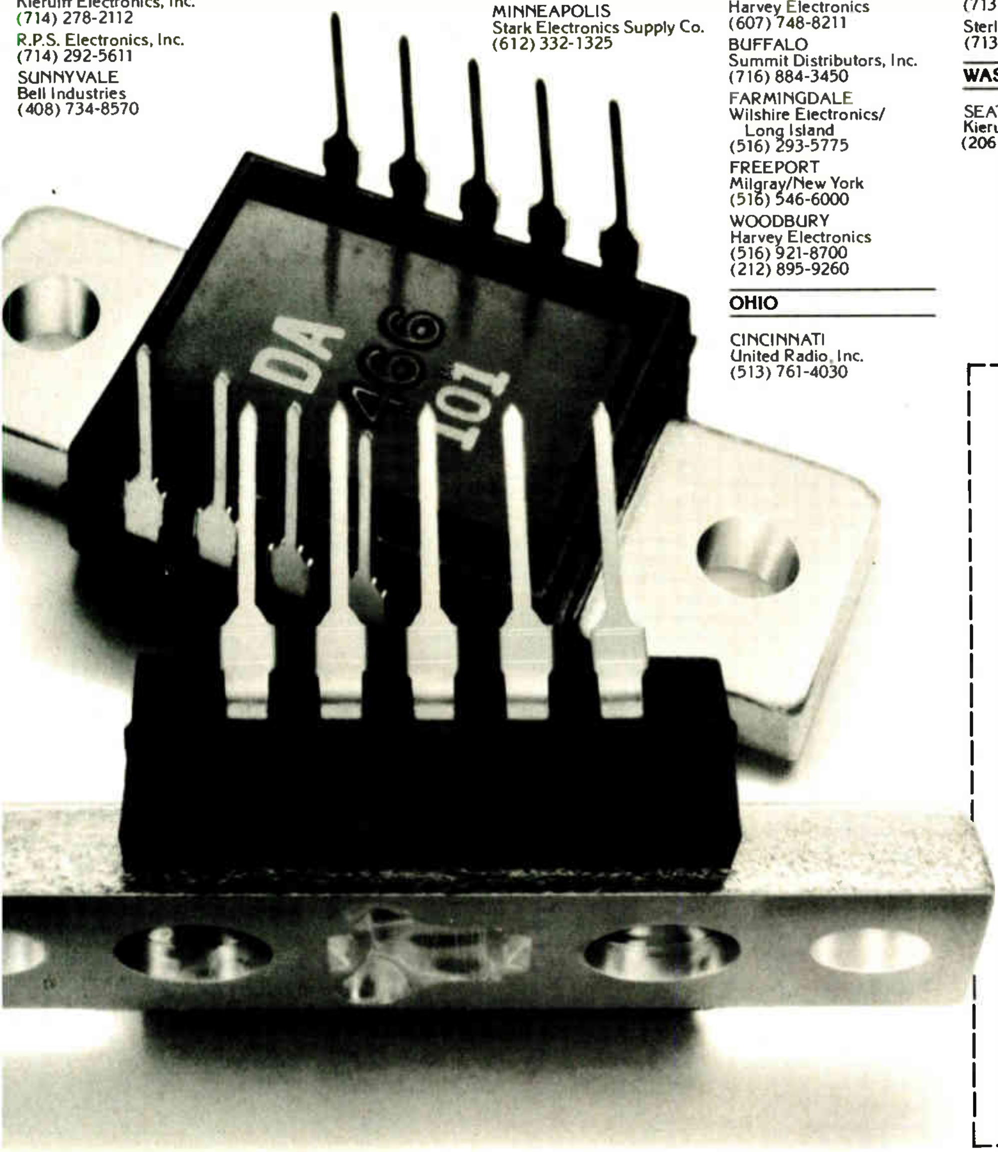


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**Delco Electronics**

9/29

# Desktop computer challenges minis

Self-contained system leads HP's desktop line in speed, power, and flexibility; easy-to-operate machine uses enhanced Basic

*by Raymond P. Capece, Computers Editor*

**Minicomputers have a** tough new competitor in Hewlett-Packard's 9845 desktop computer. With the most powerful central processor and the largest built-in mass-memory storage of any desktop unit, the latest addition to the 9800 desktop line crowds even the minis made by HP's own Data Systems division. The 9845, built by the Calculator Products division, is an easy-to-use, self-contained system—processor, cathode-ray-tube display, keyboard, thermal printer, and cartridge-tape memory storage are all combined in one unit.

Significant developments in hardware, architecture, and software are scattered throughout the 9845's design, which was begun over two years ago at the division in Loveland, Colo. Advances in both hardware and architecture are found in the computer's processing arrangement, which comprises two n-type, metal-oxide-semiconductor chips—a 7-megahertz execution interfacing processor and a peripheral processor that primarily manages interfacing and input/output control. The two chips normally operate in serial fashion, but can be commanded into an overlap mode that amplifies the throughput of the computer several times.

The high-speed operation of the computer is also attributable to programming developments. Jack Walden, the product manager and group leader, explains: "The 9845 is pseudo-compiled—the hierarchy of expressions is predetermined and embedded in the program, and keywords have pointers to subroutines and to locations in a symbol table—giving it a speed that's comparable to the faster minicomputers."

Marketing officials at HP now have to consider the overlap of the 9845 with the products of the Data Systems division, HP's minicomputer builder. The desktop computer, being a turnkey type of system, is geared more towards technical communities, such as engineering, statistical, and even financial programmers, rather than towards computer programmers. Frederick Bode, marketing manager at the Calculator Products division, explains that "the 9845 is aimed at vertical market areas—technical users who need a powerful computer that's self-contained and easy to operate." HP promises software packages for many different fields, including medicine, business, and management sciences.

The computer is highly efficient in

the operation of its built-in "peripherals." A separate processor controls the tape drive, which accepts standard microcartridges that each store 210 kilobytes of data. All the computer's peripherals are in a file-by-name arrangement, which does not care whether tape, disk, or any other medium is being addressed.

The 12-inch cathode-ray-tube display combines an alphanumeric mode with optional raster-scan graphics. The alphanumeric mode displays 25 80-character lines in a 720-by-360-dot matrix, whereas the high-resolution graphics are displayed in a 560-by-455-dot matrix. The marriage of the two different arrays avoids the tradeoff in aspect ratio between graphics and alphanumeric data, but requires two scan systems.

Storage in the 9845 is independent—32 kilobytes of random-access memory just for the graphics and 16 kilobytes for user storage, which can be expanded to 64 kilobytes.

The 9845 programs in Basic, actually an enhanced version of the ANSI standard, and any software meeting the standard can be run as is. Enhancements overcome many of the shortcomings of standard Basic. For example, the limit of variable names and labels is increased to 15 characters, which enables programs to be practically self-documenting. The array-handling capability of the computer is also extended, allowing up to six-dimensional arrays of either bit-string or alphanumeric data with up to 32,767 elements. String manipulation accommodates lengths of up to 32,767 bits. Subprogram capability has also been increased.

The computer is priced at $11,500 for a minimum configuration that includes a single tape transport and 16 kilobytes of random-access memory. The price for a full configuration, with 64 kilobytes of memory, two tape drives, the thermal printer, and graphics, is $20,000. Delivery time is 8 to 12 weeks, and the machines may be leased.

Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif. 94304 [338]

# Dual technique pinpoints digital faults

In-circuit emulation and signature analysis are combined
in test instrument designed for checking microprocessor-based systems

*by Stephen E. Scrupski, Instrumentation Editor*

**By combining two** of the latest digital diagnostic techniques, Millennium Systems has developed a test instrument for microprocessor-based systems that it says can be used successfully by service personnel having widely different levels of skill. Designated μSA, the microsystem analyzer employs the software technique of in-circuit emulation to classify faults and then uses signature analysis [*Electronics*, March 3, p. 89] to pin the faults to the component level.

Moreover, in-circuit emulation can inject signals to generate signatures for analysis at the various nodes. The system designer therefore need not build the requirements of signature analysis in from the beginning, although, as originally introduced by Hewlett-Packard, the technique required just that.

The new instrument is the first of a family. It is similar to Millennium's Universal-One microcomputer development system [*Electronics*, Sept. 16, 1976, p. 91], which is also the basis for the Tektronix 8001 and 8002 development systems.

The μSA has two sections. Those features that are related to the operator are controlled by a master central processing unit, and those related to the particular system under test are controlled by a slave CPU. With this setup, new microprocessors can be handled simply by changing the slave CPU. In its initial form, the system analyzer will handle equipment built around the 8080 or the 6800.


A read-only memory plugged into the front panel allows both go/no-go testing and signature analysis, and test programs also can be stored in the random-access memory. The signature is displayed on a light-emitting-diode display comprising 20 alphanumeric characters. The display is also used for operator prompting. Discrete LEDs indicate various states of the machine.

The system also has a real-time trace option that allows a record of 128 bus states—any combination of address, control data, or auxiliary data conditions. With another option, the analyzer may be connected to an RS-232-compatible modem, so that diagnostic programs can be loaded remotely from a central point. As a result, an on-site technician could dial a diagnostic specialist for help with a problem, since all functions and all status lines can be read remotely.

The system is built in a card cage with seven slots. Only three are required for the basic model, so there is room for future expansion.

Basic price of the instrument, without signature analysis, is $2,475 in small quantities, but the price drops to below $2,000 in quantities greater than 50. Low-quantity price of the signature analysis capability is about $500, with corresponding decreases for large quantities.

Millennium Systems Inc., 19020 Pruneridge Ave., Cupertino, Calif. 95014. Phone (408) 996-9109. [339]


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Circle 121 For Data

Semiconductors

# Multiplier built for on-line use

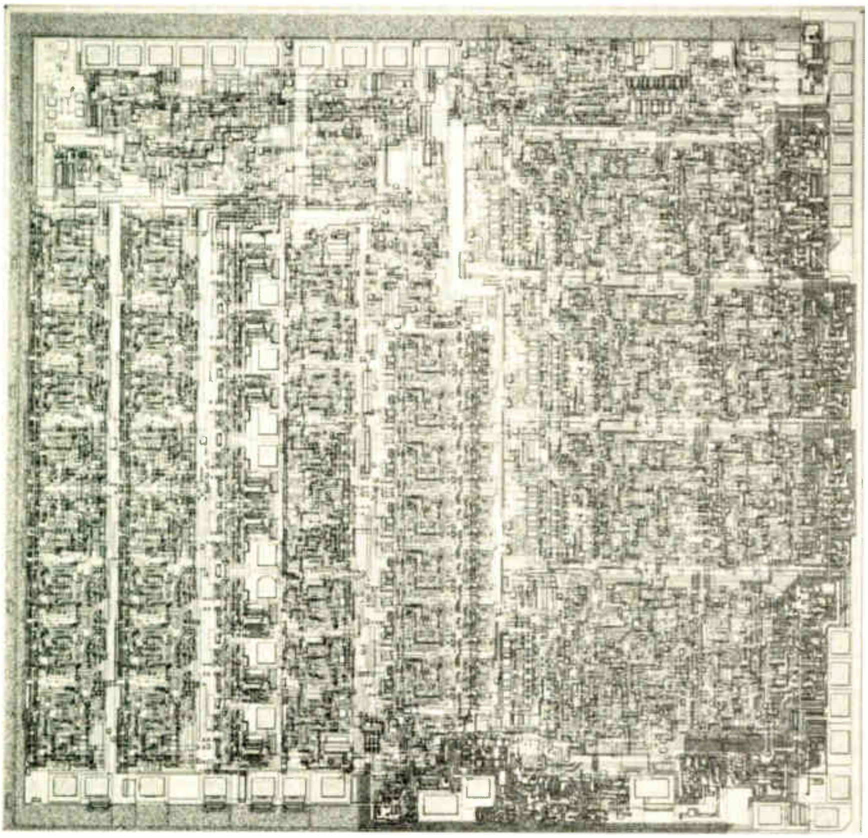
## 8-bit-by-8-bit device is microprogrammable, includes on-chip accumulator

Until the advent of digital multipliers, as much as one third of a computer's time went on repetitive multiplication. To increase throughput, designers of computer systems have often taken this function away from the central processing unit and assigned it to one or several peripheral boards containing arrays of small-scale and medium-scale integrated multipliers plus associated support circuitry. Now, Advanced Micro Devices Inc. is introducing an 8-bit-by-8-bit microprogrammable multiplier-accumulator that in some applications replaces 30 ICs.

Designated the AM25LS2516, the low-power Schottky device is aimed at what some consider the fastest-growing portion of the digital multiplier market—real-time multiplication in such microcomputer or minicomputer applications as process control.

Other 8-by-8, 12-by-12 and 16-by-16 large-scale integrated multipliers are already on the market. But John Mick, applications manager for bipolar digital products at AMD points out that they are of the so-called combinatorial type, aimed at high-speed applications and more suitable for the traditional signal-processing jobs. When used for on-line, real-time multiplication in computer systems, Mick adds, these multipliers still require much external circuitry.

The AM25LS2516, on the other hand, he explains, is a serial/parallel device specifically designed for on-line use, as well as for medium-performance signal-processing applications like digital filtering, fast Fourier transforms, and statistical correlation. Even more important for computer system designers is the fact that the 40-pin device is configured to work with AMD's 4-bit-slice bipolar microprocessor family of computer components.

