AUGUST 3, 1978

AT&T BID FOR SWITCHED DIGITAL SERVICE JARS INDUSTRY/79

What designers should know about thin-film resistor networks/99

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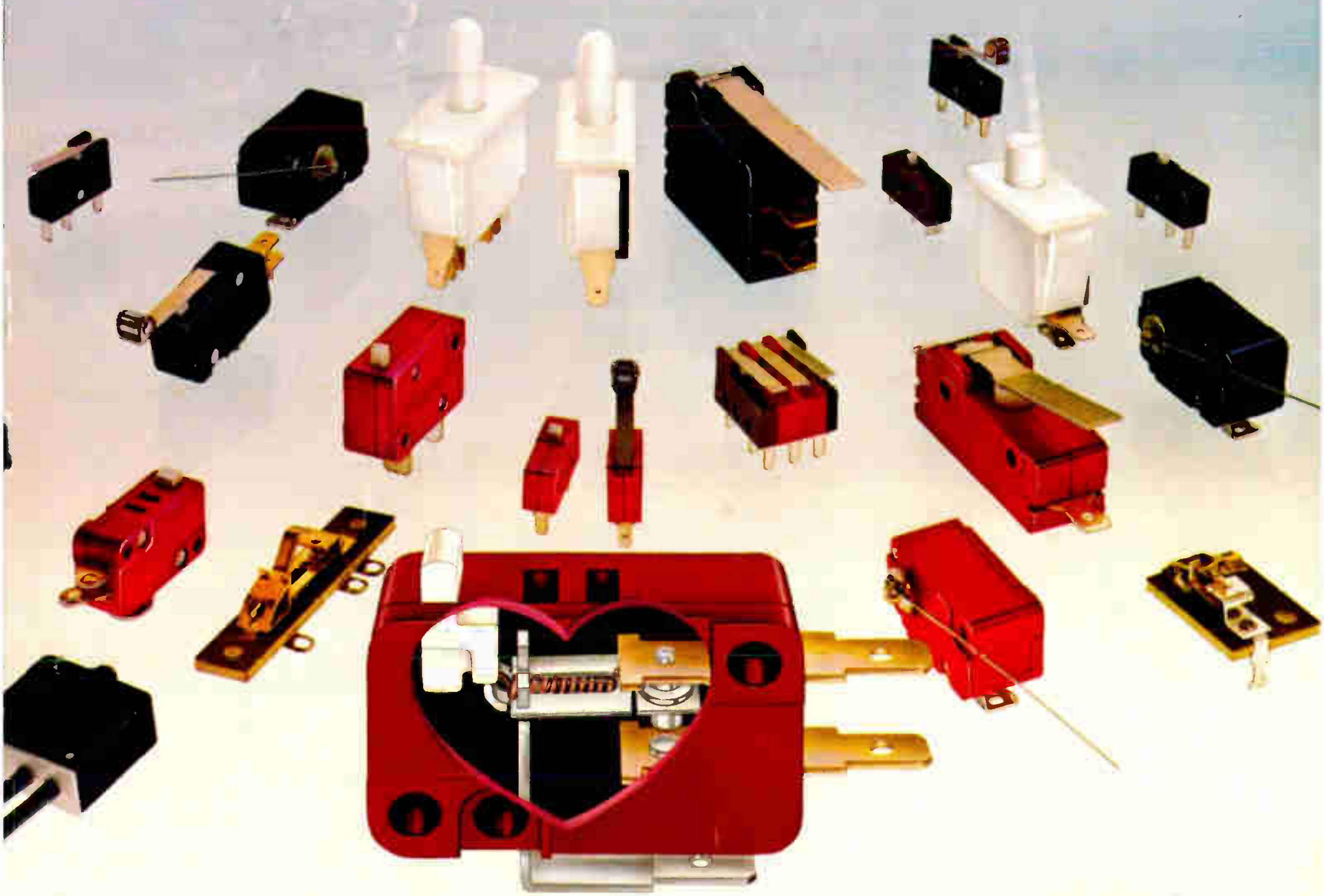

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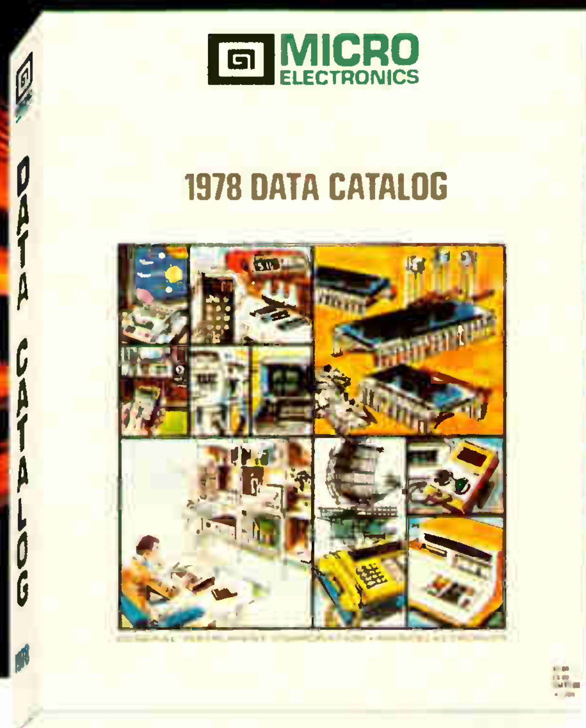

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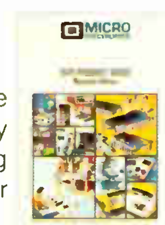

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Electronics

The International Magazine of Electronics Technology

Vol. 51, No. 16 • August 3, 1978

Highlights

Cover: Evaluating bit-slice processor elements, 91
The world of bit-slice microprogrammable processor sets is a complex one, so this comparison of the processor chips aims at easing designers' choices. A second article, in the next issue, will deal with the other half of the sets: the microcontroller that sequences the instructions.

Cover is by Art Director Fred Sklenar.

Government to aid Italian electronics R&D, 84
The data-processing, components, and telecommunications industries in Italy will benefit from the government's financial-aid plan, now working its way through the multilevel approval process. Though the subsidies and low-cost loans, mostly to finance research and development, total $605 million, sources in these three electronics sectors see the effort as merely adequate.

All about monolithic thin-film resistor nets, 99
Adapting wafer batch processing from semiconductor manufacture has produced microminiature integrated resistor networks that offer precise performance, convenience, and low cost. A look at the manufacturing techniques gives an idea of the design considerations in using them.

Expansion storage CRT speeds oscilloscope, 110
Adding a magnifying image-projection lens to a variable-persistence storage cathode-ray tube gives an oscilloscope a 1,800-cm/μs writing speed and a 100-MHz bandwidth. The lens expands the display image about 10 times over the image written on the storage surface, thereby increasing the write speed a like amount.

In the next issue . . .
A distributed microprocessor-development system . . . all about plasma etching . . . a programmable communications controller with on-board random-access memory.

Electronics

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Publisher's letter

Few engineers today have the chance to learn about the various bit-slice families from the ground up that Scott Smith and Tom Adams have enjoyed. Their two-part article, which starts in this issue (p. 91), is a result of this experience.

Actually, Smith and Adams worked with bit slices independently at first; Smith at Texas Instruments, Adams at Raytheon. They then pooled their know-how working together on a Navy contract at the Applied Research Laboratories of the University of Texas, Austin, Texas. (Both now work for IBM.)

"We had worked on several bit-slice families between us," Smith reports. "Then the Navy contract got us together, and we felt it was time to publish our findings."

Smith's first brush with bit slices at TI was in the design of peripherals for minicomputers. Meanwhile, Adams at Raytheon was working with bit slices for interfacing sonar equipment with militarized minicomputers aboard Navy submarines. His interest in bit-slice processors grew to the point where he studied each new family of parts.

Adams was at the Applied Research Laboratory when Advanced Micro Devices first announced the now-famous 2900, and he felt from the start that the device would catch on. "I even built a test box for it as a learning aid," he recalls. At the time, there was a minimum of support from manufacturers. Today, vendors are better at supporting these products, he believes.

The two worked closely together at the lab to prepare the article. But they didn't rely entirely on their personal experience. They also studied all the available parts and consulted with co-workers who were more familiar with certain bit-slice families.

Part 1 of the article focuses on the processor elements of six bit-slice families. Part 2, which will appear in the next issue, will cover the equally important microcontroller elements, as well as special-purpose chips and development aids.

It may be years before the full impact of the AT&T proposal for Advanced Communications Service can be appreciated. As the story on page 79 points out, the shock wave concerning the telephone company's desire to operate a dial-up digital data-communications service has hit two electronics industries—data communications and computers.

The complex proposal will be the responsibility of the Federal Communications Commission, which is itself undergoing close scrutiny by the Congress as part of the communications reform bill. (Items on this legislation appear on pages 52 and 60.) To complicate matters more, Walter Hinchman, the veteran chief of the Common Carrier Bureau, a key unit in handling the AT&T petition, is leaving the FCC.

One thing is certain: ACS will provide a long-running story as it wends its way through the regulatory process. "The subject is becoming an industry in itself," reports Computer Editor Tony Durniak. "Consulting firms are already setting up seminars on ACS, and it looks as if they will be well attended."

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Readers' comments

Revising the table

To the Editor: Table 4 of Alan Weisberger's article, "Data-link control chips: bringing order to data protocols" [June 8, p. 104], which compares available data-communications controller chips, contains some inaccuracies about Zilog's S10 device.

To be specific, the S10 provides a character length of 1 to 8 bits in the transmitting mode; it does have separate interrupt vectors for transmitting and receiving in both channels; and it has a much more elaborate line-fill scheme than the simple FCS-flag listed.

Janak Pathak
Zilog Inc.
Cupertino, Calif.

More revisions

To the Editor: The June 8 cover article, "Data-link control chips: bringing order to data protocols" [p. 104], is a well-written tutorial describing the latest in large-scale integrated devices for data communications. There are, however, several errors concerning the Motorola 6854 in Table 4 on page 112.

The following features should be changed to read: maximum data rate (b/s), 660-K/1-M/1.5-M; receiver FIFO buffers, 3; transmitter FIFO buffers, 3; loop-back self-test mode, yes; underrun line fill (BOP), abort/flag.

Mike Newman
Motorola Semiconductor
Products Inc.
Austin, Texas

Inhibiting cranks

To the Editor: The Probing the News article on fancy new telephone instruments ["New firms rush into new phone market," July 6, p. 81] was very interesting. But what would be most useful and what I would really like to have on my phone is a display of the number *from* which I am being called. Of course, that would require a central-office modification, but it would cut down crank calls significantly.

J. Dale Holt, USAF
Wright Patterson AFB
Dayton, Ohio

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News update

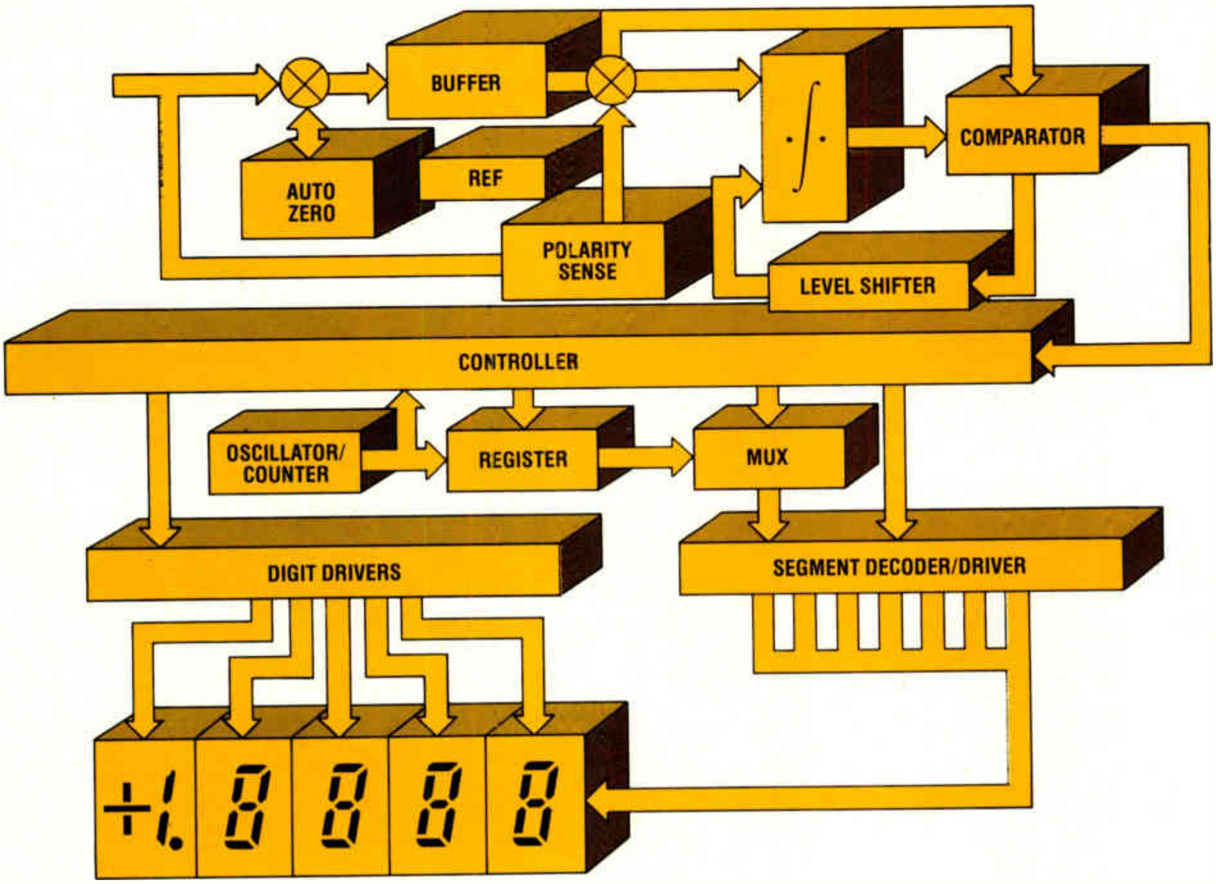
■ Westinghouse Electric Corp.'s Integrated Logistics Support division in Hunt Valley, Md., and Sperry Rand Corp.'s Sperry division in Great Neck, N.Y., have won $3,752,589 and $3,482,697 contracts, respectively, to design and fabricate engineering models of a modular automatic test equipment (MATE) system for use with all Air Force avionic systems. Awarded by the Aeronautical Systems division at Wright-Patterson Air Force Base, Ohio, the 33-month contracts are the first under the MATE program, which aims to stop the proliferation of expensive automatic test equipment that is dedicated to only one kind of aircraft [*Electronics*, Sept. 15, 1977, p. 50].

The Air Force wants hardware and software standards for ATE to be used at all maintenance levels—factory, field organization, intermediate shop, and depot. The program calls for the Air Force to develop interchangeable hardware and software modules to be used in fabricating specific test systems tailored to specific weapons systems, notes program manager Lt. Col. Kenneth D. Wilkinson.

"If the maintenance man can't find a shorted-out $2 circuit board that's preventing a $15 million aircraft from flying, there's a tremendous cost incurred by the Air Force," he adds. "Eventually, modular ATE will drastically cut the $700 million spent annually by the Air Force for separate pieces of ATE."

Engineering models to be built include four different test-station configurations for four kinds of electronic equipment. Other phases of the parallel efforts require contractors to define levels of test hardware modularity, develop software, and conduct human engineering studies, as well as develop guides and handbooks for electronic testability design and guides for test equipment acquisition and application.

The next major MATE contract will be awarded in three years to one contractor for the design and fabrication of a prototype system for a specific aircraft system, not yet determined. **Bruce LeBoss**



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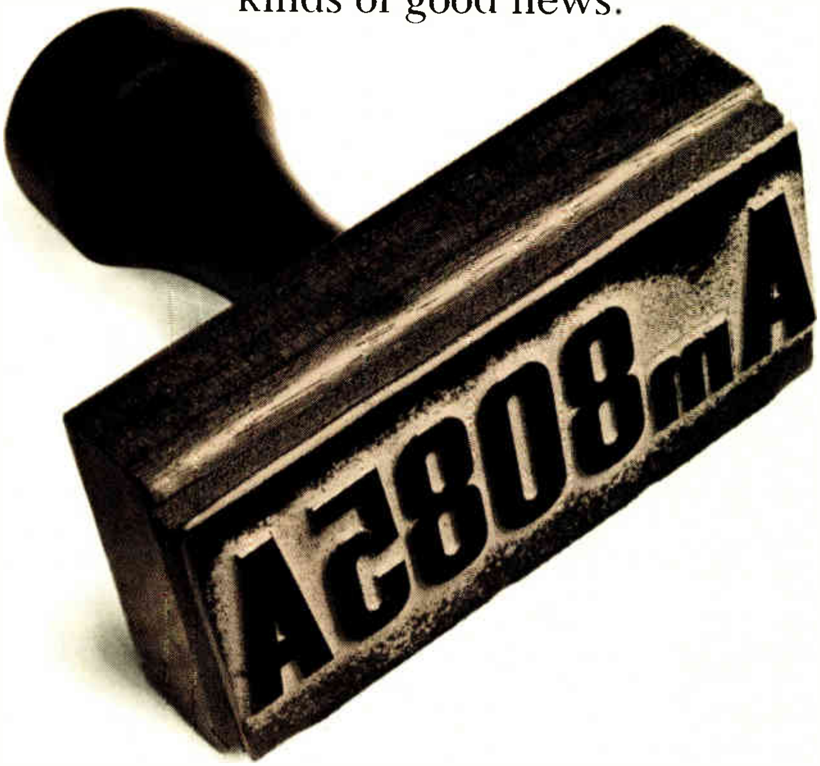

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Let's not rush to answer the phone

The proposal by AT&T to weld its phone system and digital data services into a single giant data-communications network is of the kind that casts its shadow over vast territories of business and technology. It involves not merely questions of tariffs and terminals, but extends into broad philosophical areas of free competition and to what extent small, young businesses should be nurtured by a protective government.

Only a fool would predict at this early stage whether the phone company will eventually receive permission to implement its Advanced Communications Service, or ACS: the tortuous process of application, approval, and appeal could very well keep a generation of lawyers in three-piece suits. But even as the lawyers prepare their arguments, there are questions that transcend approval or disapproval, questions that lie at the very roots of the way technology is born and nourished in this country.

It must be conceded right at the top that AT&T's plan is based on a sound concept of service—and the key word here is "service." After all, if the object is to deliver more data to more people more efficiently, then the phone company's network is a neat way of doing it. That's good.

But what price in competitiveness are we willing to pay for that service? Or, putting it another way, would ACS plunge Bell too deeply into data processing as opposed to data communications?

Assume the perspective of the small, young, technologically innovative manufacturer of data-communications equipment. Such a network would efficiently siphon of all his customers by adding data processing to the intelligence it already contains. Those customers would no longer have to come to him for their intelligent terminals—that need would be met by the phone company.

But couldn't such a small manufacturer build equipment to fit ACS and, in the time-honored American tradition, do it more efficiently and cheaply than Bell itself? The need would certainly be there, and so would the desire. But not so fast—that route seems to be blocked already, because Bell has disclosed only the sketchiest technical details of its network. This has the effect of giving the phone company's manufacturing arm, Western Electric, a manufacturing and marketing headstart, one that would last perhaps as long as two years (see p. 79).

A service and equipment monopoly of that duration would be enough to put many a small competitor out of business. Also lost would be the opportunity for technological competition that is the wellspring of innovation. That's bad.

As if that weren't enough, the Federal Communications Commission, which must decide for or against ACS, could be a lame duck agency. The proposed revision of the 1934 Communications Act would eliminate the FCC—and, incidentally, separate Western Electric from its parent. While that bill has a long route of its own to go before passage, its shadow, too, is hanging over the proceedings.

One conclusion to be drawn from all this is that now is a nice time not to be an FCC commissioner. More seriously, though, the FCC cannot be too careful in its examination of ACS and the precedent-making implications of any decision. In fact, the more one thinks about it, the more one likes the idea of all the hearings and deliberations that will take place. This is not the time for hasty decisions.

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People

Five months, and Blanchette moves to the top of CTC

Gene Blanchette concedes that being made president only five months after joining Communications Transistor Corp. is a meteoric rise, but after top management posts in the semiconductor operations of Fairchild, Motorola, Teledyne, and Nortec, the 44-year-old industry veteran is ready for anything. Having run plants with 5 to 5,000 people, he says that the management principles are the same for a large semiconductor maker or a $12 million very-high-frequency microwave power-semiconductor house like CTC.

Blanchette moves up from operations vice president as founder Thomas E. Ciochetti takes on new duties as special assistant to the president of parent Varian Associates' Electron Device Group, to which CTC belongs.

The basic job is managing people so that "you create discipline without disturbing creativity," says Blanchette, an Englishman who holds a degree in physics. "In a high-technology company, you must ensure that all the key people believe you are fair, open, and competent."

But managing the San Carlos, Calif., company, which typically makes products on the leading edge of microwave power technology, does present some special problems. Though 1/40 the size of Intel Corp., it makes 100 times as many devices or 1,500 different device types among the 1 million devices produced each year. "We're the biggest custom house in the discrete business," Blanchette observes.

GaAs coming. To survive and prosper in the microwave power business, "we will have to eventually go to the next level of integration" in hybrid modules and power modules, he continues. Also, "we'll have to take a look at gallium arsenide, because silicon runs out of steam above 4 gigahertz." This major undertaking will "almost be like starting a new company," he says.

Meanwhile, CTC, which plows about 11% of its revenues back into

Growing. Gene Blanchette sees lots of semiconductor growth at 1 GHz and above.

research and development, will continue to perfect microwave and field-effect transistors and the gold metalization techniques required in high-reliability silicon power devices.

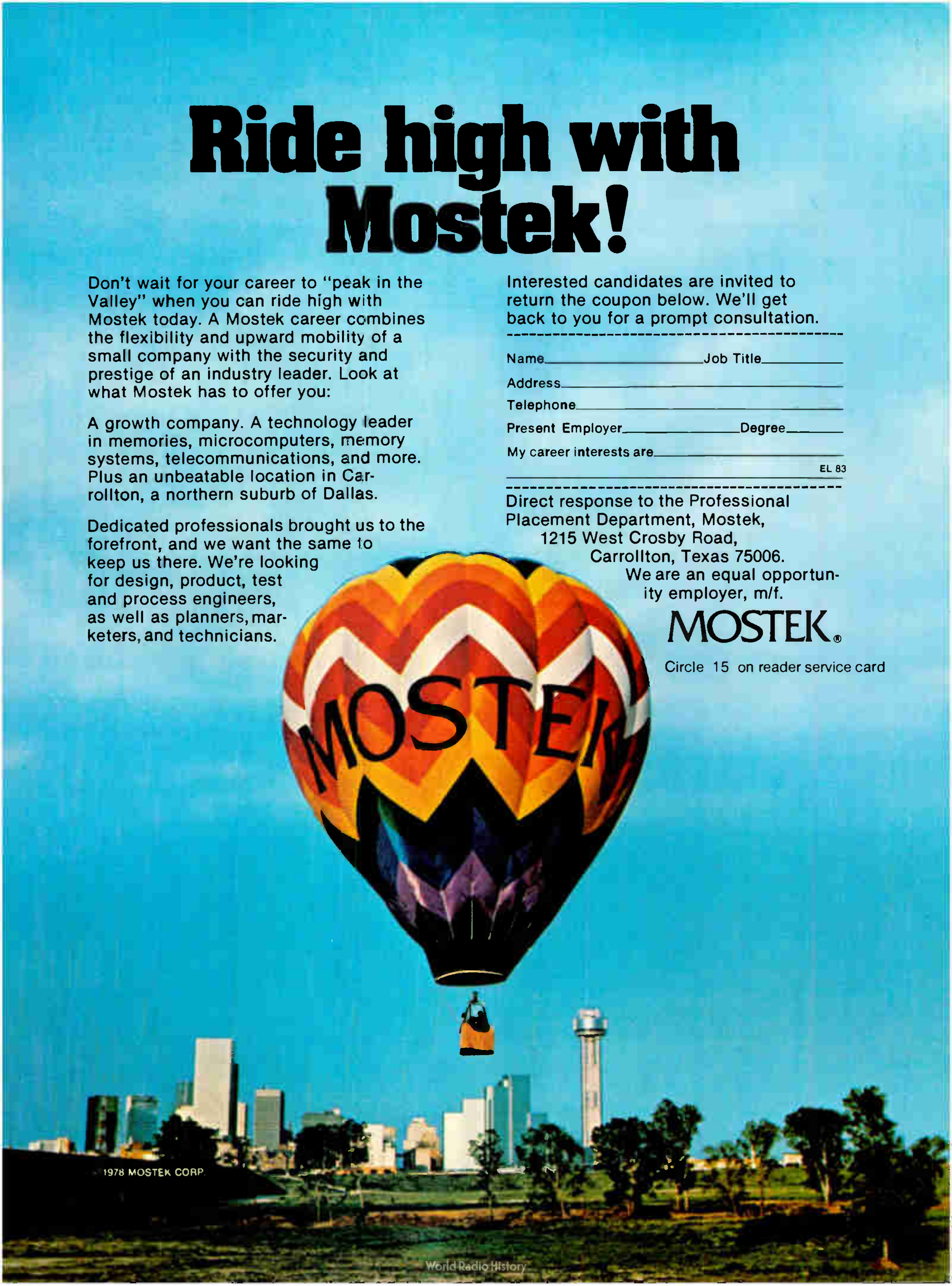
Blanchette, who looks for 15% growth this year and 25% the next, says the market is expanding and that semiconductors of 1 gigahertz and up show tremendous potential. One market is the 900-megahertz mobile-telephone market, "which is almost a high-performance microwave semiconductor market."

Other growing markets include point-to-point communications, L- and S-band radar, and the ultra-wide-band gear needed for electronic-countermeasures equipment. Blanchette says that CTC is readying parts for all those markets, including devices with tens of watts output.

RCA's Krall sees computer, CCD cameras in home

A color TV camera the size of a thick novel is only about a year away from being good enough and cheap enough to hit the consumer market with a bang. So says Harold R. Krall, who recently was named product line director for systems and equipment within RCA Corp.'s Electro Optics and Devices operation.

Krall, 39, has an unusual vantage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point from which to gage what the home-of-the-future will be like, electronically speaking. His several-hundred-person operation in Lancaster, Pa., part of RCA's Solid State division, builds several systems he believes will have an important place in the home. These range from the TV camera, built around charge-coupled devices, to closed-circuit TV systems, which now use conventional vidicons, and the increasingly popular personal computer.

Right now, he is most enthusiastic about the color CCD camera he says his group will eventually be able to introduce for less than $500—one that will "play" with RCA's Selectav-

Coming. CCD color TV cameras like this one will attract consumers, Krall says.

ision video cassette recorder.

But he also looks for CCD cameras to be widely used in closed-circuit TV surveillance systems. And there will be more and more of those in homes, he says. "At one time, people only bought CCTV systems after they were robbed," he explains. "Now, brand-new homes are being equipped."

Tying together the cameras for surveillance to those for home entertainment is the home computer, says Krall. "The CCD camera and computer combination is a natural—the serial digital nature of the camera's output can easily be processed by the computer."

The processing results in the computer "learning" the image of the scene, so that an alarm may be sounded if things change—as when someone has entered an area that is supposed to be empty. And of course, the home computers will be applied to entertainment and learning systems, as well as to burglar alarms and systems for controlling appliances, he says.

Krall points out it will be easy to phase the CCD cameras into the TV equipment line, but he intends to see to it that they mesh with the computers as well. RCA's VIP personal computer, which has just graduated from a kind of learning-aid kit to the status of an assembled, full-blown microcomputer, will be continually improved with new programs so that there will soon be "at least one new-product announcement a month," Krall says. □

MEASUREMENT COMPUTATION news

product advances from Hewlett-Packard

AUGUST, 1978

HP's new intelligent graphics terminal is programmable and speaks BASIC

HP-IB

The HP 2647's multiple automatic plotting capability can display tabular data in formats of your choice, even if you have little or no programming knowledge. A simple menu helps you enter your data parameters on the keyboard, after which a single keystroke plots the data automatically.

The HP 2647A brings a new level of intelligence to our growing family of terminals. It combines user programmability in BASIC with sophisticated graphics capabilities to help you process and visualize complex data, or detail an idea from concept to execution—with or without the assistance of a CPU depending on the complexity of the task.

By virtue of its microprocessor intelligence, plus 220K bytes of local storage on dual tape cartridges, the HP 2647A terminal is able to come up with some bright ideas:

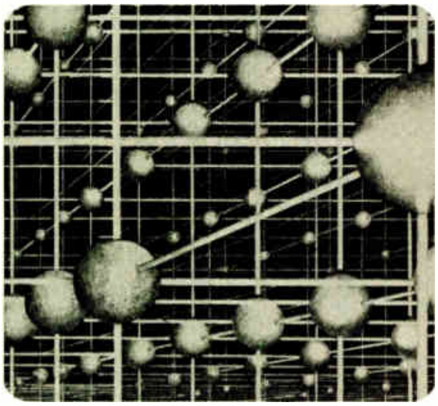
- Tabular data can be entered, the desired type of graph selected (bar, pie, X-Y, Cartesian, or logarithmic), and the terminal will automatically label, scale, and plot the data for you.
- A simple BASIC program in the terminal can reformat or post-process data from a CPU into an appropriate graphic form, or check the accuracy of data prior to transmission to the CPU data base.
- Processing loads can be effectively shared or distributed between terminal and CPU; for example, repetitive tasks can be performed by the terminal leaving the CPU free to perform complex tasks using its full power.

Other graphics capabilities of the HP 2647A include: multiple automatic plotting, zoom and pan, user definable area shading, independent display memories, and rubber band line. Optional hard copy of the terminal screen display can be obtained from HP's 9872A four-color plotter or 7245A plotter/printer.

For complete details, check B on the HP Reply Card.

IN THIS ISSUE

Transpose a 2 megabyte matrix in 44 seconds with new F-Series minicomputer



The new F-Series computer is top-of-the-line for the HP 1000 family. Its design has been optimized to provide users with the high speed and accurate computation so needed in scientific, industrial, and engineering applications.

Fast FORTRAN

The cumulative effect of the F-Series computer's features is an amazingly fast execution of FORTRAN programs. To achieve it, we took a control processor with a base instruction set whose execution speed was one million instructions per second. Then, a second processor was dedicated to floating point operations. Next, we established a library of "Scientific Instructions" that quickly calculate commonly used trig and log functions. Finally a subroutine set common to FORTRAN and crucial to performance was microcoded. The result is fast FORTRAN.

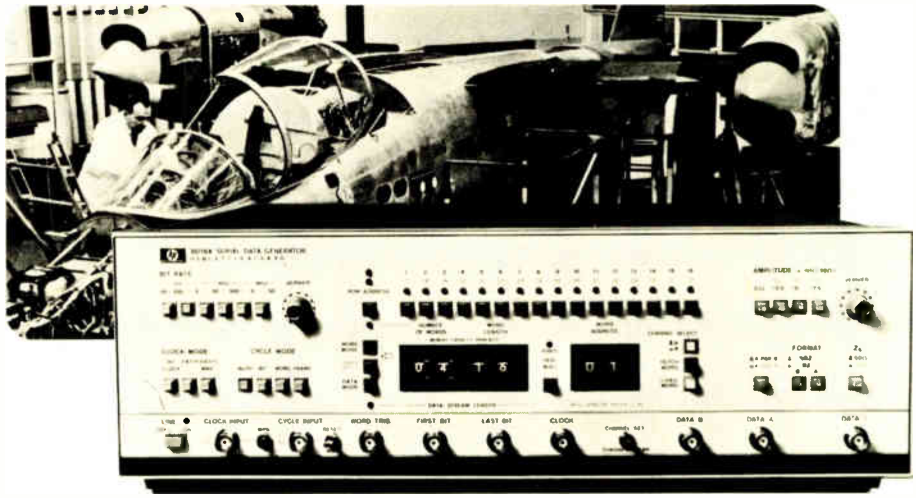
Megabyte data arrays

Even further power in FORTRAN is available for all HP 1000 computer systems with the addition of a new version of our real time operations system—RTE-IV. It enables users to quickly access memory resident data arrays of nearly two million bytes of CPU memory with simple FORTRAN statements. The combination of fast FORTRAN and the megabyte arrays, enables the F-Series to transpose a two million byte matrix in just 44 seconds—a significant contribution for a 16-bit machine.

Check C on the HP Reply Card for details.

For testing today's logic, serial data stimulus delivers over one-million-bit data streams

HP-IB



Hewlett-Packard's Model 8018A is a high-performance data generator that meets all of your requirements for serial stimulus up to 50 M bits. Included is an innovative new technique for mixing PRBS and programmable data words in a single stream over one million bits long. This technique is perfect for stimulating preamble-data-postamable patterns.

DC to 50 MHz clocking rates and clean 15V output pulses provide speed and signal levels to work directly with logic families from ECL to CMOS. A switchable 50 Ω source lets you choose the termination configuration that delivers the best pulses in your test set-up, and a full complement of cycling modes and trigger signals allow easy synchronization to it.

Memory contents and data output format are remotely programmable via the optional HP-IB. This gives even faster data loading and affords application of its serial data generation capabilities in automatic test systems.

For more information, check D on the HP Reply Card.

General purpose lab instrument offers power and performance

The new HP 214B, a 10 MHz pulse generator, employs semiconductor technology for high power pulse generation 10 times faster than its predecessor, the 214A. Delivering 100 V pulses with 15 ns risetimes, the 214B meets the speed demands of today's high power applications.

State-of-the-art VMOS FETs used as current sources for the output amplifier tubes enable pulse width to be specified down to 25 ns. The 214B is thus well-equipped for low duty cycle applications such as laser diode pulsing or transient simulation on power transmission lines.

Where changing duty cycle threatens device destruction, the 214B Constant Duty Cycle (CDC) mode provides device protection. In CDC operation, power remains constant as frequency is varied. Operating out of CDC mode, the 214B is protected against excessive duty cycles via an overload detect circuit.

External trigger, synchronous gate, manual trigger, single pulse, double pulse, pulse delay/advance, selectable output polarity, and optional counted burst equip the 214B for the many applications encountered in general labs use. Easy operation is assured by the timing error indication. Calibrated dials enable fast, accurate adjustments.

Operating into unmatched loads, clean pulse shape is guaranteed by the low reactance 50 Ω source impedance. Typical pulse distortions such as preshoot, overshoot, and ringing are only 5% specified at all amplitudes. All specifications are guaranteed in ambient temperatures from 0-50°C.

For more details, check E on the HP Reply Card.

Sophisticated yet convenient new digitizer converts analog data from virtually any graphical form

The 9874A is the first digitizer to have an adjustable glass platen, microprocessor intelligence, built-in memory (16K bytes), cursor vacuum system, and control key pad all in one compact, easy-to-use unit.

System 45 and the 9874A Digitizer provide you with a powerful graphics system that lets you plot your digitized data on the CRT for analysis.

A new, microprocessor-controlled peripheral, the HP 9874A Digitizer, provides an accurate, speedy, and convenient method of entering your analog data into any 9800 Series desktop computer or other HP-IB devices. The 9874A will convert your graphic information, such as maps, 35 mm slides, x-rays, photos, and movies, into numeric form for computer analysis. In fact, this sophisticated digitizer will convert analog data from virtually any graphical form placed on its adjustable glass platen into a series of discreet X,Y coordinates.

A valuable tool for a broad range of applications, including engineering, business, manufacturing, medicine, and research, the 9874A can digitize with optimum efficiency and less operator dependence than you would expect. Simply turn it on, place your document on the platen, load the program into your desktop computer, and digitize.

This HP digitizer integrates an assortment of advanced, yet easy-to-use features:

- 16K bytes of built-in memory control
- microprocessor intelligence
- system resolution of 25 microns
- an adjustable glass platen for rear projection of graphic images
- a unique cursor vacuum system that lets you position the cursor with pinpoint precision and leave it unattended, regardless of the platen angle
- a keyboard with control, special function, and numeric entry keys that allow commands to be made directly from the digitizer
- a stylus for fast tracing of curves, lines, irregular shapes, as well as complex documents
- ready made HP-IB interface capability
- 40 different graphic instructions to simplify programming and increase communication efficiency.

In addition, there are numerous other advantages to digitizing with the 9874A.

The Axis Align key automatically aligns the X and Y axes of the digitizer with those of your document. It establishes the new coordinate system, and all points it sends to the computer are based on that coordinate system. It does all the rotation and translation automatically.

Special Function keys initiate branching routines in your program so there's no need to dash back and forth between the digitizer and computer.