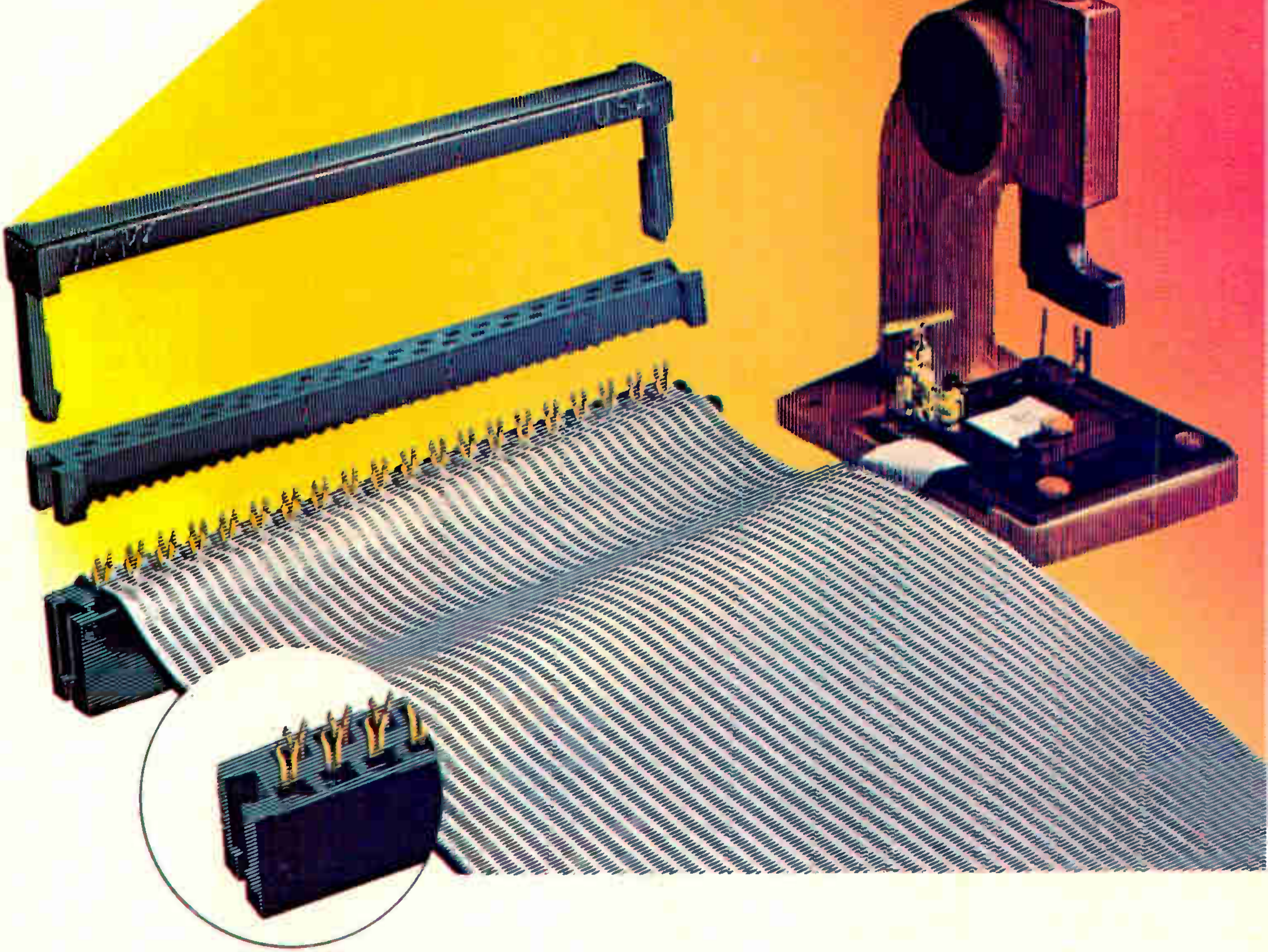


Key elements in the device are an 8-bit X-input register followed by an 8-bit X latch, an 8-bit Y register, a 4-bit-by-2-bit multiplier, a 2-bit adder, two 8-bit accumulators (high order and low order), a byte-selection multiplexer, and instruction decode logic. These components, equivalent to about 625 gate elements, are fabricated onto a chip measuring about 200 by 205 mils. "The on-chip accumulator is provided to minimize component count and power dissipation in high-density systems," says Mick. "It allows completion of a multiply and add operation in the time normally required for a multiply only."

Using two's-complement carry-save arithmetic, the AM25LS2516 delivers an 8-bit product in four clock cycles and a 16-bit product in eight clock cycles. A single device can, as a result, perform an 8-by-8 multiplication in 400 nanoseconds, drawing only 1.7 watts of power, 600 milliwatts of that in the multiplier array itself. Two devices may be cascaded to achieve a 16-by-16 multiplication in less than 900 nanoseconds. Power required, says Mick, is at least 1/10 to 1/5 that required of boards containing multipliers and surrounding circuitry.

Perhaps the most novel feature of the AM25LS2516 is that it is microprogrammable from an external read-only memory controlled by four instruction lines. "This programming capability is the key to its flexibility," says Mick. "Two cascaded 25LS2516 devices, for example, can be programmed to perform in a number of different multiplication configurations, not only square functions such as 4 by 4, 8 by 8, 12 by 12, and 16 by 16, but rectangular ones in which the multiplicand is different from the multiplier. "Sixteen microinstructions are provided that can be grouped into three major functions—data move, read, and multiply. A control array is provided on chip to test for overflow during the last add cycle of the operation—that

# Flat cable connector system ...high reliability in ultra-compact design



In TRW Cinch flat cable connectors, two gold-plated wire contact points for each conductor assure extra reliability. The socket contact also provides two surfaces for electrical contact when mated with feed-thru pins or headers. Integral molded-in locking tabs on the cover increase cable retention, as does the optional cable strain relief assembly.

The ultra-compact design saves valuable space, and the connectors can be positioned on .250-inch centers on a mother board if required. One contact size accepts 24 gauge solid and 26 gauge solid or stranded wire and another gauges 28 and 30 solid and stranded.

The cable supplied by TRW Holyoke Wire & Cable has conductors positioned on .050″ centers. The connector contacts are positioned on two staggered rows of .100″ centers.

Fast, positive cable positioning and registration is assured by molded-in guides in the connector cover. Only one fixture is required to accommodate all six connector sizes—10, 20, 26, 34, 40 and 50 positions.

**STOCKED BY DISTRIBUTORS.** Off-the-shelf delivery is available from your local TRW Cinch Connectors distributor. For additional information contact your TRW/ECD field sales office or write to TRW Cinch Connectors, an Electronic Components Division of TRW Inc., 1501 Morse Avenue, Elk Grove Village, IL 60007: phone (312) 439-8800. CC-7718

**TRW CINCH CONNECTORS**

*ANOTHER PRODUCT OF A COMPANY CALLED TRW*



Circle 123 on reader service card

is, cycle 8 for 8-bit and cycle 16 for 16-bit operations. The timing and control of this specific cycle is accomplished by the microcode chosen. In contrast, says Mick, most present arrays are fixed; that is, to do a 4-by-4 multiplication, a 4-by-4 array is necessary. "In a typical computer system, performing a number of different types of multiplication," says Mick, "considerable time and space is saved if the same device can do them all." In hundreds, price of the unit is $68 each.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086 [411]

## Voltage regulator offers low temperature coefficient

Expanding its line of monolithic three-terminal adjustable voltage regulators, National Semiconductor Corp. is adding the LM137, a negative-output device. It complements the company's LM117, a positive-output unit that when announced was the industry's first three-terminal adjustable regulator [*Electronics*, Nov. 27, 1975, p. 133].

"The LM117 introduced the concept of an adjustable voltage regulator that fits into the same slots as its fixed-voltage, three-terminal counterparts," says Robert C. Dobkin, director of advanced linear circuits at National. "The LM137 series—adjustable from −1.2 to −37 volts with two external resistors—extends the concept over the full range of voltages in common use today, positive and negative."

In many systems, there are requirements for variable voltages and nonstandard voltage options. Until the development of the adjustable three-terminal regulator, designers were often forced to maintain a large inventory of fixed-voltage devices over a wide range of voltages and currents. The other option was to redesign circuit boards around one of several nonstandard, multiterminal, adjustable regulators.

The new LM137 series is a 1.5-ampere family featuring internal current limiting, thermal shutdown, and safe-area compensation, making the devices virtually blowout-proof against overload. Regulation for the unit is within 0.02% for line variations of up to ±10%, and load regulation is less than 0.05%.

The addition of a new specification—thermal regulation—fully characterizes the regulation of the LM137 series. According to design engineer Robert Pease, the real significance of the LM137 series is in its tight specification for thermal regulation: output voltage varies no more than 0.004% per watt of power change. "The LM137 is the first IC regulator in the industry to guarantee that the output voltage will shift less than 0.2% when a 10-watt pulse is applied for 10 milliseconds," he says. "All other regulators are specified for regulation for only a few microseconds, before the junction warms up."

When power is dissipated in an IC, explains Dobkin, a temperature gradient occurs across the chip, affecting the individual circuit components. With an IC regulator, this gradient can be especially severe, since power dissipation is large.

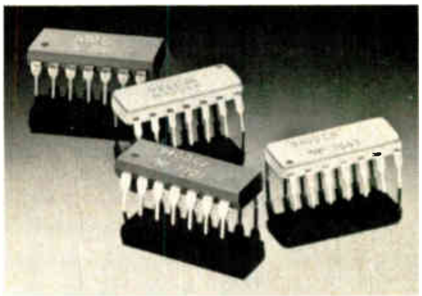
Because of its thermal regulation, the LM137 minimizes the effect of these temperature gradients on output voltage. Thermal regulation is independent of line and load regulation, as well as temperature coefficient, Dobkin says, and occurs within 5 to 50 milliseconds after a change in power dissipation.

Regulators in the LM137 series are easy to use, requiring only two external resistors to set the output voltage and one output capacitor to ensure dynamic stability and low output impedance. The series features one on-chip −1.250-v reference voltage, which is stable to within 35 parts per million per °C. This low temperature coefficient, says Pease, prevents case temperature changes from degrading accuracy. Other features of the LM137 series are high ripple rejection of 75 decibels and a root-mean-square output noise of 0.003% of the output voltage up to 10 kilohertz.

The units are available now in four standard, low-cost, three-lead transistor packages: the TO-3 (steel), TO-5 (hermetic), and TO-220 and TO-202 (plastic). Pricing depends on package and temperature range. The LM137, guaranteed over the military temperature range from −55°C to 150°C, sells for $13.60 each (for 100 to 999) in the steel TO-3 package. The LM337, guaranteed over the commercial temperature range of 0°C to 125°C, is priced at $3.60 each in the TO-3 package and $2.80 in the plastic packages.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [412]

## Monolithic v-f-v converter sells for $3.70 in thousands



A monolithic voltage-to-frequency converter that also functions as a frequency-to-voltage converter interfaces with all logic families and is available in a standard 14-pin dual in-line package sells for only $3.70 each in thousands. The model 9400 is a mixed-process device fabricated with a combination of bipolar and complementary metal-oxide-semiconductor technology. As a v-f converter, it operates from 10 hertz to 100 kilohertz with a typical nonlinearity of 0.01% to 10 kHz. In its f-v mode, the 9400 operates from dc to 100 kHz with a typical nonlinearity of 0.1% over the full range.

Typical applications of the converter are in 13-bit analog-to-digital converters, four-digit panel meters, data-acquisition systems, analog data-transmission systems, scales, frequency meters, and voltage-controlled oscillators. The units are available from stock.

Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94043. Phone Michael Paiva at (415) 968-9241 [414]

Packaging & production

# Tester checks all boards

## Low-noise integrated system exercises digital, analog, and combinations of circuits

Equipment for production-testing of loaded circuit boards is often a collection of instruments and modules that were never designed to play together in an integrated system. Engineers at GenRad Inc., Concord, Mass., claim their GR 1799 is the first board tester in its price range that was conceived from the outset as an integrated system for production testing of boards with analog or digital—or any combination of both—circuits.

Brendan Davis, product marketing manager in the Electronic Manufacturing Test division, says a typical 1799 system will sell for between $100,000 and $110,000. He adds that system noise is lower in an integrated system that is optimized for production board-testing than in the so-called "rack and stack" collection of instruments.

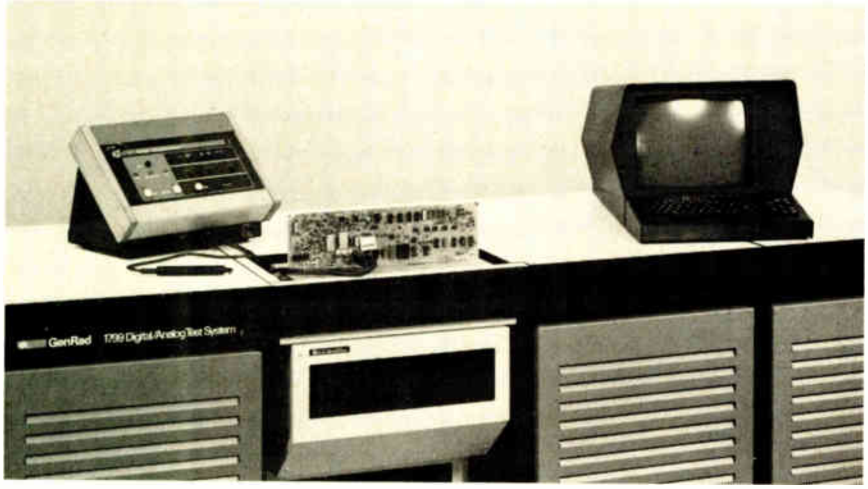
The 1799 measures ac and dc volts, dc current, and dc resistance. In addition, it provides peak and hold measurements on the voltmeter to measure positive and negative peaks of a waveform; offers frequency period and time measurements; has a tracking mode that allows voltage tracking; and has a low-pass filter mode that Davis says eliminates high-frequency effects to produce true dc measurements.

Sources that come with the system include an ac function generator, programmable pulse generator, and programmable power supplies. The latter, says Davis, were designed for an automatic test system, offering software-programmable voltage, current, and time-period limits. Like the earlier and more expensive GR 1976, the 1799 has a universal scanner that allows each pin, under program control, to be analog or digital, with analog or digital stimuli. Scanner bandwidth is approximately 10 megahertz, as in the 1976, says Davis.

The test system will handle up to 480 pins that are programmable as driver or sensor pins, but Robert Szpila, division marketing manager, points out that most of the GenRad test systems sold recently have averaged 200 pins. The 1799 is software-compatible with all of those models, including the 1796, 1795, and the older 1792D. That includes the capability to run the company's computer-aided programming system (CAPS), a logic simulation package, and automated program generation (APG) for quick preparation of test programs.

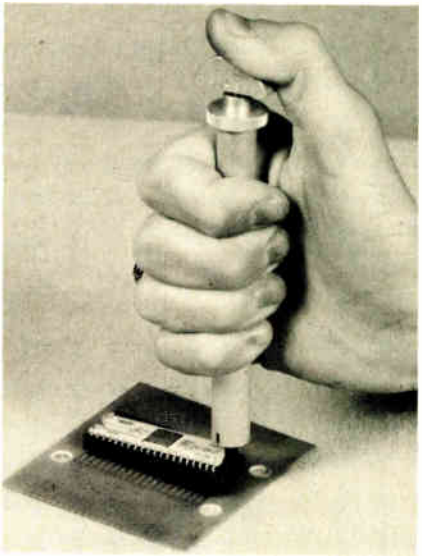
With today's circuit board holding an average of about 100 integrated circuits, many of them large-scale devices, Davis says APG is an especially useful option, leading to fast generation of programs that catch more than 90% of the faults on a board. Deliveries of the GR 1799 will begin in November.

GenRad Inc., 300 Baker St., Concord, Mass. 01742. Phone Brendan Davis at (617) 369-8770. [391]



## IC extraction tool won't damage DIP leads

A universal tool for removing integrated circuits from their sockets has a lift-height control that prevents damage to the circuit leads. De-



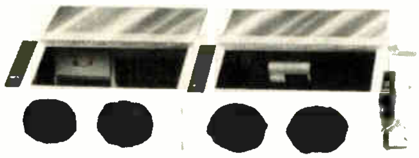
signed to extract any dual in-line package, the tool's lift height is continuously adjustable from 0.0 to 0.5 inch. It must be applied to each end of the IC before the package can be removed from the socket.

Chuck-A-Chip Inc., P. O. Box 1137, High Point, N. C. 27261. Phone (919) 887-1374 [395]

## Screen-imaging system needs no yellow room

A table-top system for coating and imaging screens for thick-film circuits can be operated in ordinary

## New products



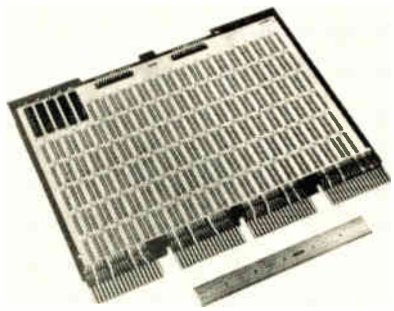
room light without exposing the photosensitive film emulsions. The system consists of two amber-paneled glove boxes and a temperature-controlled tank. From left to right these are a coating-and-drying glove box, an exposure glove box, and a developing tank. Stretched screens enter the left side of the system and move through sliding-panel ports towards the tank. After leaving the tank, the screens can be washed under ordinary room illumination.

A key advantage of the SIS-900 is that it allows screens to be coated and imaged in the same area where the screen printers are working. And the process is fast: starting with a stretched frame, a screen can be produced in less than an hour. Screen sizes up to 8 inches by 10 inches can be accommodated.

Qualco, One First St., Los Altos, Calif. 94022. Phone (415) 964-7666 [393]

### Boards interface with standard computer buses

Series CIP4 and CIP4/11 wire-wrappable integrated-circuit boards are designed to plug directly into Digital Equipment Corp. Omnibus and Q-Bus systems. The boards, which can thus be used with the LSI-11 microcomputer and with PDP-8 and PDP-11 minicomputers,

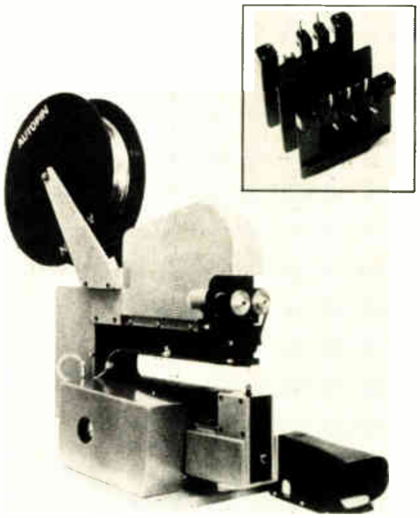


provide 32 columns of 60 low-profile socket terminals per column with alternate rows of committed ground and supply-voltage wire-wrap terminals. The boards will accommodate up to 110 16-pin dual in-line packages or a lesser number of larger packages or mixtures of packages. Available in dual, quad, and hex sizes, the boards range in price from $1.50 to $2.00 per IC position.

Garry Manufacturing Co., 1010 Jersey Ave., New Brunswick, N. J. 08902. Phone Harry A. Koppel at (201) 545-2424 [396]

### System makes and inserts round and square pins

A pin-terminal insertion system called Autopin actually makes its own pins from a continuous coil of wire and then inserts them into coils, bobbins, printed-circuit boards, etc.



The wire may be either round or square.

In a typical operation the operator positions the work in the machine and steps on a foot pedal. The machine then feeds a length of wire, cuts it with a proper point profile, and inserts it into the work. The point profile is determined by the cut-off tool; it may be square-cut, tapered, or concave.

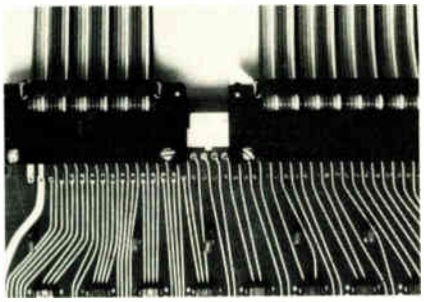
A major feature of the Autopin system is its provision for easy adjustment of pin length up to 1.125

inches. In addition it can be set for different board or bobbin thicknesses. Standard pin materials include brass, phosphor bronze, and cupro nickel—all with various platings. An operator can insert from 1,500 to 2,500 pins per hour with the system at a cost of $3 to $7 per thousand depending upon length and material. The equipment is available both for sale and for lease.

Autosplice Division, General Staple Co., 220 East 23rd St., New York, N. Y. 10010. Phone Irwin Zahn at (212) 674-4369 [394]

## Flat-cable connectors handle up to 50 wires

The PS series of insulation-displacement connectors for mass termination of flat cables comes in sizes that can handle from 10 to 50 wires. The two-row connectors are available in seven contact layouts. They require



no prestripping of the cable and can be applied at the cable ends or at any point along the cable for daisy-chain applications. In lots of 5,000 pieces, a 10-wire receptacle sells for $1.07. Delivery time is three to four weeks.

ETC Terminal Products Unit, ITT Cannon Electric, 29000 Aurora Rd., Solon, Ohio 44139. Phone Allen Guth at (216) 248-8800 [397]

## Flexible-circuit connectors cost less than 0.7¢/line

The model M-1255 flexible-circuit connector is available with any number of contacts on a single strip. The connectors have a patented circuit-gripping design which needs no solder or hardware to form a sound connection. Priced at less than 0.7 cent per line, the connectors are available in copper-based alloys and with a pre-tinned finish. Contact pins for insertion into printed-circuit boards can be supplied at various angles to accommodate many mounting configurations. The connectors are available from stock.

Precision Concepts Inc., Bohemia, N.Y. Phone Robert J. Nicola at (516) 567-0995 [398]

## Computerized unit controls deposition of thin films

A microprocessor-based system that can be linked directly to a process-control computer contains a library of programs for controlling the deposition of thin films. By activating a combination of program elements, the instrument is capable of controlling rise, soak, deposition, and other parameters for as many as 99 film layers.

Designated the MDC 9000, the controller can be programmed manually or by remote automatic equipment. Manual programming is done through an alphanumeric keyboard, which is equipped with an interactive data display that monitors the values being entered into the unit's memory. Remote programming is handled by a teletypewriter or paper-tape reader.

The MDC 9000 is equipped with four crystal sensor inputs and four source-control outputs. A layer-saver circuit prevents the loss of a run in the event of crystal failure by computing the required power and time values and instructing the controller to complete the deposition to the programmed thickness. In high-volume production applications, this feature could save thousands of dollars worth of material.

Supplied complete with a manual programming keyboard and a manual source-control unit, the MDC 9000 sells for $4,995.

Sloan Technology Corp., 535 East Montecito St., Santa Barbara, Calif. 93103. Phone (805) 963-4431 [399]

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**ATTENTION — FILTER AT WORK** We use only the highest grade certified virgin solvents and propellants (all propellants are nonflammable — TWA 1000ppm — the surest, safest propellants available.)

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**WE'RE FUSSY ABOUT OUR LOADING ENVIRONMENT** Our loading room environment is immaculate, controlled by Clean Room conditions. Each loading line is kept exclusive for an individual product. This avoids the danger of contamination often caused when loading lines are used for multiple products.

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Circle 131 on reader service card

Subassemblies

# SCR bridges come in single packages

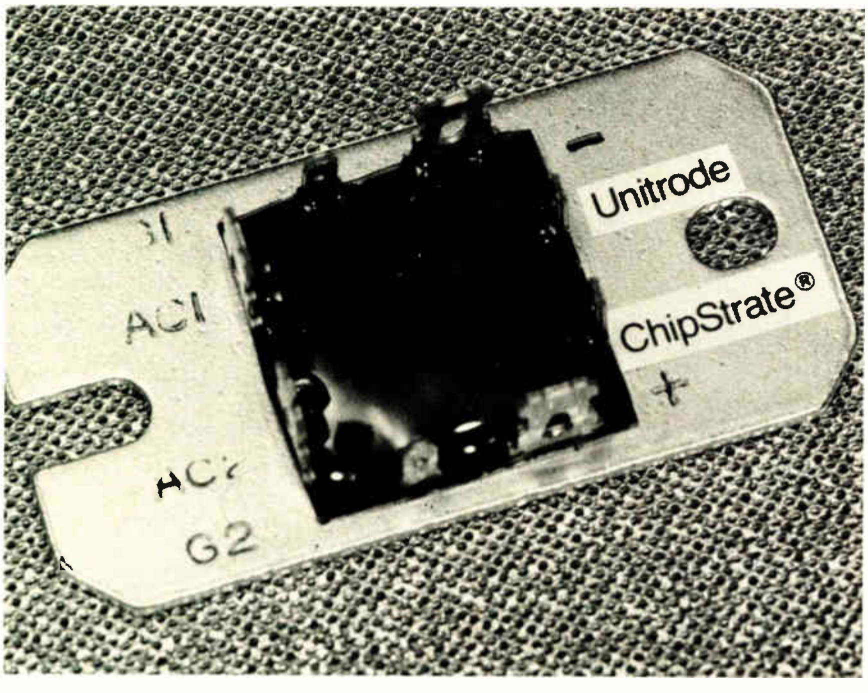
## Two series of power devices handle up to 40 amperes at up to 800 volts

Power thyristor bridges for use in such applications as phase controllers, pulse modulators, and transformer control circuits are rarely available in a single package, and that is precisely the gap for which Unitrode Corp. has designed two new series of silicon phase-control bridges made of silicon controlled rectifiers. The glass-passivated devices are housed in the company's solderable ChipStrate package.

The two series are designated SMA 1250–SMA 8250 and SMA 1400–SMA 8400. The former handles 25 amperes of root-mean-square current at up to 800 volts, and the latter is rated at 40 A rms up to 800 V. Each series has eight different circuit configurations, and each has models handling 200 V, 400 V, 600 V and 800 V. Carl Uretsky, product marketing manager for thyristors, says the current ratings are conservative because each of the four devices—two SCRs and two rectifiers—in some of the circuits can handle 25 or 40 A at 85° C.

Uretsky adds that the biggest advantage the bridges offer is their one-step assembly by Unitrode, "which means these parts aren't expensive for the power they handle." A representative price in either series would be less than $9 for the 400-V units in quantities of 1,000. Joseph Pappalardo, applications engineer, adds that the single-package design simplifies mounting for the customer. "Formerly," he says, "circuit designers had to buy large power SCRs and power rectifiers, isolate them from each other, and mount them on large heat sinks."

With the Unitrode bridges, there is a single alumina or beryllia substrate and rugged quick-connect terminals with holes in them so that customers can plug them in or solder them down after wrapping wires around the terminals, if that is required. There are three basic variations in the eight circuit configurations in both series: two SCRs and two rectifiers, four SCRs, and two SCRs and one SCR, with the largest package having an area of approximately 2 square inches.




The peak one-cycle, nonrepetitive surge current for the 25-A units at 60 hertz is 300 A; for the 40-A devices, it is 600 A. Both series are available with an optional free-wheeling diode for especially inductive loads.

Delivery time is four to six weeks for standard parts, 12 to 14 weeks for custom configurations.

Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172. Phone Carl Uretsky at (617)926-0404 [381]

## Opto-isolators boast high gain at low input current

A line of optically coupled isolators with transistor-transistor-logic-compatible outputs and 3,000-volt dc isolation voltages is noteworthy for its high current-transfer ratios at low input currents. The model 6N138, for example, has a minimum CTR of 300% at an input current of 1.6 milliamperes, and the 6N139's is 400% at 0.5 mA. The units are housed in 8-pin dual in-line packages and are pin-for-pin compatible with Hewlett-Packard 5082-4370 (6N138) and 5082-4371 (6N139) isolators. In thousands, the 6N138 sells for $1.65 each, while the 6N139 carries a price tag of $2.05 each for the same quantities. Delivery time is 30 days.

Spectronics Inc., 830 East Arapaho Rd., Richardson, Texas 75081. Phone (214) 234-4271 [383]

## 10-bit d-a converter settles within 20 ns

Designed for summing-point applications where voltage outputs are not required, the DAC-V digital-to-analog converter is well suited for video reconstruction applications, including TV and radar, and for digitally controlled transmitters and displays. The unit combines a resolution of 10 bits and a maximum error of 0.05% of full scale with a settling time of only 20 nanoseconds. This settling time is for a full-scale input

Even in today's digital world, there are hundreds of applications where the infinite resolution and graphic indication of a linear slide control work best.

Duncan Series 400 Slideline™ instrumentation pots are already in use in rapid transit speed controllers, X-ray and blood analysis equipment, petrochemical plant servo-controls, office copiers, solar energy instrumentation and many other unique applications.

Duncan linears can be set instantly and accurately. And reset perhaps 50 million times without significantly changing their characteristics (thanks to our special RESOLON® conductive plastic element). Even lay people find their operation self-explanatory.