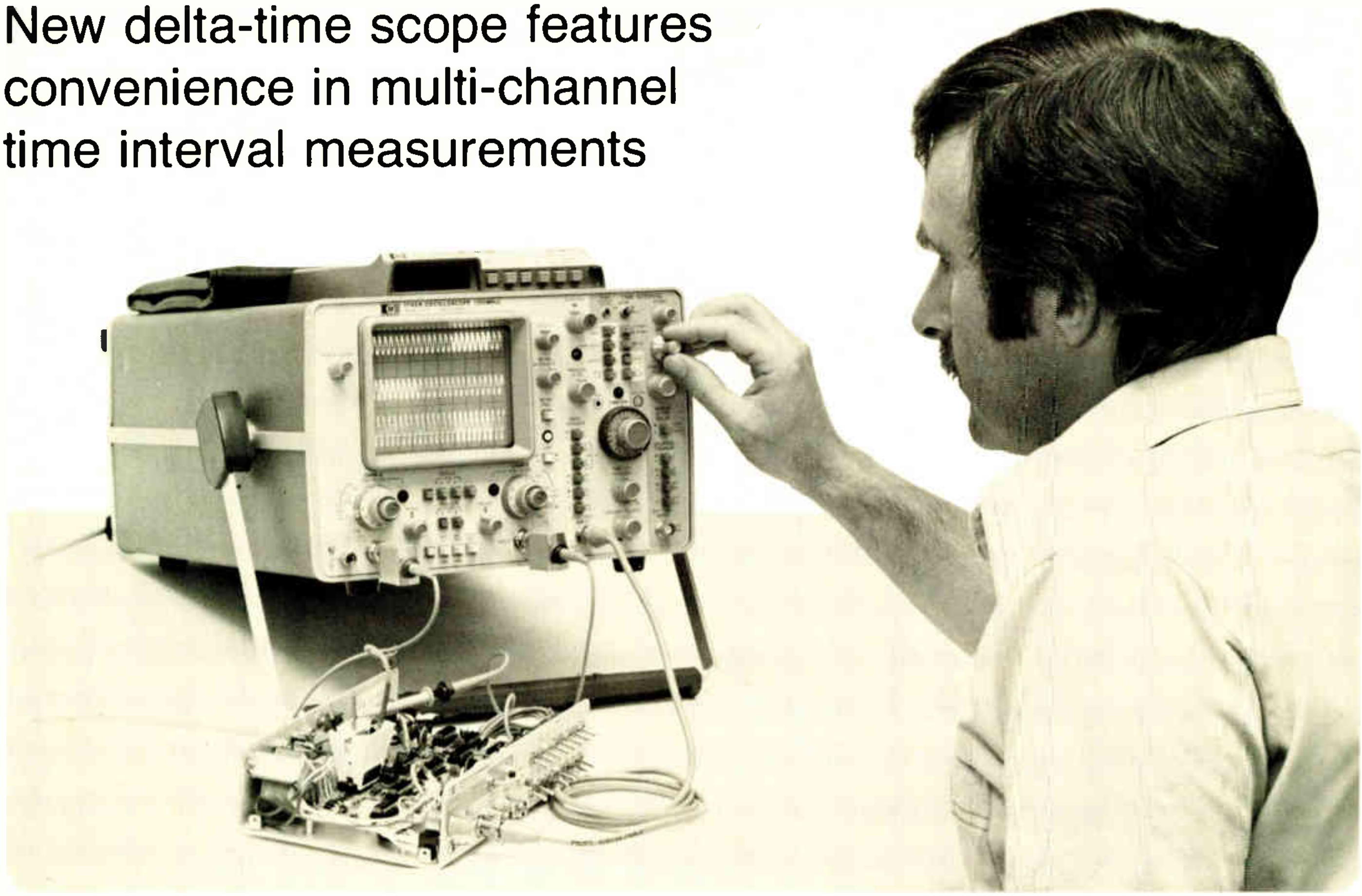
The key pad lets you enter numerical annotations to be attached to specific points. The display verifies the annotation before you enter it into the computer.

The Axis Extend key allows you to digitize documents up to 53 kilometers long, and the points transferred into the computer will still be referenced to the initial origin. To further enhance your digitizing system, HP manufactures a continuum of computers and peripherals to meet today's needs as well as to provide a growth path to the future.

System 45, HP's powerful graphic desktop computer, makes an ideal partner for the 9874A. Its enhanced BASIC language has many of the powerful features of FORTRAN and APL to make programming fast and easy.

Whether you're already using another digitizer or thinking of adding one to your application, find out more about the advantages of HP's 9874A. Check F on the HP Reply Card.

New delta-time scope features convenience in multi-channel time interval measurements



HP's Model 1742A, 100 MHz oscilloscope offers convenient single-, dual-, or three-channel time interval measurements with easily obtained accuracies of 0.5% of reading ±0.05% of full scale.

The new HP 1742A oscilloscope combines the time interval measurement benefits of the two-marker delta-time system with the capabilities of the general purpose 1740A oscilloscope. This analog referenced delta-time system with an optional DMM readout provides the same accurate, time interval measurements in the 100 MHz bandwidth range which have proven so useful in the 1715A (200 MHz) and 1725A (275 MHz) oscilloscopes.

Time-interval readout is provided in three ways: 1) on the optional built-in DMM, 2) on an external DVM from a rear panel analog output voltage, and 3) on the calibrated delay dial.

The two-marker delta-time system offers improved accuracy (0.5% of reading ±0.05% of full scale) over the single-marker delayed-sweep system. Because two events separated in time can be displayed simultaneously, measurements such as period and width jitter can be easily performed.

Multi-channel measurements are also easily performed and the need to move probes in a circuit is eliminated with an A Start/B Start switch. Simply select the desired start channel with the switch and the start marker can be positioned at the start of the time interval of interest. By using the 1742A's third-channel trigger display mode, time-interval measurements from an external trigger signal to either vertical channel can also be accomplished.

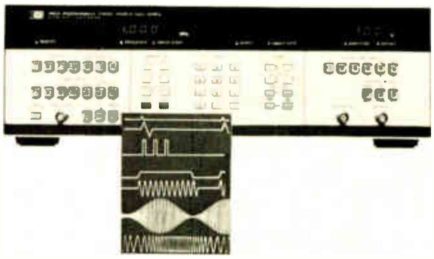
A Delta Time Off mode can be selected for conventional single-marker delayed sweep applications such as trace magnification. In this single-marker mode, delayed gate output can be used to trigger other instruments such as a frequency counter for pulse RF measurements.

For more information, check G on the HP Reply Card.

New AM capability added to HP's 8165A Programmable Signal Source

For increased versatility, sweep and amplitude modulation capability have been combined in the new option 002 for HP's 8165A. Sweep can be initiated externally or internally and extends over a range of three decades maximum. AM allows modulation of the output signal by an external voltage at a modulation depth from 0-100% and a modulation frequency of up to 10 MHz. These features emphasize the usefulness of the 8165A in linear circuit applications as well as in general-purpose automatic test systems.

For more information, check H on the HP Reply Card.



Distortion measurement set makes true-rms THD measurements of audio amplifier performance

An industry-wide effort to promote uniformity in the field of audio amplifier performance recently culminated in the establishment of a new standard method for such measurements. This 16-page standard, (IHF-A-202-1978), is available from the Institute of High Fidelity, Inc. in New York. It recommends music waveform signals be used in testing amplifier power output rather than continuous sine-wave signals. That recommendation, along with others outlined in the standard, provides for meaningful comparisons of audio amplifier performance by high-fidelity system consumers.

HP's 339A Distortion Measurement Set is an excellent instrument for true-rms signal measurements as required on page 9, paragraph 2.9 in the standard. A combination of true-rms analyzer, AC voltmeter and low distortion oscillator, the 339A makes true-rms THD measurements as low as 0.0018% from 10 Hz to 110 kHz, including harmonics to 330 kHz.

As a true-rms voltmeter, the 339A can also measure inputs from 1 mV to 300 V full scale over a 10 Hz to 110 kHz range. It is calibrated in volts, dBV, and dBm into 600Ω. As a low distortion oscillator, the 339A provides sine-wave output from 10 Hz to 110 kHz, with distortion from 20 Hz to 20 kHz specified as low as 0.0018%.

To find out more about HP's 339A, check I on the HP Reply Card.

New low distortion audio test source

Light-weight and small enough to pick up with one hand, the 239A is convenient to use on the bench or easy to carry for remote tests.

A new low distortion audio test source from Hewlett-Packard can deliver sine waves over a 10 Hz to 110 kHz frequency range with THD <−95 dB to 20 kHz and >3 rms into 600 Ω. Called the Model 239A Oscillator, this instrument is designed for engineers in audio, broadcast, hi-fi, and amplifier design and development. The 239A is also an excellent companion oscillator for distortion analyzers and spectrum analyzers in low distortion stimulus applications.

The 239A has an accurately calibrated step attenuator with 60 dB of range and a vernier for continuous adjustment between steps. With the amplitude vernier in CAL, the output level is known across the full frequency range, eliminating the need for time-consuming recalibration at each frequency.

Check J on the HP Reply Card for complete details.

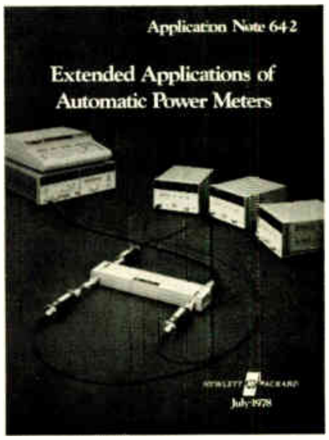
Latest application note in microwave power series

By combining a desktop computer with a programmable signal source and three programmable power meters, a very powerful, accurate, microwave measurement system can be assembled from bench instruments. Such a system is described in Application Note 64-2, *Extended Applications of Automatic Power Meters*.

One of the more difficult and tedious jobs done in metrology laboratories is the periodic recalibration of power sensors for calibration factor and effective efficiency against a traceable standard sensor. The system described in AN 64-2 measures calibration factor and computes its own measurement uncertainty at each cardinal frequency by using stored calibration data for the system components.

The usual 40-50 dB of sensor dynamic range can be doubled to 80 dB by using a signal source with programmable output level. In this way, the sensor which monitors input power uses up its 40 dB range after which the 40 dB range of the sensor is used. A broadband coupler allows both SWR and attenuation to be measured at one time, with high accuracy and high resolution.

For a complimentary copy of AN 64-2, check K on the HP Reply Card.



New HP scientific calculators put unequalled performance within your reach

The new Series E scientific calculators provide more calculating power, more ease-of-use features, and a lower price than any comparable calculators HP has ever designed.

Each calculator features a larger, easy-to-read display plus commas to help you read long numbers. What's more, every Series E scientific calculator includes an exclusive self-check capability, error codes, and a new level of accuracy. These qualities, coupled with the time-proven RPN logic system and traditional HP attention to detail, add up to outstanding values.

The new Series E scientific calculators have been designed in every detail to be the finest of their kind in the world.

Convince yourself by visiting the nearest HP dealer, or send for detailed literature by checking A on the HP Reply Card.

HP-31E, Scientific. Trigonometric, exponential, and math functions. Metric conversions. Fixed and scientific display modes, 10-digit display, and 4 user memories.

HP-32E. Advanced Scientific with Statistics. More math and metric capabilities than HP-31E, plus 15 user memories, hyperbolics, comprehensive statistics.

HP-33E. Programmable Scientific. 49 program lines of fully merged key codes. Editing, control, and full range conditional keys, plus 8 user memories.

A more accurate solution for 30 W power measurements to 18 GHz

Previous methods of measuring medium power levels usually involved adding a separate 30 W attenuator in front of a 100 mW sensor. Such a combination created significant measurement ambiguities because each element had its own accuracy specification and an interacting mismatch effect. Now, two new HP power sensors for 30 W measurements combine the attenuator and sensor into one unit. This reduces mismatch uncertainty errors and improves accuracy by including the attenuator in the measured Calibration Factor curve. Calibration data is traceable to the National Bureau of Standards and when used along with the Calibration Factor control on the power meter, compensates for the effects of power sensor efficiency.

These sensors, the 8481B and 8482B, were built to be used with the well-known HP 435A and 436A Power Meters. Model 8481B has a frequency range of 10 MHz to 18 GHz and the 8482B covers 100 kHz to 4.2 GHz. Both models have a 50 dB dynamic range (−5 dBm to +45 dBm), a peak power rating of 500 W, and are supplied with type N connectors. In addition, the design of the 8481/82B incorporates light-weight, heat dissipating fins to prevent burns from the heated attenuator.

The SWR specification for the 8481B is 1.10, 10 MHz to 2 GHz; 1.18, 2 to 12.4 GHz; 1.28, 12.4 to 18 GHz. The 8482A SWR specification is 1.10, 100 kHz to 2 GHz; 1.18, 2 to 4.2 GHz.

Additional information can be obtained by checking L on the HP Reply Card.

Measurement accuracy of medium power levels is improved since the attenuator is included in the Calibration Factor curve.

Hard-copy graphics benefit a multitude of instrument systems

HP-IB

The importance of hard-copy graphics to instrument systems is evidenced by the variety of applications that make use of them. Two HP plotters, the 9872A four-color plotter and the 7245A plotter/printer, are used with a large number of different HP instrument systems in applications ranging from highly dedicated electronic design, to process monitoring in a cement plant.

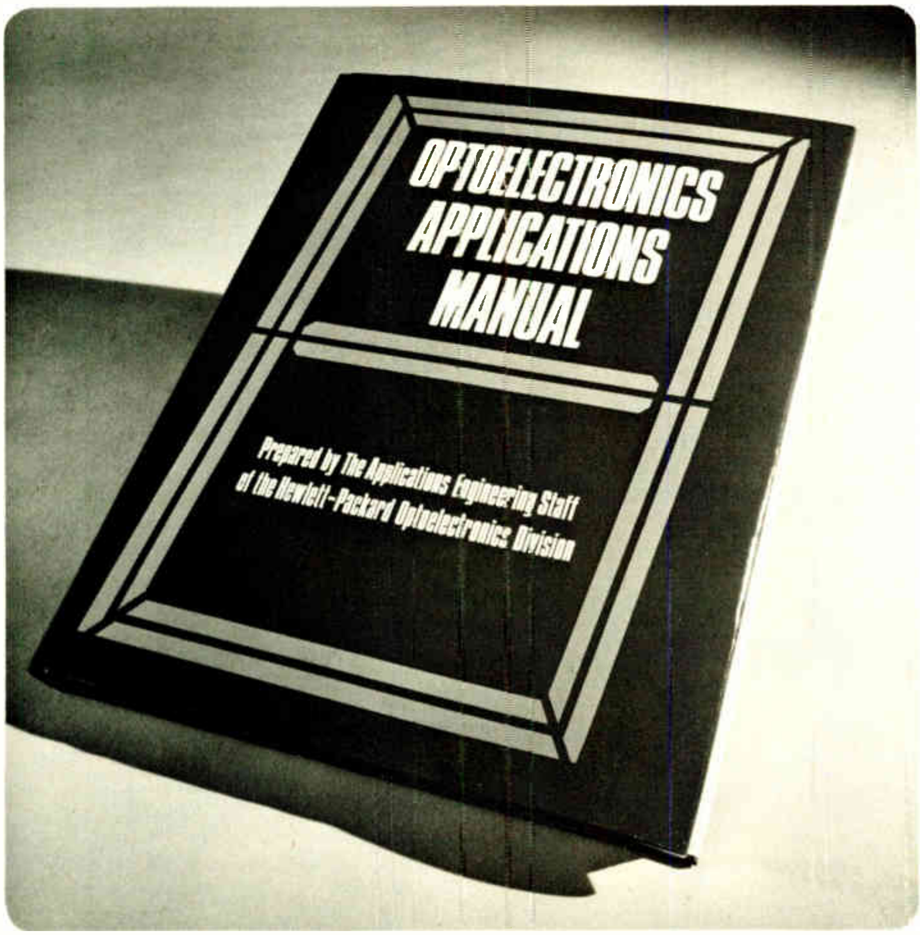
HP 5420 Fourier Analysis Systems in mechanical applications, use the HP plotters not only to produce necessary hard copy of the CRT display but also to provide four-color plotting grid lines, individualized line styles, and changes of plot size.

With transceiver test systems, four-color plotters provide hard-copy Bode plots of circuit performance quickly, accurately and through remote control.

A versatile graphic instrument, such as HP's 8568A Spectrum Analyzer finds an able accomplice in the 7245A plotter/printer which easily reproduces hard copy of the instrument's CRT display, be it any form of graphs or words.

For details on HP's plotters, check M on the HP Reply Card.

HP publishes optoelectronics applications manual



Practical solutions to the most common applications problems of optoelectronic devices are fully analyzed in Hewlett-Packard's *Optoelectronics Applications Manual*, one of the first books on these versatile design tools from a leading firm in the field.

The *Manual* covers such subjects as photometry/radiometry, contrast enhancement in visible displays, and reliability of optoelectronic components and their mechanical handling.

Designed both as a practical guide to the use of optoelectronic devices and as a foundation for the development of new design ideas, this volume demonstrates the broad potential for these components that exists in systems being designed today.

Of special interest to experienced designers is the *Manual's* treatment of CTR degradation, a controversial and frequently misunderstood subject among users of optically coupled isolators.

Members of the applications engineering staff of the Hewlett-Packard Optoelectronics Division were involved in the preparation of the *Manual*, published by McGraw-Hill.

Copies are available from your HP franchised distributor.

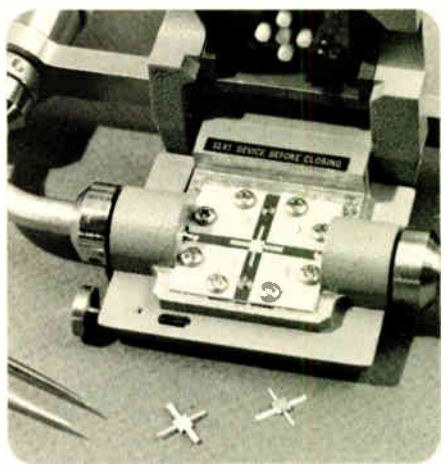
Guaranteed power and gain in new linear microwave transistor

Low cost, accompanied by ruggedness and reliability, establish the Hewlett-Packard HXTR-5101 as a standard for general purpose linear power transistors. If your amplifier design objectives dictate fewer stages with no accompanying reduction in output power, the HXTR-5101 may well be the answer. It provides a *guaranteed* linear power of 21 dBm at 1 dB gain compression and a superior, guaranteed associated gain of 6.5 dB at 4 GHz.

The reliability and consistency inherent in the design of this new silicon, NPN, bipolar transistor make it an excellent choice for high reliability applications such as radar, telecommunications, and fuses in the 1 to 6 GHz frequency range. The transistor is well suited for systems requiring intermediate linear power in excess of 100 mW, with minimal distortion, as the final state on a receiver amplifier, or as a driver for a subsequent linear or Class C state in a transmitter.

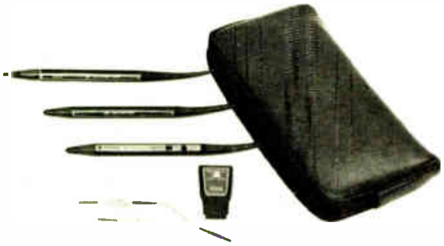
The HXTR-5101 comes in the HPAC-100.

Check N on the HP Reply Card for more information on this product.



Test for yourself the power and gain of HP's HXTR-5101 linear power transistor.

Which of HP's IC troubleshooters is best for you?



HP's IC Troubleshooters are available in various combinations, including the 5022A Kit shown here (545A Probe, 546A Pulser, 547A Current Tracer, 548A Clip).

Each of HP's seven IC troubleshooters provides outstanding benefits in troubleshooting digital circuits. For example, the *logic probe's* lamp indicates voltage pulses, while the *logic clip* shows the state of all pins of an IC at once. In contrast, the *current tracer* indicates current pulses—inductively. It is used where the logic probe has located a fault that cannot be isolated lower than the node level—as in a bus where all components are stuck low by a faulty one. For stimulus-response testing, use the *logic pulser* with the logic probe or current tracer—it generates the circuit input signals needed.

For details on all of HP's IC Troubleshooters, check O on the HP Reply Card.

FAULT	STIMULUS	RESPONSE	TEST METHOD
Shorted Node	546A Pulser[1]	547A Current Tracer	• Pulse shorted node • Follow current pulses to short
Stuck Data Bus	546A Pulser[1]	547A Current Tracer	• Pulse bus line(s) • Trace current to device holding the bus in a stuck condition
Signal Line Short to Vcc or Ground	546A Pulser	545A Probe Current Tracer	• Pulse and probe test point simultaneously • Short to Vcc or Ground cannot be overridden by pulsing • Pulse test point, and follow current pulses to the short
Vcc to Ground Short	546A Pulser	547A Current Tracer	• Remove power from test circuit • Disconnect electrolytic bypass capacitors • Pulse across Vcc and ground using accessory connectors provided • Trace current to fault
Internally Open IC	546A Pulser[1]	545A Probe	• Pulse device input(s) • Probe output for response
Solder Bridge	546A Pulser[1]	547A Current Tracer	• Pulse suspect line(s) • Trace current pulses to the fault • Light goes out when solder bridge passed
Sequential Logic Fault in Counter or Shift Register	546A Pulser	548A Clip	• Circuit clock de-activated • Use Pulser to enter desired number of pulses • Clip onto counter or shift register and verify devices truth table

1. Use the Pulser to provide stimulus, or use normal circuit signals, whichever is most convenient.

East-4 Choke Cherry Road, Rockville, MD 20850, Ph. (301) 948-6370.
South-P.O. Box 10505, 450 Interstate North Pkwy., 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. 29-21 Takaido-Higashi 3-chome Suginami-ku, Tokyo 168, Ph. 03-331-6111.

HEWLETT hp PACKARD

MEASUREMENT COMPUTATION news
product advances from Hewlett-Packard

July/August 1978
New product information from
HEWLETT-PACKARD

Editor: Bojana Fazarinc-Bitencourt

Editorial Offices:
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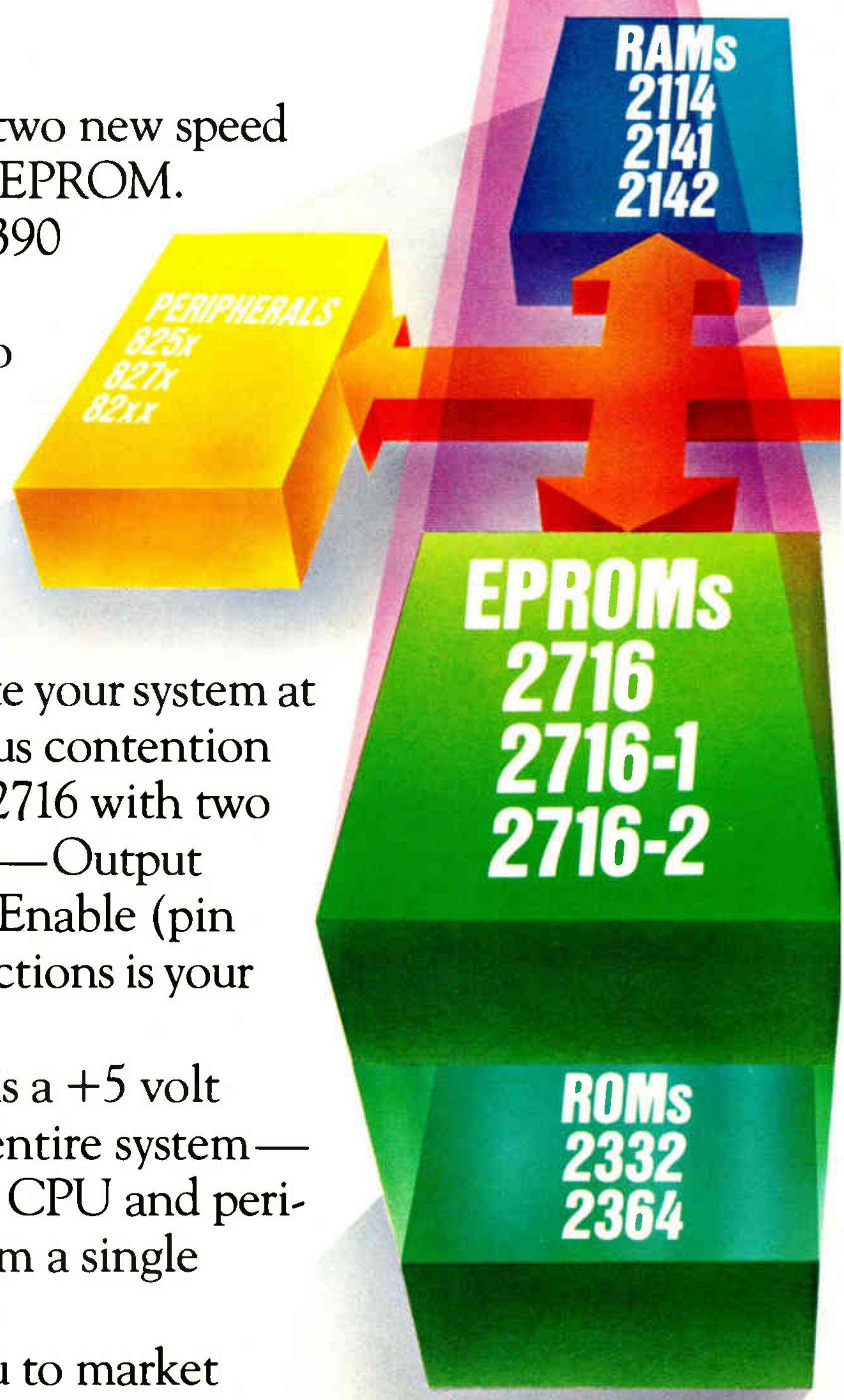
Palo Alto, California, 94304 U.S.A.

00884

Why microcomputer with our 2716



We've just introduced two new speed selections of our 2716 16K EPROM. The 2716-2 access time is 390 nanoseconds, the 2716-1 is just 350 ns—fast enough to take full advantage of the new multiplexed microprocessors, such as the 5MHz 8085A-2 and the HMOS, 16-bit 8086.

To enable you to operate your system at high clock rates without bus contention problems, we've built the 2716 with two separate control functions—Output Enable (pin 20) and Chip Enable (pin 18). Using both control functions is your key to high performance.

And because the 2716 is a +5 volt part, you can design your entire system—EPROMs, ROMs, RAMs, CPU and peripherals—all operating from a single +5 volt supply.

Using the 2716 gets you to market sooner, too, with fast, easy reprogrammability and no "turnaround time" for

Meetings

Time and Frequency: Standards, Measurements, Usage, National Bureau of Standards, Boulder, Colo., Aug. 22–26.

Sixth Colloquium on Microwave Communications, International Union of Radio Science, Budapest, Aug. 29–Sept. 1.

Eighth European Microwave Conference, Microwave Exhibitions and Publishers Ltd. (Sevenoaks, Kent, England) Hotel Meriden, Paris, Sept. 4–8.

International Optical Computing Conference, IEEE, Imperial College, London, Sept. 5–7.

CompCon 78—17th IEEE Computer Society International Conference, Capital Hilton Hotel, Washington, D. C., Sept. 5–8.

International Machine Tool Show 1978, National Machine Tool Builders' Association (McLean, Va.), McCormick Place, Chicago, Sept. 6–15.

Wescon/78 Show and Convention, Electronic Conventions Inc. (El Segundo, Calif.), Los Angeles Convention Center, Los Angeles, Sept. 12–14.

ECOC—Fourth European Conference on Optical Communications, IEEE Italian Section (for information contact Istituto Internationale Comunicazioni, Genoa), Genoa, Italy, Sept. 12–15.

Conference on Information and Systems Theory Used in Digital Communications, IEEE German Section (for information contact VDE-Zentralstelle Tagungen, Frankfurt), Technical University, West Berlin, West Germany, Sept. 18–20.

ESSCIRC 78—Fourth European Solid State Circuits Conference, IEEE Benelux Section (for information contact ESSCIRC 78, Delft University of Technology, Delft) Tropen Instituut, Amsterdam, the Netherlands, Sept. 18–21.

Mostek's tone receiver. The 16-pin solution to reducing system cost.

16pins vs. 24pins

	Mostek MK5102N-5	Rockwell-Collins CRC8030
Number of pins	16	24
TTL compatible outputs	YES	NO
Filtering required for typical system	33dB	40dB
Number of power supplies	1	2

The cost of digital communication systems is coming down. With Mostek's new MK5102 tone receiver, the complete tone decoding function can now be implemented using a single 16-pin IC plus minimal pre-filtering. That means your system can be less expensive, less complex and easier to design.

Mostek's 5102 tone receiver features 5-volt ±10% power supply, latched three-state outputs with data valid strobe, low pre-filtering requirements and superior talk-off protection. This CMOS circuit operates at a low 5mA typical current. And the compact 16-pin package makes it a natural for high system density.

Use the 5102 with our 5087 tone dialer. Both microprocessor-compatible IC's reference the economical TV color crystal (3.58MHz) and use the world recognized TOUCH TONE* DTMF system. And both meet or exceed standards for stability, distortion, and timing.

Mostek's Communication Family includes a wide choice of tone dialers, pulse dialers, and now a full line of industry's most versatile codecs. All provide low-cost solutions for fixed supply and direct phone line applications.

For more information on Mostek's communication products, contact Mostek at 1215 West Crosby Road, Carrollton, Texas 75006. Telephone: (214) 242-0444. In Europe, contact Mostek Brussels; Telephone: (49)(0711) 701045.

MOSTEK.

How Fairchild Takes the Thorns out of LSI Testing.

Choosing the right LSI test system is tough. There are many things to consider, and one of the most important is customer support. Here's how Fairchild makes the difference. Whether you buy our Sentry general purpose LSI tester or our Xincom memory test system, we'll back you with the largest and most professional service and support team in the industry.

Applications Engineering. Our team of applications specialists will program our systems to give you all the information you need about how to test your device. Whether you buy a system or not. If you do buy, all that information and programming are yours.

A world of training. Even the best system is only as good as the people who run it. To make sure your people know everything they have to about LSI testing, we've built the largest and most comprehensive training center in the world. With every Sentry or Xincom system, you're covered with course credits. Even before your system is installed, your people will learn operation and maintenance, basic programming and assembly language. They can also take special courses in programming and advanced LSI testing techniques. And they'll get all the hands-on training they'll need in our test lab.

On-site preparation. While your people are training at one of our centers in the U.S., Europe or Asia, our engineers are at your plant helping you get ready for delivery. Our product specialists help you find the best locations for your system. They make sure all your device programs have been checked out. And they make sure your system gets up and running fast.

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Circle 34 on reader service card

Electronics newsletter

IBM uses tunable dye laser to store more data

Scientists at IBM Corp.'s San Jose, Calif., research laboratory are using a tunable dye laser, which can be adjusted to emit light of various frequencies, to further refine a new method of increasing the amount of information that can be packed into a given space. In this method, **computer data is stored and identified by its location in the frequency range as well as its spatial position.**

The monochromatic laser light is directed onto a small sample of photoreactive material cooled to a few degrees Kelvin. A few of the molecules absorb energy at the beam's frequency and are altered into slightly different compounds. A shift in the frequency targets a new set of molecules. The encoded information can subsequently be read out by reducing the laser's power, varying its frequency over the same range used for writing, and monitoring absorption.

George Castro, one of the patent recipients, cautions that a new technology is still a long way off. "You aren't going to make any products with the dye laser right now. The tunable laser itself is still in the research stage," he says.

Shared elements cut cost of multistation MDS

Aiming to beat the rising cost of microcomputer development systems, a Los Angeles firm has put together a multistation network that it says will drive the price under $7,700 per station. The key is that the stations will share use of the most expensive elements, like disk drives and printers, in common. "Sharing disk memory storage and printer resources," says Bruce Gladstone, vice president of Futuredata Computer Corp., "our network **allows up to eight stations to operate simultaneously,** and each designer has his own terminal and target processor." The system presently provides software support for the 8080, 8085, 8086, 6800, 6802, and Z80 processors. Each station is fitted with 64 kilobytes of random-access memory and can also operate as a stand-alone unit.

National aims Starplex at two markets

Driven by 1978 market estimates of $100 million for microprocessor development systems and more than $500 million for small computers, National Semiconductor Corp., Santa Clara, Calif., will unveil a disk-based development system at next month's Wescon/78 that is designed to grab a share of both. Called Starplex, the product, which is to compete with other high-end development systems, has a $13,800 price tag. The company's Microcomputer Systems group counts on Starplex's Basic and Fortran language capabilities **to give it small-computer application appeal.** Slated for October availability to original-equipment manufacturers, the system includes 64 kilobytes of random-access memory, a 12-inch display, 96-key multifunction keyboard, 50-character-per-second thermal printer, and a 512-kilobyte dual floppy-disk drive.

Mostek fleshes out one-chip line of microprocessors

Once known only for its memories, Mostek Corp., Carrollton, Texas, will soon bring out products to solidify its position as a microcomputer manufacturer. **The first of two new one-chip microcomputers will be the 3876,** which is a 3872 with half as much read-only memory, followed by the 3873, essentially a 3870 (the first Mostek processor, a second-source version of the Fairchild F-8) with a serial input/output port. The 3876, to be available in sample quantities in the fall, has 2,048 bytes of ROM, a power-drain mode, and 128 bytes of random-access memory, half of which is executable. The 3873, also with 2 kilobytes of ROM but with 64 bytes of RAM, has a fully programmable bidirectional serial I/O port; samples will be available around the New Year.

Air Force to buy $14 million Sperry Lorans

The first all-solid-state operational Loran systems to support tactical air operations have been purchased by the Air Force Electronic Systems Division from the Sperry Gyroscope Company of Great Neck, N. Y. **Each of the $14 million transportable systems, to be delivered in January 1980, features three 400-foot antenna towers** placed in a triangular pattern 400 miles apart. Each tower sends out a computer-controlled signal to Loran-equipped aircraft or ground troops. The differences in time of arrival of the three signals allow the exact calculation of receiver location.

DEC opens LSI-11 to user microprogramming

Users of Digital Equipment Corp.'s LSI-11 microcomputer and its half brother, the LSI-11/21, may write their own instruction sets. The Maynard, Mass., firm is allowing them up to 1,024 22-bit words of writeable control storage, **marking the first time a microprogramming option has been offered in a microcomputer.** DEC will mask-program users' microcode into 512-by-22-bit read-only memories, two of which are usually used for the PDP-11 instruction set. Through microprogramming, users can design in lookup tables, special functions that compute fast Fourier transforms, for example, and even emulators of other processors' instruction sets.

Intel soups up its 4-K PROM to guaranteed 50 ns

Intel Corp. of Santa Clara, Calif., has redesigned its 3605 512-by-8-bit bipolar programmable read-only memory with double layer metalization to shrink cell size and boost speed. **The result: the 3605A, which has a guaranteed worst-case access time of 50 ns.** The part, to be available in sample quantities later this year, has a cell size of 1.3 mil^2—some 30% smaller than that of most other PROMS.