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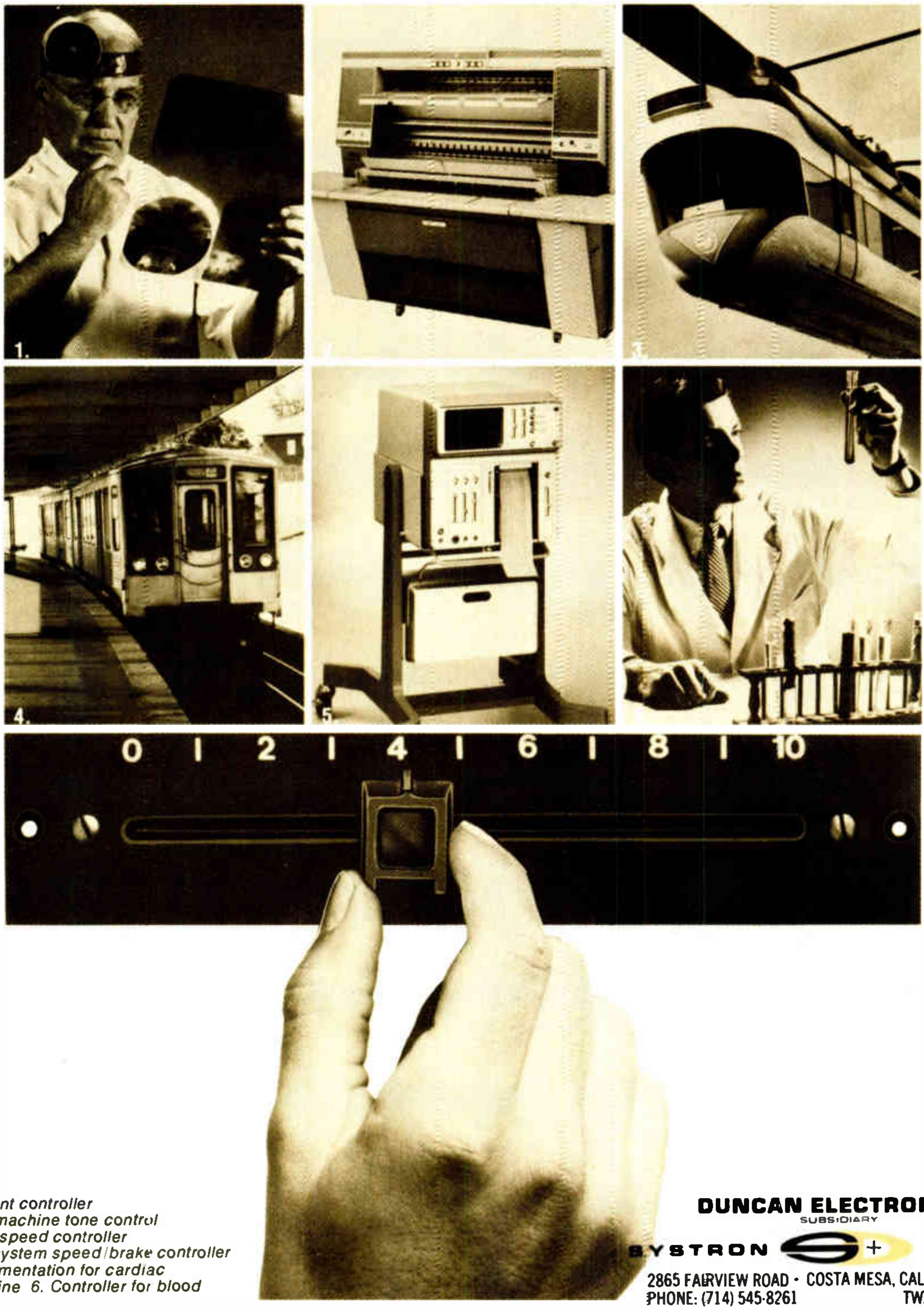
So next time you're designing a control system, stop and think about the advantages of going analog. Then grab onto a Slideline and take control! Write us for complete literature.

# Series 400 puts you in control.




*1. X-ray equipment controller*
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Circle 133 on reader service card

change and represents the time required to get within 1 least significant bit of final value. Temperature coefficient is a maximum of 15 parts per million per °C.

Housed in an encapsulated module measuring 2.3 by 2.3 by 0.4 inches, the DAC-V weighs 1.5 ounces. It includes a temperature-compensated voltage reference and is fully protected against short circuits. The unit sells for $135. A similar converter with 8-bit resolution and a maximum error of 0.2% of full scale has a typical settling time of 15 ns and a price of $110.

ILC Data Device Corp., Airport International Plaza, Bohemia, N.Y. 11716. Phone Paul Roberts at (516) 567-5600 [384]

## 8-bit converters are aimed at video applications

Two new video devices, the ADC 820 analog-to-digital converter and the DAC 850 digital-to-analog converter, are 8-bit units that have been optimized for video applications. The ADC 820 is a 20-megahertz board that includes a low-pass anti-aliasing filter right at the input to the quantizer. Its differential phase and gain errors are 0.5° and 1% root mean square, respectively.

The DAC 850 is a 50-MHz unit built on the same size board (6 by 8 by 1 inch) as the ADC 820. It is available with or without an output filter and has maximum differential phase and gain errors of 0.25° and 0.75% rms, respectively. In small quantities, the ADC 820 sells for $1,650, and the DAC 850 for $525.

Tektronix Inc., P. O. Box 500, Beaverton, Ore. 97077. Attn: Charles R. Payne at Delivery Station 58-699. Phone (503) 644-0161, Ext. 6597 [385]

## F-v converter produces only 0.5 mV of ripple

Intended to be used with voltage-to-frequency converters as part of a communications system for rate information (outputs of tachometers, flowmeters, etc.), the model 22A frequency-to-voltage converter has as its most outstanding characteristic an essentially ripple-free output. Because its peak-to-peak ripple is less than 0.5 millivolt (0.005% of full scale), the unit's output can be sampled at any time with practically no ripple uncertainty. The result is that the 22A can be inserted between a rate data signal and the input port of a data-acquisition system with no need for averaging filters, counters, or other expensive and time-consuming measures.

The converter covers the four decades from 1 hertz to 10 kilohertz with 12-bit linearity. It is inherently monotonic and features an optically isolated input which greatly reduces the effects of noise and ground loops. Other key specifications of the 22A are a slew rate of 2.5 volts per millisecond, a scale-factor temperature coefficient of 20 ppm/°C, an offset voltage of 1 millivolt, and an offset-voltage temperature coefficient of 20 $\mu$v/°C. In small quantities, the 22A sells for $49; delivery is from stock to two weeks.

D-B-D Developments, 7709 Kilbourne Rd., Rome, N. Y. 13440. Phone Dave Manzolini at (315) 339-1265 [387]

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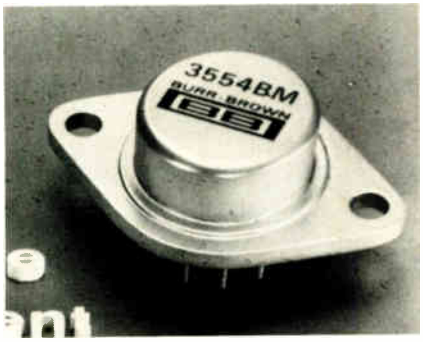
## Op amp has gain-bandwidth product of 1.7 gigahertz

The model 3554 operational amplifier is an extremely wideband unit with a gain-bandwidth product of 1.7 gigahertz, a minimum slew rate of 1,000 volts per microsecond, and a maximum settling time (to within 0.05%) of 150 nanoseconds. Prime applications are in digital-to-analog converters, sampling circuits, multiplexers, integrators, pulse amplifiers, and waveform generators.




The op amp has output ratings of ±10 v at ±100 milliamperes, making it a good choice for line-driving applications involving fast pulses or wideband signals. It is available in three grades. The 3554AM operates from −25°C to 85°C, has a typical input-offset drift of 20 microvolts/°C, and sells for $60 in small quantities. The 3554BM operates over the same temperature range, but has a typical drift of only 8 $\mu$v/°C. It sells for $70. For operation from −55°C to 125°C, Burr-Brown offers the 3554SM. This unit has a typical drift of 12 $\mu$v/°C and a small-quantity price of $75. All three units have a minimum open-loop dc gain of 100 decibels, an input bias current of 50 picoamperes, and a common-mode rejection ratio of 78 dB. They are protected against continuous output shorts to ground, but not to the supplies.

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85734. Phone Dennis Haynes at (602) 294-1431 [386]

## TOPICS

### Subassemblies

**Etatech Inc., Placentia, Calif.,** is introducing dc-input versions of its series 3A triple-output power supplies. Four standard models are being offered: two take a 28-V dc input, the other two require 48 V dc. The 110-watt units sell for $485 each in small quantities. . . . **Burr-Brown, Tucson, Ariz.,** has cut the price of its model 4341 rms-to-dc converter by as much as 20%. Formerly priced at $31.50 in singles, the unit now sells for $26 in lots of 1 to 24, $20 each in lots of 25 to 99, and $16.50 apiece in quantities of 100 to 999. . . . **Deltron Inc., North Wales, Pa.,** has announced a series of 78 power supplies that are drop-in replacements for ACDC's OEM series units. Prices range from $40 to $233 each in small quantities. Typical delivery time is six weeks.

Microprocessors

# Computer serves many users

## Fast floppy-disk system and special format maker for efficient timesharing

A quantum jump in the application and use of a microcomputing system, is how Mupro Inc. describes its new timesharing software and disk operating-system package.

The timesharing software, called Mute for multi-user/task executive, provides task-queuing and -scheduling capabilities similar to those of Digital Equipment Corp.'s RSX-11 and file management much like that of Hewlett Packard Co.'s HP-3000 system. The software also supports disk data transfers through direct memory access. This operating system is contained on diskettes in the Mupro 80D system, which operate in conjunction with the Mupro family of microcomputers, development systems, and in-circuit emulators.

According to Larry Gray, manager of system software at Mupro, this multi-user, multi-task disk operating system makes the one-machine, one-operator concept obsolete. The combination of the Mupro 80 and Mute, he says, allows many users to share the microcomputer and development system, with no noticeable holdups.

The Mute software provides the capability of executing multiple tasks on an event-driven basis. As many as 256 tasks divided into 64 priority levels can be scheduled by a task-queuing algorithm. A combination of linear and circular queues ensures that both task priority and resource sharing are accomplished efficiently. Those system peripherals that critically affect system throughput receive the highest priority, and all devices, including disk drives, printers, terminals, and other peripherals are interrupt-driven with Mute.

File-management routines maintain the file structure of the data stored on the disk and permit applications programs to access peripheral devices.

Proper operation of the Mute is ensured, says Gray, by extensive checks for errors at various stages within the operating system. Error conditions are flagged to the operator by messages on the terminal.

Mupro 80D disk system hardware includes a dual floppy-disk drive, made by Persci Inc., with a voice-coil actuator that reduces track-seek delays by a factor of 7½ compared to conventional drives. Average seek time, according to Gray, is less than 50 milliseconds, and therefore no appreciable delays in operating time are observed.

The IBM 3740-compatible disk system contains a programmable real-time clock that offers an accurate time reference for system operations. The disk controller, contained on a single circuit card within the Mupro 80 chassis, accommodates up to two dual-drive units, or four single drives. Provision is made for upper- or lower-head selection, which doubles the regular 256-kilobyte capacity of the diskette by permitting it to be recorded on both sides.

The Mupro 80 chassis itself is an 8080-based microcomputer system containing central processing unit, memory, power supply, input/output, and a self-documenting front panel. The display panel lets the user peer into all the workings of the processor, including all registers, storage locations, and flags. Hexadecimal displays provide the information. The microcomputer system contains 64 kilobytes of addressable memory for user programs, data, and I/O. In addition, storage is available for 256 device codes each for input and output.

The Mupro system uses a block-structured assembly language to minimize coding time. Called BSAL-80, the versatile language combines high-level-syntax Algol-like statements with the flexibility, the size, and the speed of assembly language.

The complete Mupro 80D dual-disk system with microcomputer and power supply can be rack-mounted in a space only 5¼ inches high. In single quantities, the complete system with the Mute software is priced at $9,000. Pricing for original-equipment manufacturers is $5,800 in single quantities for units shipped without power supply and front panel.


Mupro Inc., 424 Oakmead Parkway, Sunnyvale, Calif. 94086. Phone (408) 737-0500 [362]

## Control-oriented computer demands no expertise

For manufacturers and users who cannot afford the learning and development time to build microproces-

# Dialight is your second source to C&K for miniature rockers and toggles...

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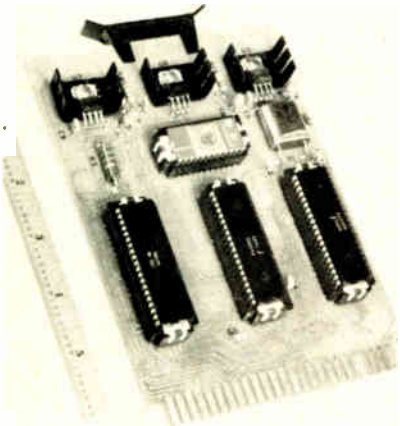
Circle 137 on reader service card



sors into their equipment, a company in Indiana has put together an attractive microcontroller package. The product, offered by Environmental Technology Inc. of South Bend, is a single-board microcomputer. With it, ETI "takes customers by the hand" in helping them to design microcontroller prototypes.

The microcomputer board, called Little Bit, is built around the F8 microprocessor from Fairchild Camera and Instrument Corp. But the board, which sells for $125 in hundreds, might be upstaged by the service that goes along with it.

"What we're actually selling are the board, service, and software as a cohesive unit," says the company's president, Thad Jones, "and it's not an easy package to market." Jones explains that ETI is aiming at those manufacturers whose production quantities are too limited to warrant heavy investment in controller development.

Little Bit simplifies this development. Specifically, since control applications seldom require much in the way of main and program memory but need a lot of input/output capability, the board carries only 1,024 bytes of programmable read-only memory and 64 bytes of random-access memory but has 32 bidirectional I/O lines.

One of the ways ETI saves customers' money is through the use of a timesharing network for software development. The company charges only $17 per hour for the service, which includes all computing and printing charges. The network is Terminet, part of the National Computer Network of Chicago, which has locations in 80 cities across the country.

"Using the timesharing, a customer can get us on the phone to discuss a problem, and we can both look at his program listing simultaneously," says Jones. Terminet also provides services like remote printing of listings and loading of programs onto paper tape. "With timesharing," Jones points out, "the customer can do a lot of development and testing that couldn't be done with a box sitting on his table."

An unusual service offered by ETI is what it calls "dial-a-PROM." Dial-a-PROM lets customers send their microprograms over phone lines by modem and order them to be stored into a PROM. ETI can also access the program from a dataset stored in the Telenet library. Says Jones, "We usually offer next-day service, but a customer in a hurry can have his programmed ROM in a half-hour if need be."

Jones makes the point that the actual operation of the F8 microprocessor, which was chosen because of its orientation towards control applications, need not be completely understood by the user. "We're more dedicated to the niche of control technology—not to the processor itself," he says. "Next year we could change over to the Intel 8085, or some other microprocessor that might be better suited for control, and the users wouldn't feel any effects at all."

Plans for the future include the introduction of Little Bit More, an enhanced version of the controller board, which, to date, has been employed in windmill power-generating systems, motor starters, and heating-system controllers.

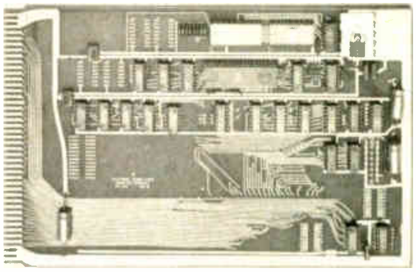
The $125 price of the single-board controller does not include the erasable programmable ROM, which—fully programmed—is an additional $20. Delivery of the Little Bit is from stock.

Environmental Technology Inc., 2821 West Sample, South Bend, Ind. 46619. Phone (219) 233-1202 [361]

## Board interfaces computers with calculator chips

Users of 8080, Z-80, 6800, and other microprocessor systems can now perform mathematical functions not provided for in many Basic interpreters and Fortran compilers if they interface their devices with an inexpensive board to a powerful scientific-calculator chip: MOS Technology's 7529-103.

With the board, calculations can be performed with less than 1 kilobyte of memory. Without it, if they can be done at all, they require from



8 kilobytes to 16 kilobytes.

Two versions of the board are available: the RM series, which is compatible with the Motorola Exorcisor bus and a second version that works with the S-100 bus. The RM unit is easily adaptable to Intel SBC 80/10 systems. Software is included for both 8080 and 6800 systems. The board is available in kit form for $99.95.

Mini Micro Mart, 1618 James St., Syracuse, N. Y. 13204. Phone (315) 422-4467 [365]

## Compact DC100A cartridge drive stores 672,000 bytes

An extremely small drive for the 3M Company's DC100A miniature data cartridge weighs about 1 pound and stores up to 672,000 bytes of unformatted data on the cartridge's 140 feet of tape. Designated the model 200 Minidrive, the storage module measures only 3 by 4 by 4.125 inches. In its basic OEM form, the Minidrive includes a tape-transport mechanism and such essential elec-

# AVX SkyCaps®: They're economically number 1.

AVX SkyCaps give you more for less. Like more consistent life-cycle performance at operating voltage frequency and temperature. More to select from in our broad range of sizes and ratings. And more quality than you're used to for the price.

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**AVX: The Insiders**


SkyCap dipped monolithics are available in the broadest range of sizes and ratings.

**Dimensions**
Body: 0.15 square to 0.5 square
Leads: Length 1.25 standard (others available)
Space 0.1 to 0.4 standard (others available)
**Capacitance:** 4.7pf to 4.7mfd
**Voltages:** 50, 100VDC
Three temperature characteristics

AVX Distributors: Cramer Electronics / Elmar Electronics / Future Electronics / Jaco Electronics / Liberty Electronics / Texas Instrument Supply Company tronics circuitry as read and write amplifiers, a motor-drive amplifier, speed-control circuitry, track-selection logic, and so on.

Three capacities are offered: a one-track version stores 168,000 bytes at a density of 800 bits per inch; a two-track version stores 336,000 bytes at the same density; and the top unit stores 672,000 bytes at a density of 1,600 b/in. Data-transfer rates are 24,000 bits per second for the 800-b/in. units and 48,000 b/s for the high-density drive.

In addition to the basic unit, the drive can be furnished complete with all the interface and control circuitry


needed to make a complete functioning memory.

The basic one-track 200 Minidrive sells for $250 in unit quantity and $205 each in hundreds. The no-frills 672,000-byte unit has a one-piece price of $350. The one-track unit with all the electronics needed to make a functioning recorder sells for $485 ($397 each in hundreds). Delivery times for all units are about four weeks.

North Atlantic Industries Inc., Qantex Div., 200 Terminal Dr., Plainview, N. Y. 11803. Phone (516) 681-8350 [364]



## Video terminal board uses Mostek 3870 micrcomputer

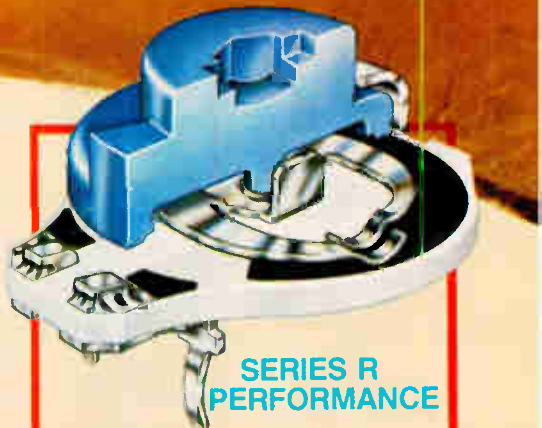
Sized to work with S100 systems, an inexpensive video terminal board that needs only a keyboard and TV monitor to form a full-duplex video terminal is built around the Mostek 3870 microcomputer. Called the SCT-100 single-card terminal, the board provides both absolute and relative X-Y cursor control, screen clear, clear to end of line, page mode, and autoscroll features. It has a repertoire of 96 characters.

The SCT-100 is available in three forms. A completely assembled and tested board sells for $185, a complete kit goes for $155, while a partial kit that includes the printed-circuit board, the custom-programmed 3870 microcomputer, and the character-generating read-only memory is priced at $85.

Vectron, P. O. Box 20887, Dallas, Texas 75220. Phone (214) 350-5291 [366]

# Who put long-track stability into a ceramic trimmer no larger than this?

# CENTRALAB!



Centralab, a leading producer of ceramic-based trimmer resistors, now offers the long-track stability of full-size trimmers with a resistor element measuring .750" in a unit only .475" x .640" . . . and with terminals which meet IEC requirements of 0.100" spacing.

We call it "Series R".

Despite its miniature size, this new trimmer provides set-stability of 0.2% total voltage, thanks to its long-track resistor element which permits 300° mechanical and 260° electrical rotation.

In addition to big-trimmer stability, the new Series R retains all the most-wanted quality features of the Centralab Series S. See the cutaway view and listing of features at right.

Shown above are prices for both series of Centralab trimmer resistors.

For full specifications and complete pricing for the Series R, talk to your Centralab Technical Representative, or call (915) 779-3961.

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(1,000 lot quantities)

| | Series S Vert. Mount | Series S Horiz. Mount | Series R |
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| CERMET | .26 | .28 | .29 |

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## SERIES R PERFORMANCE

**Set-stability, Adjustability, Low Noise**
- Long-track resistor element.
- Dual tine contacts.
- Mechanical ruggedness.

**Reliability**
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- Rigid soldered terminals with hold-in option.
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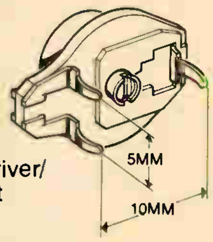
**Flexibility**
- *CERBON* and cermet resistor systems.
- 1-¼ watts cermet, ¾ watts *CERBON*.
- Hex hole/ screwdriver and screwdriver/ finger adjust knobs.




Ceramic Capacitors • Filters • Thick Film Circuits • Switches • Potentiometers • Trimmer Resistors

Circle 141 on reader service card

## New products/materials

A **polyester-film tape** with a thick layer of adhesive is designed to protect printed-circuit patterns during solder stripping and final gold or rhodium plating of finger tabs. Translucent 576 plater's tape consists of 3.1 mils of silicone adhesive on a 1-mil polyester film; its thick adhesive coating provides excellent conformability to circuit lines, eliminating undercutting and leakage. When removed, the tape leaves no adhesive residue.

Finite Industries Inc., 2 S. Commercial Ave., Carlstadt, N. J. 07072. Phone (201) 939-0565 [476]

**Void-free rosin-cored solders** for manual and automated soldering consist of a central core of solder, an intermediate layer of rosin flux, and an outer layer of solder. Because the outer sleeve of solder is very thin, it melts quickly, resulting in fast flux release and simultaneous flow, chemical action, and wetting. Called Cen-Tri-Core II, the solder is available in 60Sn/40Pb alloy, 32 to 156 mils in diameter, with 2.4% or 3.6% of either a mildly activated or fully activated flux. Other alloys, diameters, and flux percentages can be made on special order. Packaging is in 1-, 5-, and 20-pound spools.

Alpha Metals Inc., Route 440, Jersey City, N. J. 07304. Phone (201) 434-6778 [477]

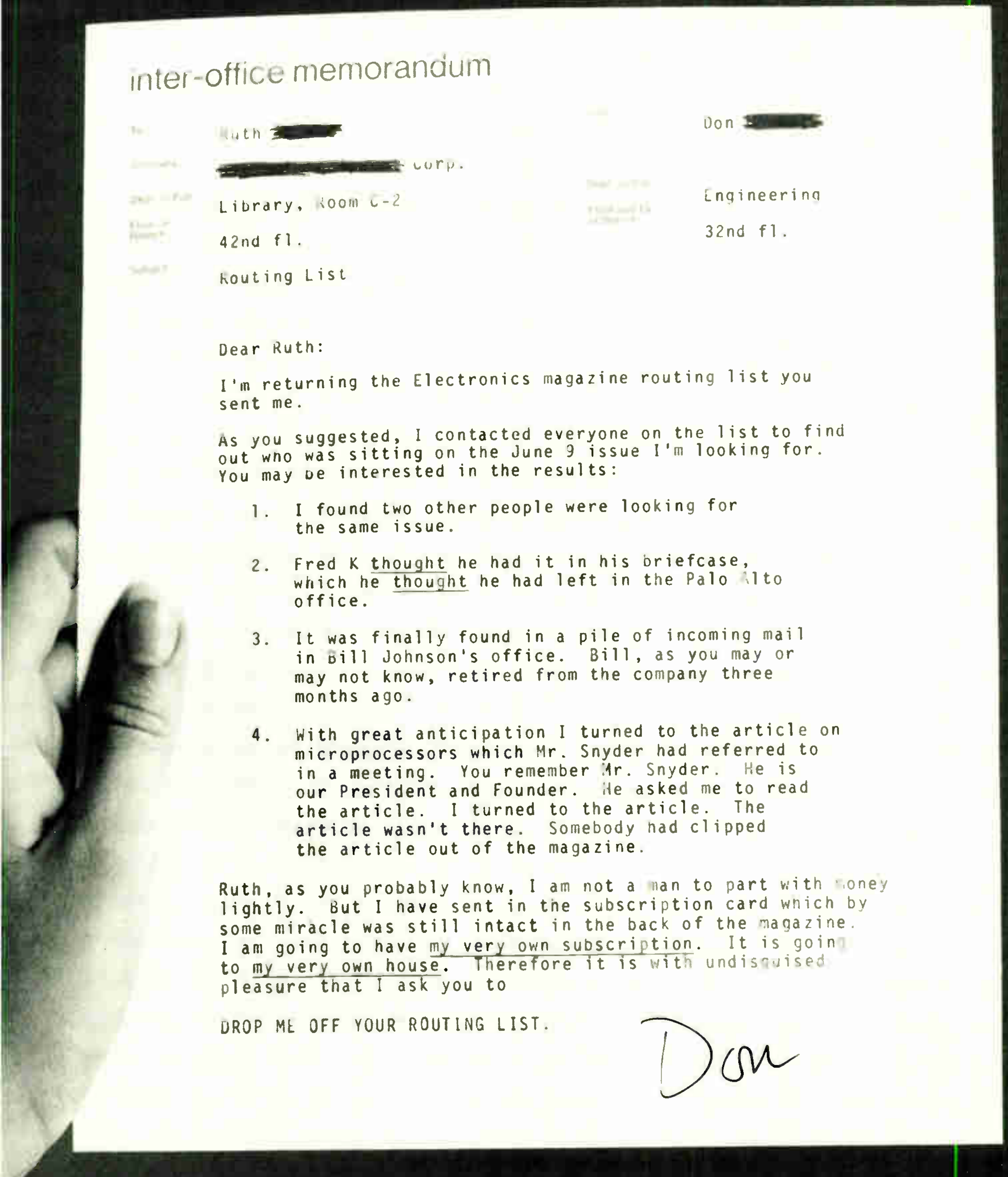
A **high-temperature coating** for insulating thermocouples, Cerama-Dip 538 has a high alumina content for good thermal conductivity. The material, which has a dielectric strength of 100 volts per mil at 1,000°F, can

be used up to 3,200°F. It is a thixotropic paste that can be dipped or brushed onto the ends of thermocouples to insulate them. A kit consisting of one quart of Cerama-Dip base and a quart of thinner sells for $46.20. It is available from stock.

Aremco Products Inc., P. O. Box 429, Ossining, N. Y. 10562. Phone Herbert Schwartz at (914) 762-0685 [478]

# The Story of a Routing List Dropout

(as told in the tormented words of the victim)



inter-office memorandum

To: Ruth [redacted]

[redacted] corp.

Library, Room C-2

42nd fl.

Subject: Routing List

From: Don [redacted]

Engineering

32nd fl.

Dear Ruth:

I'm returning the Electronics magazine routing list you sent me.

As you suggested, I contacted everyone on the list to find out who was sitting on the June 9 issue I'm looking for. You may be interested in the results:

1. I found two other people were looking for the same issue.

2. Fred K thought he had it in his briefcase, which he thought he had left in the Palo Alto office.

3. It was finally found in a pile of incoming mail in Bill Johnson's office. Bill, as you may or may not know, retired from the company three months ago.

4. With great anticipation I turned to the article on microprocessors which Mr. Snyder had referred to in a meeting. You remember Mr. Snyder. He is our President and Founder. He asked me to read the article. I turned to the article. The article wasn't there. Somebody had clipped the article out of the magazine.

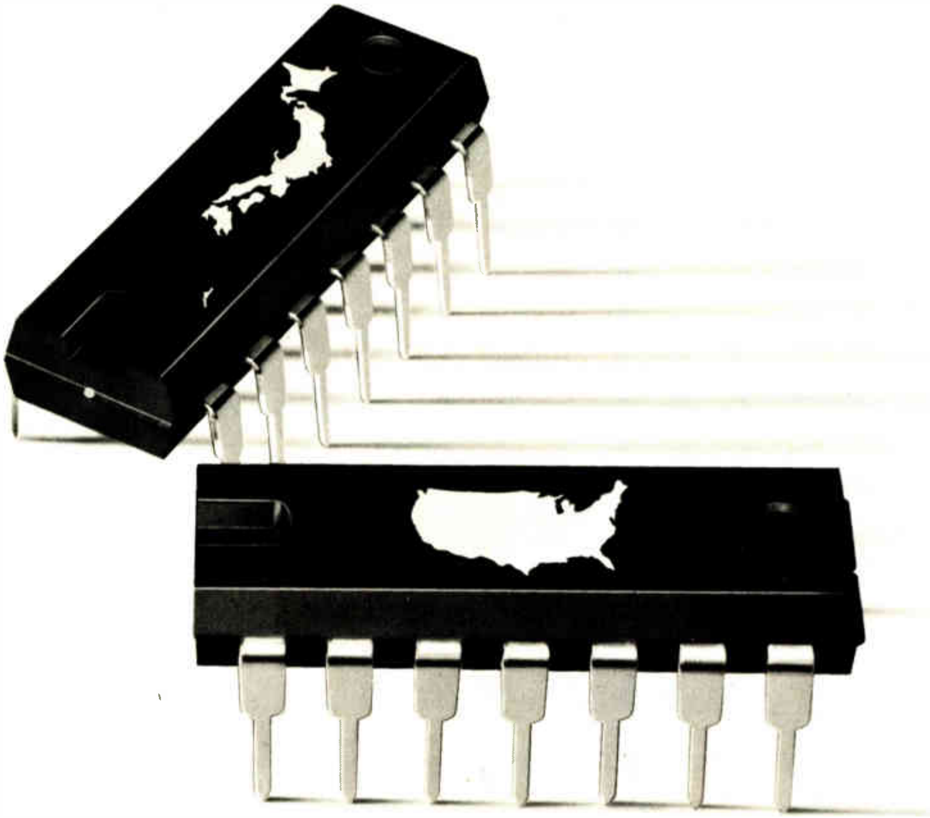
Ruth, as you probably know, I am not a man to part with money lightly. But I have sent in the subscription card which by some miracle was still intact in the back of the magazine. I am going to have my very own subscription. It is going to my very own house. Therefore it is with undisguised pleasure that I ask you to

DROP ME OFF YOUR ROUTING LIST.