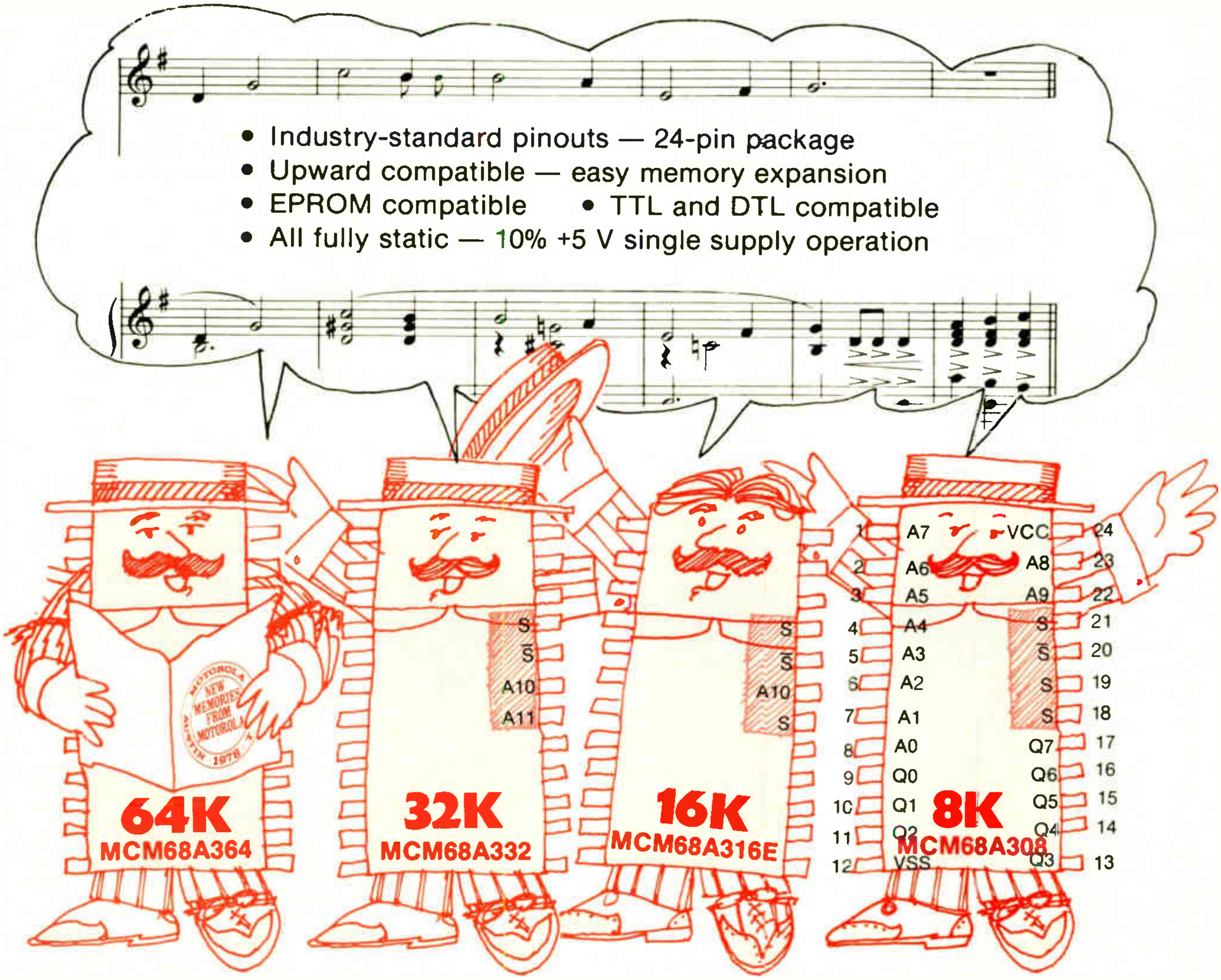
16-K ROM, PROM rated at 250 ns

Most chip makers might be investing in the 23,768- and 65,536-bit read-only memories and programmable ROMS, **but American Microsystems Inc. is about to spring a matching pair of parts:** a 16,384-bit ROM and PROM. Built with V-groove MOS technology, the parts have a maximum access time of 250 ns. Samples of the S4216 ROM and the S4716 PROM are being shipped this month.

Addenda

Mass production of lasers for short-haul and medium-distance fiber-optic communications systems as well as other high-volume applications will result in a dramatic drop in laser pricing, predicts International Resource Development Corp. of New Canaan, Conn. The specialized research and management consulting firm projects that **today's price of approximately $1,000 per laser will fall to below $20,** and perhaps even below $10, by 1988. . . . Attracted by the high speed of V-groove MOS, IBM Corp, has contracted with American Microsystems Inc. of Santa Clara, Calif., **to develop 40-ns static random-access memories for mainframe-memory add-ons.** The deal, which could run to $10 million, covers R&D on 4,096-bit devices but does not provide for production.

Perfect harmony from 8K to 64K with this Motorola ROM quartet.



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For data sheets on Motorola's industry-standard pinout ROM quartet, write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036, or circle the reader service number.

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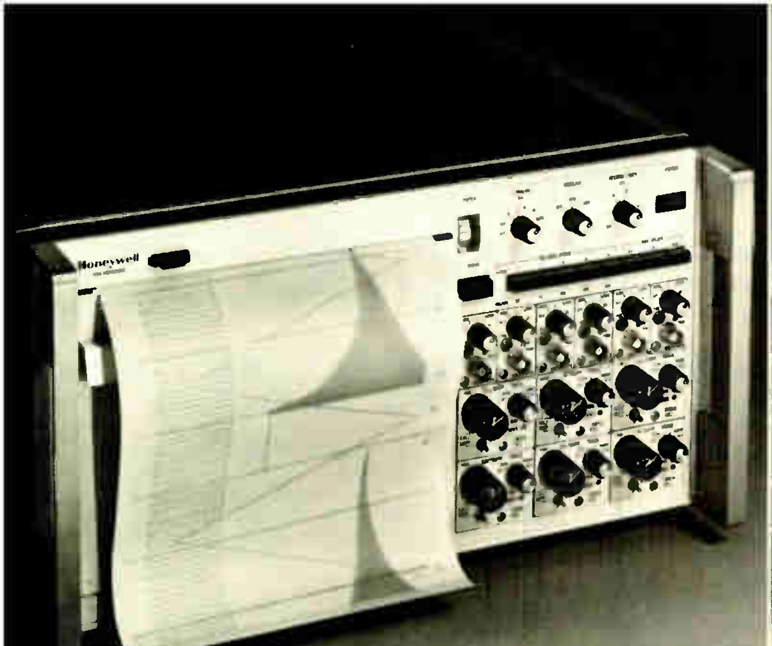

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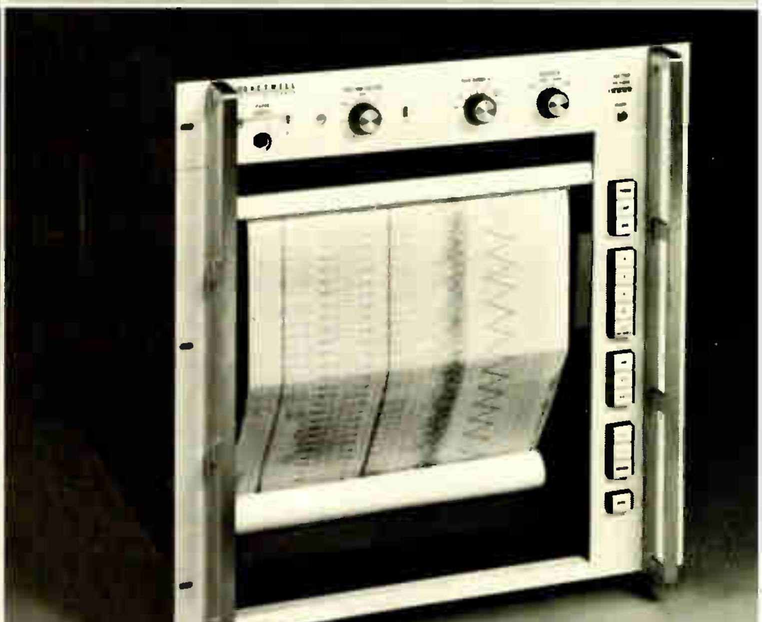
Visicorder Model 1508C



Visicorder Model 1912

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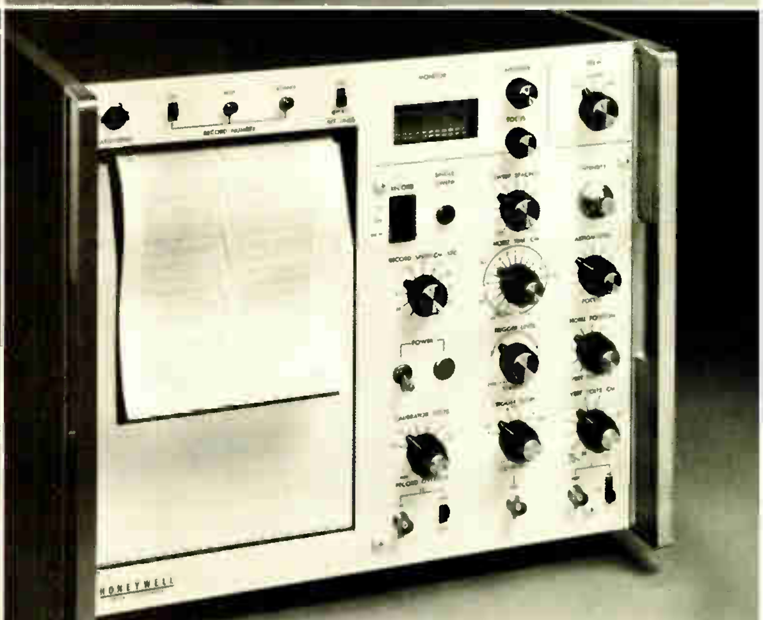

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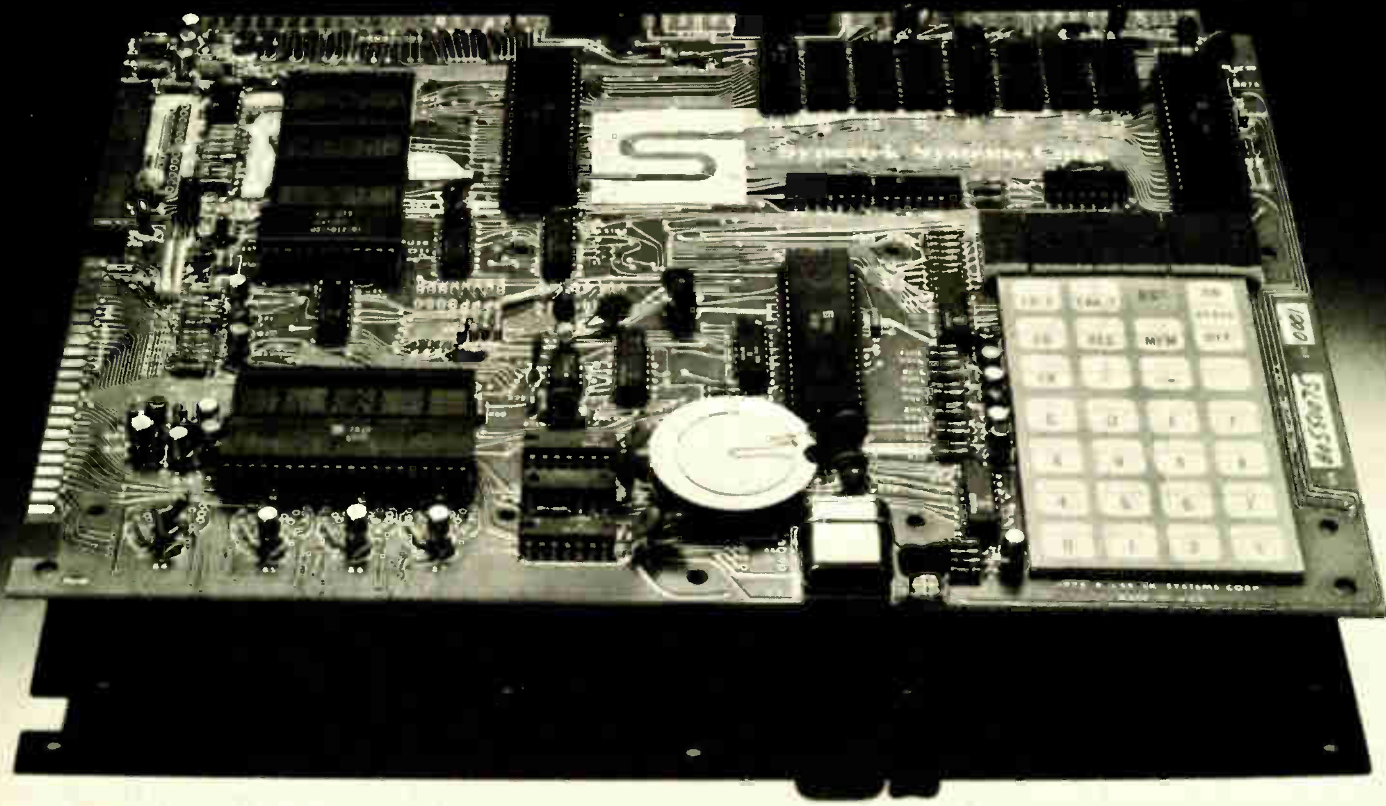

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Circle 40 on reader service card

TRW puts most of an rf receiver on single silicon LSI chip

L-band receiver is close to completion; oxide-aligned process used for transistors, films for discrete components

Radio-frequency receivers have long resisted the onslaught of large-scale integration. LSI transistors have not operated at high enough frequencies, diffused resistors have not been accurate and stable enough, and on-chip capacitors have just not had the capacitance to couple wideband signals. The result: higher-frequency receivers, especially for the military, must depend on hundreds of discrete devices. This keeps not only costs but physical size from shrinking, and it penalizes reliability.

TRW Inc.'s Microelectronics Center in Redondo Beach, Calif., says it has licked all three of these problems. It is coming up with an L-band, 1,200-to-1,600-megahertz receiver on a single silicon chip. The first major step was in the transistors.

"The key for integrating analog or rf functions in a monolithic form is oxide-aligned transistor technology," says Barry Dunbridge, who manages the center. This technique relies on an Isoplanar variation of high-density bipolar processing the TRW unit has polished for years (see "TRW knows its OATs"). It doubles mask-alignment resolution, so that transistors can be built with a narrow enough emitter structure to have unity-gain frequencies (f_t) of 4 to 5 gigahertz.

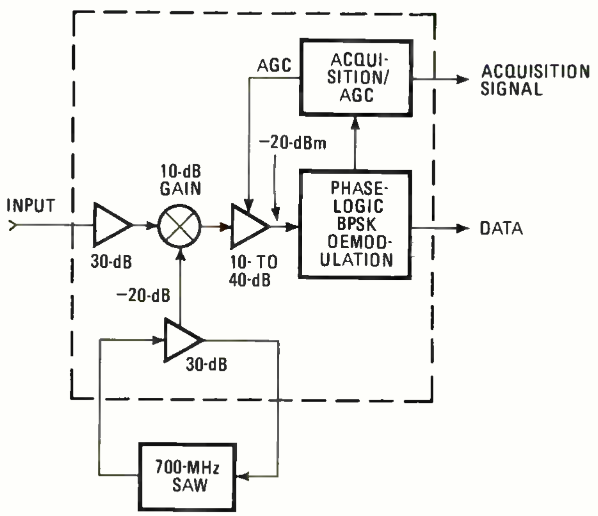
Complementing the high-frequency transistors in the LSI receiver are cermet resistors, thin-film devices that are actually deposited on the monolithic substrate. Diffused resistors, which ordinarily bias active elements in a monolithic design, are difficult to produce with any accuracy. Also, they have a poor temperature coefficient and stability. TRW's technique for depositing the cermets, which are composed of chromium–silicon-dioxide material, even permits laser trimming to high precision, although the trimming is not necessary in the receiver.

Finally, the relatively large values of coupling capacitors needed by the receiver have also been attained by laying thin films down on the chip. TRW uses a metal-oxide-metal sandwich made with an extremely thin deposition—1 micrometer—of silicon dioxide that serves as the dielectric between aluminum and a final metalization layer.

These three advances have allowed the chip to operate up as high as 2 GHz. "It's the only LSI receiver I know about that goes above 50 MHz," says Dunbridge.

The receiver chip consists of a phase-logic, bandpass shift-key (BPSK) demodulator that accepts input data between −100 to −70 dBm, supplied from an antenna, as shown in the diagram. The analog output from the demodulator feeds an automatic gain control circuit that holds the input to the demodulator at −20 dBm. At the input to the chip, the data signal is amplified by 30 decibels and mixed with a 700-MHz-wide signal from an off-chip surface-acoustic-wave filter. The chip's output data stream is accompanied by a separate acquisition signal.

System to come. By the end of the year, Dunbridge will have an L-band chip ready to design into a system. Although what system is not yet



On chip. All components of TRW's L-band (1200-1600 MHz) receiver, save for surface acoustic wave filter, fit on one chip. Thin-film resistors and capacitors placed on the monolithic silicon do the job of discrete parts.

TRW knows its "OATs"

The key to the gigahertz transistors TRW uses in its L-band receiver-on-a-chip is the company's self-aligning bipolar process, called OAT for oxide-aligned transistors. OAT was developed several years ago to boost the operating frequency of transistors in large-scale integrated circuits and to improve yields. Transistors with unity-gain frequencies of several gigahertz require extremely narrow emitter structures on the order of 2 micrometers across, which would necessitate special processing and cripple yields. The OAT process, however, extracts 2-μm resolution from conservative 4-μm geometries.

The process puts deep oxide wells into the n-type epitaxial layer normally grown on a p-type substrate for npn transistors. These wells serve as boundaries, so that both the masks used for subsequent isolation and the collector, base, and emitter diffusions can have a degree of play yet still resolve a fine emitter structure.

TRW has used the OAT process in place of standard epitaxial processes for all high-speed devices since 1976. Improvements since then include a more-than-doubled yield, better step-coverage in first-layer metalization, better contact and etching of second-layer metal, and reduced photoresist defects because of proximity printing.

OAT is at present used by TRW for analog-to-digital converters, subnanosecond digital logic, and rf analog circuits. In digital logic, for example, the high-frequency transistors have been used in D-type flip-flops that toggle at an exceptionally high 1,300 megahertz. All the work that TRW has done has been on 2¼-inch wafers.

certain, the company is considering a receiver for the Air Force's Global Positioning System [*Electronics*, June 22, p. 48], which could become operational in the early 1980s. Large numbers of low-cost receivers will be needed for the system, which will obtain position data from an orbiting network of satellites.

The chip itself will "replace something on the order of 100 discretes," Dunbridge says. It will measure 140 by 60 mils and dissipate less than 750 milliwatts. In its final package, the receiver will occupy a volume of 1 cubic inch—about a fifth the size of a unit with discrete components, according to Dunbridge.

He is reluctant to be pinned down on what a complete receiver might cost. A few thousand dollars each in large quantities seems reasonable, he says. This figure is well below present prices.

Building blocks. Beyond the L-band receiver chip, the LSI building-block chips could be designed for bands of frequencies anywhere between 100 and 2,000 MHz, for communications, radar, and electronic warfare systems, Dunbridge says. And frequencies could go even higher because of the results of a parallel effort also under way under Dunbridge's direction. "Using gallium arsenide, 10 gigahertz is in sight by 1981," he says. ☐

Companies

UK venture launched amid U. S. doubts

Can a new British semiconductor company with over $45 million in startup funds from the UK's National Enterprise Board find success in the U. S. by concentrating on advanced microprocessor and memory design?

The answer is no, according to industry analysts on this side of the Atlantic as the wraps came off Inmos Ltd. in England late last month. They point to the poor potential they see for any government-sponsored semiconductor startup, the international shortage of experienced personnel, and the highly competitive nature of the markets.

Anerican companies have quite a head of steam up and will be very hard to catch, says Lee Allgood, manager of MOS memory marketing at Signetics Corp., Sunnyvale, Calif. The British company will really have to work hard to intercept us competitively some time in the future, he says.

"The big hurdle will be whether they can draw the people they will need to do the job from the United States," he continues. "There's too much money still to be made over here—they may get a few of the entrepreneurial types they'll need, but they'll probably never put together the whole team."

Asks an observer from Wall Street, "If the British government wanted to get into advanced semiconductors, why didn't it invest in a going concern that would perform on the incentive of profits?"

But the Inmos sponsors have already attracted a proven and highly talented management team. At the top, as anticipated, is Richard L. Petritz, one-time president of Mostek Corp. and former head of strategic planning for Texas Instruments Inc., who masterminded the venture [*Electronics*, July 6, p. 86]. On the technical side are Paul Schroeder, a superstar in memory design lured away from Mostek, and Iann Barron, one of the UK's leading computer systems designers (see "Meet the designers").

The new company will have plants in the UK and U. S. The critical process development will take place in the United States, at a site to be named. Volume production will be in the United Kingdom also at an unnamed site. The company will concentrate initially on n-channel large-scale integrated devices of its own design and has no intention of being a second source.

Barron will head up a design operation in the UK concentrating on microprocessor technology, and Schroeder will head up a U. S. team working on memory products. The aim is to have a U. S. pilot plant up and running in six months to a year and volume production in a British plant by 1981. By then, financial support from the NEB could rise to a total of $90 million. In addition, key

British are coming. Founders of Inmos Ltd., new semiconductor firm supported by the U K's National Enterprise Board, (from left) are Iann Barron, Paul Schroeder, and Richard Petritz.

Meet the designers

Paul Schroeder and Iann Barron get Inmos Ltd., the new British semiconductor company, off to a pretty good start in technology. Schroeder, for example, has put Mostek on the map in memory. He has supervised the firm's present 64-K RAM development effort, headed design of a sub-100-nanosecond 8-K static RAM, and spearheaded the first 64-K read-only memory, to name a few projects. He also knows metal-oxide-semiconductor technology for dynamic RAMS.

Less well-known in the U. S., Barron, now a consultant, founded the UK's first minicomputer company, Computer Technology Ltd., in 1965. His Modular One, built with fast emitter-coupled logic, pioneered many distributed-processing concepts.

employees will be able to invest in up to 27.5% of the company's voting shares.

Undeterred by criticism, Inmos' founders argue that there has never been a better opportunity to establish a leading-edge semiconductor company because there is a world shortage of LSI parts, particularly in computer and automotive fields.

The firm's product strategy is still unclear. It is assumed that its target, like everyone else's, is a 64-K random-access memory. Petritz believes that Inmos does not have to be first to make it big with this product. In the meantime, he observes that production of 16-K RAMS is only now building, a clue that this will be Inmos' entry point.

The Inmos executives concede that the most critical element in the whole project remains the task of starting a high-yield, high-density process very quickly. Pointing out that there is no production equipment around today that will put out 64-K RAMS in volume, they have precise ideas of what equipment they want, according to Schroeder. They will not go immediately to direct electron-beam lithography on wafers, though they have made provision for phasing in some electron-beam technology. Apparently, Inmos is going to start with conventional optical exposure techniques, which does not rule out the use of masks generated by electron beam. □

Displays

Flat LCD panel has big potential if . . .

Take some liquid-crystal displays, add fiber-optic light pipes, illuminate with a very bright lamp—and *voilà*, a new kind of flat, TV-like display that could be as large as several feet on a side. The idea belongs to Izon Corp. of Stamford, Conn., but unless the privately held company attracts a partner with money, electronics expertise, and marketing knowledge, "it won't go anywhere," says marketing vice president Peter Genereaux.

The display would use much the same technology as a microfilm page reader the size of a textbook Izon brought to market in the spring. But it took more than $6.5 million and three years to develop the reader, and apparently the firm is too exhausted to develop the technology further.

What Izon would like to do first is develop a demonstration display measuring 10 inches on a side and about 4 in. deep. The imaging core of the panel would be a 10-by-10 array of individual LCDs, each measuring 0.2 in. square and able to address a 100-by-100-dot matrix. In front of each LCD would be a compound lens, and behind it an optical fiber connected to a light source—an intensely bright halogen lamp, for example.

Light would pass through the LCD, whose image would be magnified and focused by the lens onto a translucent viewing screen. The optics would be arranged so that the dot matrixes on the viewing screen would butt up against each other to form a continuous matrix of dots, 10,000 on a side. Images would be formed by controlling the pattern of 0.1-mil-square dots in the individual LCDs, thereby controlling the light transmitted to the lenses. The size of the display would be varied by adjusting the optics. Genereaux says he will be content with a demonstration model with only two LCDs and

Distributor. Optical fibers in page reader distribute light to lenses from bright source, placed to shine into dark circle at bottom. In new flat display, light from each fiber would project the dot matrix of individual LCDs onto a translucent screen.

their electronics in place.

Many of the individual design elements have been proven out in the micrographics reader, which sells for $275, according to Genereaux. He points out that Izon holds a patent for using optics in parallel for recording and display. In the reader, a piece of film measuring 8 by 10 in. and containing segmented images of as many as 195 different pictures is used instead of the liquid crystals. And the technique for making the lenses—they are injection-molded all at once in a single piece of acrylic—has been perfected.

Series of blocks. As stored on the film, the picture segments appear as an incoherent series of blocks of light and dark. A coherent image is produced on the viewing screen by moving the film into position, illuminating it with the fiber-optic light sources, and focusing each segment with the lenses. A slightly different film position yields a different picture. Izon produces the film using its own optical equipment.

"The new idea will be even easier to implement," Genereaux says. The main reason is that the display must project fewer individual picture elements. Only 100 optical fibers and 100 lenses would be needed in the display; the reader has 504 of each, he points out. "Since the lenses will be further apart, they can be made larger, which will reduce processing costs," he says. The hard part will be to design the X-Y drive electronics to fit on the same ceramic substrate containing the LCD. Genereaux points out, though, that the ability to distribute the interconnections around each LCD is a great advantage over other flat-panel approaches that butt the display elements against each other. □

Consumer

Electronic watch has LCD hands

With 120 separate elements on the face of a new watch with liquid-crystal hands, Texas Instruments Inc.'s engineers had to go some to be able to connect to all of them. They do it with a multiplexing technique that uses only 26 contacts, as well as a programmable logic array built with integrated-injection-logic technology. The use of I^2L also allows a voltage regulator to be built into the 154-by-268-mil chip.

"It's an overall system achievement," says Hector Cardenas, manager of advanced technology development for the Consumer Products group. "We're able to drive highly capacitive LCD elements from I^2L circuits, which hasn't been done before. And we have designed an on-chip voltage regulator that provides automatic temperature compensation to match the temperature coefficient of the display."

Complementary-metal-oxide-semiconductor technology is favored for LCD watches because it uses little power, but it would not have been feasible to build the regulator on a C-MOS chip, Cardenas says.

TI would not have been happy with C-MOS for another reason as well. It can only drive a type of liquid-crystal display that must be protected with either a yellow- or green-tinted filter against ultraviolet light. This would have limited the styling of the watch, as well as the viewing angle of the display.

Styling is one thing Cardenas and TI are certainly concerned about. Priced from $275 to $325 and in gold-plated cases, the watch, called The Time Indicator, is pegged at the high end of the firm's line.

Until now, TI has concentrated on high-volume digital products, with a $10 light-emitting-diode display watch at the low end and an $80 LCD watch at the other. The new watch, which also operates as a stopwatch and will be available in October, will not remain at the high end for long.

"We [will] take on the whole analog watch spectrum," says Bob Zlotky, TI's manager of time products. "You can expect the same technology in stainless-steel cases selling for under $50 within 12 months."

Competition. TI's new high-end watch competes against electronic watches with mechanical hands made by Seiko Time Corp., the U. S. marketing arm of the leading Japanese watch maker. Like all electronic watches, these keep time with a quartz-crystal oscillator, but they use a stepping motor to move the hands. Hideaki Moriya, president of Seiko Time, says his company's market research showed that an analog LCD display like TI's will not be accepted by the consumer.

Also last month, Seiko announced the world's thinnest watch—a 0.95-millimeter-thick case housing quartz oscillator, stepping motor, 0.9-mm-thick silicon-oxide battery, and C-MOS chip. With an 18-carat-gold case, the watch is in the $5,000-to-$10,000 price range.

TI uses a special low-voltage ester mixture for the LCDs, of the twisted-nematic field-effect type used in many LCDs. The on-board voltage regulator compensates for the negative temperature coefficient of the material, as well as for the variable voltage output of the lithium-manganese-dioxide battery. The regulator provides on and off drive voltages (2.6 and 1.3 volts) to bipolar drivers

SCIENCE/SCOPE

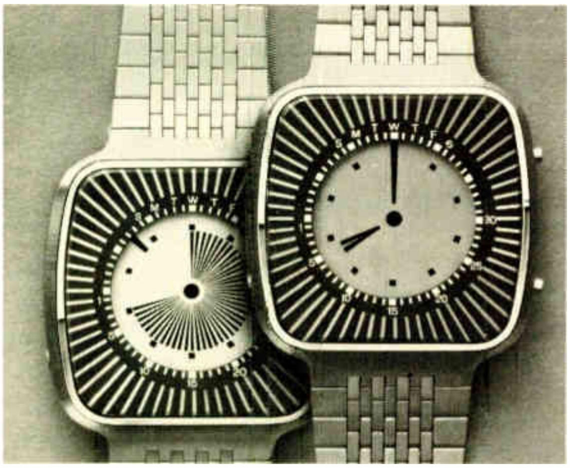
For the first time, airborne radar can be reprogrammed without the expense and delay of changing hardware. A new Programmable Signal Processor (PSP), developed for use in the U.S. Navy and Marine Corps F/A-18A Hornet, the Navy F-14 Tomcat, and the Air Force F-15 Eagle, gives their radar systems exceptional automation and mode flexibility. The processor's heart consists of 21 circuit boards, some with as many as 256 chips, each chip the equivalent of 4000 transistors. These highly complex circuits enable the radar systems to be reprogrammed almost immediately, and on a service-wide basis to meet future threats, or to be upgraded as new weapons are introduced. Developed by Hughes, this new design is expected to effect substantial cost savings now and in the future.

A bright, high-resolution, large screen liquid crystal projection system that can display dynamic tactical military situations in real time has been delivered to the U.S. Navy for evaluation. It can project virtually anything that can be displayed on a cathode ray tube either in raster scan or random scan mode. Typical applications include symbols, alphanumerics, geographical maps, and text. Its bright, clear display reduces requirements for specially controlled lighting during briefing sessions or command conferences.

The system uses a liquid crystal light valve developed by Hughes, and has a reliability never before achieved in large screen displays. Mean-time-between-failure is estimated at 5000 hours, and, as no consumables are required, this results in lower operating and maintenance costs. Other features are 1000 line resolution and 30 millisecond response time.

Hughes Missile Systems Group has many immediate openings, in the San Fernando Valley area of Southern California, for engineers and scientists in new, expanding, long-range R&D programs associated with the design and development of advanced radar and electro-optical guided missiles. Typical openings include systems analysts to perform preliminary design in the areas of control systems and signal processing; RF/IF, digital and analog circuits engineers, aerodynamicists, product engineers, digital system design engineers, microwave and electro-optical engineers and many others. For immediate consideration, please send your resume to: Engineering Employment, Hughes Aircraft Company, Canoga Park, CA 91304.

Canada was the first nation to launch a national communications satellite program (1972). Now it will utilize a third-generation series of satellites (called Anik-C) to handle digitized telephone traffic across the densely populated southern border region. The new Anik ("brother" in Eskimo) space vehicles will also provide additional TV channels. Their K-band frequencies will provide 16 channels -- or four more than the first model has. After completing contract negotiations with Telesat Canada, Hughes will develop the Anik-C satellite for launch from Space Shuttle or by expendable rocket. Initial scheduled liftoff date: late 1980.


Hands. TI's watch with its 120 LCD segments also functions like a stopwatch (shown at left) at the push of a button.

designed to rapidly charge up the highly capacitive display elements. The drivers supply 100 to 150 microamperes of drive current for 100 microseconds and power down to a low sustaining current of 100 nanoamperes when the display is off. □

Communications

Laser, Trapatt diode yield speed, power

A major problem for designers of coded burst-communications systems requiring both high speed and high power is to achieve these characteristics in a simple device. Perhaps the record for simplicity is being set by researchers R. A. Kiehl, R. E. Hibray, and E. P. EerNisse of Sandia Laboratories in Albuquerque, N. M. They are doing it by illuminating a Trapatt diode transmitter, a three-layer device used for pulsed microwave-frequency oscillators, with a stream of optical pulses from a gallium-aluminum-arsenide laser diode.

A first. Their transmitter is probably the first ever to generate an information-bearing microwave signal by using light to directly control the internal operation of a microwave source. This is achieved with an actual data rate of 120 megabits per second with 64 watts of radio-frequency power for some modes of operation. Since the digital modulation rate is limited only by the laser, Kiehl feels that "speeds up to multigigabits are possible with millimeter-wave Trapatts."

In addition, because the modulator is optically isolated from the radio-frequency energy being transmitted, there is no interaction to cause loading effects. Arbitrarily high transmitted power levels are possible, Kiehl says.

The single-stage laser-modulated transmitter is far simpler than the previous approach that uses an oscillator followed by multiple amplifier stages. There, the modulation was done in an early low-power stage. Other approaches such as modulation of the transmitter with varactors or p-i-n diodes just cannot be made to switch fast enough at high power levels.

Structure. In Sandia's approach, the Trapatt diode is mounted in a slug-tuned coaxial cavity with electrical contact to the diode layers made so that 80% of the active diode region is illuminated by the laser. This illumination produces rapid changes in the diode's oscillation frequency and amplitude as a result of the diode's constantly changing internal carrier dynamics.

Both the Trapatt and the laser are commercially available devices. The laser itself is a double-heterostructure stripe-geometry diode that emits 7 milliwatts of continuous-wave power at 890 nanometers. It is modulated by a simple transistor driver circuit in which the laser looks like a collector load in an emitter-coupled pair.

The Trapatt diode is pulse-biased and illuminated by a synchronized optical pulse stream from the laser. Either frequency-shift or amplitude-shift keying is obtained by simply tuning the Trapatt oscillator circuit.

Transponders. Kiehl believes there are applications for the new device in transponders where the communication is done in short, digitally coded bursts. Downstream possibilities include high-speed digital radio links, spread-spectrum systems with high percentage bandwidth, and high-resolution radars, he says.

So far, Sandia has worked mostly with pulsed systems. With a Department of Energy contract, it is now beginning to develop a system built around a continuous-wave Impatt diode. Commercial Impatts are used, and it is hard to couple enough light to the diode's interior because its electrode connections are in the way, Kiehl explains. The connections could be etched away, however.

Others are interested in optical modulation of solid-state oscillators as a result of Sandia's work. For example, the Defense Advanced Research Projects Agency is supporting a study by Hughes Aircraft Co., Culver City, Calif., of injection-locking transistors with light beams for phased arrays. And the Harry Diamond Laboratory in Washington, D. C., is looking into amplitude modulation of 70-gigahertz Impatts with laser light. □

Microprocessors

C-MOS bows in TI's 4-bit controller

That Texas Instruments Inc. is now offering its 4-bit microprocessor-controller family in a lower-power technology seems to make sense. The reason: the Houston consumer and automotive division handling the part has corralled the business of a major share of the cost-sensitive electronic toy and game manufacturers, who want low power to conserve battery life.

But, in fact, the game makers are not the first in line for the new TMS 1000C family—TI is aiming it initially at more sophisticated applications like telecommunications and industrial controls. Prime examples are repertory dialers and call-routers that use the chips directly off the telephone lines.

TI did not just reduce power by moving from p-channel to complementary metal-oxide-semiconductor technology. It also enhanced the microcontroller's performance by adding some desirable features like

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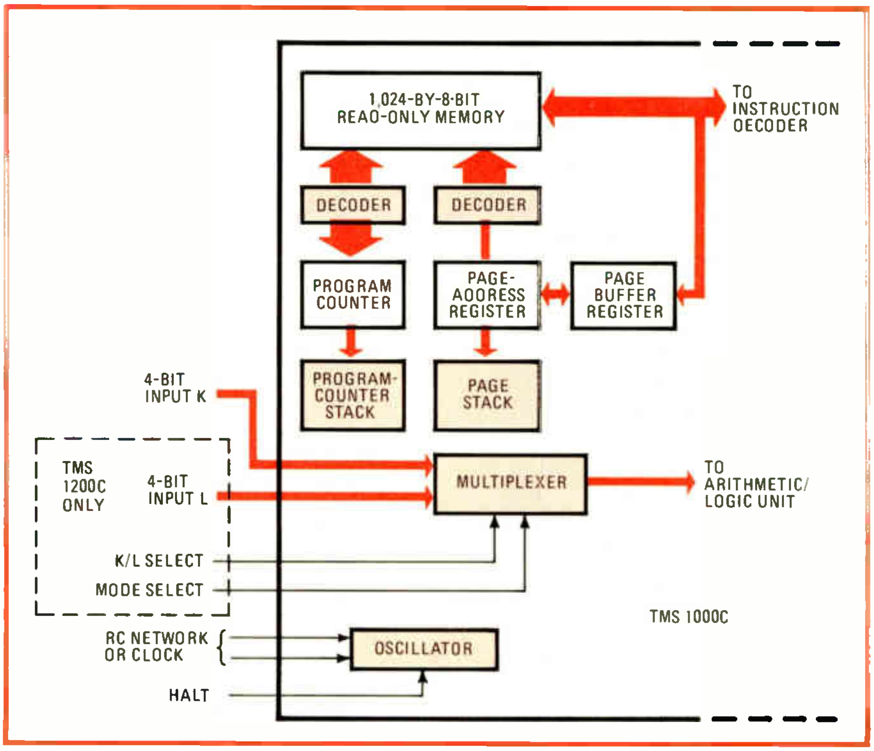

Enhanced. TMS 1000 family, now made in C-MOS, has added features, including a stack for subroutines, a halt line for the clock, and, in the TMS 1200C, four extra inputs.

faster operating speed and more inputs and subroutine levels.