Don

*Note to other routing list victims:*

Turn to the subscription card in the back of this magazine.
Fill it out. Mail it in. We can't promise you happiness.
But you will remove one frustration from your professional life.



# We Know You Need a Special Circuit in Japan.

To many —even the most seasoned businessmen in the electronics field— finding the way to make profitable deals with their Japanese counterparts may seem as much a labyrinthine maze as complicated circuit wirings look to the man in the street who only knows how to plug in and turn on his electrical appliances. It is not really so. Japan is actually engaged in extensive import and export of electronic products, technology and know-how with all nations all over the world. But, whether it is a simple purchase or a complex exchange agreement or tie-up, it is done differently because the Japanese are different.

We are Japanese and publish Nikkei Electronics, a biweekly magazine in Japanese, and our readers are the people who run the show and have brought Japan to the fore in electronics today.

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# THE ELECTRONICS CONFERENCE ON MANAGING ENGINEERS

**The growing challenge of motivating, training, and utilizing the EE**

sponsored by Electronics,
McGraw-Hill's International Magazine of Electronics Technology

*If you hire, fire, manage, motivate, train, or educate EEs, here are some facts that you should know:*

- *74% of 1,300 engineers surveyed this year by* Electronics *believe that electrical engineers in the next decade will not attain the professional status of physicians or lawyers;*
- *55.4% think that employers practice age discrimination;*
- *51.5% are only moderately satisfied with their engineering careers;*
- *Over 45% said that their companies do not have adequate dual ladder systems for engineers who prefer to stay in technical assignments;*
- *Fewer than half of those responding—45.3%—said that employers usually recognize engineering contributions appropriately;*
- *49.4% feel underutilized in their present positions;*
- *Many engineers believe that promotions are slow in coming.*

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*These are just a few of the findings from the* Electronics *survey of engineers' attitudes. Such career-oriented attitudes will be analyzed at the* Electronics *Conference on Managing Engineers at the Fairmont Hotel in San Francisco on November 8th, and at the McGraw-Hill Corporate Headquarters in New York City on November 15th. You can't afford to miss the opportunity to learn more about the significant role managers must play in successfully handling these emerging EE career problems.*

---

**Conference Program:**

**9:00-9:30 AM** **Electronics Career View Survey**

What are 1,300 electrical engineers' attitudes toward the engineering career, its satisfactions and frustrations? What is the impact of the microprocessor on the way EEs do their jobs? What are the future career trends, both professional and technical?

**Gerald M. Walker**
Senior Editor
Electronics

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**10:00-11:00 AM** **The Thompson-Dalton Study of the Four Stages of Career Development**

How do you get a company to recognize the problem of obsolescence—the corporation's and the individual's? What is the relationship between age and performance? How can you educate management to include the EE's career in its planning? How do you convince management that the project engineer is as important as the project?

**Gene W. Dalton**
Professor of Organizational Behavior
Brigham Young University

**Paul H. Thompson**
Associate Professor and Chairman
Department of Organizational Behavior
Brigham Young University

**11:00-1:00 PM**

**Coping with the problems of education, motivation, and utilization of the EE**

Part I: The academic world: Can engineering schools stay up-to-date with current technologies—especially in the field of microprocessors? Is there too much theory and not enough practical application?

Is it necessary to achieve a graduate degree or is an MBA more valuable? How can universities counter complaints of current graduates—unqualified instructors, inadequate textbooks, etc?

**James D. Bruce**
Associate Dean
School of Engineering
Massachusetts Institute of Technology

**Kenneth S. Down**
Assistant Dean and Director,
Stanford Instructional Television Network
School of Engineering
Stanford University

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Part II: The Corporate World: How do your deal with the underutilized EE? The problems of shifting technologies? Career anxiety? Career motivation? Is the 'dual ladder' a myth? What should the EE consider when deciding to remain in technology—financial gain, career potential, etc? What in-house programs have corporations developed to keep EEs updated?

**William O. Nilsson**
Corporate Training & Management
Development Manager
Hewlett-Packard Company

**1:00-2:15 PM**

**Luncheon**

---

**2:30-3:30 PM**

**Is competency assessment the wave of the future?**

Is it possible to identify the successful performer? What are the pros and cons? The alternatives?

**George Klemp**
Director of Research
McBer and Company

*Other speakers to be announced*

---

**3:30-5:00 PM**

**Performance Appraisal**

Should performance appraisal become an integral part of the career development program? Is forced turnover an effective means of achieving high performance? Is it possible to quantify performance so that the individual who is of most value to the department receives the best salary?

**John D. Porter**
Organizational Development Consultant
Lawrence Livermore Laboratory

**C. R. Wischmeyer**
Director of Education
Bell Laboratories

---

Your registration fee includes the *Electronics* 140-page survey of over 1,300 electrical engineers (the suvey will not be sold independently), and the magazine's three-part editorial analysis of the Career View Survey.

---

***NOTE:*** *While the program issues will remain the same in both New York and San Francisco, some of the above speakers will appear in only one city.*

**Who should attend . . .**

- **Design and development managers**
- **Engineering services managers**
- **Basic research managers**
- **Manufacturing and production managers**
- **Training directors**
- **Personnel directors**
- **Engineering school deans and professors**
- **Career counselors and consultants**

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THE **ELECTRONICS** CONFERENCE ON MANAGING ENGINEERS
The growing challenge of motivating, training, and utilizing the EE

____San Francisco, November 8, 1977, Fairmont Hotel
____New York, November 15, 1977, McGraw-Hill Corporate Headquarters

Conference fee: $250 Academic fee: $150

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Title__________
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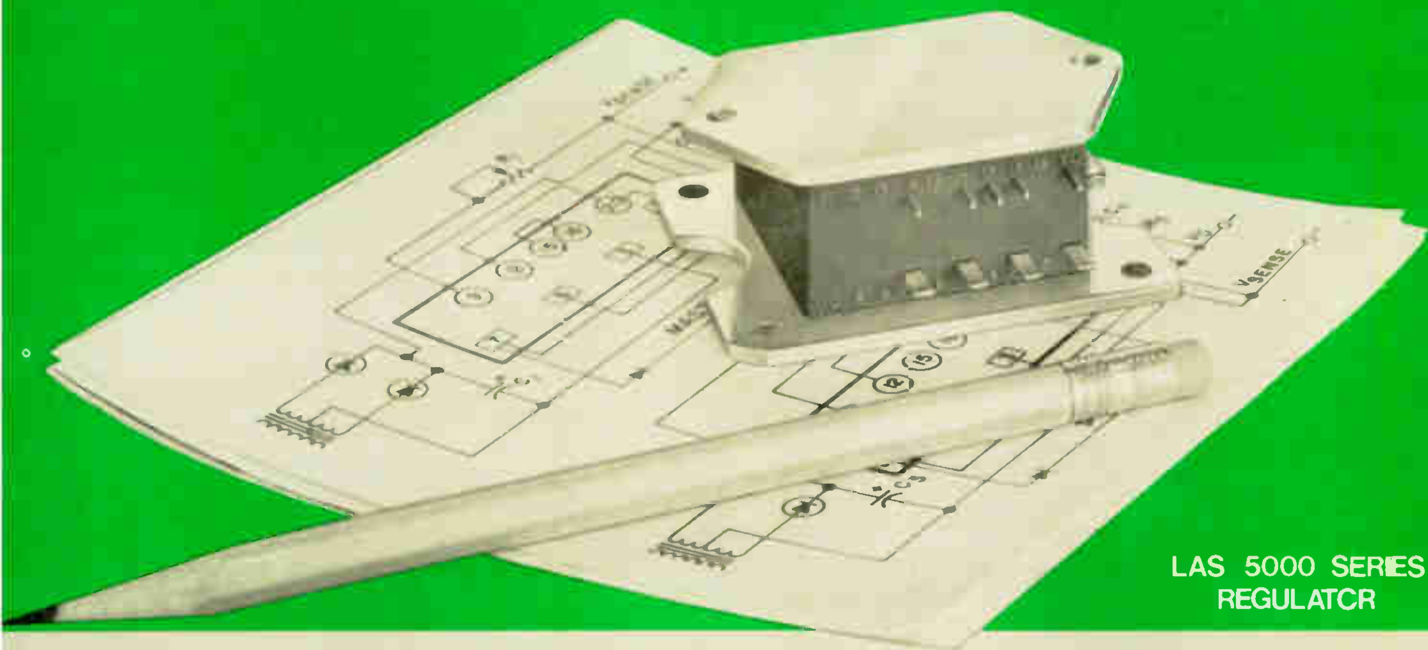
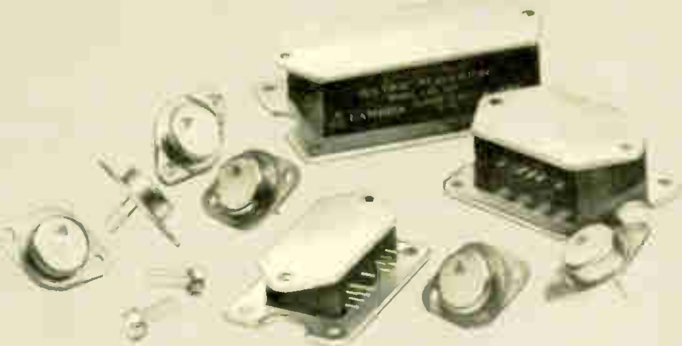
# BUILD YOUR OWN POWER SUPPLIES WITH Λ LAMBDA'S 270 WATT POWER HYBRID VOLTAGE REGULATOR.



LAS 5000 SERIES
REGULATCR



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0.01% line reg, 0.2% load reg
built-in short circuit and overload protection
replaces up to 40 components for simple circuit design

# LAS 5000 SERIES

# Regulator Performance Specifications

## 20 amp, 270 watt positive regulator

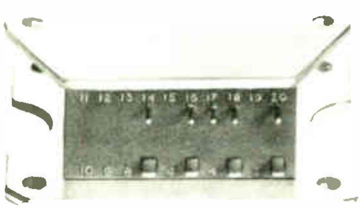
General Description

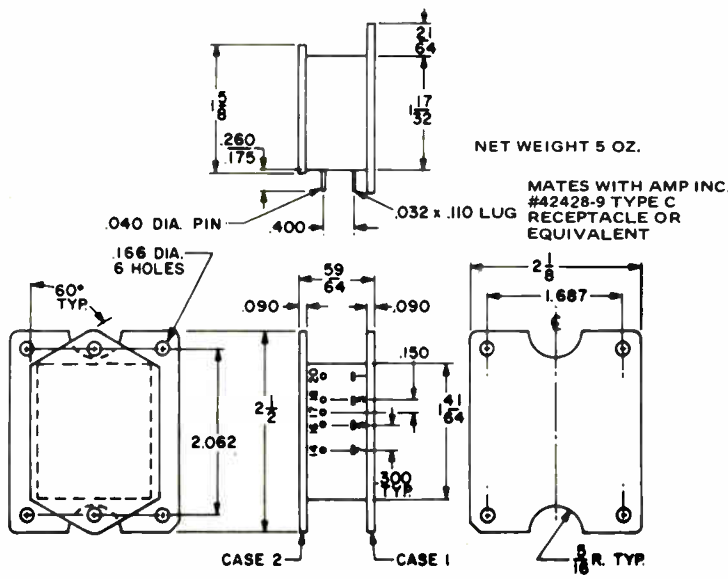
The LAS 5200 Series of Power Hybrid Voltage Regulators is designed for applications requiring a well regulated output voltage for load current variations up to 20 amperes. A key feature of the LAS series of Power Hybrid Voltage Regulators is its construction. A high degree of thermal isolation between the heat generating power elements and the heat sensitive control and reference elements is achieved by the placing of the power section on the heat-dissipating base of the unit, and the control stage on the heat-dissipating upper surface. This thermal isolation results in extremely low thermal drift characteristics for changes in power levels. In addition, a unique thermal power limiting circuit is built into the power section of the unit for increased operational reliability. This reliability is accentuated by a demonstrated MTBF of 100,000 hrs.

| PARAMETER | SYMBOL | CONDITIONS | MIN. | MAX. | UNITS |
|---|---|---|---|---|---|
| Input voltage to pin (1) [(A) (H)] | $V_{IN}$ (1) | | 7.25 | 40.0 | volts |
| Input voltage to pin (20) [(A)(G)] | $V_{IN}$ (20) | | 11.9 | 40.0 | volts |
| Output voltage | $V_O$ | | 4.75 | 29.4 | volts |
| Input-output differential [(A)(F)] | $V_{IN}$ (1) – $V_O$ | | 2.5 | 28.6 | volts |
| Input-output differential [(B)(F)] | $V_{IN}$ (20) – $V_O$ | | 7.20 | 28.6 | volts |
| Output current | $I_O$ | | | 20.0 | amps |
| Standby current | $I_Q$ (1) | | | 30.0 | mA |
| Standby Current | $I_Q$ (20) | | | 7.0 | mA |
| Power dissipation | $P_D$ | Plate #1 @25°C | | 270 | watts |
| Power dissipation | $P_D$ | Free Air @25°C Amb | | 11 | watts |
| Thermal resistance junction–Case #1 | $\theta_j$ – C1 | | | 0.65 | °C/watt |
| Thermal resistance junction–free air | $\theta_j$ – FA | | | 12.0 | °C/watt |
| Storage temperature | $T_s$ | | –55 | +125 | °C |
| Power transistor junction temperature | $T_j$ | | | +200 | °C |
| Regulation line [(C)] | | | | 0.014 | %/$\Delta V_{IN}$ |
| Regulation load [(D)] | | | | 0.2 | % |
| Programming resistance | | | | 1000nominal | ohm/volt |
| Programming voltage | | | | one/one | volt/volt |
| Temperature coefficient | | | | 0.015 | %/°C |
| Ripple attenuation [(E)] | | $V_{IN}$ (1) minimum, $I_O$ maximum | 60 | | dB |

NOTES:

A. Separate DC input voltages for power circuit (pin 1) and control circuit pin (20).
B. Common input voltages for power circuit (pin 1) and control pin (20).
C. Io constant for entire input voltage range from [$V_{IN}$(1) & $V_{IN}$(20) min.] to [$V_{IN}$(1) (20) max.]
D. $V_{IN}$ constant for entire range from 0 to full load.
E. Ripple attenuation is 54 dB min. for 24V and 28V models.
F. Minimum input-output differential based on $T_j$,> 25°C.
G. For AC source to Pin 20 with source resistance less than 10 ohms, minimum VAC = 12V rms. For other conditions consult factory.
H. Maximum input voltage is 30V for LAS 5205 and 5206.