"Right now, the aim is toward more functions and better performance," says Andy Brock, strategy manager for the 4-bit TMS 1000 microcontroller family to which the new C-MOS devices belong. "Until the games manufacturers move to liquid-crystal displays, there'll be no need to move to lower-power chips—the light-emitting diodes and other displays they use draw lots more power than any of the microcomputer chips, even those built with p-channel technology."

Standby. The cut in power using C-MOS instead of p-MOS is significant: the 28-pin TMS 1000C typically dissipates 5 milliwatts (at 5 volts), compared with 68 mW (at 15 V) for the older part. But it is with a new standby mode that the C-MOS parts really shine—standby power is a tiny 7.5 microwatts. The earlier TMS 1000 designs could operate only in the active mode.

Also, Brock notes, C-MOS has other desirable features like high noise immunity and inherently higher speed than the p-channel MOS of the TMS 1000 line. The 1.3-megahertz upper operating frequency of the 1000C family triples that of the p-MOS parts, which top out at 400 kilohertz. "Customers are always asking for higher speed, for applications from industrial control to audio systems," Brock says.

More ROM. Among the other enhancements, shown in the partial block diagram of the chip at the top of the page, are additional subroutines, which, Brock points out, mean that less memory would be needed by a cleverly written program. The savings translates into the equivalent of 20% more read-only memory, he says.

Added to the oscillator is a halt line, also shown in the diagram, that stops the clock while preserving the machine state. It is useful in duty-cycling the microcontroller to a very low average power consumption in power-critical applications.

Finally, the company has added an input multiplexer to a version of the new line, called the TMS 1200C, that has 13 outputs instead of 11. The new multiplexer doubles the available inputs to 8, answering

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another customer concern, Brock says. In addition, a mode-select pin used with the input-select pin latches data in, a handy feature for transient data, he points out.

The toys and game market is not really out of the reach of the TMS 1000C, which will cost less than $5 each in large quantities, Brock continues. "The way we see it, by the time toy manufacturers are ready to go to C-MOS—in about a year or two—we'll have the price down to one they can afford," he says. □

National aims at low-end units

"Customers don't want cost-effective—they want cheap," declares National Semiconductor Corp.'s Fred Horne, manager of engineering for the Santa Clara, Calif., company's new line of 4-bit microcomputer chips. National is out to sweep the low-end microprocessor field with the COP 400 (for control-oriented processor) family n-channel silicon-gate devices that will range in price from $3 down to a meager 99 cents in large quantities.

Unlike Texas Instruments with its new TMS 1000C line (see story above), National, often called a "jelly bean" semiconductor house because of its commodity lines of linear and discrete components, is using price pressure to try to garner more of a market share. The company concedes that it did not have much of a chance to catch industry leaders Texas Instruments Inc. and Rockwell International Corp. with its old COP (for calculator-oriented processor) line because the p-channel metal-oxide-semiconductor devices were not very well thought out and the company did not really push them.

Texas Instruments and Rockwell have a nearly equal share of more than 90% of the low-end microcontroller market. But Horne emphasizes that this market, encompassing such high-volume consumer products as intelligent light switches and handheld games, demands low price. Low-end microcontrollers have been offered for less than $2 by some manufacturers in 100,000-piece quantities and have gone as low as around $1.75.

More options. In addition to price considerations, National's rethinking included two other objectives: a wide offering of memory and instruction-set options and enough speed-power combinations to extend the COP 400 applications over the microcontroller gamut.

The result is a family of 12 devices having various mixes of read-only memory (from 512 to 2,048 bytes), random-access memory (from 32 to 128 4-bit nibbles), five output options, and a set of either 43 or 57 instructions.

Of course, National has competition in chasing TI and Rockwell. American Microsystems Inc. is pushing its S2000 family of 4-bit parts, and Panasonic Corp. has its MN1400 series. General Instrument Corp. sells the 8-bit PIC1600 in the same market. Sharing the 8-bit perspective is Intel Corp., which recently added its 8022 with on-chip analog-to-digital conversion to its microcontroller family [*Electronics*, May 11, p. 183].

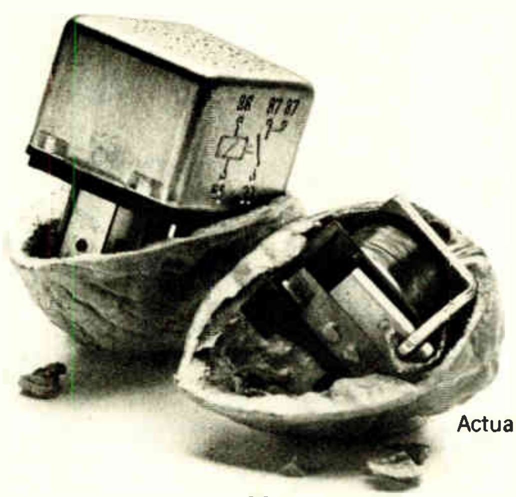
For its part, National plans to broaden its attack by bringing out a low-power complementary-MOS version of COP 400 in January for a little over $3, and in a few weeks will add muscle to its effort by nailing down a second source. □

Communications

Deregulation seen as easy by Justice

The rapid economic growth and fast pace of technological change in U. S. telecommunications should make Federal deregulation of the market relatively easy, says the Justice Department. John Shenefield, assistant attorney general for antitrust, says the industry's $120 billion estimated annual revenues are expanding 10% to 20% a year. Compared to less dynamic industries, he says,

Robert Bosch Mini-Giants® in a nutshell



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Circle 51 on reader service card

News briefs

4-K RAM shortage seen throughout rest of year

The shortage of 4,096-bit dynamic random-access memories currently plaguing the industry is expected to continue to the end of the year, according to consensus opinions among marketing executives at Intel, Mostek, Motorola, National Semiconductor, Signetics, and Texas Instruments. Current lead times stretch from 8 to 18 weeks for 16-pin versions and from 16 to 18 weeks for most 22-pin packages. In gearing up for 16-K RAMs, chip makers were wrong about 1978 demand for 4-Ks, which was accelerated in part by aggressive pricing that tags 4-Ks from $3 to less than $1.50 depending on quantity, package, and access time. Many believe that 4-K shipments this year will easily exceed last year's. However, some say that 16-Ks, now in the $10-and-up range will attract 4-K users when the bigger units decline in price to between $7 and $8.

TRW negotiating for space materials processing

TRW Defense and Space Systems Group is expected to be named prime contractor for the National Aeronautics and Space Administration's space material processing program—recently subjected to strong criticism by the National Research Council [*Electronics*, July 6, p. 56]. NASA says it is negotiating a $9.7 million proposal with the TRW group in Redondo Beach, Calif., for the initial three-year phase of the program set to begin in September. Under the proposal, TRW would develop experimental payloads for the space shuttle and Spacelab to produce purer materials—such as silicon crystals for semiconductors—in a gravity-free environment.

Cable & Wireless to study 4-to-6-GHz interference

Britain's Cable and Wireless Ltd. will begin a study in Hong Kong next year to try and find out why apparent ionospheric changes are impairing communications-satellite transmissions. Intelsat, the 102-nation consortium sponsoring the study, believes the signal fluctuations—which occur only during the evening and mainly during the equinox periods, when the sun crosses the celestial equator—are produced by sunspot activity. Since 1979 is forecast to be a year of high sunspot activity, Intelsat is eager to discover the cause, extent of, and remedy for the problem.

NASA prepares launch of second Venus probe

Countdown checkout continues as the National Aeronautics and Space Administration prepares for the August 7 launching of the second part of its $175 million Pioneer probe of the atmosphere of Venus. When the multiprobe craft nears the planet next December, it will split into five separate spacecraft that will descend into the hot, hostile atmosphere. The multiprobe and a Venus orbiter that was launched in May are expected to yield data to answer questions like why a planet so similar in many respects to earth is so different in atmosphere and whether that atmosphere can provide clues about our own weather system.

such growth leaves a lot of room to accommodate new companies with new ideas.

The Justice Department disclosure of its estimates on market size and growth came in congressional testimony late last month that generally supported the pro-competition stance of H. R. 13015, the rewrite of Federal communications regulation [*Electronics*, June 22, p. 84]. However, Shenefield hedged on the bill's specifics in his preliminary views, reserving these for later judgment.

The market estimates embrace everything from broadcast and cable television, plus radio, to telephone and satellite hardware and services. More hearings are set for later this month before the House subcommittee on communications.

Cable conflict. With cable TV markets still having room to grow in most rural and many urban areas, the bill's proposal to eliminate Federal regulation altogether produced

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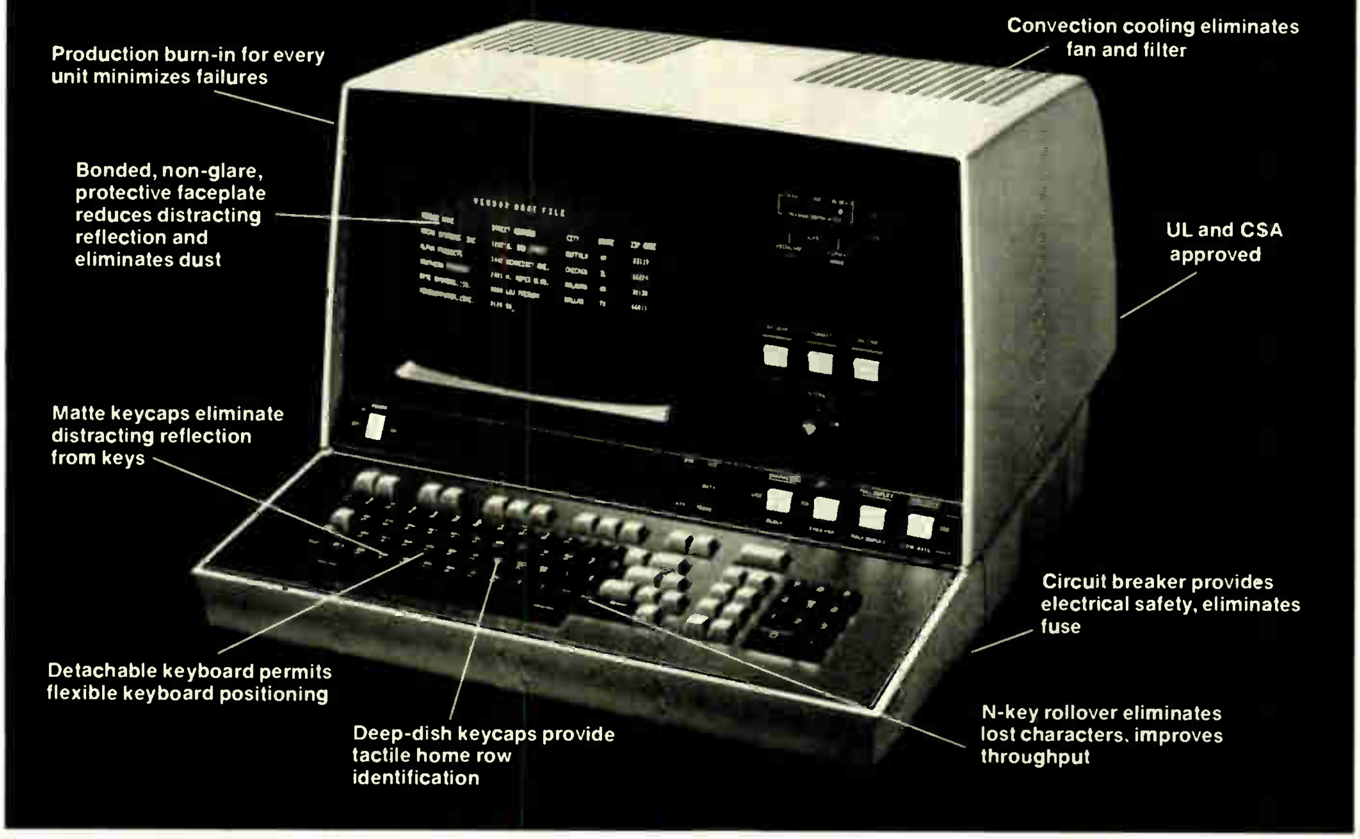

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sharply conflicting views. A fully developed market, industry officials estimate, could balloon receiver sales by 2 million to 3 million units a year from 1978's most optimistic forecast of a record 10 million.

Nevertheless, the bill's plan to define community-antenna TV as an intrastate service and permit telephone companies to enter the market came under fire. Leaving CATV regulation and licensing to the 50 states and an estimated 9,400 municipalities would create "a crazy quilt" of rules based on "parochial and not national interests," complains Robert Hughes, chairman of the National Cable Television Association.

Interstate service. His association's insistence that cable television's increasing use of satellites and its importation of distant signals make it an interstate service subject to Federal oversight was supported by Federal Communications Commission chairman Charles Ferris, former chairman Dean Burch, and other past and present FCC commissioners who testified.

Nearly all agreed that a diversity of regulations and fees would inhibit further development and use of the technology even more than the FCC's rigid supervision in the past. The commission has been widely criticized by CATV advocates as protecting market shares of over-the-air broadcasters by limiting CATV growth. Nevertheless, most NCTA members now operating systems also predict disaster if they are obliged to compete with telephone companies previously barred from the market.

Richard Elkin, president of the National Association of Regulatory Utility Commissioners, representing state and local governments, predictably favored giving CATV control to the states in cases where signal distribution is within a state.

Justice's Shenefield hinted that he may later come out in favor of retaining Federal jurisdiction over cable television, since the increasing use of satellites for distribution "may result in cable television emerging as a national service much more effectively competitive with existing network television." □

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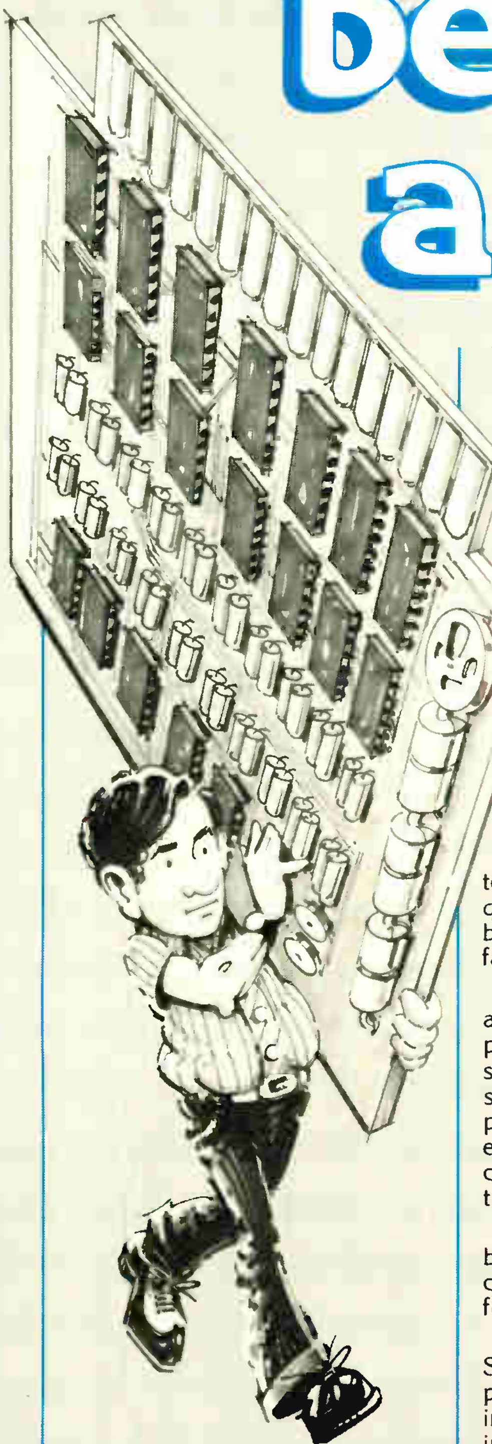
How do you best test a PCB?



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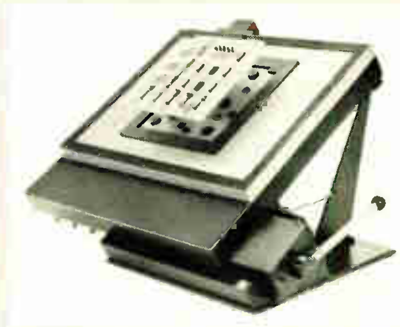

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NEC Newscope

Facsimile Readout Revolution By Tiny New NEC Image Sensor

Actual size of the "μPD792D" linear image sensor.

NEC recently unveiled a completely new device which will revolutionize facsimile equipment.

The device, a CCD (charge coupled device) linear image sensor named "μPD792D", incorporates 2,048 picture elements, and converts a photosignal into a voltage signal. It consists of a charge input circuit, a sensor array made up of 2,048 MOS capacitors driven by a single photogate, two CCD shift registers located one on either side of the sensor, a transfer gate and a charge detector with noise compensation circuit.

The μPD792D, having 2,048 elements, a preamplifier and a compensation amplifier on a 3 x 30mm chip, can resolve patterns over B4 size paper (25.6cm wide) at a rate of 8 lines/mm. In addition, it features a wide dynamic range and a high transfer efficiency of more than 99.996%. Power supplies required are all below 15V.

Thanks to its outstanding features including long service life and low cost as well as trouble-free performance, the new image sensor is expected to revolutionize "readout" performance of facsimile equipment.

NEC has adopted this new product for its NEFAX series facsimile equipment.

Full-Electronic Key System

The latest addition to the versatile Patrician key telephone family is the stored program control Electra-28.

It is the first commercially-available full-electronic type in the world. Drastic cuts in installation costs are achieved because thin 3-pair cables are used for connection of the key service unit and the telephones. Conventional types require thick 25/50-pair cables. With a built-in microprocessor, the Electra-28 offers a wide scope of standard and optional services including such unique features as "Meet-me-answer," "Call pickup" and "Add-on conference."

It can accommodate up to 28 stations with 10 CO/PBX and 4 intercom or 11 CO/PBX and 3 intercom or 12 CO/PBX and 2 intercom lines.

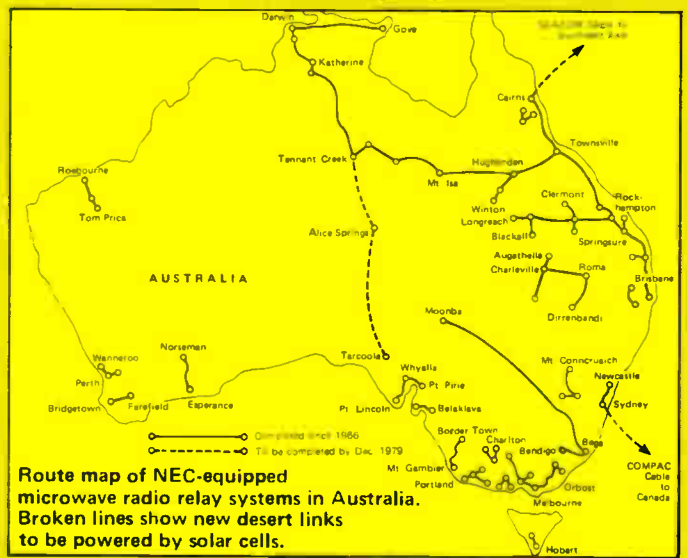
More than 2,000 systems were installed in the U.S. during the past 12 months.

1,300-km Australian Microwave System To Be Powered By Solar Cells

Australia is to have a 1,300-kilometer,solar-powered microwave communications link extending through the central desert.

The link will consist of a 4,000 MHz low power consumption, high reliability heterodyne relay microwave system covering a distance of 500 kilometers between Tennant Creek in the central north and Alice Springs in the central area, and a 2,000 MHz low power consumption, high reliability baseband relay microwave system between Alice Springs and Tarcoola in the south, a distance of 807 kilometers.

The 4,000 MHz Tennant Creek-Alice Springs system, to be constructed by Telecom Australia, will provide 1,260 high-grade telephone channels or one color television channel. On the other hand, the 2,000 MHz Alice Springs-Tarcoola system will be built by the Australian National Railway (ANR), and will have a channel capacity of 300.



Route map of NEC-equipped microwave radio relay systems in Australia. Broken lines show new desert links to be powered by solar cells.

As there is no commercial power supply available along the projected link running mostly through barren areas, the 1,300 kilometer Tennant Creek-Tarcoola link will be equipped with compact, economical low power consumption and high reliability equipment, and will be designed to run on solar cells. The new microwave link will be the first of its kind to extend 1,300 kilometers.

In Australia, NEC-made microwave systems are now in service in major microwave links which form a nationwide network. The first NEC-equipped link was put in service in April of 1966 between Brisbane and Cairns, a distance of 1,500 kilometers along the east coast. This, the world's first solid-state microwave system, is now acting as a vital link between the SEACOM (Southeast Asia Commonwealth) submarine cable landing at Cairns and the COMPAC (Commonwealth Pacific) submarine cable extending to New Zealand and Canada from Sydney.

The Tennant Creek-Alice Springs system will be completed in December 1978 and the Alice Springs-Tarcoola system in December 1979.

1978 Annual Report

Our annual report for the fiscal year ended March 31, '78 has been published. To receive your copy, please write the Customer Relations Division, Nippon Electric Co., Ltd., P.O. Box 1, Takanawa, Tokyo 108, Japan.

DSI Terminal Doubles Digital Voice Transmission Capacity

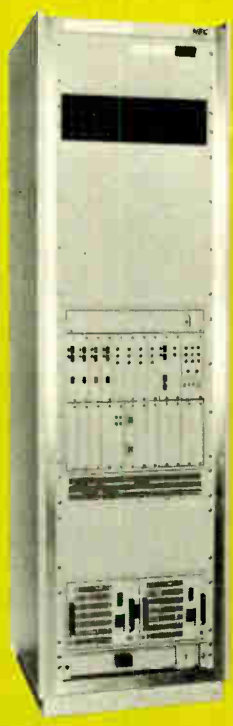
NEC has developed a compact, fully-digitized device capable of doubling the transmission capacity of digital voice systems.

The new device, Digital Speech Interpolation (DSI) terminal, is designed to utilize the idle time in normal telephone conversations. Actual speech in normal telephone conversation is said to occupy considerably less than 50% of the total time and the remainder is left unutilized.

The DSI terminal compresses four 1.544 Mb/s T1 type PCM signal streams carrying 96 digitized speech signals into two 1.544 Mb/s T1 compatible bit signal streams. To attain this two-to-one bit rate compression, the status of each telephone channel is examined in the terminal and only active portions of speech are transmitted, thus allowing transmission of other speech in the idle time through the same channel and enabling the channel capacity of a digital voice transmission system to be doubled.

Use of a microprocessor has made it possible to develop a compact, inexpensive DSI terminal having extensive operating and maintenance monitoring features.

The new DSI terminal will contribute greatly to the reduction of transmission costs through efficient utilization of frequencies in digital voice transmission.



Two DSI terminals with a total capacity of 192 channels are mountable in the standard 7-ft high, 19-inch wide and 20-inch deep rack.

NEC-Equipped Microwave Network In Brazil Now Covers 20,000 km

Commander Euclides Quandt de Oliveira, Brazilian Minister of Communications, inaugurates completion of the Recife-Petrolina 1,100-km microwave link with a call from Petrolina to Mr. José de Moura Cavalcante, Governor of Pernambuco, in Recife.

People living in the State of Pernambuco in east central Brazil can now enjoy improved telephone and television services with completion early this year of a new microwave link running across the state from Recife in the east to Petrolina in the west.

The microwave link, which covers a total distance of about 1,100 kilometers, was installed for the Telecomunicações de Pernambuco S/A in Recife.

The link, consisting of a total of 31 hops, is equipped mostly with NEC's 2GHz and 7GHz 960-channel systems. It can handle 960 telephone channels and a television channel.

In addition to manufacturing, supplying and installing all the necessary equipment including supervisory equipment for the new microwave link, NEC has also installed coaxial cable systems to connect local stations with the link and is completing a total of 300-kilometer UHF links. NEC also conducted the site and route survey for the project.

In conjunction with a number of cable PCM systems supplied by NEC, which have been in operation in Recife and its vicinity since the beginning of last year, the new microwave link covers almost the entire area of the State of Pernambuco.

With the completion of the Recife-Petrolina link, the total length of NEC-equipped microwave links now in service in Brazil has reached about 20,000 kilometers, equal to the distance from Japan to Brazil. About 50% of them, including a 1,500-kilometer trans-horizon system linking Manaus in the north central region to Belém located at the mouth of the Amazon River, were built for the Empresa Brasileira de Telecomunicações (EMBRATEL). The rest is shared more or less equally among state telephone companies and power companies.

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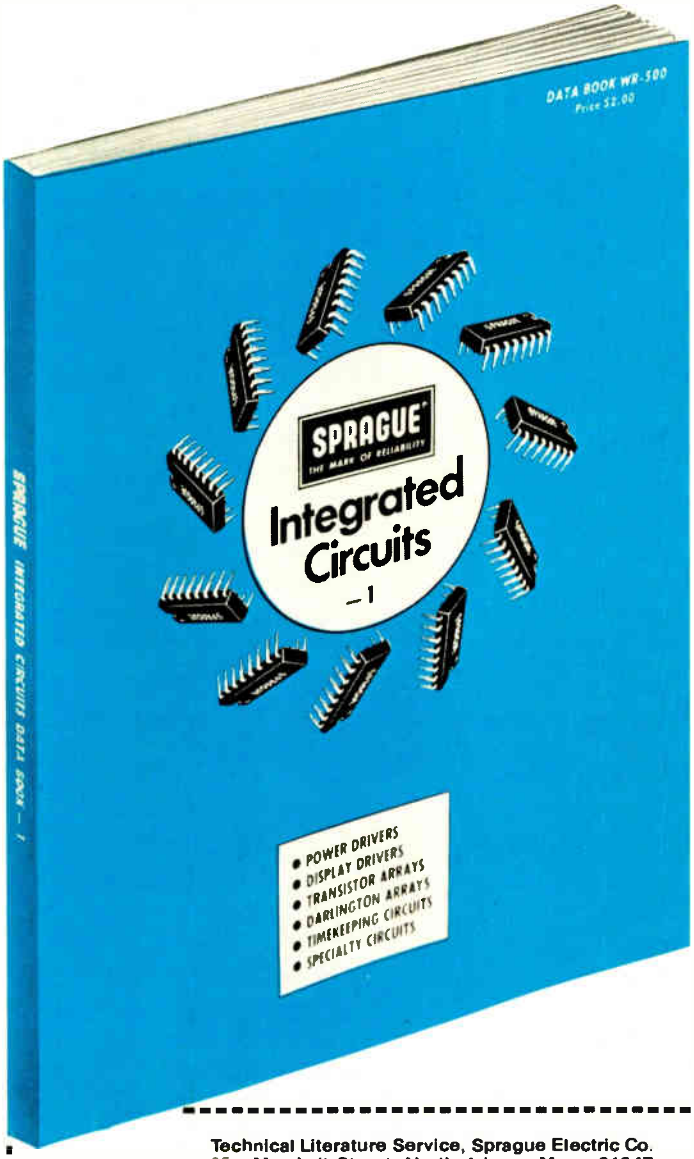

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Washington newsletter

U. S. widens issues after Japan offers cuts in tariffs

Japan's compromise offer to cut import duties on integrated circuits and computer mainframes by more than half and to slash tariffs on peripherals by two thirds still isn't enough for U. S. Special Trade Representative Robert Strauss. White House sources say Strauss "isn't ready yet to take the offer and run." Instead, he wants to wrap it up in a totally new and complete package for both industrial and agricultural products, plus broad international trade rules covering new areas such as brand-name counterfeiting, government subsidies to industries, and government procurement.

Officials in the Commerce Department and affected U. S. electronics companies question whether even the hard-driving Strauss can achieve that goal and **are nervous that Japan's offer might be lost in the subsequent bargaining shuffle.** Japan proposed to cut tariffs on mainframes and peripherals to 4.9% and 6%, respectively, beginning in 1980, from present levels of 10.5% and 18.5%. Duties on ICs would drop to 4.2% from the current 12%. When might a broader agreement come? "By the end of the year with luck," opines one ranking official, "but don't hold your breath."

1981 implementation of common language seen by DARPA . . .

The Defense Advanced Research Projects Agency is shooting for a 1981 release of specifications and first procurement of production compilers for its DOD-1 standard higher-order language for military computers [*Electronics*, June 10, 1976, p. 45]. Development of DOD-1, which evolved from the Strawman/Steelman programs, has taken a major forward step with DARPA's selection of Honeywell Inc., Minneapolis, and Intermetrics Inc., Cambridge, Mass., as finalists for development of software specifications and test translators. Honeywell is getting $800,000 and Intermetrics approximately half that amount under 10-month awards for the second development phase, scheduled for completion by April. One will be selected next year for the third and final development phase. **Successful development of DOD-1 and its compiler is expected to produce significant reductions in the military's annual $6 billion software budget. This could spread the system's use throughout other Federal agencies and effectively leapfrog the National Bureau of Standards' lagging standardization program [*Electronics*, Feb. 2, p. 39].**

. . . with Honeywell to develop DOD-1 at French affiliate

A novel aspect of DOD-1's second development phase is that Honeywell's entry will evolve largely from a language developed in France called LIS. **Developer was the company's affiliate there, CII-Honeywell Bull, which will perform most of the contract work.** The job will be monitored by Honeywell's Systems and Research Center, named by DARPA as the contractor. All four competitors in last year's first-phase competition began their development using the Pascal language.

India's satellite to combine TV and meteorology

The first multipurpose satellites to combine direct TV broadcasting, domestic public telecommunications, and meteorology services will be launched in 1981 for India aboard the National Aeronautics and Aviation Administration's space shuttle. Known as Insat, **the satellite and a twin will be built by Ford Aerospace & Communications Corp.,** San Francisco. Dollar value was not disclosed. The geostationary spacecraft will be three-axis-stabilized and was described by a Ford official as "similar to NASA's ATS-6 applications-technology satellite but with much greater capacity."

Reforming the FCC: views of the veterans

A rare gathering of five former chairmen of the Federal Communications Commission resulted last month in an even rarer event: agreement among them that significant deficiencies exist in the bill now before Congress to rewrite telecommunications regulation in the United States [*Electronics*, June 22, p. 84]. Many of their views were echoed by the six out of the seven current FCC commissioners who also appeared to critique H. R. 13015 in initial hearings before the House Communications subcommittee.

The bill's elimination of the FCC's mandate to be guided by "the public interest, convenience and necessity" and the limitation of its regulatory powers only "to the extent that marketplace forces are deficient" provoked much criticism. No one disputed the need for greater competition, rather than regulation. Yet all the commissioners past and present agreed that the public interest should not be set aside. "Deficiencies vary from market to market," noted Charles Ferris, the FCC's present chairman, "and vary as technology changes. All communications markets are highly dynamic, and future 'market deficiencies' cannot all be foreseen or predicted. I would recommend inclusion in any rewrite of a 'public interest' standard, and along with it clear congressional direction that the public interest is served by competition and diversity." The bill's failure to define its terms was clearly of concern to every witness in the early hearings.

Chairman or czar?

The FCC's leaders agreed that the bill is weak not only in defining the terms it uses to express Federal policy, but also in becoming too specific in a number of administrative and procedural areas. For example, it seeks to speed up the regulatory process by giving the chairman of the proposed new five-member Communications Regulatory Commission full authority to determine the commission's agenda and control expenditure of its funds. That comes close to establishing a Federal communications czar, a concept no one is ready to buy.

Nor do any of the present or past FCC commissioners like the bill's idea of assigning frequency allocation responsibilities not to the independent CRC but to the presidentially appointed administrator of a new National Telecommunications Agency. "By giving the CRC a secondary role in frequency allocation," complains former chairman Dean Burch, the legislation would be "building in an inevitable conflict between the CRC and NTA."

FCC chairman Ferris goes further, noting that the price of achieving administrative efficiency by taking Federal communications policy responsibility away from the CRC and assigning it to a single NTA administrator might be too high. "How long would policies made in such a manner last? Ferris asks. "Would those on the losing side push their arguments into the political arena? Would 'invisible' executive branch officials, using 'invisible' procedures, make mysterious deals, bartering policy positions for political considerations—without evidence, without a [public] record, and without even the pretense of reasoned opinions?"

The hearings quickly made clear that the new legislation's authors were ignorant of the caution advanced by an earlier Congress when it created the Federal Radio Commission, the FCC's predecessor. Communications technology and its potential impact on American society is powerful, Congress wrote in 1926. "The exercise of this power is fraught with such great possibilities that it should not be entrusted to any one man nor to any administrative department" but rather to "an entirely independent body." This regulatory power "should be as free from political influence or arbitrary control as possible."

A separation of powers

Newton Minow, perhaps the most articulate of the FCC's former chairmen, offers an alternative solution to the commission's proclivity to entanglement in its own rules. Concurring with former chairman Fred Ford's view that "the FCC has been due-processed to death," Minow believes the problem can be resolved by separating the responsibilities for drafting, administering, and enforcing communications regulations. The Internal Revenue Service, he points out, has operated that way for years, with the commissioner of internal revenue drafting regulations, while all challenges are decided independently by the U. S. tax court. A communications court separate from the CRC could conceivably resolve disputes between the commission and the industries it monitors by legally binding judgments. Moreover, it could operate without the inhibitions of the administrative law judges who are now FCC employees and who, Minow recalls, can almost guarantee that issues assigned to them will remain unresolved for three years.

Minow's solution to a complex problem sounds simple. But it is the product of years of reflection on FCC service that made him feel "I was in a straitjacket." The Congress should consider it well as it begins searching for ways to improve on H. R. 13015. **Ray Connolly**

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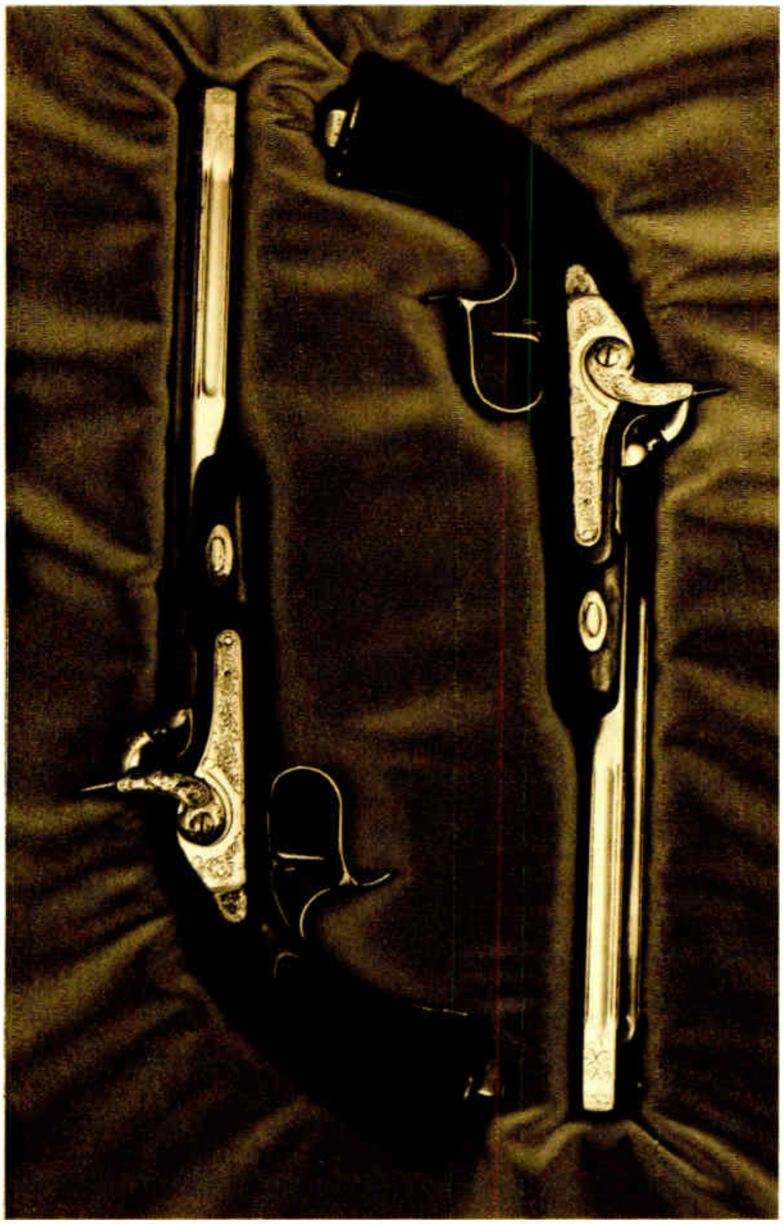

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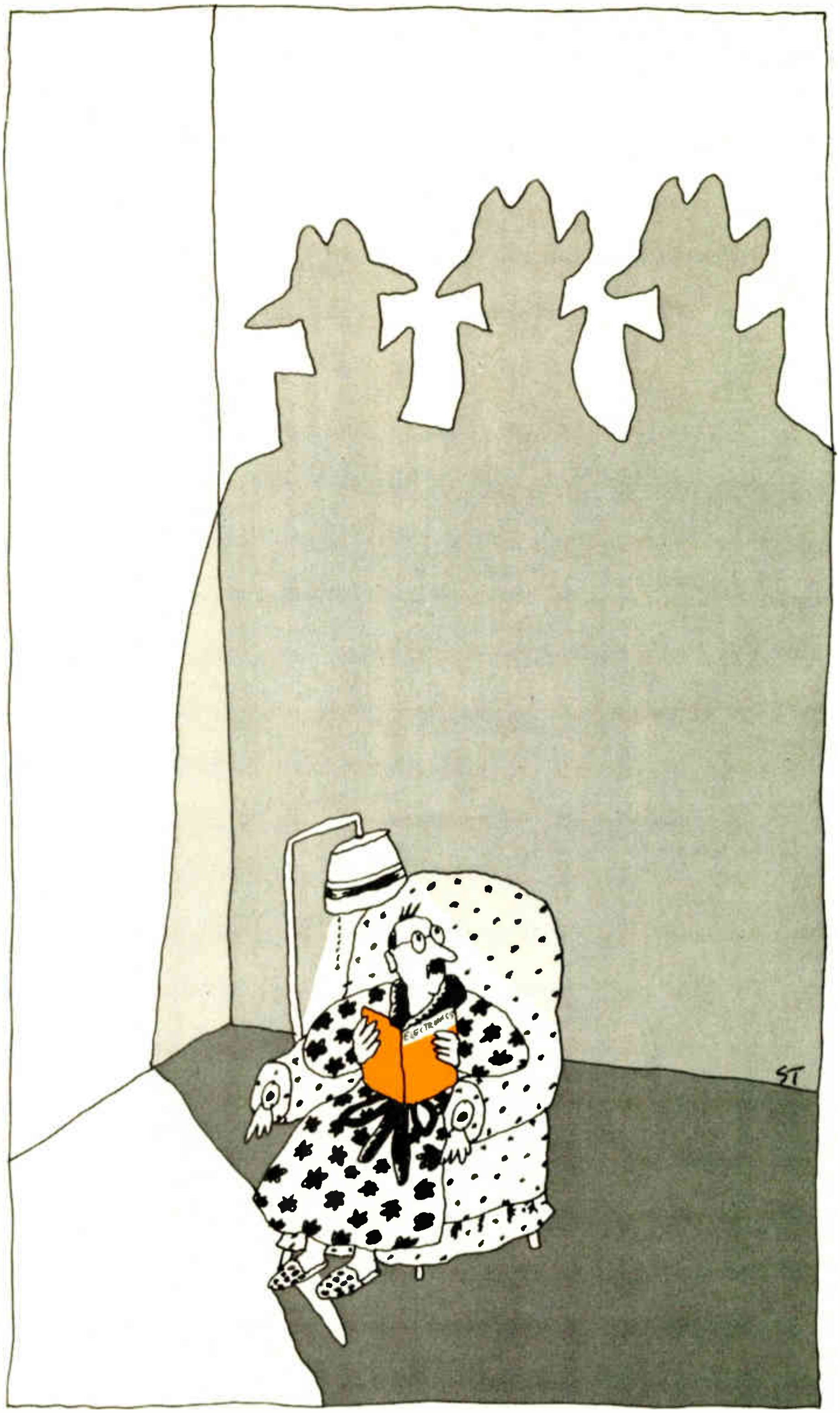

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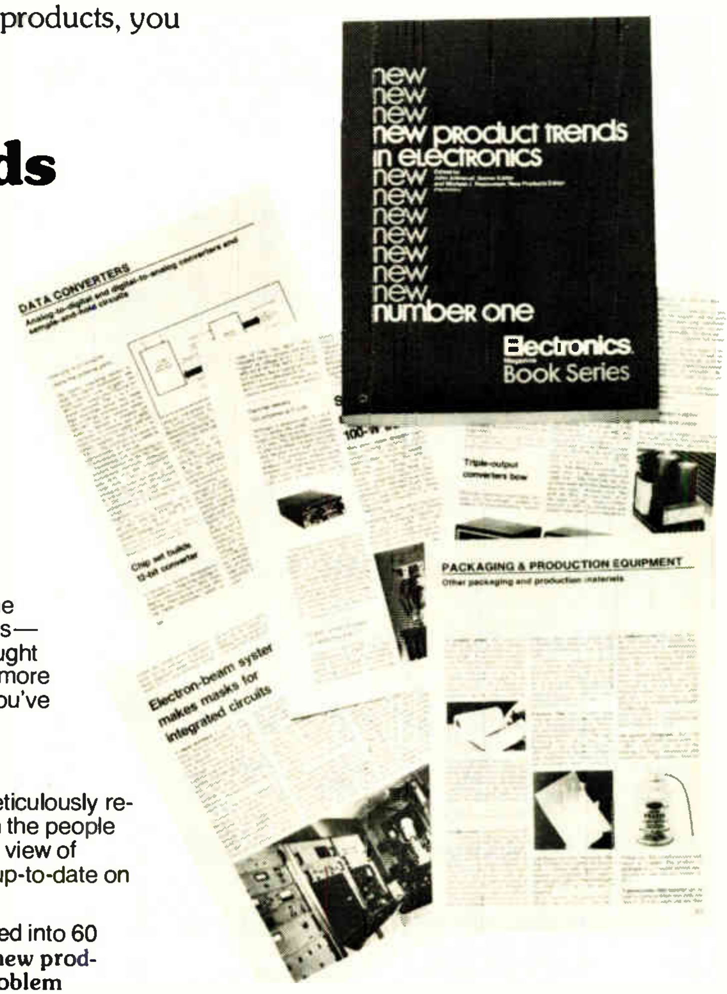

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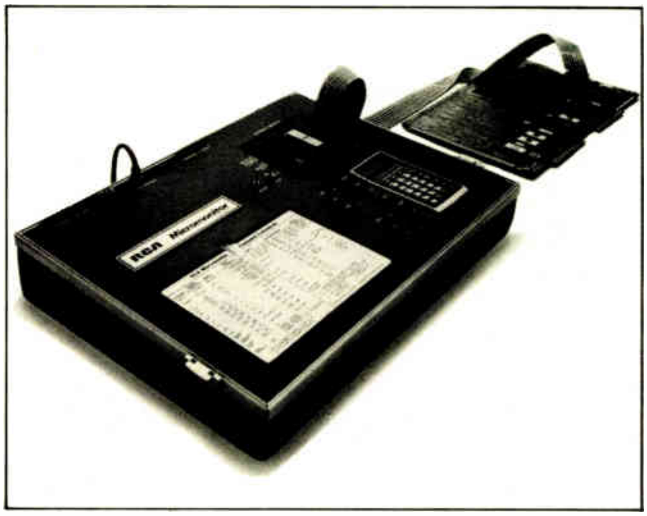

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International newsletter

Toshiba markets double-duty electron-beam unit

For a little more than $2 million, Japanese semiconductor manufacturers now can buy a Toshiba electron-beam exposure system that makes both full-wafer masks and single-device reticles. In its most precise mask-making mode, the minimum line width is 1 μm ±0.1 μm. **The patterns formed can occupy a 105-mm² area on a 125-mm² mask, which can be used with 4-in. semiconductor wafers.** For making step-and-repeat reticles, which will be reduced 10 times during optical printing, minimum line width is 4 μm ±0.15 μm. The machine will also be available overseas.

Hitachi to push fast 16-K RAM with single supply

After recent visits to U. S. computer makers, Hitachi is ready to push a new 16-K dynamic random-access memory. The 4816 operates from a **single +5-V supply and has a worst-case access time of 100 ns** through a narrow, 15-ns window to multiplex the address. Sample quantities will be available in September, about the time that Intel is expected to jump into the fray with a similar part.

Branier radar planned for UK Tornado

Details are skimpy for security reasons, but the Royal Air Force's version of the upcoming all-European Tornado aircraft will get a radar with significantly greater capabilities than present systems. The equipment, to be developed by Marconi Space and Defence Systems Ltd., **will provide information on the sector and direction of any airborne intruder, as well as being largely able to determine the type of threat.** It will also assist the pilot in deciding the type of counteraction he should take. The system will be modular so that it can be readily fitted to other aircraft.

64-K ROM is pin-compatible with Mostek part

Launching Japan into the 64-K ROM market, Nippon Electric Co. will be accepting orders next month for a read-only memory that is pin-compatible with Mostek's MK36000. Access time is 450 ns maximum, and power dissipation is 450 mW typical from a +5-V power supply. The **pin compatibility with the Mostek part puts NEC in the camp of all other makers of 64-K ROMs—save for Intel,** which is going its own way just as it did with 32-K parts. NEC says that initially it will fabricate 30,000 of the μPD2364D a month, with price in lots of 1,000 to 2,000 at $1.50. The part will be available overseas.

Chip converts 525-line TV set into data terminal

Coming up from Sescosem, Thomson-CSF's semiconductor division, is a 60-Hz, 525-line version of its successful interface chip for cathode-ray tubes. It is aimed at the U. S. and Japanese markets. **The chip, the SF.F 96364 is based on n-channel MOS silicon-gate technology** and provides the control circuitry needed to convert a standard TV receiver into a data terminal. It costs between $15 and $20, depending on quantity. The present 50-Hz, 625-line version, on the market for nearly a year, has already picked up a roster of users that includes some U. S. firms.

Now, 110 millimhos in a JFET

Japanese semiconductor firms seem well launched on a race to hike the transconductance of junction field-effect transistors: hard on the heels of new models from Toshiba (p. 72) and NEC, Mitsubishi Electric Corp. is introducing a chip with a typical rating of 110 millimhos, more than twice that of the competitive models. Rather than employing the exotic geometry of the competing new models, **the Mitsubishi devices use very fine patterns to get a short gate length of 2 μm,** together with small source and drain regions. The firm's engineers opted for large, 1.5-mm-square chips to achieve a total gate width of almost 10 cm. Two matched chips in a single in-line package will cost $4.50 in sample quantities.

Time-encoded speech uses bits economically

There's a new voice transmission technique on the horizon in Great Britain, based on the principle of time-encoded speech. Computer simulations show that a transmission meeting the European standard for voice quality can be encoded and reproduced at a bit rate of 16,000 bits per second, **which allows four channels instead of one in a conventional 64,000-b/s pulse-code-modulated link.** A prototype using an analog-to-digital converter, buffer, store, and microprocessor will be ready in 18 months, but the developers say that optimizing the basic coding strategies could take five years.

China buys computer; Ghana, Eire go for communications gear

West Germany's Siemens AG is about to ship a data-processing system to the People's Republic of China: a model 7,738 medium-sized machine **to perform calculations on industrial steam-turbine design** and to support the planning and manufacturing operations. . . . Montreal-based Spar Technology Ltd. will supply and **install Ghana's standard satellite telecommunications system, including an international switching center.** The Canadian government's Federal Export Development Corp. is lending Ghana $6 million to underwrite the Spar contract. . . . Fujitsu Ltd. of Japan has a $3.5 million contract with Eire's Department of Posts and Telegraph **for a computer-controlled time-division-switching system for Telex traffic** and for three line concentrators to work as remote message controllers under direction of the central computer.

Addenda

The USSR has announced the Elbrus-2, said to be a fourth-generation multiprocessor of 100 million operations a second. The announcement says **that speed is superior to most foreign computers, but direct comparisons are difficult** because of the vagueness inherent in the MOPS measurement. . . . Official total for the UK five-year support scheme for the semiconductor industry is $127 million. However, **there will be $27 million in development grants** to encourage the adoption of microprocessor technology by general industry, and there is the substantial support planned for the new Inmos firm (p. 42). . . . Researchers at Siemens AG are working with samples of semiconductor stripe-geometry lasers **that promise an operating life of more than 100,000 hours at room temperature while allowing a maximum increase in threshold current of 10%.** The devices are gallium-arsenide/gallium-aluminum-arsenide double-heterostructure laser diodes with stripe widths of 6 to 13 μm. . . . Thyristors that boast **a forward current rating of 3,000 A and reverse and forward blocking ratings of 4,000** V are about to go into production at Toshiba Corp. The company will start using the devices soon and expects to be selling them for $5,000 each next spring. . . . Sweden plans to investigate the **effects of industrial robots on employment, industry survival, and factory environment.** There should be about 5,000 such machines in Swedish factories by 1985.

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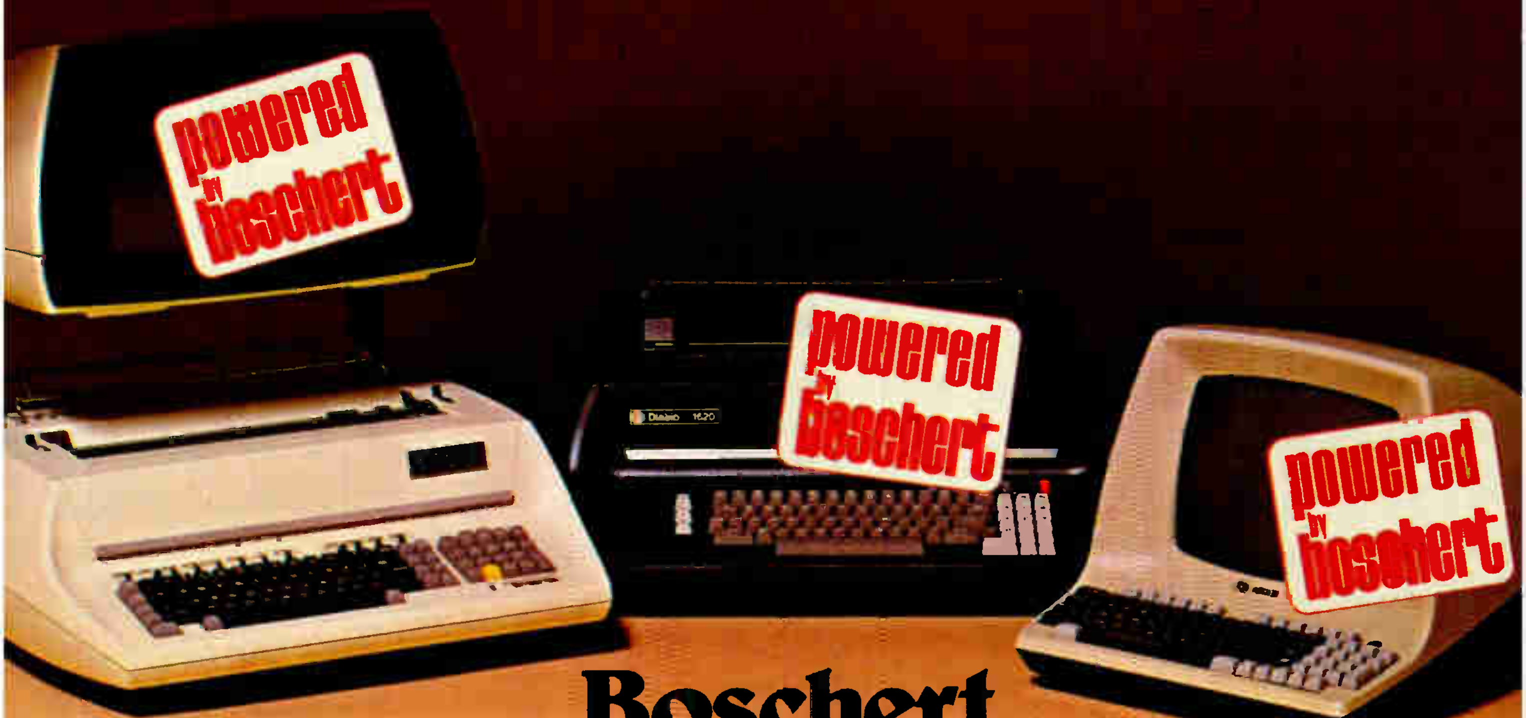

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X-ray lithography system achieves ultrafine resolution

NTT lab's experimental unit overcomes alignment problem of X-ray systems and cuts exposure times as well

The ultrafine resolution of electron-beam lithography plus the speed and convenience of optical pattern making: that's a combination that should prove a hit in the era of very-large-scale integration. It is embodied in an X-ray exposure system under development at the Musashino Electrical Communication Laboratory.

As well as putting down lines 1 micrometer wide, the prototype system can achieve a positioning accuracy of better than $\pm 0.1\ \mu m$. Thus it overcomes the alignment problem plaguing the still nascent field of X-ray lithography [*Electronics*, July 20, p. 84].

What's more, the Nippon Telegraph and Telephone Public Corp.'s lab has already achieved pattern-exposure times comparable to optical lithography: 5 to 10 minutes with positive photoresists, and about 1 minute with negative resists.

Experimental. The Tokyo lab's work is just reaching the point of fabricating practical semiconductor devices. Nippon Kogaku KK (Nikon) of Tokyo built the prototype for Musashino and is working on a commercial prototype scheduled for completion next spring. When sales begin, the price should be between a fifth and a fourth that of the $1.5 million electron-beam units.

The positioning accuracy begins with the system's masks, which are transparent to light, although the gold film that makes up the pattern to be exposed is opaque to both light and X rays. An automatic photoelectric microscope aligns mask and wafer using their target reflections.

Five positioning axes are used in the prototype aligner and exposure unit. They are: wafer horizontal and vertical positions, wafer rotation with respect to the mask's axes, the spacing between mask and wafer, and correction of parallelism of the mask-to-wafer spacing. The leaf-spring support of the positioning table permits fine movements without friction or backlash.

The result is positioning accuracy as high as $0.03\ \mu m$ in experiments (see photo). Overall accuracy, including sensing, positioning and etching, is within $0.2\ \mu m$.

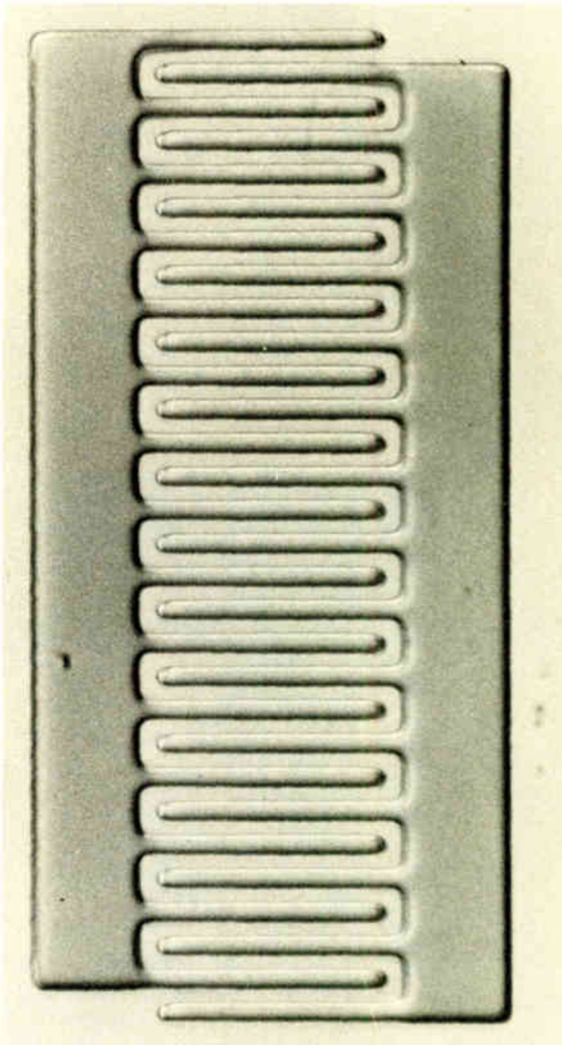
Operation. In the X-ray tube, a potential of 20 to 25 kilovolts accelerates electrons, which strike a rotary target made of copper with a thin film of silicon. The target emits X-rays with a wavelength of 7.13 angstroms, comparable to other experimental X-ray exposure systems.

Where the NTT system exceeds state-of-the-art performance is in its input power of 20 kilowatts, leading to an X-ray output power on the order of 100 microwatts per square centimeter. It is this power that gives the low exposure times.

Exposure is carried out at a predetermined spacing from mask to wafer of 5 to $10\ \mu m \pm 1\ \mu m$, with a distance from wafer to X-ray source of 350 millimeters. While the X rays' slant does cause a $0.05\text{-}\mu m$ displacement between mask and wafer image (for features at the edge of the mask), this is within the guaranteed positioning accuracy.

Exposure is performed in air, for much more convenient operation than with electron-beam systems, in

Clean-cut. Experimental Japanese X-ray lithographic unit exposed the same pattern twice on the wafer. The pattern's clean edges show the precision with which alignment and exposure were carried out.



which vacuum locks are required. Yet another advantage of an X-ray system is that it is unaffected by dust on either resist or mask. Dust is transparent to X rays.

Mindful of the fragility of the ultrathin membranes that make up the masks in X-ray exposure, Mushashino researchers have devised a three-layer film that permits balancing of compressive and tensile stress for maximum strength. The film, silicon dioxide sandwiched between silicon nitride, is about 1.2 μm thick and is fabricated on a silicon wafer that is etched away in the regions that will correspond to chip locations on the wafer to be processed. The circuit patterns are defined by electron-beam lithography on a layer of gold less than a micrometer thick. ☐

West Germany

TV picture looks good after long trip

The pictures on the two color-television monitors were identical, and while the scene wasn't exciting, the duplication was. One, the original picture, came from a tape, but the other had made a 70,000-kilometer round trip to a satellite and back to West Germany's ground terminal in Raisting.

The test was Europe's first transmission of digital TV signals by satellite. The quality of the resulting picture points the way to full-scale commercial development.

Conducting the still ongoing trials is the German ITT subsidiary Standard Elektrik Lorenz AG. Serving as the space relay is the Franco-German communications satellite Symphonie 2. Bonn's ministry for research and technology is sponsoring SEL's work, which began in 1973 with terrestrial digital TV links.

Differential modulation. As is common in terrestrial digital TV transmissions, SEL is using differential pulse-code modulation for its satellite trials. In DPCM, only the differences between adjacent picture elements on the scanning lines (or the differences between a specific element and an estimated value for several neighboring elements—the prediction value) are transmitted.

To be sure, the differential technique calls for more elaborate equipment than does straight PCM. But this drawback is offset by a roughly two-thirds reduction from the PCM bit rate about 100 megabits per second. Hence, DPCM can accommodate much more information in a given bandwidth than normal PCM.

Significantly, the SEL engineers settled on 34 Mb/s for their satellite trials. This bit rate is widely used in terrestrial PCM links, and the European Broadcasting Union favors it as a worldwide standard for satellite PCM systems. The 34-Mb/s rate is suitable for transmitting 480 telephone channels or one complete TV channel together with two high-quality sound channels.

"The aim of our trials is to find out how well the 34-Mb/s rate is suited for satellite TV-signal transmissions under varying conditions," says Roland Burghardt, head of SEL's department for advanced communications development. First results are heartening: on the internationally used 1-to-5 picture-quality scale, the satellite-transmitted picture scored between 4 and 5.

Bit-error rate. That rating is achieved with a bit-error rate of better than 10^{-9} but at the fairly high equivalent isotropic radiated power (EIRP) of 80 decibels above 1 watt for the ground terminal. However, suitable bit-error protection equipment will make possible an EIRP of 75.4 dBW with the same 10^{-9} bit-error rate, Burghardt says.

SEL's experimental DCPM setup uses an 8-bit coding scheme for the picture. The sound signals are digitized with normal PCM techniques and with 14-bit coding. After multiplexing both TV and sound signals, a 34-Mb/s rate is obtained.

The 34-Mb/s signal, together with digital synchronization signals, is fed over a four-phase modulator to the transmitter and then to the satellite. After its reception at the ground terminal, the signal is demodulated and converted into its original analog form. ☐

Good show. Sending a test TV picture on a 70,000-km round trip to a satellite hardly affected quality when SEL used its experimental 34-Mb/s equipment with a 10^{-9} bit-error rate.

Switzerland

Voltage measuring tests hardness

Traditionally, engineers and scientists have checked the hardness of a workpiece by forcing a hardened steel ball or a diamond pyramid against its surface and measuring the resulting dent with a calibrated magnifier. There is a simpler way, says a Swiss company marketing an

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Hopefully, your board-repair pipeline is not as long as that of the field service engineer making a call in the illustration below. The chances are, however, that it's a lot longer than you would like it to be. The length of the repair pipeline is one of the major factors leading to the need for large inventories of spare boards which, in turn, is a major cause of escalating service costs.

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GenRad

electronic hardness tester that in effect measures the voltages induced in a coil when a small test head carrying a magnet is bounced off a workpiece.

There is nothing to measure afterward: the hardness value shows up on the Equotip's three-digit liquid-crystal display, which is linked by cable to the test head. The instrument covers almost the entire range of conventional hardness scales, from the low end of the Brinell soft-material scale up the 940 value of tool steel on the Vickers scale. It provides a readout in L value, a scale named after Dietmar Leeb, the Austrian inventor of the technique. Included with the operating instructions are conversion curves to other hardness scales.

The modulus of electricity of the material under test affects the rebound as well, and this is taken into account in the conversion curves. Among samples of similar materials—mild steels, for example—the L value gives a direct comparison of hardness.

Ratio. There is nothing mysterious about the L value. It is simply the ratio of the rebound and impact velocities of the test head multiplied by 1,000. The harder the material, the faster the rebound speed.

To make the measurement, a spring projects the test head, tipped with a 3-millimeter tungsten carbide ball, off the surface under test. The configuration of the head's permanent magnet and the coil around the guide tube ensure that a voltage pulse develops when the tip is about 1 mm from the surface and headed toward it. A pulse of opposite polarity follows when the head reaches the same point on its rebound.

The two pulses, up to 200 millivolts maximum, go to the instrument's indicator unit, powered by three 1.5-volt dry cells. After amplification, the peak value of each pulse is translated by a dual-slope analog-to-digital converter.

The two values feed to counting circuits that divide them and multiply the result by 1,000 to get the L value for the readout. The result stays displayed until the next test or until the instrument is shut off; there is a jack for a printer as well.

Proceq, the Zurich-based company marketing the Equotip, has priced it at just under $1,800, including carrying case and a test block. It figures the instrument will appeal particularly to users testing the hardness of items too large to go to a standards laboratory. □

Japan

Checkerboard pattern boosts gain up to 11 times in junction field-effect transistors

A new angle on layout and a better-quality junction should open a world of new applications for junction field-effect transistors designed by Toshiba Corp. The new layout increases gain, and the process change cuts an already low noise level.

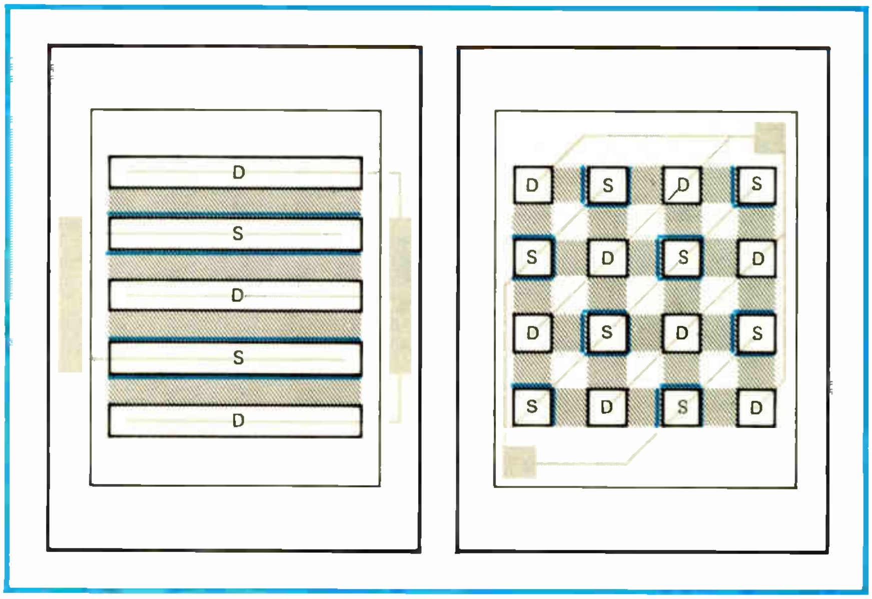
What all FETs have over bipolar transistors is intrinsically low noise and high input impedence. Also, since they can operate at zero bias, they can sometimes do without an input coupling capacitor, which often is a source of noise. But the limited gain of conventional JFETS has restricted use to impedance converters and switches, whereas Toshiba's new devices look like naturals for use in low-level audio amplifiers, equalizers, and tone controls.

Conventional n-channel JFETs have the layout shown at the left in the figure. To obtain high yield and reliability, the area of the active region is kept to a moderate value, but this limits gain.

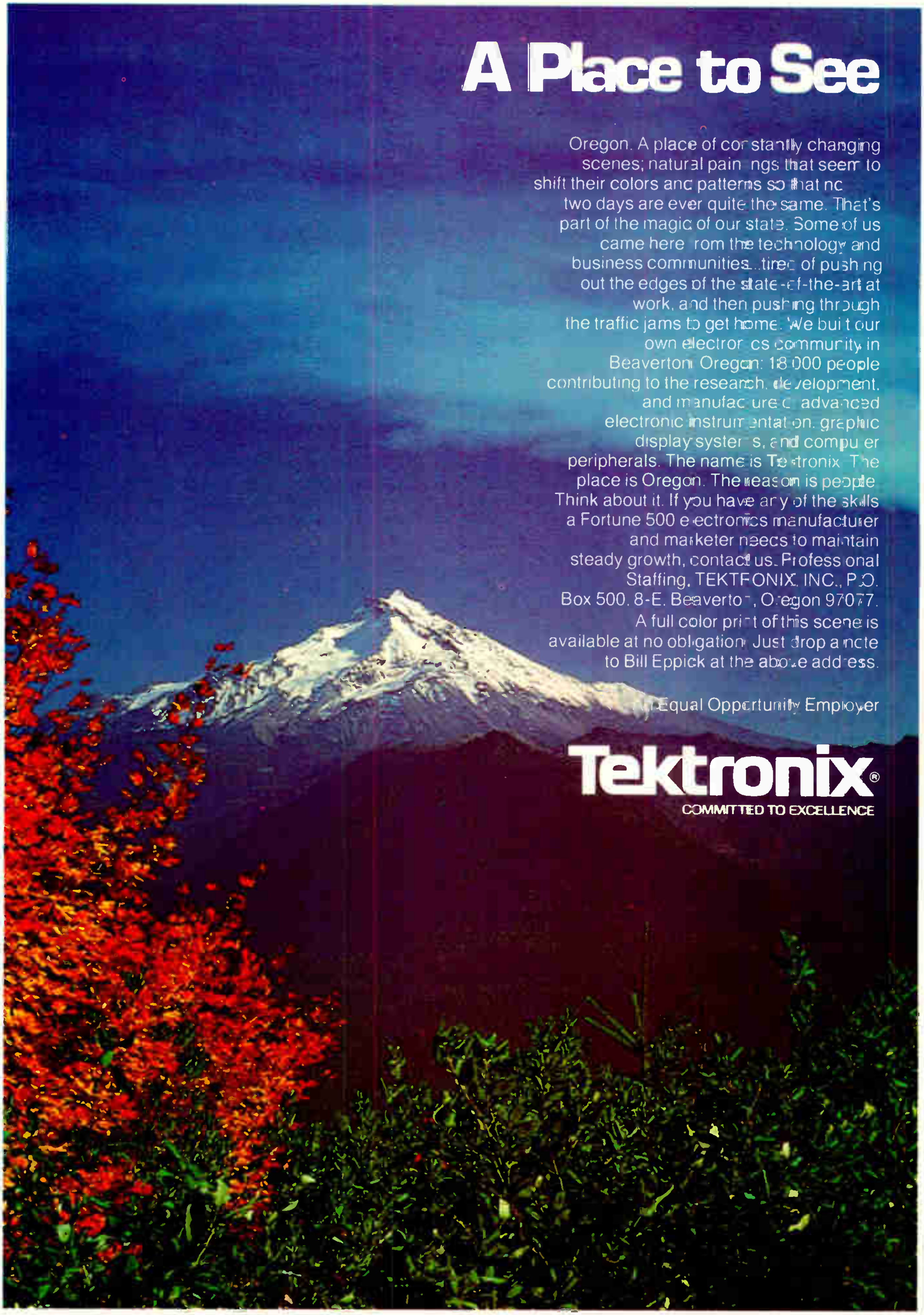
In forming the gates, boron is diffused from a doped silicon oxide, which must be stripped off and replaced with new oxide because it is unstable. However, the exposed junction risks contamination.

Another process problem is that parasitic channels can occur where metalization connecting the drain with bonding pads passes over oxide overlying gates around the periphery of the active region.

The new. Toshiba's new layout looks like the righthand part of the figure. As the colored lines show, the new geometry nets about a 40% greater total channel width with the



Gain up. In new Toshiba JFET (right), channels between source and drain elements have greater overall width, as red lines show, than conventional chip (left). Cross-hatching indicates gate regions; gray lines indicate connections to source and drain contacts.



A Place to See
Oregon. A place of constantly changing scenes; natural paintings that seem to shift their colors and patterns so that no two days are ever quite the same. That's part of the magic of our state. Some of us came here from the technology and business communities...tired of pushing out the edges of the state-of-the-art at work, and then pushing through the traffic jams to get home. We built our own electronics community in Beaverton, Oregon: 18,000 people contributing to the research, development, and manufacture of advanced electronic instrumentation, graphic display systems, and computer peripherals. The name is Tektronix. The place is Oregon. The reason is people. Think about it. If you have any of the skills a Fortune 500 electronics manufacturer and marketer needs to maintain steady growth, contact us. Professional Staffing, TEKTRONIX, INC., P.O. Box 500, 8-E, Beaverton, Oregon 97077.
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same design rules and chip size. The greater width gives transconductance of up to 40 millimhos typical, or up to 11 times that of earlier Toshiba JFET devices. A similar layout appears in new JFETs from Nippon Electric Co.

In the Toshiba devices, better-quality junctions reduce noise to a fifth or sixth that of earlier devices. The better quality comes from a process improvement: a doped polysilicon layer, which is stable and need not be removed, replaces the doped silicon oxide for the boron-diffusion step. Furthermore, the polysilicon shields the substrate from the metalization connecting the drains with bonding pads, thus preventing the occurrence of parasitic channels.

Toshiba is making three basic chips with the new layout and process. One chip appears in the 75¢ 2SK147, usually operated at zero bias and typically drawing drain currents on the order of 10 to 20 milliwatts. It has a dissipation rating of 600 mw. The $1.60 2SK146, a dual with two matched chips of the 147 version, has double the dissipation. Also available are the 2SK117, a smaller 20¢ single unit with a transconductance of 15 millimhos, and the 2SK150, a 75¢ monolithic dual in which each transistor has a transconductance of 12 millimhos. □

Different approaches to a CAD service

Like GEC Semiconductors, Hughes Microelectronics Ltd. in Glenrothes, Scotland, and Racal-Redac Ltd. in Tewksbury are offering computer-aided design services for designers of complementary-metal-oxide-semiconductor integrated circuits. All three approaches share the concept of a library of standard logic-cell designs, but they differ considerably in the degree of design automation.

Hughes offers its Comic service, and spelling out the acronym gives an idea of the degree of automation: the customer-organized MOS-integrated circuits service hands over the design responsibility to the circuit designer. It is an easy-to-use process with wide-tolerance design rules. Its development was financed by the United Kingdom Ministry of Defence, with the aim of setting up an inexpensive CAD service producing C-MOS custom circuits that could be multisourced. So design tolerances have been relaxed to accommodate different manufacturers' processes.

The customer takes about half a day to lay out his design in a special format and to enter it on a Hughes Calma graphics terminal. Then the computer takes over and produces a block diagram complete with interconnections and a logic diagram with all necessary labeling. After the customer enters any necessary editing, the computer spews out the final plot.

The Racal-Redac system uses semiautomated layout techniques, and the firm takes full responsibility for the design from the customer's complete logic diagram. "We can use more finely toleranced design rules than Hughes, and consequently can produce more economic chips," says Ian Truson, marketing manager for the Redmos process.

However, Hughes points out that for small production runs, the absolute minimum chip size may not be critical; moreover, their service has guaranteed confidentiality since the designer retains control at every stage. All three companies agree that there is room for each in the custom-design marketplace, where a fourth competitor—Swindon Silicon Systems Ltd., formed by a group of ex-Plessey engineers—is ready to start offering designer-crafted circuits in a variety of processes.

Great Britain

CAD service zips through its work

Completed layouts of complementary-metal-oxide-semiconductor integrated circuits within minutes is the promise made by GEC Semiconductors Ltd. for its new computer-aided-design service. Its highly automated process uses a library of logic-cell designs and can perform cell placement and interconnection tasks without designer intervention.