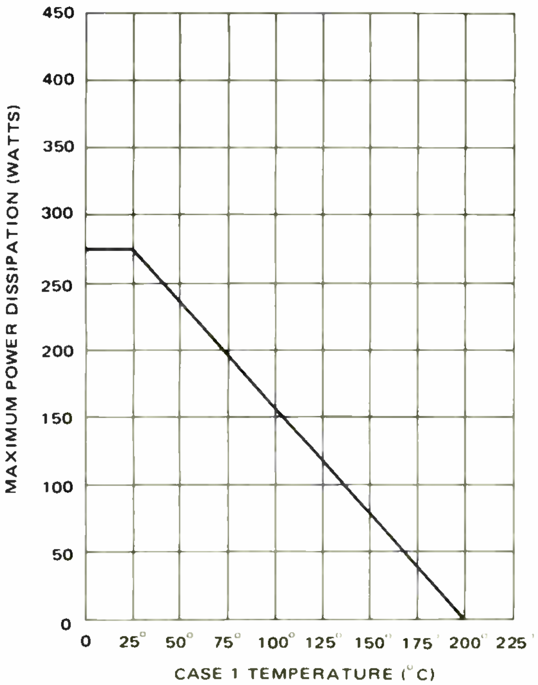




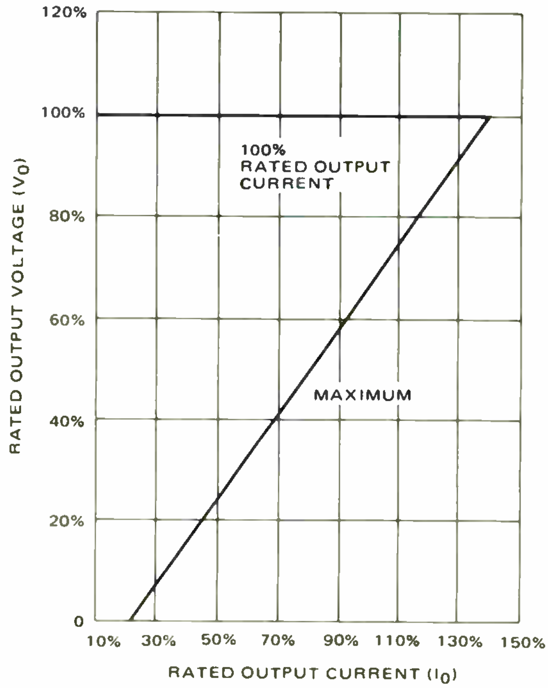

OUTLINE DRAWING, POWER HYBRID VOLTAGE REGULATOR, LAS 5000 SERIES

| VTGE VOLTS | MODEL | $I_o$ AMPS | PRICE QTY 1-24 | 25-49 | 50-99 | 100-249 | 250-499 | 500-999 | 1000 |
|---|---|---|---|---|---|---|---|---|---|
| 5±5% | LAS 5205 | 20 | $80 | $65 | $55 | $46 | $46 | $42 | $38 |
| 6±5% | LAS 5206 | 20 | 80 | 65 | 55 | 46 | 46 | 42 | 38 |
| 12±5% | LAS 5212 | 15 | 80 | 65 | 55 | 46 | 46 | 42 | 38 |
| 15±5% | LAS 5215 | 15 | 80 | 65 | 55 | 46 | 46 | 42 | 38 |
| 24±5% | LAS 5224 | 14 | 80 | 65 | 55 | 46 | 46 | 42 | 38 |
| 28±5% | LAS 5228 | 13 | 80 | 65 | 55 | 46 | 46 | 42 | 38 |

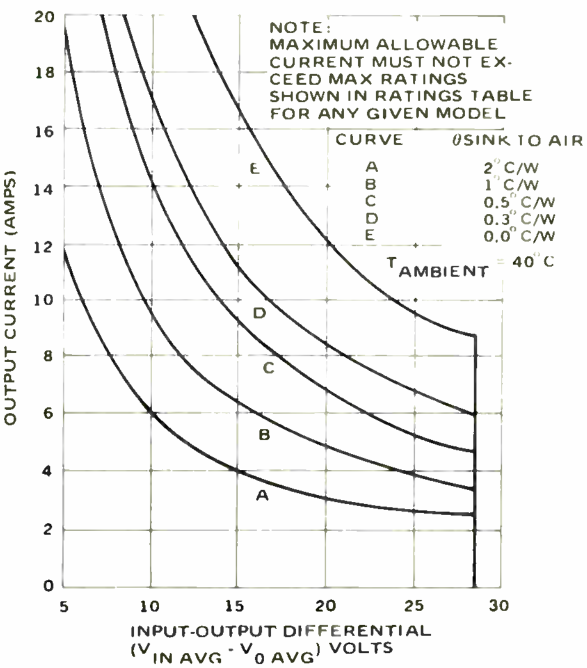
# Operational Data



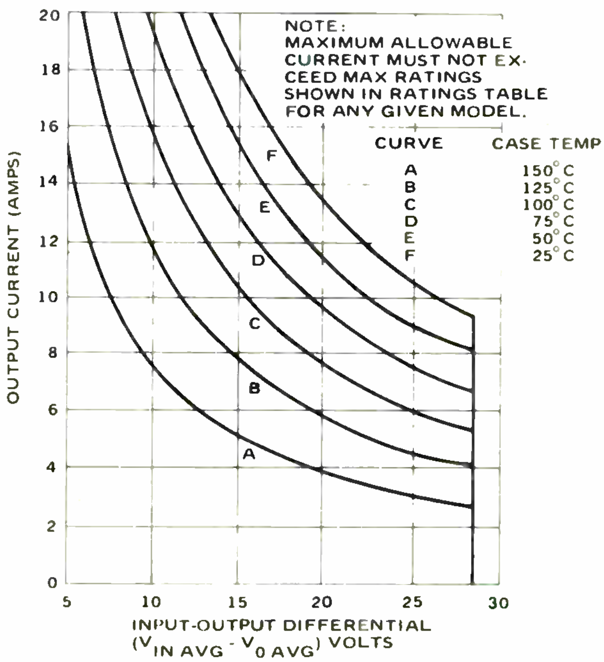

POWER DERATING CURVE AS A FUNCTION OF CASE 1 TEMPERATURE




SHORT CIRCUIT PROTECTION CHARACTERISTIC, LAS 5000 SERIES



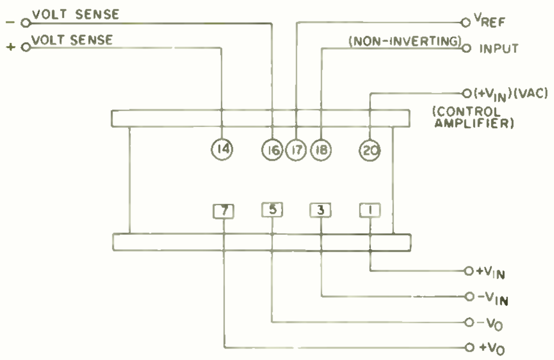

DC SAFE OPERATING AREA AS A FUNCTION OF HEATSINK THERMAL RESISTANCE TO AIR AT 40° AMBIENT TEMPERATURE FOR LAS 5000 SERIES



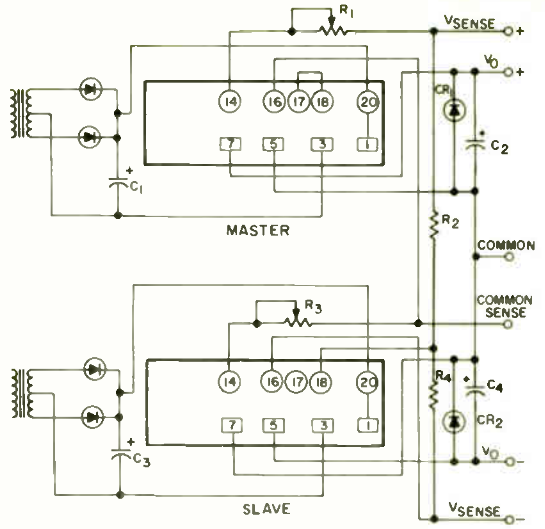

DC SAFE OPERATING AREA AS A FUNCTION OF MODULE CASE TEMPERATURE FOR LAS 5000 SERIES

# LAS 5000 SERIES

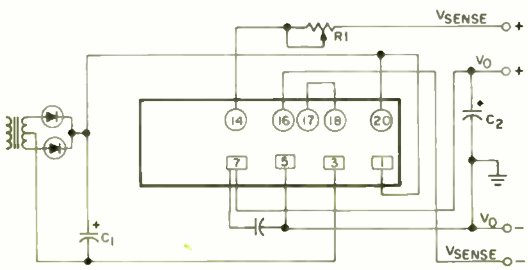
# Connection Diagrams




9-PIN POWER HYBRID VOLTAGE REGULATOR




DUAL TRACKING POWER HYBRID VOLTAGE REGULATOR CIRCUIT




POSITIVE POWER HYBRID VOLTAGE REGULATOR CIRCUIT

## NOTES

1. Minimum value of input filter capacitors C1 and C3 is determined by: C1, C3 = $I_O$ (1000 mfd/amp) recommended.
2. Minimum value of output capacitors C2 and C4 is determined by: C2, C4 = $I_O$ (100 mfd/amp):
3. Minimum value of output voltage adjust resistors R1 and R3 or LAS 5205, ohms. See note 4 to determine value for all other models.
4. Minimum value of output voltage adjust resistors R1 and R3 is determined by: R1, R3 = (0.25$V_O$ x 1000Ω/V) ohms wirewound. Use next highest standard value.
5. Values of tracking reference voltage divider resistors R2 and R4 for all models are determined by:
   a) R2 = (2000$V_O$ – 2490) ohms, ± 1%, ½W film
   b) R4 = 2.49K ohms, ± 1%, ½W film
6. Rectifiers CR1 and CR2 should be rated at peak inverse voltage of 50V and forward current equal at least to maximum rated $I_O$.

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**Digital Logic Design Engineers.** You will need a BSEE or technical degree in a related area plus 3-7 years' experience in GENERAL PURPOSE LOGIC DESIGN using high speed integrated circuit logic devices and familiarity with State-of-the-Art digital devices and computer aided design techniques. You should also have experience in DIGITAL CIRCUIT DESIGN, including A/D and D/A Convertors and Worst Case Design.

**Signal Processing Design Engineers.** Background should include a BSEE and 8-15 years' experience in Digital Logic Design (emphasis on Signal Processing techniques) and a thorough knowledge of Digital Hardware, Radar Principles, Timing, Coding/Decoding, Formatting, Data Transfer and Control Logic, including Worst Case Analysis.

**Microwave Design Engineers.** Background should include conceptual definition through design and development of microwave circuits & components necessary in design of antennas (including phase arrays) knowledge of computer applications and a familiarity with RF amplifier design, various type microwave & solid state devices, pulse modulator circuit design, fault sensing logic design.

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**MANAGER, MECHANICAL DEVELOPMENT**

Leading the team responsible for development and application of mechanical aspects of ink jet technology, you will have a subtantial annual budget, and a staff of approximately 10 engineers, technicians and support personnel. A BSME, MS preferred, plus a minimum of 10 years' related experience, including accountability for the design of a portion of a manufactured product are required. A background in low cost design and project management is also desirable.

**PRINCIPL SCIENTIST**
**Electrophotographic printers**

Lead a technology development team in establishing design approaches to new products. Ten years' EPG design and development experience with specialization in EPG image development and fusing required. A BS in engineering or physical science is also required.

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You will be responsible for the development of a new generation of band printers utilizing low cost innovative designs, in addition to responsibility for development of band printer paper stacker. Your background must involve the ability to direct a staff of approximately eighteen engineers, technicians and design and drafting personnel. Position requires BSME or the equivalent (MSME desirable) and a minimum of ten years' previous related experience including previous design accountability for a portion of a manufactured product, experience in project management and low cost design.

**MECHANICAL ENGINEERS**

Mechanical production design background including mechanical processes as they apply to design, and value engineering techniques. Proven product development experience with expertise in mechanisms, structures, electromagnetics, electronic packaging/cooling, and value engineering. A BSME or th equivalent plus 4-6years' related design and manufacturing experience.

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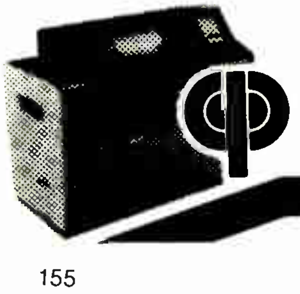

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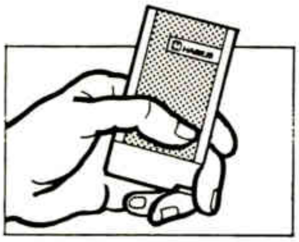
# With a Stroke of a Pen...



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# MICROPROCESSOR APPLICATIONS MANAGER

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## The person

We seek an outstanding digital-system designer and technical manager, with extensive experience in designing digital systems, especially microprocessor-based (hardware, software, peripheral devices). This person must be thoroughly familiar with the latest logic and LSI families. A degree from a leading technical university is required. Previous experience in managing highly skilled professional people is desirable. Age is open. English is currently spoken at ZELTRON, so knowledge of Italian is not a prerequisite.

## The position

Responsibilities include: definition of specifications; technical excellence in design; timeliness and level of effort; P & L for Laboratory and individual jobs.

The person will report to the General Manager, with whom he will cooperate in defining objectives and in expanding the company.

Salary is open and a function solely of qualification and experience. We can offer either a renewable fixed-length contract or a permanent position with ZELTRON.