Fast. "We have had a customer come in with a logic diagram to discuss a custom solution, and by the time he has left the meeting, we have been able to give him the proposed cell layout complete with interconnections and an estimate of the chip size," says David Broster, section manager for the firm's Cellmos design service.

The CAD service of the Wembly, Middlesex, subsidiary of General Electric Co. Ltd. is cheaper, as well as faster. Thus it makes computer-aided design much more attractive for relatively low-volume applications where the cost must be spread over fewer ICs. The lower cost is largely due to the library of standard cell designs, a feature Cellmos shares with the CAD services of two other British companies (see "Different approaches to a CAD service," above).

To use Cellmos, the designer need only list the logic cells in his system and all interconnections on a symbolic logic diagram. After compatibility checks, the GEC4070 mainframe computer initiates an automatic placement and routing program. Guided by a complex algorithm, this program works through different permutations of cell configurations to minimize the interconnecting tracks.

Real estate. Laid between the rows of cells, these interconnection tracks can account for as much as 50% of the IC's real estate. GEC Semiconductors thinks its algorithm will reduce this wastage even below the savings possible with a designer doing an optimized layout.

The computer also carries out a full logic-circuit simulation, producing a set of waveforms in 1 to 13 minutes. From these, the customer can verify that the IC works as intended.

"It's a simple matter to generate a test tape," says Broster. "Each gate in turn is exercised until a discrepancy shows in the output. Other gates are averted, and patterns are identified to check all logic gates." □

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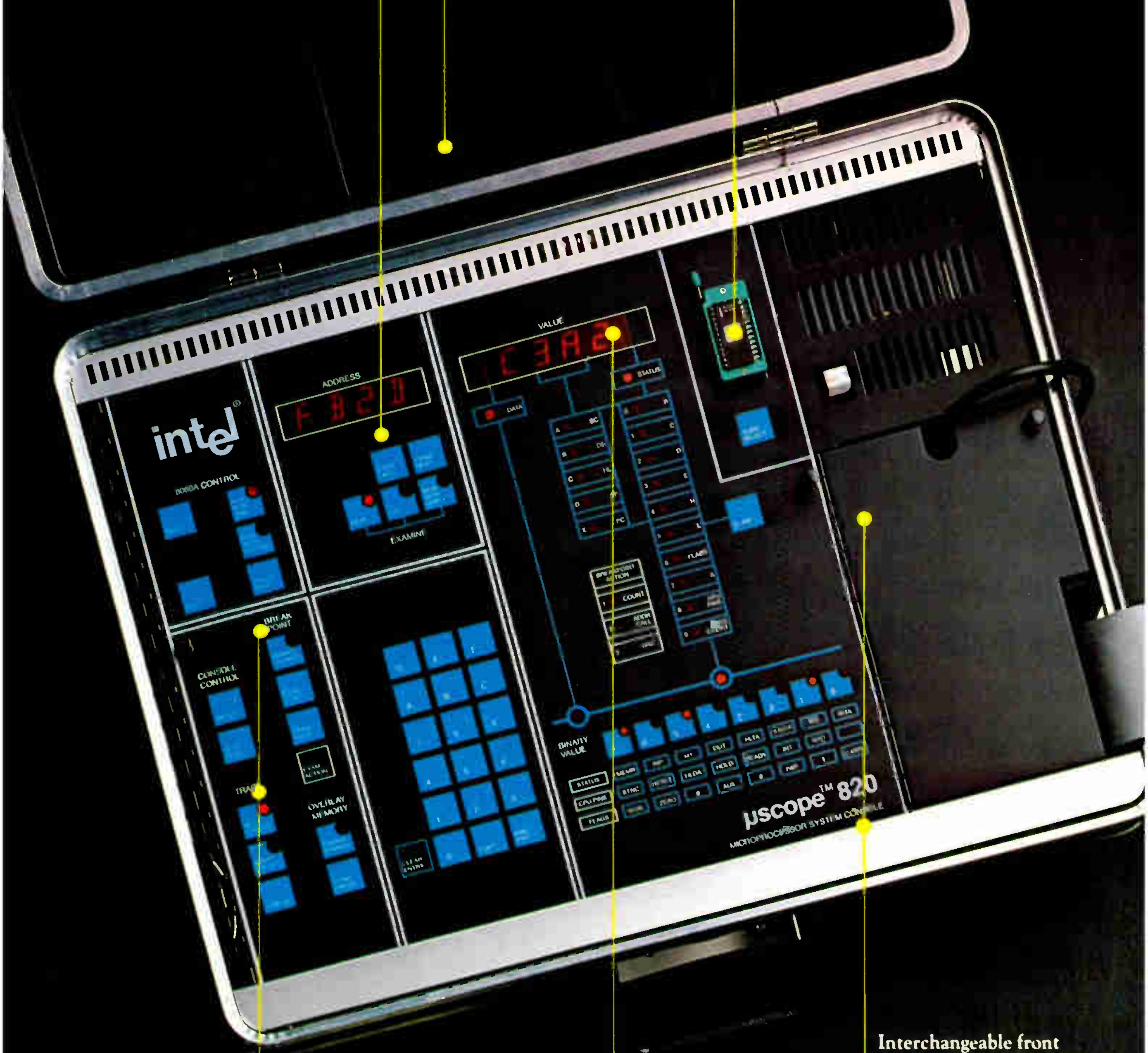

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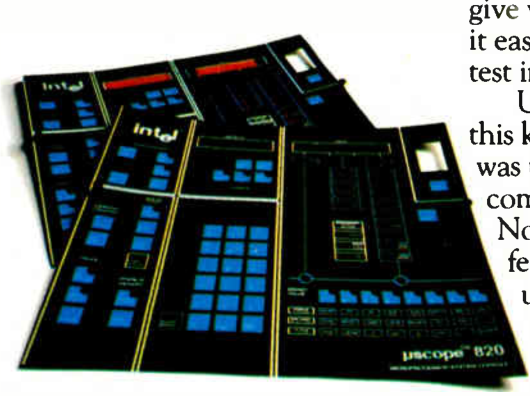

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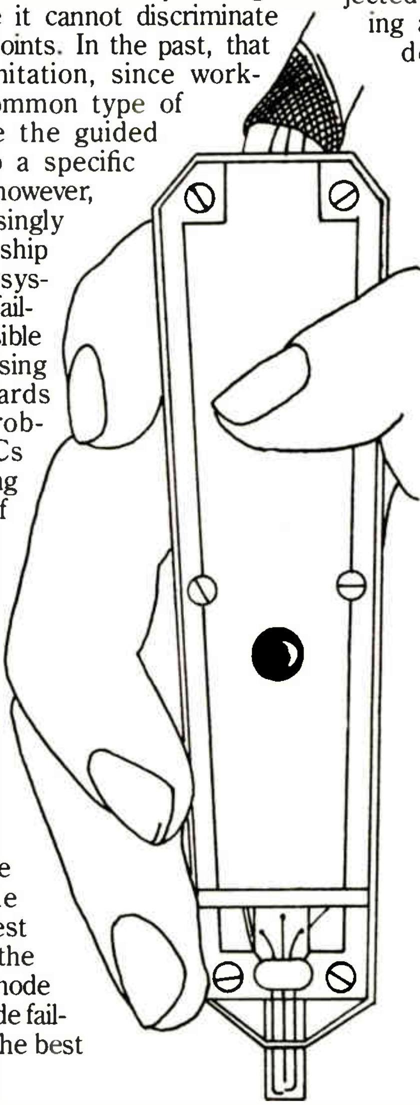
The electronic knife

On the cutting edge of board-testing technology

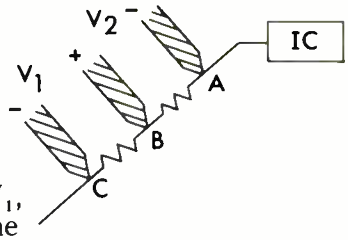
Ever since its introduction by Teradyne in 1972, guided probing has been the accepted technique for tracking down functional faults on a circuit board. All the leading functional board test systems now include guided probes, and Teradyne offers an automated version for high-volume applications.

Conventional guided probing does, however, have one shortcoming: Its fault diagnosis is almost always ambiguous to some degree, because it cannot discriminate between electrically common points. In the past, that has not proved a serious limitation, since workmanship errors (the most common type of fault) are easy to spot once the guided probe narrows the search to a specific section of the board. Today, however, with in-circuit testers increasingly used to screen out workmanship errors, the functional board test system is left with mostly device failures, which are of course impossible to detect visually. The increasing use of bus-oriented LSI boards further complicates the problem, since a great many ICs may be connected to the failing node. One can replace each of the suspect ICs in turn, of course, but that's usually too time-consuming to be practical. Besides, trial-and-error replacement of 40-pin LSI devices can easily do the board more harm than good.



Teradyne's answer to this problem is the "Electronic Knife," a revolutionary new probe designed to sense the impedance of an IC relative to the impedance on the rest of the node. Since the IC with the lowest relative impedance is generally the one controlling voltage on the node (and thus responsible for any node failure), the Knife is far and away the best method devised for finding a bad IC without pulling it off the board.

To sense the relative impedance, the probe contacts the IC lead at three points, thus:



The Electronic Knife injects ac at point A, and the fraction of the injected current flowing away from the device causes a voltage drop, V_1, from B to C. The Knife measures and stores this value.

Then the same ac is injected at point C, and the Knife measures and stores V_2, the voltage drop caused by the fraction of the injected current flowing into the IC. From the measurements of V_1 and V_2 the Knife derives the relative impedance of the probed IC.

The voltage drops that must be measured are in the nanovolt region, which means that an ac approach is essential to avoid the effects of dc probe-to-lead contact potentials. Moreover, with the resistivity of various lead materials differing by as much as an order of magnitude, meaningful measurements would be out of the question without the three-point probe approach, which cancels lead resistances out of the calculations. Even then, the measurement technique called for skillful and innovative circuit design.

Before its introduction on the L135 LSI Board Test System, the Electronic Knife took its first cuts on a variety of boards at Teradyne, including many with microprocessors. In almost every instance, the Knife zeroed in on defective ICs with deadly precision. Clearly, the fast-moving technology of circuit-board testing has just made another fast move.

TERADYNE

Early reaction to ACS is wary

Even though AT&T's proposed dial-up digital service seems to aim at IBM, computer and communications firms are not happy

by Anthony Durniak, Computers Editor

In proposing to operate a dial-up digital data-communications service, the American Telephone & Telegraph Co. has sent shock waves through the data-communications and computer industries. As is to be expected, companies are divided about whether the shock will generate good or ill.

Considered by many to be aimed against IBM Corp., the proposed Advanced Communications Service [*Electronics*, July 20, p. 41] would therefore also help IBM's competitors establish a beachhead in the giant computer firm's installed base of computer and terminal users, now estimated at almost 80% of the market.

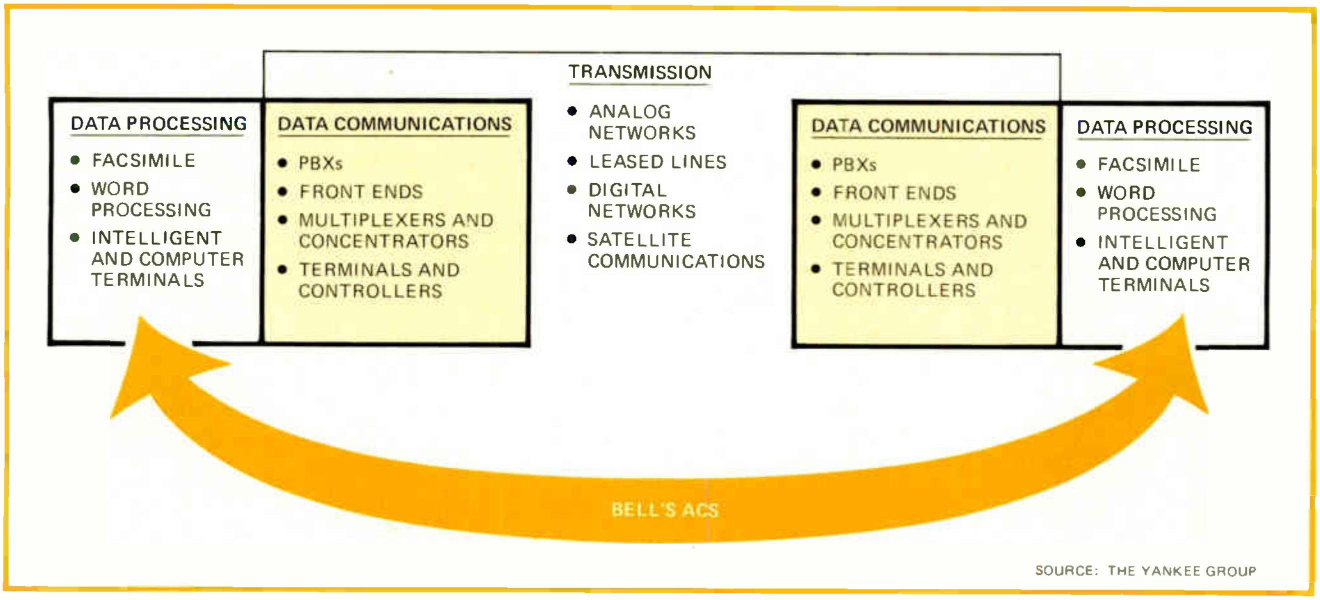
But the industries are not welcoming AT&T and its ACS as allies just yet. Instead, they fear that the phone company, with its regulated monopoly status, will have an unfair advantage in offering services and equipment similar to what they provide now.

At the heart of the controversy is whether the protocol transparency and other advanced message-editing and -handling features of ACS constitute data processing and are thus ineligible to be offered by a regulated common carrier such as AT&T. Similar issues were raised when the phone company introduced its Dataspeed 40/4 synchronous cathode-ray-tube terminal with editing capabilities. But a Federal court of appeals upheld a decision by the Federal Communications Commission that the editing functions were not data processing.

For its part, AT&T cites the Dataspeed decision as precedent and claims that "the provision of ACS as a common-carrier communications service is fully consistent with well-settled FCC policies and decision." Still, the industry is not convinced. A. G. W. (Jack) Biddle, president of the Computer and Communications Industry Association, which speaks for many of the vendors, says he "is very concerned that the proposals for storage of the user's data and programs by ACS will be expanded to the point where, in fact, AT&T will be providing a full range of data-processing services."

IBM itself also jumped into the fray. "Since ACS includes functions which go far beyond pure transmission," it said, "AT&T should be free to offer it as a separate nonregulated service but not as part of its regulated transmission service."

Associated with the regulatory issue is the question of how to



Battle map. In the communications data-processing marketplace, computer makers want to keep AT&T restricted to the transmission area, and AT&T wants to pin the computer and terminal makers in data processing. The areas of overlap, are where battle is going on.

prevent AT&T from using revenues derived from its regulated monopoly communications activities to cross-subsidize its development of equipment and services that compete with the unregulated computer industry.

"What they've proposed to do is provide data processing," says Charles Johnson, president of General DataComm Industries Inc., Wilton, Conn., a maker of modems. "I have no objection to that, but they should separate out the research and development funds used for it."

In addition, ACS could encroach on units offered by word-processing and facsimile equipment makers and on services offered by the few specialized common carriers that now offer packet switched services.

However, one of these common carriers, Telenet Communications Corp. of Washington, D. C., welcomes the competition. "We believe that AT&T's belated plan to enter our business will significantly stimulate user interest in packet data-network service," says company president Anthony A. Barnett.

Data-communications equipment suppliers that now offer modems, multiplexers, data concentrators, and network-monitoring and -control equipment are more unsure of the extent of the impact ACS could have on their business. As Arthur Carr, president of the Codex subsidiary of Motorola Inc., notes, "There is no one company or technique that captures 100% of the market. It won't eliminate networking by the larger and more sophisticated user who wants control over his network."

The one group with the most to gain appears to be the users. For example, Robert Kaufman, manager of data communications at Damon Corp., a medical laboratory service based in Needham, Mass., says: "ACS will offer high-speed synchronous services not currently available from anyone. As a potential user, I'm looking forward to it. I'm betting on it being better and cheaper."

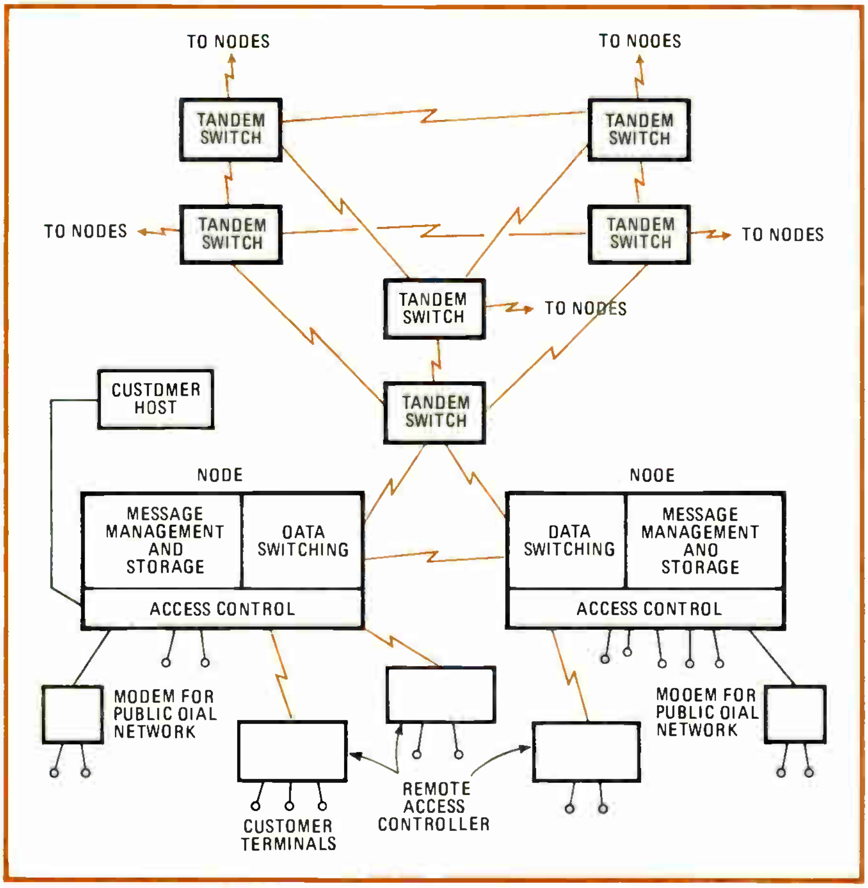
Encouragement. In theory, at least, many industry members and observers agree that a nationwide dial-up digital communications network that would be protocol-transparent would make data communications easier and thus encourage new users and broaden the market. "Anything that ultimately lowers communications costs stimulates demand for hardware and services," notes William Becklean, a securities analyst with Bache Halsey Stuart Shields Inc. in New York.

At the same time, such a system would free the equipment suppliers from worrying about spending development money on communications procedures. "If I can deal with one protocol, I can give more functions to the user and spend less time and equipment power in emulating various protocols," says Eliott D. James, vice president and general manager of Harris Corp.'s Data Communications division, Dallas. "It reduces my front-end development costs."

Delay. In any case, it appears that it will be many years before the FCC will reach a decision and, if favorable, before AT&T can start to implement the service and make it available to users. The commission has called for comments on AT&T's request for a declaratory ruling that it be allowed to file for a tariff, and most members of the industry are preparing such documents.

The summer will be gone, says one FCC staff member, before those comments can be assembled and evaluated by the Common Carrier Bureau for presentation to the commissioners, who must then find a place on their crowded calendar to begin consideration of the issue.

In view of the heated opposition that appears to be brewing, betting now within the FCC and the telecommunications industry is that the commissioners will be obliged to forgo a declaratory ruling and assign a docket number to the proposal. Such a decision would guarantee a prolonged inquiry with extended hearings. Compounding the FCC's internal problems in handling the petition is the mid-July departure of the Common Carrier Bureau chief, Walter Hinchman, leaving the bureau temporarily leaderless. □



Connections. Customers are connected to access control units at ACS nodes. Message-management portion stores and forwards and executes custom programs. Data-switching area forms and switches data packets. Shared lines connect nodes, switches.

Companies

Simplicity pays off at Nedco

Two-year-old minicomputer company features systems that are inexpensive and require little maintenance

by Lawrence Curran, Boston bureau manager

If someone asked you to name a minicomputer company that got its start within the last five years and can be considered successful today, chances are you couldn't. But little-known New England Digital Corp. may have the staying power to become a success.

The vital signs to date are good. Located in rustic Norwich, Vt., the company shipped its first 16-bit minicomputer in 1976 and now has more than 50 systems installed, most of them in scientific applications at nearby Dartmouth College, just across the Connecticut River in Hanover, N. H.

But competition in the mini market can be withering for a company Nedco's size, and officials there know that established mini vendors will not make it easy for them once Nedco gets more visibility. "The sell is uphill," concedes Yale Grayson, vice president for marketing, "but once sold, our current customer base is our best referral sales too." If so, having Dartmouth as its biggest customer and having a marketing representative only in New England, Nedco evidently has to tell its story—a simple system requiring little maintenance—more broadly outside that region.

Nevertheless, Nedco has fiscal (and calendar) 1978 bookings of about $1.5 million and is financed entirely out of profits. The average price of its ABLE systems (see "The ABLE series," p. 83) is $10,000 to $11,000 in single units, or approximately $7,000 each in volume. Grayson is projecting 1979 bookings of some $4 million.

The nonstatistical part of the Nedco story is fascinating. The company traces its orgin to 1973, when Sydney Alonso, now president, started out to build electronic music synthesizers at Dartmouth. With a Sloan Foundation grant to develop a computer-aided instruction program that would teach the instrument to eight students at once, Alonso bought a minicomputer to develop the software. Not being optimized for the music application, the mini was too slow to drive a synthesizer, "so we decided to develop our own computer," Alonso says. Wisely, however, he and Cameron Jones, then a Dartmouth freshman and now Nedco's vice president for software, set out to write the software first.

This led them to select a real-time operating system called XPL, which has been carried over into Nedco's nonsynthesizer-related stand-alone ABLE series. The operating system includes a language compiler that translates a subset of the PL/1 programming language into executable machine instructions for the ABLE series.

The XPL compiler took a year to develop, but just three months after it was finished Alonso and Jones had written a complete time-sharing system for the synthesizer, all the computer-aided music exercises, and synthesizer driver programs. The computer-aided-instruction system went on the air with the outside vendor's mini in January 1974, and only then did the group set out to

The ABLE series

New England Digital Corp.'s ABLE series of minicomputers encompasses four 16-bit models that operate asynchronously with an average execution time of 200 to 300 nanoseconds: the ABLE/20, 40, 60 and 80. Memory interleaving results in an apparent access time of 593 ns. Memory addressing is by word, using the 16-bit memory address bus to directly address 65,536 words. A typical ABLE/40 includes 32 kilobytes of main memory, automatic program load in firmware, a real-time clock, an RS-232 interface line, two mini-floppy disks and contoller, power supply, and handcrafted wooden cabinet. The price of this configuration is $4,650 in hundreds. All four models are in production, and Nedco is quoting 30-day delivery from its plant, a converted residence in Norwich, Vt.

Leaders. Cameron Jones writes program on ABLE/60 for president Sydney Alonso, right, and marketing chief Yale Grayson.

design its own machine.

"We wanted a machine that would look good putting out code from the XPL compiler and an architecture that would represent a good object machine for a compiler," Alonso says. The 16-bit ABLE design is organized around 16 registers and a bus structure Nedco calls the EZbuss, consisting of three main buses. Data transfers are made using a 16-bit bidirectional data bus. An 8-bit address/instruction bus addresses all input/output devices and carries instruction information to the registers and arithmetic-and-logic unit. Memory addressing is done on an independent 16-bit memory-address bus.

Minimal maintenance. To keep reliability high and costs low, medium-scale integrated-circuit technology was chosen for the processor, says marketer Grayson, who hammers away at high reliability in his sales efforts. The two-board central processor uses 74S Schottky transistor-transistor logic for high speed, the main memory is implemented with Intel's high-speed 2114 fully static 4-kilobit random-access memory. "Our philosophy is to build equipment that will work in any reasonable environment without monthly maintenance," Grayson asserts.

Nedco customers do not care how computers work so long as they are as reliable as appliances.

The strategy was worked so far at Dartmouth, which has replaced minicomputers from two other vendors with ABLE systems. And at Creare Innovations Inc., also in Hanover, engineer Paul Hoisington chose a Nedco machine over Data General Corp. and Digital Equipment Corp. systems, principally because the Nedco computer did his job efficiently for an initial outlay of $4,000. Creare is a small research and development firm that is developing hardware and software for pharmaceutical process controls, among other things. "We had a price range of $3,000 to $10,000," he says, "and Nedco was able to meet it."

Now Nedco has to convince some of the world outside the upper Connecticut River Valley that the ABLE's simplicity makes it an attractive alternative to other machines. ☐

Electronics abroad

Italy to push R&D

Government will provide $605 million in subsidies and loans over the next four years to EDP, telecommunications, components

by Jeff Ryser, McGraw-Hill World News

Communications. Italy's government is concerned about telecommunications. Umberto Pellegrini, head of the technology federation, says phone company is key.

Nothing that involves Italian politicians and union leaders can ever be considered a sure thing. But about as close as one can come to it is the Italian government's plan to bolster the electronics industries over the next four years with $605 million in subsidies and low-cost loans, mainly to finance research and development projects.

Already, the money has been allocated by parliament and the guidelines for spending it were spelled out in late June by a special commission under the wing of the ministry of industry. All that is needed to get things going is the accord of regional governments and the unions whose workers are involved. That should come by September, backers of the plan figure.

The plan focuses primarily on three sectors: electronic data processing, telecommunications, and components. However, company executives in these sectors generally rate the governmental effort envisaged as "merely adequate."

Data-processing firms will have access to some $150 million in cash payments disbursed by the government, plus an additional $90 million in low-cost loans channeled through the state credit agency, Istituto Mobiliare Italiano. For telecommunications hardware makers, there is $115 million in grants and a like sum in loans. Finally, components makers will be able to draw on a $80 million government cash fund over the four years that the plan will run and have a credit line of $55 million at the government's credit agency.

Zero. As for the set makers, too many and most too small in the special commission's view, they are down for nothing. "It would be folly to subsidize that sector," says Giancarlo Lizzeri, an aide to the minister of industry and head of the commission. "It would be like throwing money away." Adds another commission member, "What we are hoping is that a company—perhaps Zanussi—will step forward, truly assert itself as a leader, and present the government with its own plan for coordination."

In data processing, the government's aim is to halt a projected decline in R&D spending over the next few years. In the aggregate, funds for research projects now are running about 2.8% of sales. The idea is to boost that level until it reaches about 5%, which would put the Italians about one percentage point below the U.S. spending level. Under the plan, companies that qualify can get up to 90% of the funding for R&D projects from the government and IMI.

Nothing for TV. Giancarlo Lizzeri, a government economics aide, believes Italian TV industry is too small and too splintered to qualify for R&D aid under new program.

No trouble. Needless to say, the company most likely to qualify with the least difficulty is Ing. C. Olivetti et Cie., the sole major Italian-owned office-equipment and computer maker. However, the plan does not necessarily shut out the multinationals, even though many union leaders insist that subsidies should not be handed out to non-Italian companies. As Lizzeri points out, the government and the Communist Party members of the special commission agreed that multinational firms could get R&D grants if their Italian operations are net exporters and they are not merely selling their products in Italy.

Hence the reaction of Carlo Peretti, general manager of Honeywell Information Systems Italia, which meets the criterion. He says that he "views the plan in a substantially positive way." Indeed, his firm is now preparing to submit a proposal to the government to obtain additional research funds.

At IBM Italia, which the government would like to see do more exporting, the reaction was about what one would expect. General manager Renato Riverso thinks that "the plan could be beneficial to the country in the sense that it would improve productivity." But his company, he makes clear, also believes that there should be no provision for protectionism and that "only efficiency and quality of products and services should remain as the basic yardstick for competitive presence in the industry."

Along with the low level of R&D spending in data processing, Lizzeri says that "one of our main concerns is the lack of public spending in this area. That is why we have called for a special commission to study ways in which public agencies can modernize their methods of doing business." Software, too, is a concern, and the government will push for joint ventures among the smaller software houses.

Hoping for two. But it is in telecommunications that the government is most anxious to add muscle by consolidations among existing companies. Although firms will not be forced by law to merge their operations, the government would like to see two groups evolve, one focused on the domestic market and one on foreign markets.

It is hard to see, though, how a group concentrating on exports could thrive without a home market to fall back on. Both Lizzeri and Umberto Pellegrini, president of the national federation of science and technology associations, out of whose study of the electronics industries two years ago came the premises for the government's plan, say the key is the Italian telephone company, SIP (Societa Italiana per L'Esercizio Telefonico).

"Up to now, they have proposed nothing, as it seems they consider the situation uncontrollable," Lizzeri says. " Lack of leadership in the field has forced Italian-based companies to turn to the export market. Though some have been successful, the figures show that on the whole sales are falling off. Personally, I'm not optimistic that our companies can do that much more telephone business abroad."

Similar thoughts about the need for leadership from SIP are on the mind of Simone Fubini, general manager of Telettra SpA, a telecommunications hardware producer in the Fiat group. "SIP is a good company, very well managed," he says, "but it must delineate more clearly a future direction so that suppliers have a better idea of how to proceed." Meanwhile, he anticipates a more cooperative approach to research between his company and SIT-Siemens (which is known outside Italy as Italtel and like SIP is a unit in the government's telecommunications holding company, STET). This is the kind of talk the government likes to hear.

Components. As for components, the government's goal is to ward off the loss of jobs that is sure to come if Italian suppliers cannot stay competitive. Already, government officials point out, foreign firms have more than half of the Italian components market. To keep the foreign companies from becoming even more dominant, the government is counting heavily on SGS-ATES, the leading native semiconductor maker and part of the STET group.

To that company, apparently, will go a substantial chunk of the $135 million that is earmarked for the components sector. Says an SGS-ATES official, "It's apparent that the government is hoping that we can pull some of the other national companies along with us, first through joint ventures and then through subcontract work. We are now working on such a plan."

It figures to be a tough pull for SGS-ATES. Speaking of the components sector, Lizzeri notes, "In Italy it's neither healthy nor controllable. And though this is the area we have the greatest need to manage, it's the one for which we have offered the fewest real suggestions." □

Companies

Western Digital starts climb back

Starts new year looking to double last year's $7 million in revenues with restructured management and sound products

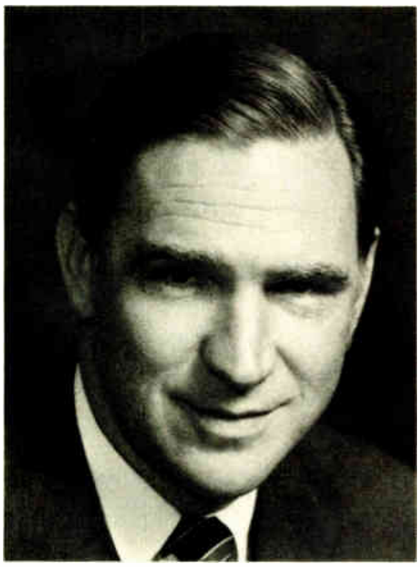
by Larry Waller, Los Angeles bureau manager

Divisions. C. A. Von Urff, left, heads Western Digital's data-communications products division, while L.A. Lotito runs a new division handling computer products.

After racking up losses that reached $9 million in the last four years and almost forced it to fold, Western Digital Corp. has cleaned up its act and is making a fresh start. The eight-year-old Newport Beach, Calif., semiconductor firm, noted for a meteoric rise and fall tied to the handheld calculator market, launches its new fiscal year this month with changed management and restructured operations. That Western Digital survived at all to emerge last February after nearly 18 months of operating under Chapter XI of the Federal Bankruptcy Act surprises many observers, including the company's aggressive president and chairman.

"It's very unusual to make it out," says Charles W. Missler, who has steered Western Digital since May 1977. Tapped by the firm's bankers for the job, Missler knows about Chapter XI, having acted as a consultant to three other companies in similar circumstances. He says revenues for the just-completed year were about $7 million, at breakeven profitability, and the current rate leads him to predict $14 million in sales for this year. Profits should improve steadily, he thinks.

Leader. President C. W. Missler is leading Western Digital to profitability by emphasizing its strengths in data-communications interface chips.



Strengths. On taking over, Missler concentrated on using the strengths he found at Western Digital. One was "a core of good people, here for the two years of trouble, with the quick-buck artists gone and the incompetents fired." He also felt the company's products were sound, "principally data-communications interface chips—and the n-channel silicon-gate technology is as proven, with eight years of experience, as anybody's in the industry." What especially impressed Missler, and gave him hope for recovery, was that "cash flow from the chips paid virtually all operating bills during Chapter XI, which is unusual."

Missler does confess to a concern that Western Digital's thinly traded issue stock, almost entirely handled by a few Southern California regional brokerage houses, has started to move up, trading recently in the $3-a-share range. "This worries me," he says, "since it is getting ahead of itself."

He feels that unwarranted emphasis on stock price is not consistent with his measured plans for growth. So far, analysts have not been beating down his door, but more months of good financial results could reawaken this interest.

Missler also mentions that Western is tight for capital, "but if we perform soundly, we'll find ways to get it." As word of the company's recovery gets around, offers come in, but Missler emphasizes that he is not looking for any fast deals.

From the customer's point of view, Western Digital may be having its financial problems, but there is one good reason to continue using the firm as a supplier: quality of product. Typical of the attitude is the appraisal offered by the head of a small microsystems firm that uses Western as a vendor. For him, he says, the answer was simple: "They were not just the best datacom chips around, they were the first and only ones at that time that did this job."

While a number of firms, including big semiconductor houses, now make such communication interface devices, Western Digital's head start in the early 1970s and subsequent product improvements kept it moving despite the financial pressures. The result is that its major customers today are minicomputer makers that are heavily involved in distributed data processing.

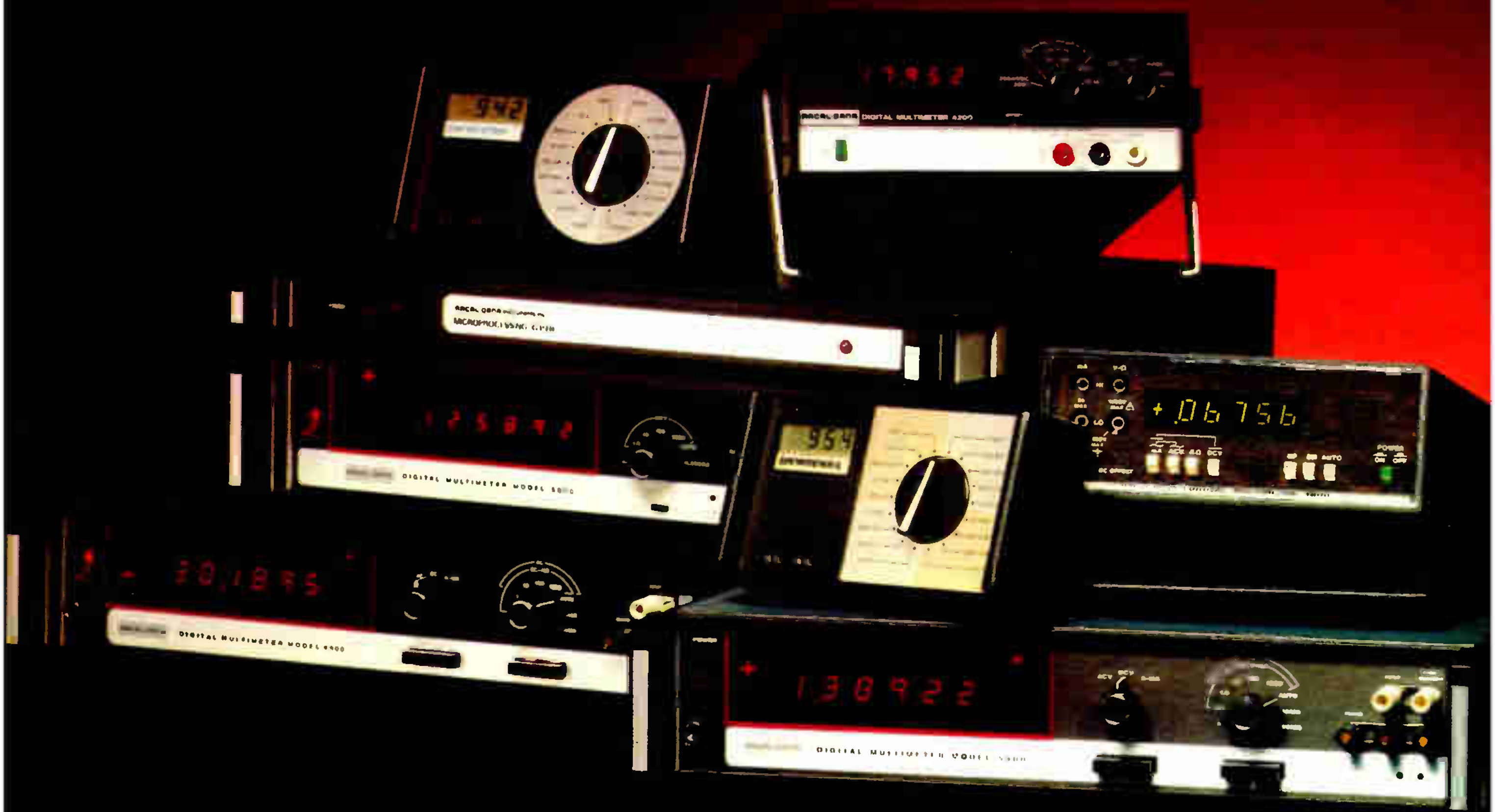
The integrated-circuit chips that carried Western Digital through its lean times are families of universal asynchronous receiver/transmitters and asynchronous/synchronous receiver/transmitters, called the Astro line. These ICs, since improved, caught on as interface devices for linking the burgeoning microprocessor population.

Microprocessor. Not surprisingly, Missler downplays Western Digital's own microprocessor offering, the 16-bit chip set that was one of the first on the market nearly three years ago. The firm not only supplied them to Digital Equipment Corp. for the LSI-11 one-board minicomputer, but the computer company still manufactures a four-chip proprietary configuration for itself. Trying to turn this processor into a standard line overtaxed the small company, even though performance was praised by users. "Our mistake was underestimating the resources it took to be a success with that business," recalls a company veteran.

But Missler is sure about his data-communications prospects and has allotted them a separate division, headed since May by a 20-year semiconductor veteran, Charles A. Von Urff, who ran telecommunications marketing for General Instrument Corp. Along with another new division for computer products, which Larry Lotito was hired in May from nearby Computer Automation Inc. to run, it is expected to account for more than 90% of sales [*Electronics*, July 14, p. 14]. A third division is for control systems products.

Moreover, von Urff is taking over a thriving chip business and Lotito is being handed a hot product that Missler says illustrates both Western Digital's technology and its ability to move fast. "We were able to come up with the 1791 dual-density floppy-disk controller, which is IBM-compatible, in seven months from idea to chip because this is our turf," he says. The company started design in December, providing samples now and production units in August, which Missler believes will give it a six-month edge over competitors.

As for microprocessors, Missler says that "building a general-purpose microprocessor doesn't make sense." But the company is in the nice position of being able to respond to custom applications. These are being evaluated and some will develop into small production contracts, he thinks. □



Model	No. of Digits	DC Volts	AC Volts	True rms AC	OHMS	Programmable Parallel	Programmable GPIB	Auto-Range	MP Based	AC/AC Ratio	Basic DC Accuracy	Base Price (U.S. List)
2000	3½	*	*		*						0.5%	$ 199.50
2100	3½	*	*		*						0.25%-1yr.	$ 249.00
4200	4½	*	*		*						.05%-1yr.	$ 399.00
4324†	4½	*	*		*						.01%-6mo.	$3,295.00
4600	4½	*	*		*			*			.01%-6mo.	$ 549.00
4800	4½	*	opt.	*	opt.	*		*			.01%	$2,995.00
5000	5½	*	opt.	*	opt.	*	*	*			.005%	$ 995.00
5100	5½	*	opt.	*	*			*			.0025%	$ 995.00
5900	5½	*	opt.	*	opt.	*	*	*			.001%	$2,195.00
5940	5½	*	opt.	*	opt.	*	*	*		*	.001%	$3,695.00
6000	6½	*	opt.	*	opt.	*	*	*	*	*	.001%	$2,995.00
6900	6½	*	opt.	*	opt.	*	*	*			3PPM	$3,495.00

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The complexity of bit-slice processor parts, compounded by minimal support from their manufacturers, has won them a poorer welcome than they deserve from designers. Although processors built with bit slices can be extremely powerful, the design flexibility of the parts in both hardware and instruction sets demands an intimate familiarity with a particular family before a designer can be confident of success.

The article that follows opens a two-part series intended as an introduction and general comparison of the various bit-slice products available. Based largely on the authors' many years of experience, it also draws upon the work they did at the Applied Research Laboratories of the University of Texas at Austin on the development of a bit-slice–based sonar interface controller for the Naval Sea Systems Command.

The first article is devoted to the processor element—the chip that manipulates the data. The second deals with the other half of basic bit-slice design—the microcontroller that sequences the instructions—as well as the support products and literature supplied by the manufacturers of families of bit-slice parts. It will appear in the next issue.

How bit-slice families compare: Part 1, evaluating processor elements

by W. Thomas Adams and Scott M. Smith,*
Applied Research Laboratories, University of Texas, Austin, Texas

☐ When they first came on the market, bipolar bit-slice processors were almost totally unsupported by surrounding circuits or design aids, much less by documentation or even advertising. Then, as more device types were brought out by the various manufacturers, it seemed that users had even less way of knowing which bit-slice processors were best suited to their applications.

What follows is a comparative survey, as complete and objective as possible, of both the parts available and the design support offered by the various manufacturers. Such a survey is all the more necessary because of the high level of skill needed to build a bit-slice processor.

Designing with a byte-oriented metal-oxide-semiconductor microprocessor, after all, consists mainly of programming a system made up of components hooked together according to the manufacturer's specifications. But bit-slice processor design involves critical hardware decisions and the creation of an instruction set as well—and only then comes the programming. Moreover, since bit-slice processor parts of different manufacturers can be mixed in one and the same design, consideration must be given individually to each of them.

A look back

In 1974, Monolithic Memories Inc. introduced the first bit-slice microprocessor device, the 4-bit-wide 6701 processor element, though it was marketed as a microcontroller rather than a microprocessor. No family of surrounding circuits and no design aids of any kind were offered to make its use any easier. In 1974 and early 1975, Intel Corp. and Advanced Micro Devices Inc. introduced families of bipolar large-scale integrated circuits promoted as "bipolar microprocessors." That marketing strategy, together with the wide acceptance of the MOS processors, brought customers' attention to the bit-slice devices. These three manufacturers were then joined by Fairchild Camera & Instrument Corp., Texas Instruments Inc., Scientific Micro Systems, Motorola Inc., Raytheon Corp., Signetics Corp., and National Semiconductor Corp., so that now there is a wide variety

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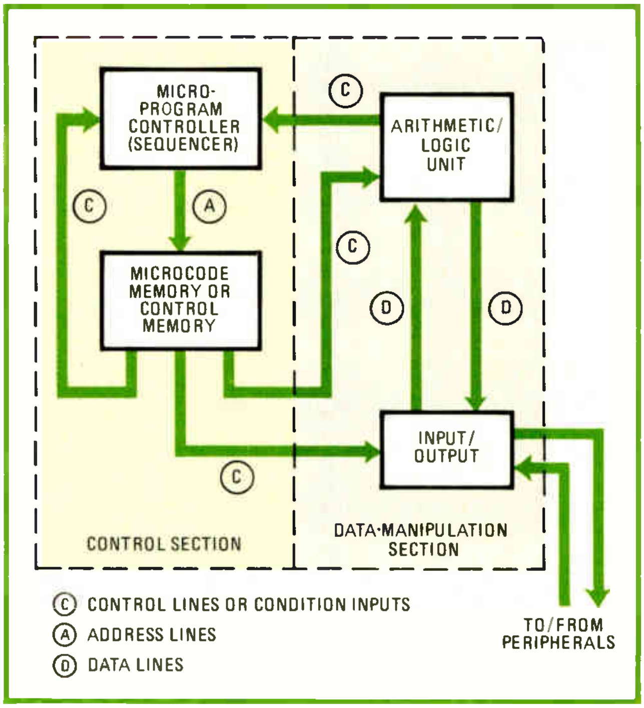
of bit-slice processor parts available to choose from.

A bit-slice processor is built with a multiple-chip set of large-scale integrated circuits that handle data not in complete bytes or words but in 2- or 4-bit chunks. Most often it uses transistor-transistor-logic technology. Such a processor has several features that make it attractive for applications requiring performance beyond the capability of the byte-oriented MOS devices or even such bipolar microprocessors as Texas Instruments' SBP9900 or Signetics' 8X300. These applications include minicomputers, high-speed peripheral controllers, signal processors, and some types of stand-alone process controllers. Also, bit-slice designs use fewer parts than a system built with discrete logic, though they do require more components than other microprocessor designs.

Bit-slice systems are microprogrammable: the designer himself—not the device manufacturer—determines the instruction set of a given processor. Such a feature is invaluable for emulating an existing machine, for example. In addition to being expandable in terms of processor and control-memory word widths, the bit-slice devices are expandable in processing power. Auxiliary arithmetic processors, special input/output devices, and other features may be added to the basic design to provide virtually any reasonable processing capability.

At present, there are six families of devices classified as bit-slice microprogrammable processor sets. These are the 6701/67110 from Monolithic Memories, Intel's 3000



1. Bit-slice basics. Two sections make up a bit-slice processor. One, built around the processor-element chip, manipulates the data. Control and sequencing of microinstructions is handled by the second section, which is built around the microcontroller chip.

TABLE 1: GENERAL CHARACTERISTICS AND ARCHITECTURAL FEATURES OF THE PROCESSOR ELEMENTS

Bit-slice device	Manufacturer	Second sources	Technology	Slice width (bits)	Pins/pack	Typical power required (mW)
9405	Fairchild	Sig	Schottky TTL/C-MOS	4	24 DIP	500 (TTL)
3002	Intel	Sig	Schottky TTL	2	28 DIP	725
6701	MMI	ITT	Schottky TTL	4	40 DIP	1,075
Am2901(A)	AMD	Fairchild, MMI, Mot, Ray, Sig, Nat'l	Schottky TTL	4	40 DIP 42 FP	925
SBP0400A SBP0401A	TI	—	I^2L	4	40 DIP	1,000[8] (programmable)
SN74S481	TI	—	Schottky TTL	4	48 QIP	1,125
MC10800	Mot	Fairchild	ECL	4	48 QUIL	1,374
Am2903	AMD	Nat'l	Schottky TTL	4	48	1,155

[1] Indicated as accumulators + register file + buffer registers.

[2] Two registers in register file are addressed simultaneously.

[3] The program counter is part of the register file, but also serves as a buffer register.

[4] Devices intended to be used with external register-file parts.

[5] The program counter and memory counter are incrementable registers and, in addition, the former feeds back into the 74S481's ALU section.

[6] Has a mask input (2 lines) that may be forced to all 1s or 0s requiring 1 extra bit of control or up to N bits for an N-bit processor if each bit is controlled separately.

TABLE 2: ARITHMETIC AND LOGIC CAPABILITIES OF PROCESSOR ELEMENTS

Bit-slice device	Logical operations[1]	Add/ subtract operations[2]	BCD add	Multiply	Divide	Cyclic redundancy checking generator	Normalize	2's complement sign/ magnitude conversion	Parity	Decoded status[3]
9405	C,A,O,EO	A	–	–	–	–	–	–	–	Z
3002	C,A,O,EN	A,D1,2C	–	–	–	–	–	–	–	Z[4]
6701	C,A,O,EO	A,S,D1,2C	–	–	–	–	–	–	–	O,Z
Am2901(A)	C,A,O,EO,EN	A,S,D1,2C	–	–	–	–	–	–	–	O,Z
SBP0400A SBP0401A	C,A,O,EO,EN	A,S,I1,2C	–	–	–	–	–	–	–	Z
SN74S481	C,A,O,NA, NO,EO,EN	A,S,I1,D1, 2C	–	yes	yes	yes	–	–	–	O,E,AG,LG
MC10800	C,A,O,NA,NO EO,EN	A,S,D1,D2, I1,I2,2C	yes	–	–	–	–	–	yes	O,Z
Am2903	C,A,O,NA,NO, EO,EN	A,S,I1,I2 2C	–	yes	yes	–	yes	yes	yes	O,Z

[1] Logical operations are:
C Complement
A AND
O OR
NA NAND
NO NOR
EO Exclusive-OR
EN Exclusive-NOR

[2] Add/subtract operations are:
A Add
S Subtract
Di Decrement by i
Ii Increment by i
2C 2C 2's complement

[3] Decoded status is:
O Overflow
E Equal
Z Zero
AG Arithmetic greater than
LG Arithmetic less than

[4] Indicated on carryout line during logic operations only.

Registers[1]	Data ports Input	Output	Bidirectional	Control lines
0 + 8 + 1	1	1	0	8
1 + 11 + 1	3	2	0	9[6]
1 + 16[2] + 0	1	1	0	17
1 + 16[2] + 0	1	1	0	18
2 + 8 + 0[3]	1	2	0	11
2 + 0[4] + 2[5]	1	2	1	17[7]
1 + 0[4] + 1	1	0	2	17[7]
1 + 16[2] + 0	1	0	2	21

[7] Does not include bits necessary to address an external register file if one is used.

[8] The SBP0400A/SBP0401A specs are written for 200-mA injector currents. If a 5-V supply is used, total power required by device and injector resistor is 1,000 mW. Both are maximum-speed configurations.

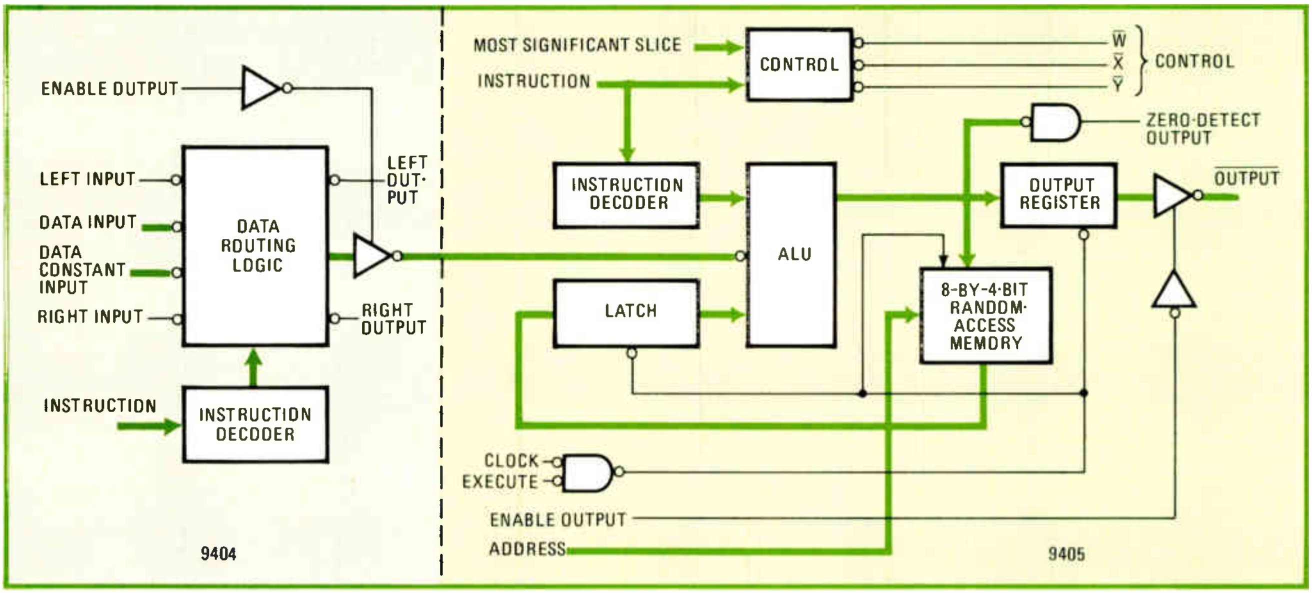
series, Advanced Micro Devices' 2900 series, the Macrologic series from Fairchild, Texas Instruments' 74S481/82 and SBP0400, and the 10800 series from Motorola. The manufacturers market their parts as families of devices that are to be used together to implement a processor.

The basics of a bit-slice processor are illustrated in Fig. 1, which shows a system divided into a control or sequencing section and a data-manipulating section. Accordingly, the two basic parts in any bit-slice family are the microcontroller, which sequences the microinstructions, and the processor element, or arithmetic and logic section. A given bit-slice family may also contain several parts that perform special functions, acting as controllers for interrupt, memory, and input/output, for instance. Other devices like random-access memories, programmable read-only memories, and bus drivers may be marketed as family members or separately.

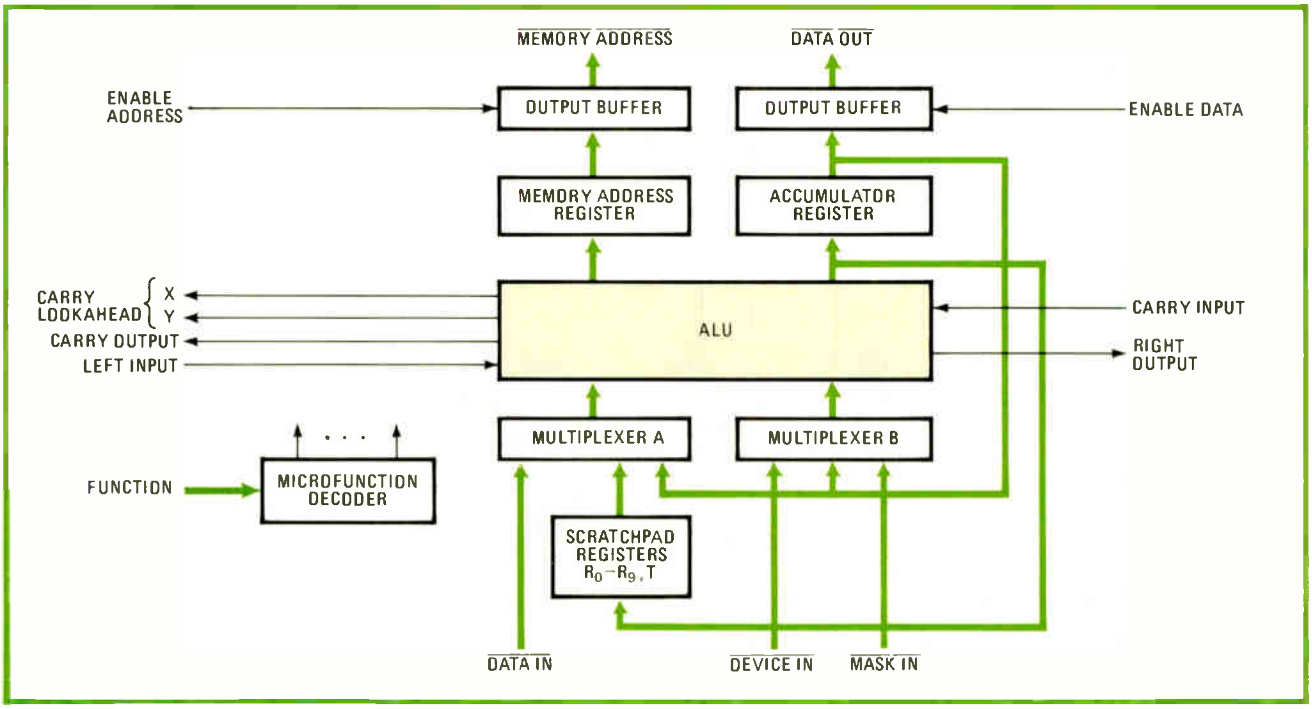
The processor elements

The processor element consists basically of an arithmetic and logic unit and associated registers. It gives the bit-slice microprocessor its name, because it generally handles data 2 or 4 bits wide at a time. The 2- or 4-bit slices are cascaded to form arithmetic processors of the desired word size. Table 1 lists the general characteristics and architectural features of the processor elements. The ALU instruction capabilities of each of the processor elements are shown in Table 2.

The 9405 from Fairchild (Fig. 2) is a relatively simple processor element. It can, however, be combined with Fairchild's 9404 data-path switch (also shown) to obtain a more capable arithmetic processor. Although a two-



2. Two-chipper. Fairchild's 9405, a relatively simple processor element, becomes a capable arithmetic processor when hooked to a 9404 data-path switch. The chip set is also available in a complementary-MOS version ideally suited for low-power applications.



3. Two bits. One of the earlier processor-element designs is Intel's 2-bit-wide 3002. Twice as many 3002s as 4-bit devices are required to build a processor of a given width, but the Intel part compensates by offering more I/O ports than any other processor element.

chip set results, each device is housed in a space-saving 400-mil-wide 24-pin package.

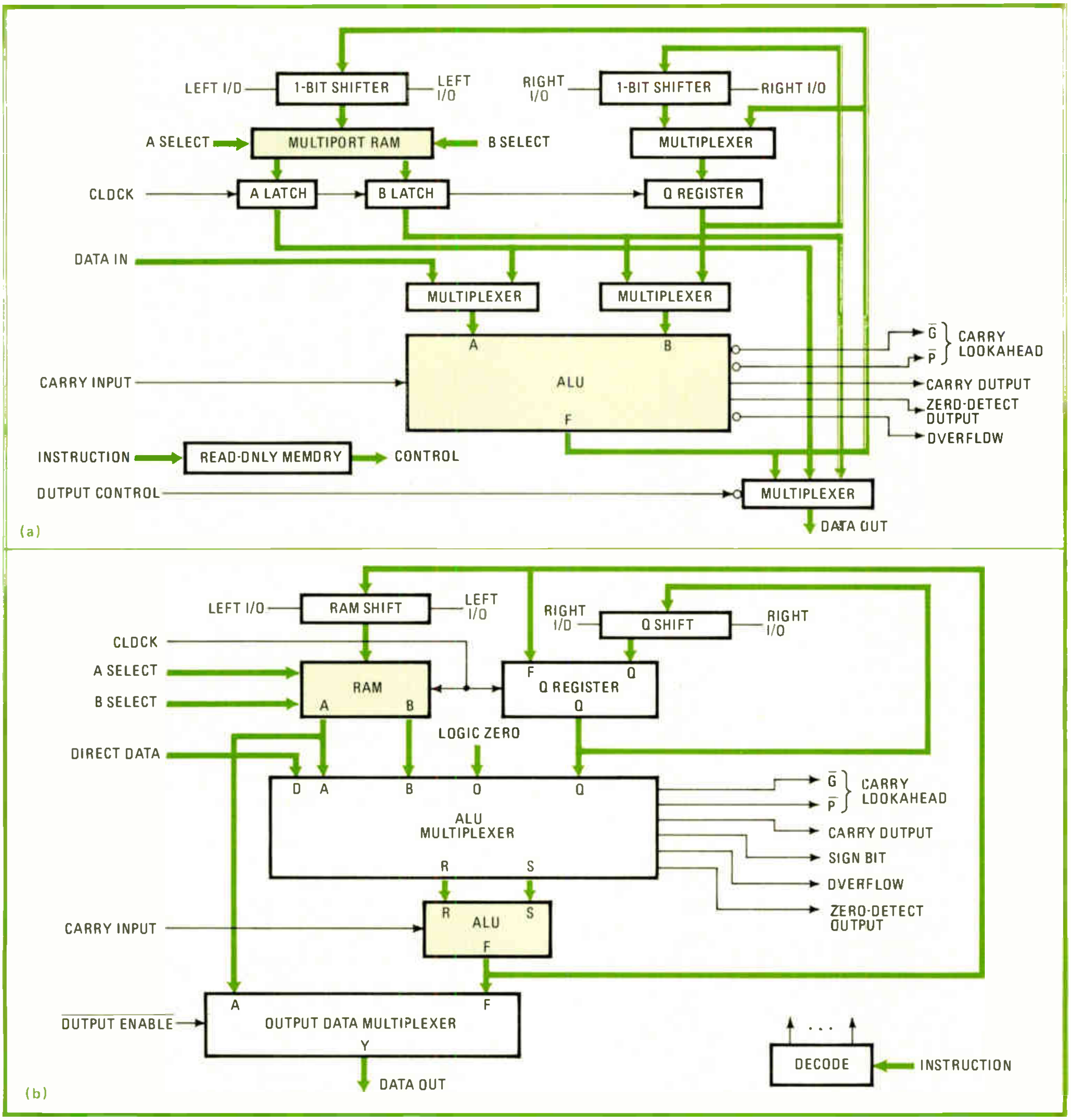
Being on the lower end of the performance scale, the 9405 is best suited for controller and processor applications that are just beyond the capabilities of the MOS and bipolar microprocessors. A plus is that complementary-MOS versions of the 9404 and 9405, ideally suited to low-power applications, are also available.

Figure 3 shows one of the earlier designs, the Intel 3002. Since it handles only a 2-bit-wide slice, twice as many 3002s as 9405s are required to implement a processor of a given width. However, Intel's part compensates by offering a larger number of I/O ports than any other device.

Since the 3002 has a single-port register file, more instructions may be required for some tasks. The trade-off here is the increased number of instructions—and longer execution time—versus the larger number of control lines required for the multiple-port register file.

With its excellent I/O capabilities, the 3002 works better in data-manipulation applications than in number crunching. Signetics offers a version, the N3002, that is significantly faster than Intel's original part.

Although not exactly identical, Monolithic Memories'



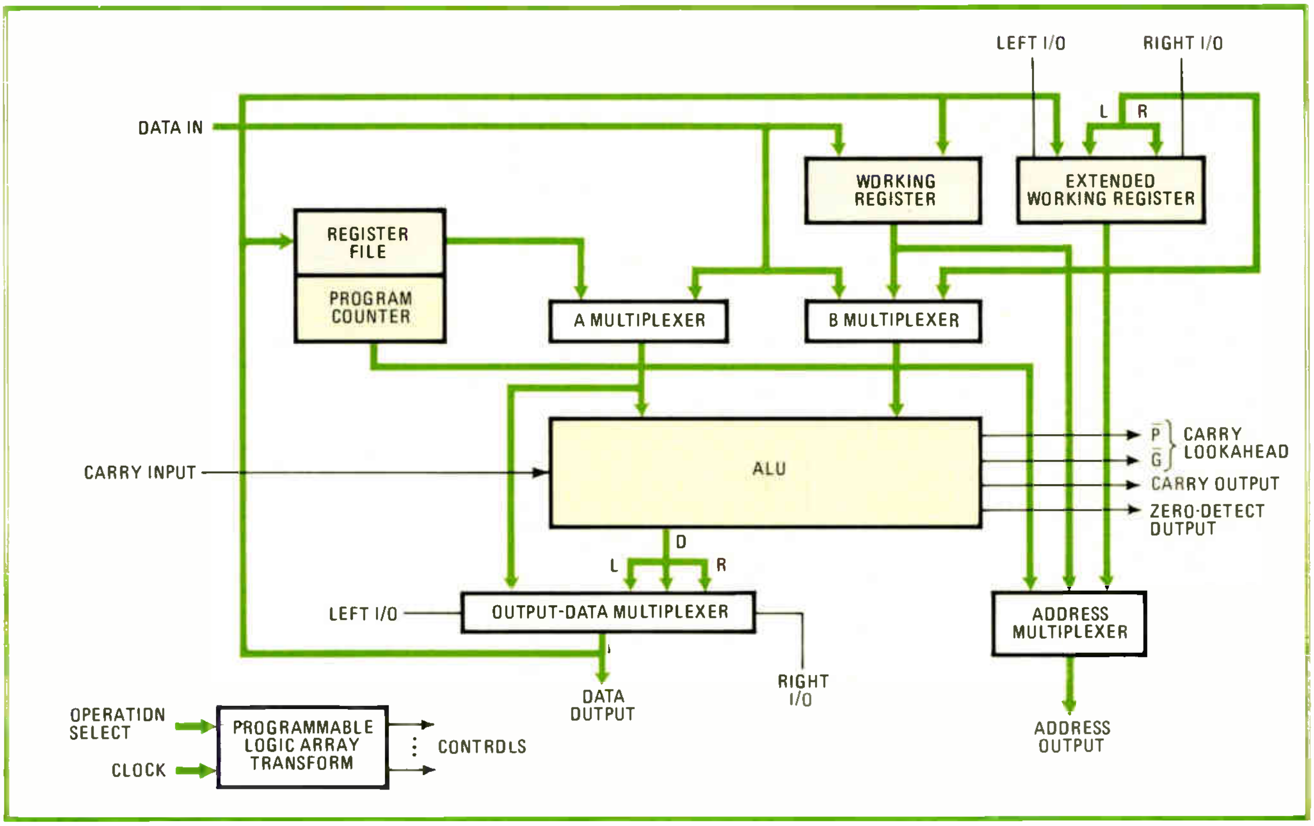
4. Similar slices. The 6701 from Monolithic Memories (a) and the Am2901 from Advanced Micro Devices (b) are architecturally similar processor elements. Outstanding in these are the dual-port, 16-register files and the cascading of ALU and shift matrixes.

6701 and AMD's Am2901 are quite similar architecturally, as can be seen in Fig. 4. The dual-port 16-register file and cascading of the ALU and shift matrixes are the most outstanding features of these processor elements. A separate accumulator with its own shift network is also provided to facilitate multiply and divide operations.

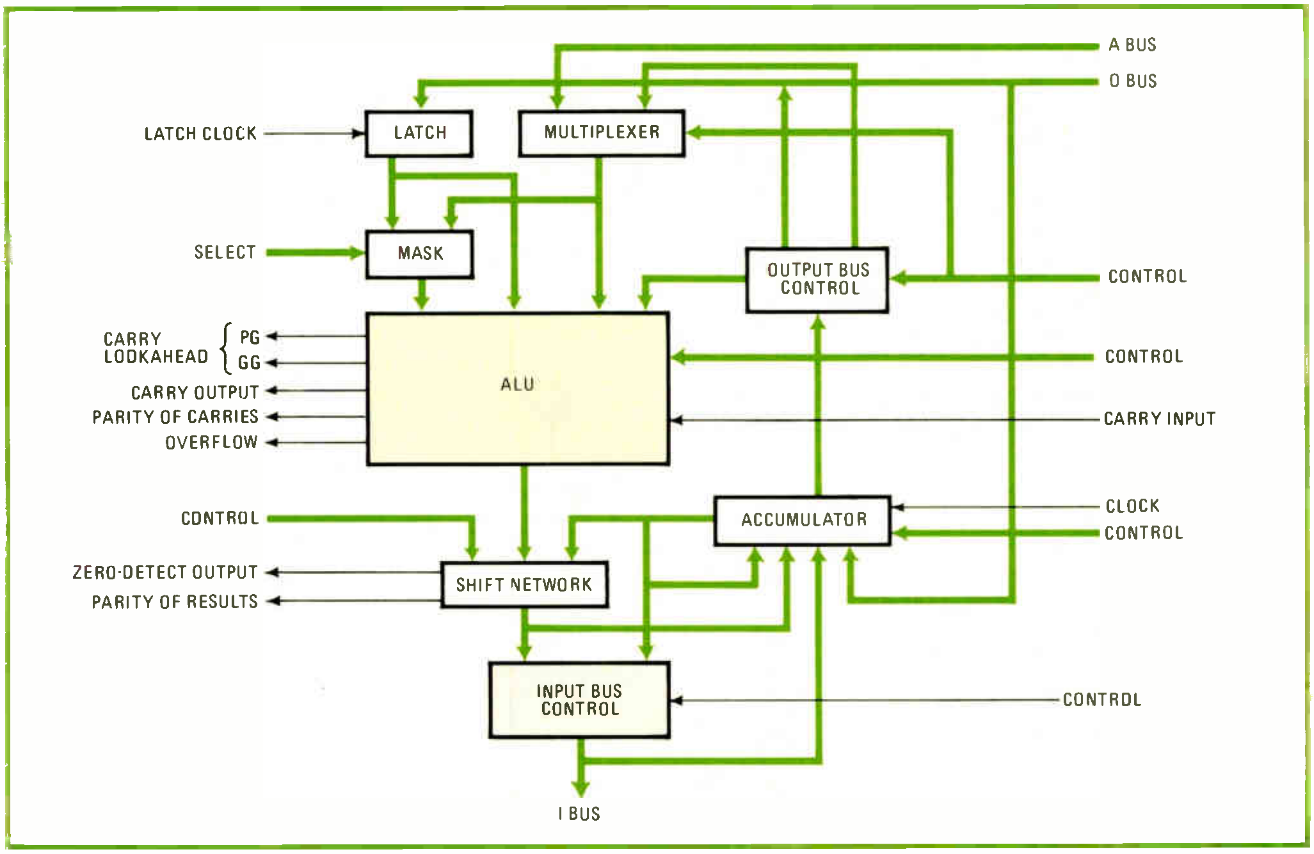
The I/O port structures of the 6701 and 2901 might at first seem limited, but are sufficient in most cases. These devices are competent to handle a large number of minicomputer and controller applications (as evidenced in particular by the sales record of the 2901). A higher-speed version of the 2901, the 2901A, is also available.

There are several other higher-speed versions of the 2901, including an interesting one from National Semiconductor that integrates emitter-coupled logic within the TTL framework. The designer should be aware when using such devices, however, that the slower versions may no longer work in his design, so that he may no longer have a second source.

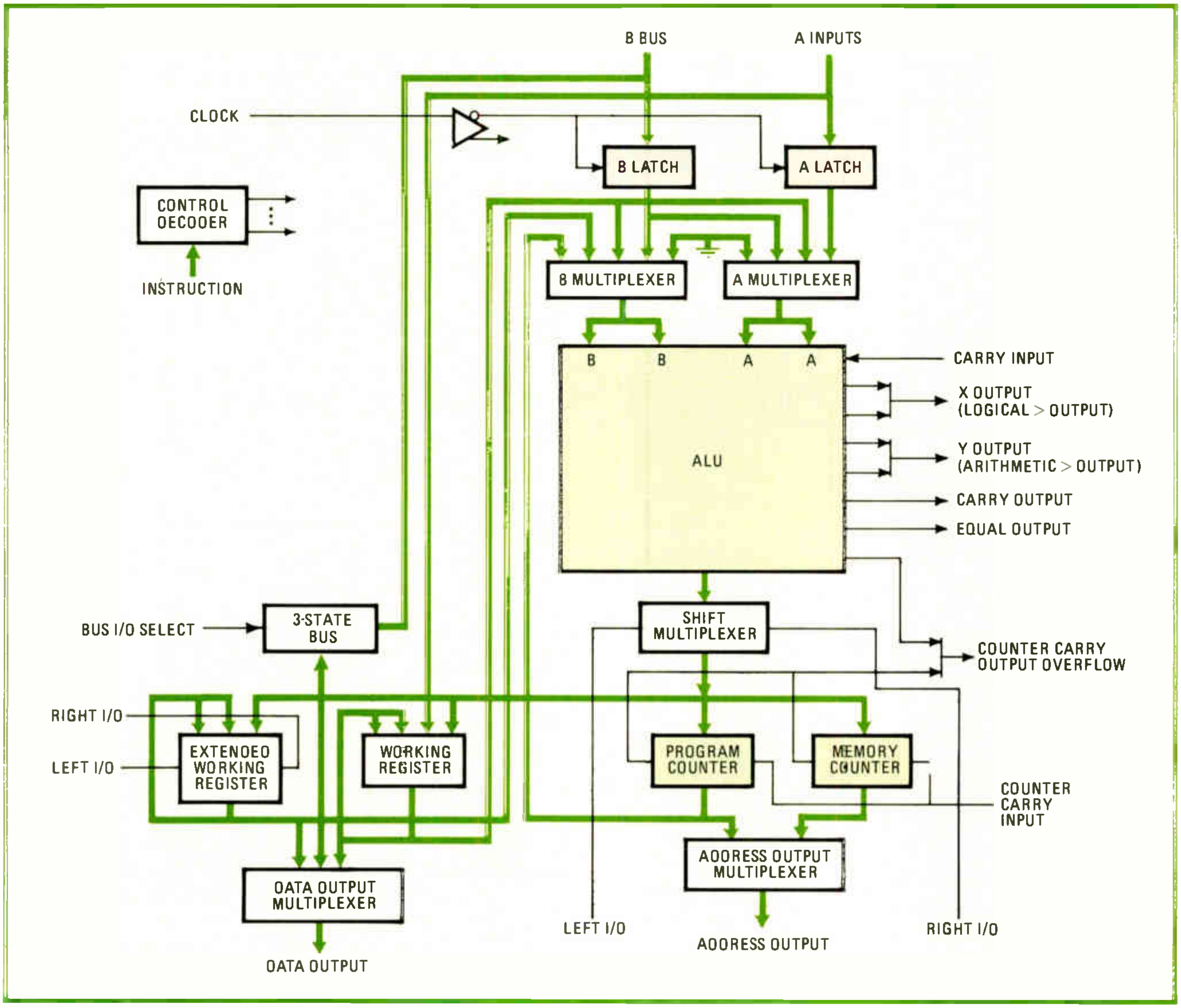
Texas Instruments' first commercial device to use digital integrated injection logic was the SBP0400 bit-slice processor element (Fig. 5). However, it is slower than any of the TTL processor elements, as is even a later and much faster version, the SBP0400A. The SBP0400's



5. I²L version. Texas Instruments' SBP0400, built with integrated injection logic, runs more slowly than TTL processor elements. Unique to the devices, however, is a programmable power dissipation that can be selected over a 1,000:1 range for a constant speed-power product.