## The Company

ZELTRON is a totally-owned subsidiary of ZANUSSI, a leading European manufacturer of appliances and electronic consumer goods (consolidated 1976 sales of US $ 650 million and after-tax profits exceeding US $ 30 million). The Zanussi Corporation employs 30.000 people and has 35 plants in Italy and divisions in 12 Countries.

ZELTRON has laboratories and offices in Udine and in Milano (Italy). It operates as an electronics engineering company, offering services in the following areas: Microprocessor Applications (development and design of microprocessor-based products); Industrial Systems (development and design of microcomputer-based process control and monotoring systems); Reliability (semiconductor component reliability, failure analysis, test and qualification, both to support ZELTRON's design activities and as a service to third parties).

## The location

Work location is Udine, a lovely, small (100.000 people) city in Northern Italy. The city, which was much shaken but not damaged by last year's earthquake, has been developing as a center of trade and light industry because of its favourable geografic position: it is only 80 miles from Venice, very close to Austria and Jugoslavia. The climate is mild and seaside and skiing resorts are at half an hour's drive.

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**ZELTRON s.p.a.**
**Istituto Zanussi per l'Elettronica**
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**MANUFACTURING TEST ENGINEERS**—BSEE with at least 5 years experience in design and checkout of sophisticated electronic test instrumentation. Knowledge of programming requirements for automatic electronic test desirable. Openings include senior level to project level.

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### ELECTRONICS ENGINEERS/ COMPUTER SCIENTISTS

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# How to cope with the Japanese trade and technology threat.

## The gathering wave of Japanese technology: What will the impact be?

Japan's share of the semiconductor market is still small, and its share of the computer market is even smaller. But the Japanese have set their sights on these targets, and their progress in the past couple of years has been so startling that many key executives in the U.S. electronics industries are mapping a counterattack. Other analysts disagree. The two keynote speakers will present each side of the issue.

**Wilfred J. Corrigan**
Chairman and President
Fairchild Camera and Instrument Corp.

Other speaker to be announced

## What must American companies do to keep their technological edge?

In the past the U.S. electronics industries have been the world's unquestioned technological leaders. A serious challenge is developing now in semiconductors, computers, fiber optics, and other areas. In the past couple of years, Japanese research and development programs have begun to close the gap, and it is the Japanese government that is financing much of the R & D. Texas Instruments is one of the most technologically sophisticated companies in the country, and its president, J. Fred Bucy, will give his views about what U.S. companies must do to retain their technological edge.

**J. Fred Bucy**
President
Texas Instruments Incorporated

## The Labor Department's Response to the Japanese Challenge

Several branches of the government are keeping tabs on the increasing threat of the Japanese electronics industries, but none more closely than the Labor Department. The reason: Greater Japanese penetration in the market means fewer jobs for U.S. workers. Howard D. Samuel, Deputy Under Secretary of Labor for International Affairs, has kept abreast of the issues involved and will give the Labor Department's view of the situation as well as its plans for action.

**Howard D. Samuel**
Deputy Under Secretary for
International Affairs
U.S. Department of Labor
Washington, D.C.

## How to succeed in business with the Japanese

As one of the biggest industrial economies in the world, Japan has a market that cannot be ignored by either small or large U.S. electronics firms. Yet doing business there is significantly different from selling in another state or even in a European country. Experts will outline some of the different ways of doing business with the Japanese, listing the advantages and potential pitfalls of each.

**Bernard V. Vonderschmitt**
Vice President and General Manager
Solid State Division
RCA Corporation

**Terry Wong**
Director, Business Development
Microelectronic Devices
Rockwell International Corporation

## How American electronic companies can win the battle for foreign markets

The Japanese semiconductor industry has about a quarter of the worldwide market and is working to expand that share as fast as possible. Likewise other sectors of the Japanese electronics industries are implementing effective marketing campaigns to increase their sales. Some portions of the Japanese marketing effort—financing terms, for example—are tough to counter, but other tools are available to U.S. companies. ITT senior vice president Richard Hodgson will explain what those tools are and how you can use them.

**Richard Hodgson**
Senior Vice President
International Telephone and Telegraph Corporation

## Japan versus the U.S.: The government response

The key government agency overseeing the entire trade question is the Office of Special Trade Negotiations. Richard Heimlich negotiated the color TV agreement with Japan and has stayed abreast of the entire electronics question. He will discuss the Carter Administration's response to the question of Japanese competition and describe what steps the Office of Special Trade Negotiations is taking.

**Richard W. Heimlich**
Assistant Special Trade Representative for
Industrial Trade Policy
Office of the Representative for Trade Negotiations
Washington, D.C.

## How can domestic electronics firms respond to the Japanese marketing threat in the U.S.?

The Japanese share of the U.S. semiconductor market is still small, but industry observers, fully aware of how the Japanese captured the U.S. color television market, predict it will grow. Simultaneously, Japanese firms are gearing up for an even bigger sales push. Leading experts from the U.S. industries will give their insights into steps U.S. firms can take to cope with the Japanese challenge.

**L. J. Sevin**
Chairman of the Board
Mostek Corporation

# 2 The potential of microprocessors: What is going to happen?

## The outlook in microprocessors: Where are they going next?

Microprocessors have made it big already, offering new business opportunities and a new tool to use in your operation. Their development is far from complete, however. One of the leading microprocessor experts will tell you how he sees microprocessors developing.

**Leslie L. Vadasz**
Vice President and Assistant General Manager
Microcomputer Division
Intel Corporation

## The microprocessor universe: What's out there?

Choosing the proper microprocessor for your needs is a crucial task, but also one that requires a good technical understanding of just what is available. What are the advantages of choosing a one-chip microprocessor? What are the advantages and disadvantages of 8-bit and 16-bit systems? What are the cost-performance tradeoffs of chips versus boards? A panel of leading industry experts will answer these questions and more.

**Colin Crook**
Group Operations Manager, Microproducts
Semiconductor Group
Motorola Inc.

**Andrew C. Knowles**
Vice President/Group Manager
Digital Equipment Corporation

**Malcolm B. Northrup**
Vice President
Microelectronic Devices
Electronic Devices Division
Rockwell International Corporation

**James Van Tassel**
Manager, MOS Microprocessor
Texas Instruments Incorporated

## How to get started in microprocessors

Many basic management considerations must go into selection and implementation of a microprocessor. What can a microprocessor do for your company? What will be the likely effect of microprocessors on your industry? Eric Garen, who has taught courses on this subject for top management of several major corporations, will answer these questions and more.

**Eric Garen**
Vice President
Integrated Computer Systems

# 3 The economy and the markets: Where are they going?

## Electronics markets in the coming year: A preview

*Electronics* publisher Dan McMillan and Executive Editor Samuel Weber will give a special preview of the annual *Electronics* market forecast, looking at worldwide market prospects.

**Dan McMillan**
Publisher
**Electronics**

**Samuel Weber**
Executive Editor
**Electronics**

## Where is the economy going and what does it mean for you?

The economy has been on a gradual upswing for the past several months, and now the question is: How long will that upswing last? Will the economy lose steam by mid-1978? What does future economic growth rate mean for the inventory levels electronics firms should maintain?

If capital spending takes off—as many think it will—what should that mean for your business? Noted economist Douglas Greenwald will announce results of some original research he has just completed that is especially pertinent to the electronics industries.

**Douglas Greenwald**
Vice President—Economics
McGraw-Hill Publications Company

# Preliminary Conference Schedule

## Wednesday December 7, 1977

| | |
|---|---|
| 8:00 — 9:00 AM | Registration |
| 9:00 — 9:15 AM | Welcome |
| 9:15 — 10:15 AM | Economic outlook |
| 10:15 — 10:45 AM | Coffee break |
| 10:45 — 11:30 AM | The outlook in microprocessors |
| 11:30 — 12:00 PM | Intermission |
| 12:00 — 1:30 PM | Lunch: Market outlook |
| 1:45 — 3:15 PM | The microprocessor universe |
| 3:15 — 4:15 PM | How to get started in microprocessors |
| 4:30 — 5:30 PM | Cocktail reception to meet speakers |

## Thursday December 8, 1977

| | |
|---|---|
| 9:00 — 10:15 AM | Keynote addresses: The impact of Japanese technology |
| 10:15 — 10:45 AM | Coffee break |
| 10:45 — 11:45 PM | How electronic companies can respond to the Japanese marketing threat |
| 11:45 — 12:30 PM | The Labor Department Response to the Japanese Challenge |
| 12:30 — 1:00 PM | Intermission |
| 1:00 — 2:15 PM | Lunch: Richard Heimlich |
| 2:30 — 3:30 PM | How Do You Successfully Do Business With the Japanese? |
| 3:30 — 4:15 PM | How Americans can win the battle for markets abroad |
| 4:15 — 5:15 PM | How can American companies keep their technological edge? |

All registrants will receive copies of *Electronics'* best selling books: "Applying Microprocessors: New hardware, software and applications" and "Microprocessors" edited by senior editor Laurence Altman as well as *Electronics'* reprints on the Japanese threat.

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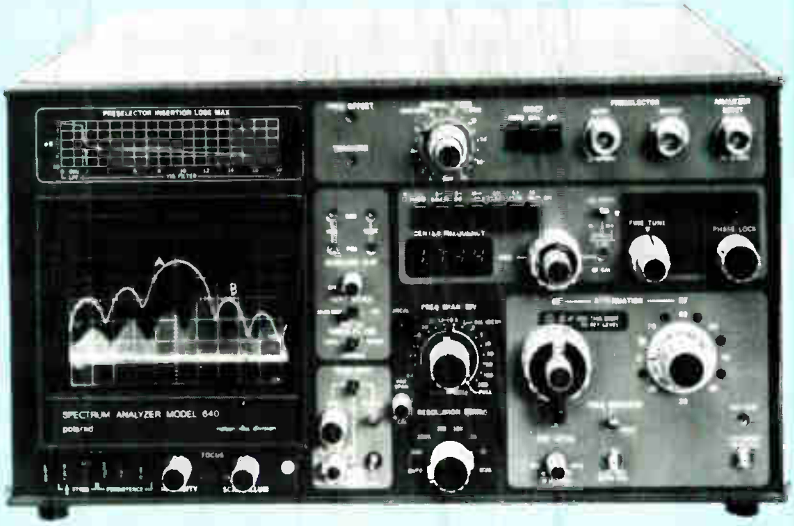


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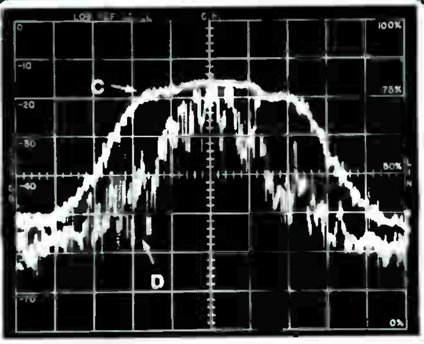


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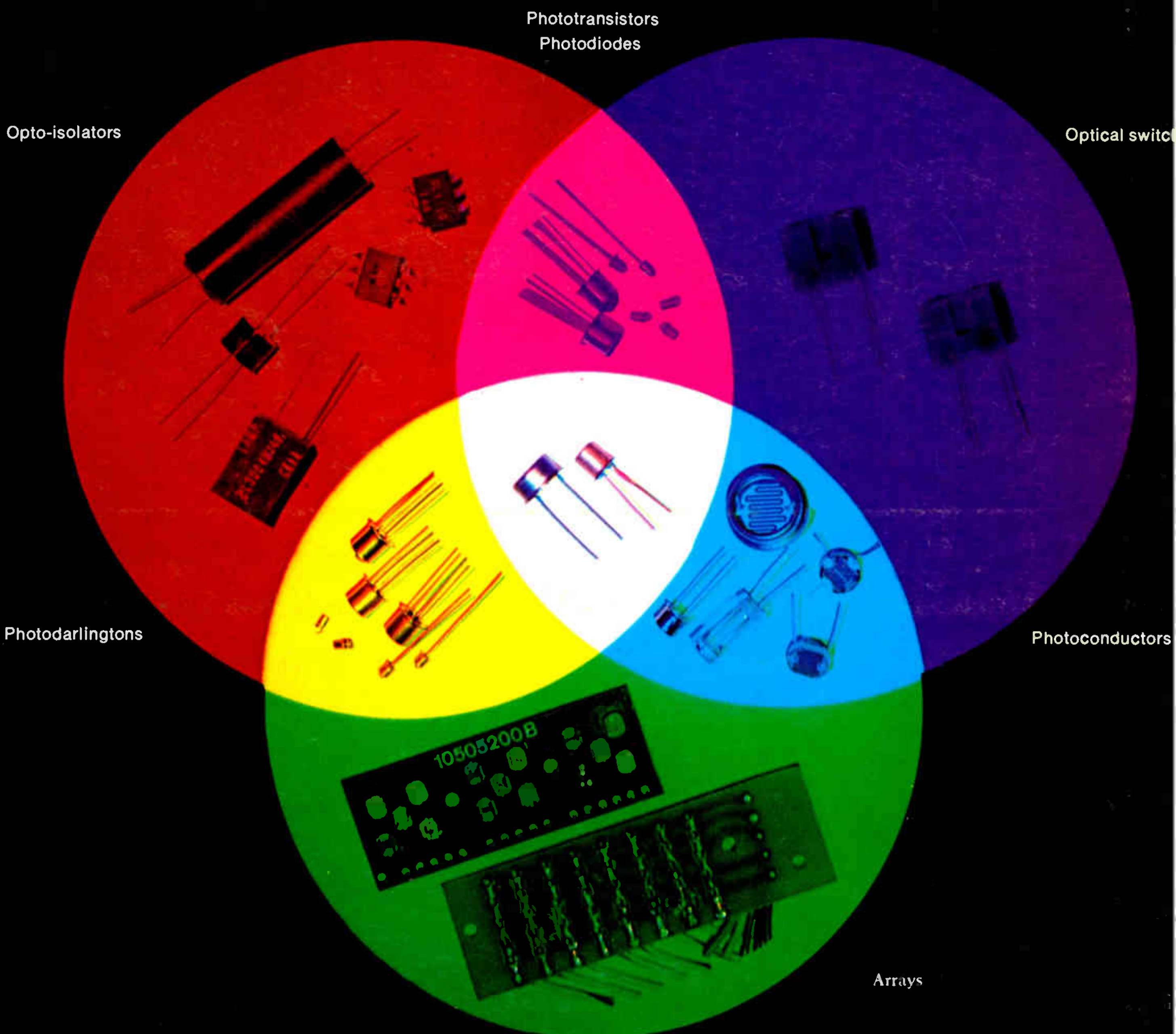


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