6. All ECL. The only processor element built entirely of emitter-coupled logic is Motorola's MC10800. Its pluses include binary-coded-decimal addition and internal parity generation for error checking. Mixing the ECL part with TTL bit-slice families is generally not recommended.



7. Complex. Structurally the most complex processor element available is Texas Instruments' SN74S481. Because of strong arithmetic capabilities, including preprogrammed multiply and divide, the part is optimized towards minicomputer and signal-processing applications.

most outstanding feature is its programmable power dissipation. The power it uses can be programmed over a 1,000-to-1 range while the speed-power product remains constant. But the device would be much more useful if there were other I²L parts to go with it.

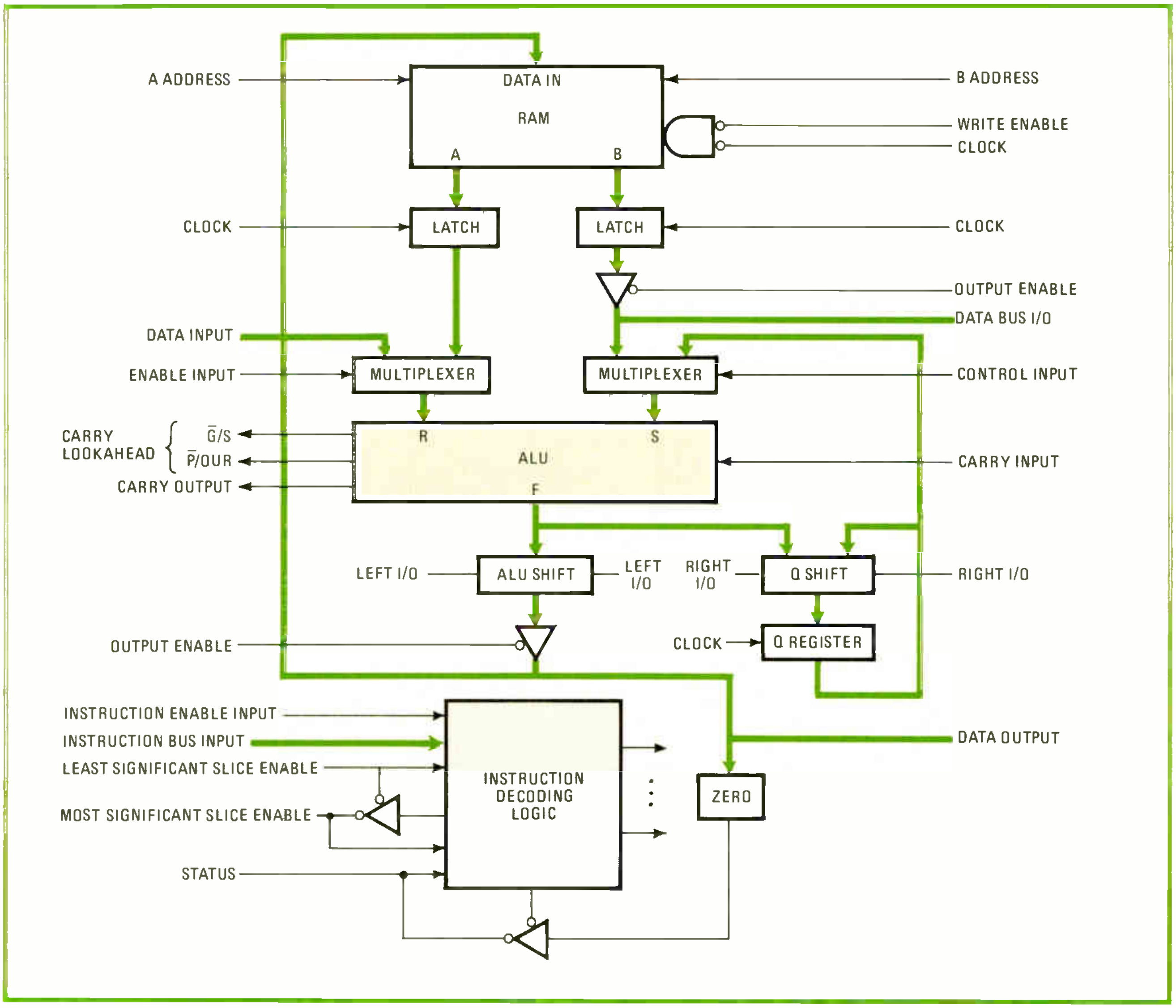
The SBP0400 has several convenient features. Although its register file is essentially a single-port unit, one register designated the program counter may be accessed separately through the address port. What's more, a separate accumulator and extension are provided to support multiply and divide operations, and those registers may be accessed directly through the address port. Any register in the register file may be accessed directly through the data port, bypassing the ALU. In sum, the design of the SBP0400 is convenient and well thought out, but the I²L technology decreases its usefulness in high-throughput applications.

Motorola's MC10800 (Fig. 6) is the only processor element built entirely with ECL and is the fastest part in the group. Although the 10800, like the 74S481, lacks an internal register file, it has an I/O-bus configuration that easily supports an external file. One register file device in the family, the MC10143, has two input ports and one output port; since all of its ports are separately addressable, it is tailored to implementing external register files in MC10800 designs.

While the 10800 has no built-in multiply or divide hardware, it can be microprogrammed to perform these operations. It is unique, however, in providing binary-coded-decimal addition, and it is one of only two devices that provide internal parity generation for error control.

In general, the use of the 10800 with members of the TTL bit-slice families is not recommended in the processor itself because of the required logic level translation and the inherent differences in speed potential between ECL and TTL. The 10800 is a member of a well-designed family of parts that is optimized for use in minicomputers, signal processors, and some types of controllers.

The most complex processor element available is TI's 74S481 (Fig. 7). In number of input and output ports, the 74S481 is second only to Intel's 3002; however, the strong I/O capability is more of a necessity in the TI



8. Refined. The Advanced Micro Devices Am2903 is a refinement of the Am2901. Normalization logic allows the mantissa and exponent of floating-point numbers to be adjusted simultaneously, and multiply and divide logic is also built in, making the 2903 a good number-cruncher.

device because it lacks an internal register file. TI's idea for the 74S481 is for it to be used in a memory-to-memory architecture similar in principle to that of its 990 minicomputer. Latches on both input ports make it easy to use any of several multiple-port RAMs in the TTL family for an external register file.

In addition to the accumulator and its extension, two other registers (which are actually counters) are provided for the express purpose of addressing memory. Either or both of these counters may be incremented while an operation is being performed in the ALU, making the 74S481 the only processor element to offer any form of multiple-ALU capability. Because of its arithmetic strength (it features preprogrammed multiply and divide), as well as the large corresponding number of instruction-control lines and its lack of an internal register file, the 74S481 is clearly optimized toward minicomputer and signal-processing applications.

A recently announced processor element is AMD's Am2903. As can be seen by comparing its diagram (Fig. 8) with that of the 2901 (Fig. 5), the 2903 is basically a refined version of the earlier device. It contains the same internal register file, but is unique in its provision of hooks to expand the file externally if needed. In addition to built-in multiply and divide logic, the 2903 contains normalization logic that allows the mantissa and the exponent of a floating-point number to be adjusted simultaneously. Moreover, as in the 10800, parity is generated for the ALU output, to facilitate error detection and for generating cyclic-redundancy-checking codes.

The 2903 requires four more instruction lines than the 2901 and is housed in a 48-pin dual in-line package as against the 2901's 40-pin DIP. Although the 2903 has several additional basic arithmetic and logic instructions, the 2901 is probably preferable in most controllers and medium-speed minicomputer applications. But the 2903 is an excellent choice for number-crunching applications because of its added capabilities. AMD is in the unique position of having two processor elements in its bit-slice family, each optimized for different applications. □

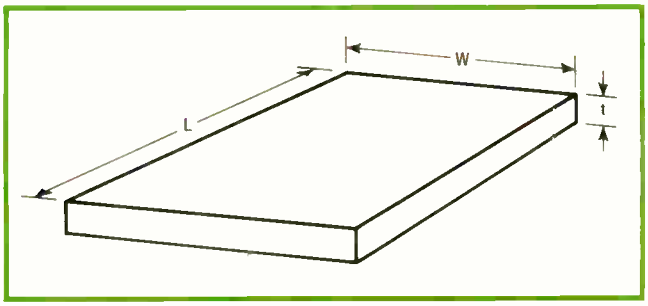
Part 2 of this article on bit-slice processors will cover their microcontroller elements, related chips, and design support considerations. It will appear in *Electronics'* next issue.

Why the design nod goes to resistors made as thin-film monolithic networks

Process adapted from IC making gives microminiature resistors that offer precision performance, convenience, and low cost

by Donald B. Bruck and Allen L. Pollens, *Hybrid Systems Corp., Bedford, Mass.*

☐ Monolithic thin-film resistor networks are rapidly winning affections away from matched assortments of wire-wound and metal-film discrete resistors. Capitalizing on advances in integrated-circuit manufacturing, these microminiature resistors are attractive, not just for small size, but for precision performance, convenience, and low cost, also. By and large, they owe these lures to wafer batch processing adapted from IC manufacture—including vacuum deposition, etching, photolithography, and computer-controlled laser trimming.

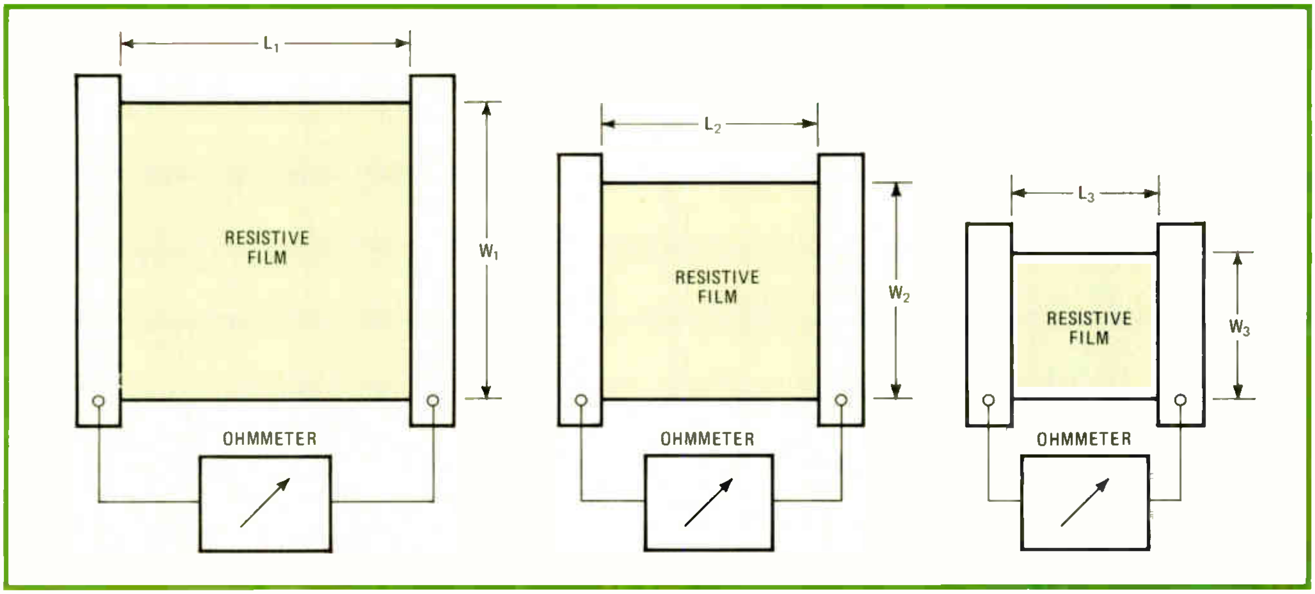


1. Thin-film resistor. The resistance of a thin film is given by the equation R = (ρt)(L/W) where ρ is resistivity, t is material thickness, and L/W is the aspect ratio. Metallic films are usually Nichrome or tantalum nitride, depending on the resistance value required.

Today's thin-film resistor networks are routinely characterized by a ratio match within 0.01%, an absolute accuracy within 1%, a tracking temperature coefficient of 2 parts per million per degree centigrade, noise of less than 0.1 microvolt per volt, absolute drift of less than 0.1% per 1,000 hours (at 125°C), and ratio drift of less than 0.01% per 1,000 hours (at 125°C).

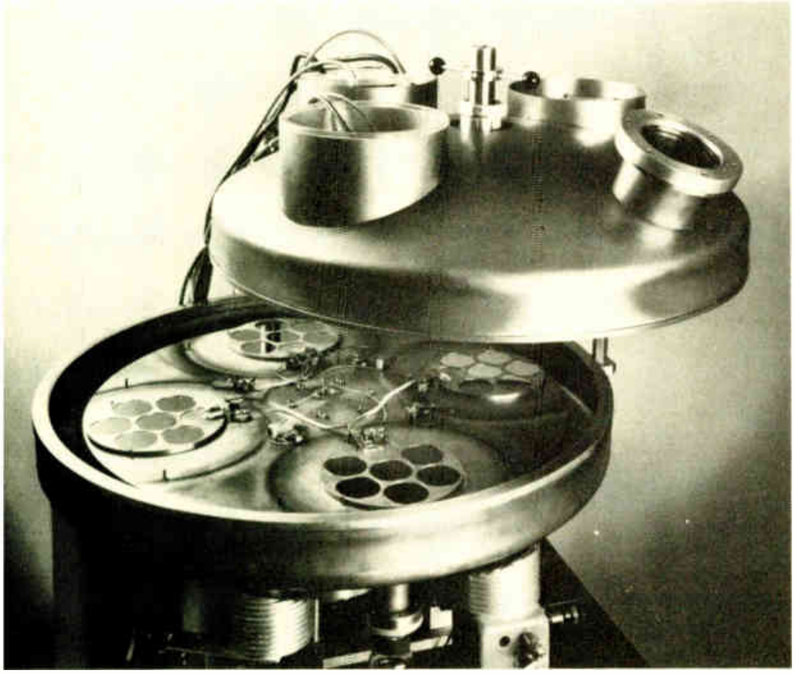
Furthermore, designers find it simpler to specify, purchase, and test a monolithic resistive network than to work with one built with discrete parts. In addition, a thin-film network eliminates all assembly of matched components. Standard and custom configurations are available in TO cans and dual in-line packages, and, if standard IC packages are not small enough, the networks are available in chip form for use in thick- and thin-film hybrids.

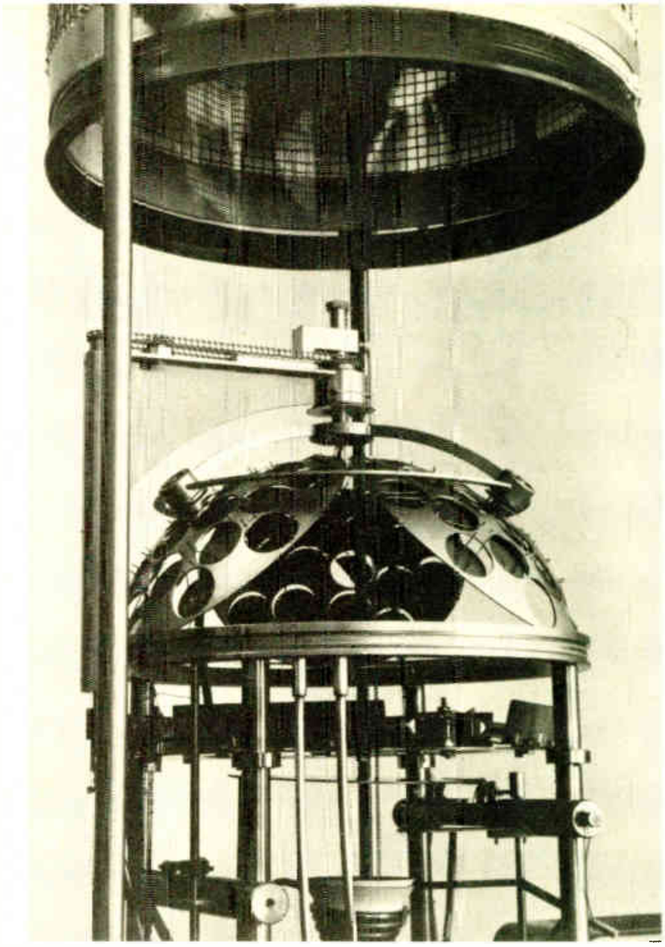
Monolithic thin-film networks are now used in sample-and-hold circuits, precision voltage references, digital-to-analog and analog-to-digital converters, instrumentation amplifiers and preamplifiers, active filters—in fact, wherever resistor accuracy and stability



2. Ohms/square measurement. The ohms-per-square parameter (ρ/t) can be measured by connecting an ohmmeter across the contacts of a film of known exact dimensions. In the case shown, the constant-aspect ratio would result in equal values for each resistive film.

3. Film deposition. Thin films may be deposited on a substrate in one of two ways. In a sputtering system, below, an ion beam hits a metal target causing metallic atoms to land on the substrate. An evaporator, right, is a heat source that boils off metal atoms.





are important to achieving desired circuit and system performance. Such accuracy and stability could not be achieved without the specialized techniques of the thin-film manufacturing process.

The thin-film process is based upon deposition of a metal film, typically of 100-angstrom thickness, on a flat, nonconductive substrate. From Fig. 1, the resistance, R, is equal to the sheet resistance times its aspect ratio, or:

$$R = (\rho/t)\,(L/W)$$

where ρ is material resistivity and t is film thickness. The ratio of ρ/t is known as the ohms-per-square resistance, and the L/W relationship of the sheet's length and width is the aspect ratio. For a constant t, the value of R is a function only of the aspect ratio, so that theoretically the resistor can be any size.

Sheet resistance

Figure 2 shows how the Ω/sq sheet resistance can be measured. Since the aspect ratios of (a), (b), and (c) are all equal:

$$L_1/W_1 = L_2/W_2 = L_3/W_3$$

Therefore, the resistances of each of the different squares of material should measure the same.

There should be no limit to how small a thin-film resistor could be. In practice, minimum line widths are dictated by power-dissipation requirements, the difficulty of etching excessively narrow lines, and so on. Line widths are typically 1 mil and are seldom less than 0.5 mil. For maximum temperature tracking, all the resistors in a network should be of uniform width.

Alumina, glass, and silicon are the three commonly used substrates for thin-film deposition. Substrate choice is a function of the special demands of the application, plus cost and ease of manufacture. Alumina (ceramic) offers the advantage of low substrate-to-network capacitance but must be laser-cut or sawed. Glass can be scribed and broken apart but has comparatively poor heat-transfer capability. Silicon is frequently the material of choice.

Silicon substrate

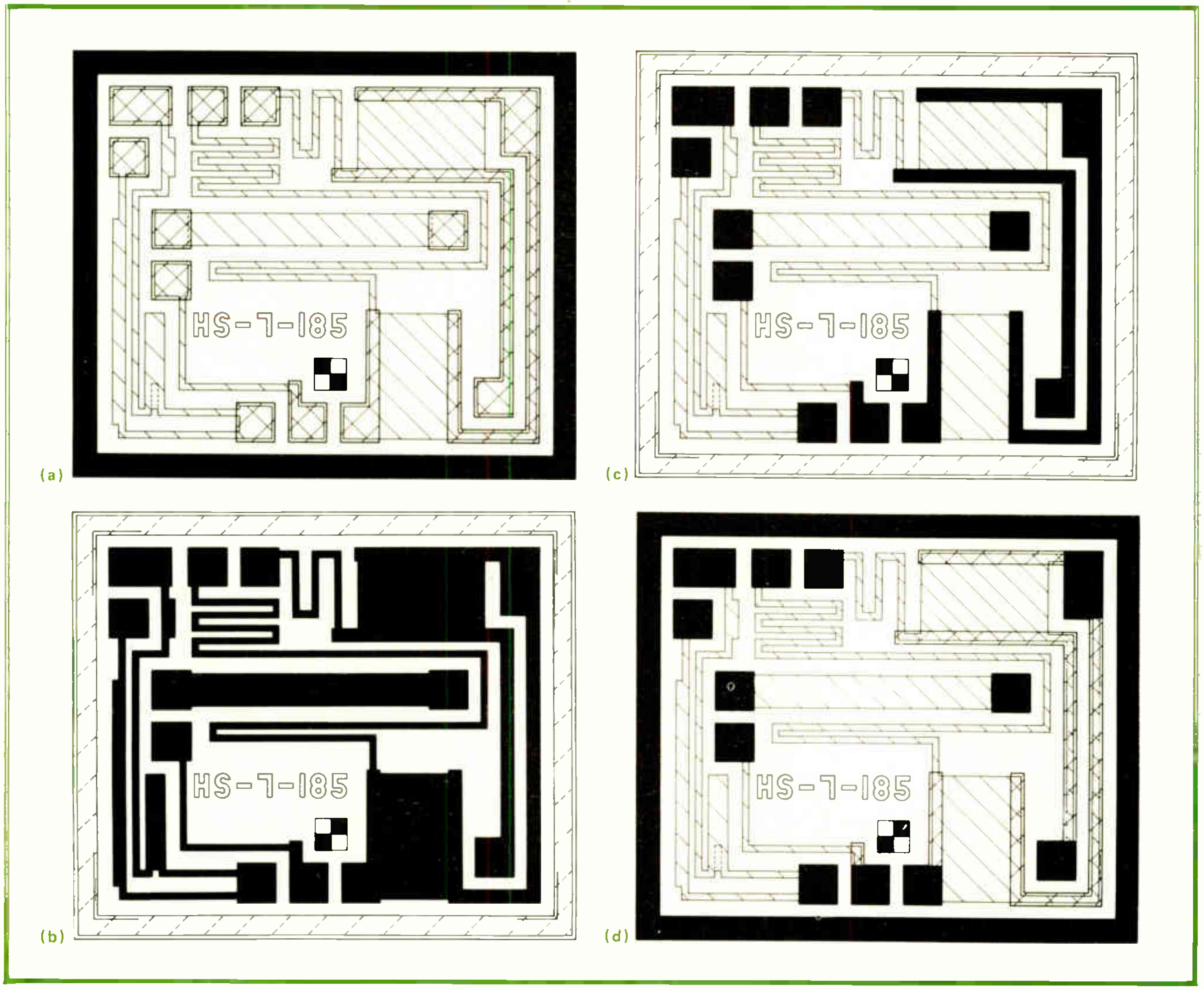
Silicon wafers with an oxide insulating layer scribe exceedingly well and have excellent thermal-conduction properties. Handling techniques for the types of silicon wafers used in the manufacture of semiconductors are now well established and can be applied to processing of thin-film networks. Moreover, substrates of silicon can be packaged and bonded by thermocompression or epoxy to another substrate in the same way semiconductor chips are bonded to an alumina substrate in hybrid manufacture.

Silicon's network-to-substrate capacitance does limit its operation in high-frequency, submicrosecond switching applications. Here, glass is the usual choice for a substrate material.

Metal-film materials

The most common materials for thin-film resistor deposition on a substrate are nickel chromium (commonly called Nichrome) and tantalum nitride. Others, such as chrome silicon, are occasionally used for high-resistivity applications.

But Nichrome and tantalum nitride are most often



4. Masked resistor. Four masks are needed to fabricate a thin-film resistive network: (a) the grid mask, (b) the Nichrome mask, (c) the aluminum mask, and (d) a glass passivation mask. All are the size of the resistor and are stepped and repeated across the wafer.

used at a sheet resistivity of approximately 300 Ω/sq. At this level, Nichrome has absolute temperature coefficients that are in the range of 0 to +50 ppm/°C with 30 ppm/°C being typical. At 300 Ω/sq, tantalum nitride produces coefficients from −50 to −200 ppm/°C with −75 ppm/°C being typical.

Above 400 Ω/sq, Nichrome resistor values tend to become unstable. However, with tantalum nitride, 1,000 to 1,200 Ω/sq can be obtained before values become unstable. On the other hand, worsening of the absolute temperature coefficient to perhaps −200 ppm/°C may render the high resistivity useless. Variables that affect sheet resistivity include the ratio of the metals in the alloy to one another, film thickness, substrate temperature during deposition, postdeposition heat treatment, and so on.

Tantalum nitride was the first metal to be used, and it continues to be specified for older, on-going resistive requirements. Nichrome is the more usual choice for new requirements. Earlier reservations concerning its ability to withstand moist environments have generally been eliminated by the use of passivation techniques such as glassivation and ultra-dry packaging (vacuum baking and hermetic sealing).

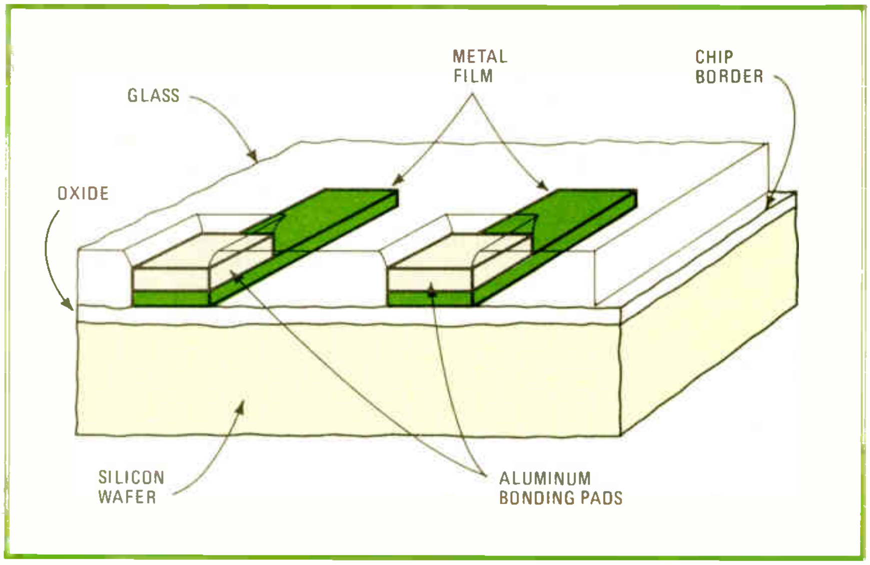
Deposition of these metal films on wafer substrates is accomplished by either of two vacuum techniques: sputtering or evaporation. Generally speaking, tantalum nitride and chrome silicon are sputtered, and nickel chromium is sputtered or evaporated.

Film deposition

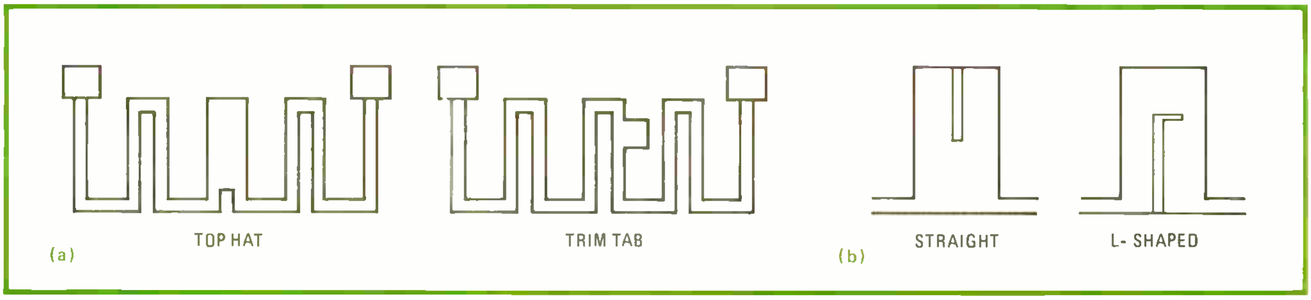
In sputtering, an ion beam bombards the metal target, causing the metal atoms to disperse and land on the substrate material. Figure 3 shows an open tantalum-nitride sputtering chamber. The wafers are loaded onto the four circular pallets, six per pallet, with a seventh position occupied by a thickness sensor.

The chamber sputters the metal film onto one pallet of wafers at a time. Upon completion of the sputtering onto a given pallet, the interior table is rotated to place a new pallet under the target. This procedure is repeated two more times, whereupon the metal film will have been deposited on the wafers of all four pallets.

An open nickel-chromium evaporator is also shown in



5. A layered resistor. A typical thin-film resistor, shown in cross section, is composed of five layers. The bottom layer is silicon, followed by a layer of silicon oxide. Successive layers of metal film, aluminum, and glass complete the resistor structure.



6. Laser trim. Monolithic thin-film resistors may be trimmed to their final values with a laser. To facilitate trimming top hats or trim tabs (a) are added to the resistor pattern. The actual laser trim may be a straight or L-shaped cut (b), but usually the latter has much greater effect.

Fig. 3. Here, 36 silicon wafers are on a planetary fixture that rotates about several axes during deposition to ensure film uniformity. The evaporator uses a heat source to "boil off" the metal atoms at typical temperatures of 1,200° to 1,500°C. A single evaporator of this type can complete three deposition runs per 8-hour shift, producing 108 wafers per shift, or as many as 200,000 40-mil-by-40-mil chips from 2-inch wafers.

No matter what choice is made among substrates, resistive materials, and deposition methods, the overall manufacturing process is pretty much the same. Usually the first step in thin-film processing is to create the 1:1 masks needed for the various steps of this process.

Resistor masks

Several masks (Fig. 4) are required in the manufacturing sequence of a resistive network. The first defines the boundaries between the many networks on the silicon substrate. These boundaries are used for scribing and breaking apart the individual chips after trimming and testing.

The second mask is the basis for the resistor pattern, and a third puts down aluminum bonding pads and conductor runs. The final mask removes glass from the bonding pads and chip boundaries subsequent to glassivation, a sealing process that deposits a layer of silicon dioxide (glass) over the entire wafer.

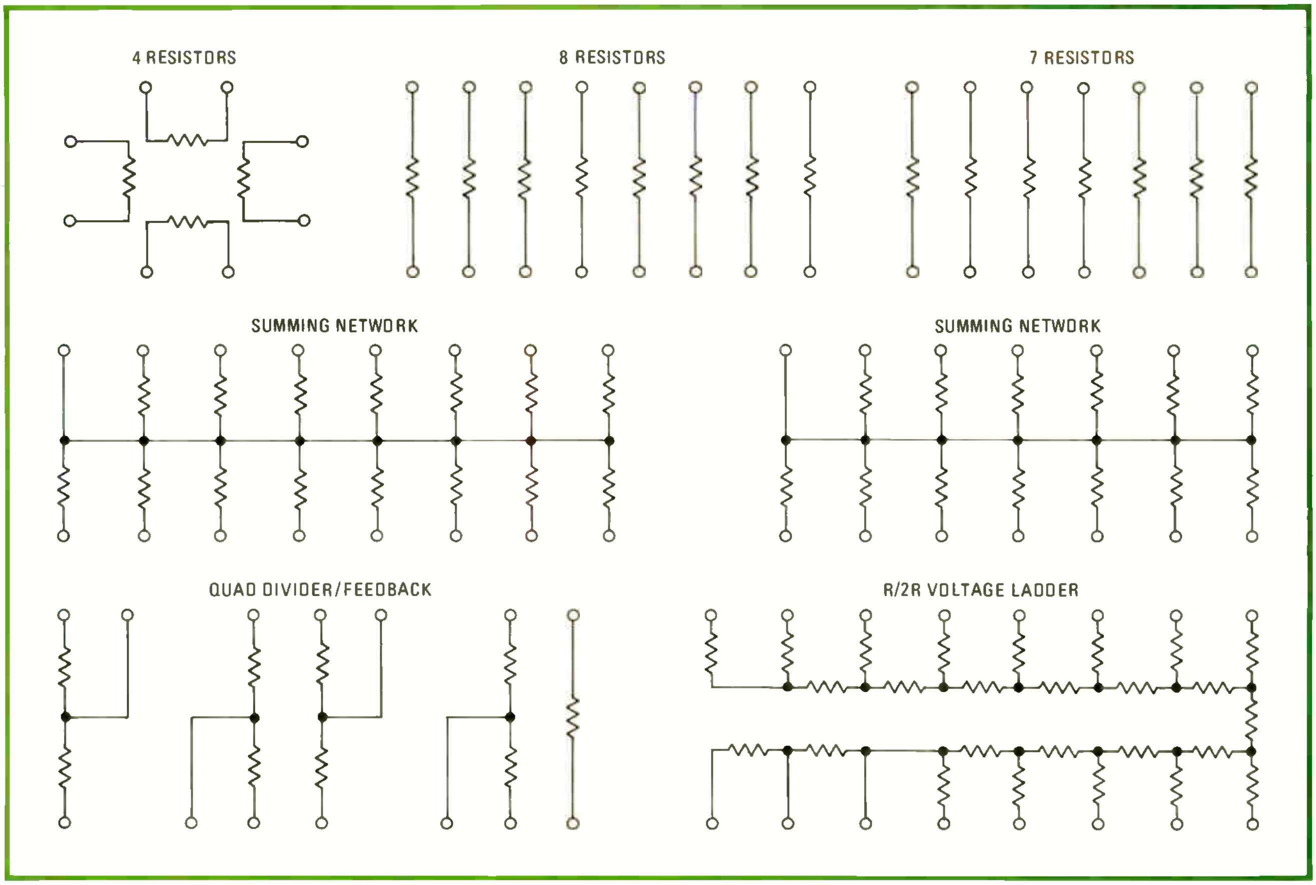
A resistor network of average complexity would require chip area of 30 by 60 mils. A chip with a center-tapped resistor, on the other hand, would typically have 30-by-30-mil dimensions. Mask patterns for either of these resistor designs are typically drawn at 200× scale, and a rubylith (cut and stripped film) of the pattern is cut on a coordinatograph.

Then the rubyliths are photographically reduced to the actual size of a resistor chip. Each chip's image is reproduced on the wafer surface on an automatic step-and-repeat basis as many times as can be accommodated by the size of the wafer. A 2-in.-diameter wafer, for example, has enough area for nearly 3,500 30-by-30-mil chips. Since the photographic plate is square rather than round, the mask pattern is actually repeated nearly 4,500 times.

Once all masks for a typical monolithic thin-film resistor network have been created by photoreduction, the actual production process flow (assuming it starts with a silicon substrate that has an oxide insulating layer) is straightforward.

Initially, a layer of photoresist (a photosensitive lacquer-like film) is uniformly applied to the oxidized silicon and allowed to dry. The grid mask is positioned over the photoresist surface and the light-sensitive surface is exposed. Chemical processing leaves photoresist only in those areas not exposed. The oxide layer, in the light-exposed borders between the chips, can then be etched away to facilitate scribing and separation.

Next, the metal film is coated on the silicon wafers by one of the vacuum-deposition methods. Another layer of



7. Off-the-shelf. Thin-film resistive networks are supplied in the seven standard forms shown. Most popular are the summing networks that are used for operational amplifiers and the R/2R voltage ladder that is used for analog-to-digital and digital-to-analog conversion.

photoresist is applied, and, with the resistor mask in position, the wafer is exposed to light. As before, the light-exposed photoresist is removed, and an etchant removes thin-film material from between resistor runs and other places where it is inappropriate.

A layer of aluminum next is vacuum-deposited on the wafers. In similar fashion to the prior two operations, photolithography and etching leave the aluminum only where desired for bonding pads and conductor runs and do not disturb the thin-film material or the oxide layer.

After the glassivation, the fourth and final use of photolithography and etching removes the glass seal from atop the bonding pads and grid borders. The resulting layered structure is shown in Fig. 5.

Trimming and testing chips

With the manufacturing techniques discussed, films can be within 10% of target resistance values. If greater precision is desired, wafers may be subjected to a trimming procedure.

Early in the history of thin-film resistor manufacturing, when tantalum nitride was the metal most often used, networks were trimmed by an anodizing process. Now it is far more common for resistance values to be adjusted by a laser beam.

With a laser, active trimming can take place. The laser beam is used to burn away portions of the resistor film, thereby altering its physical dimensions and the resistance value. The resistor can be probed and its value can be continuously monitored to determine when the laser has cut sufficiently to produce the value and precision required.

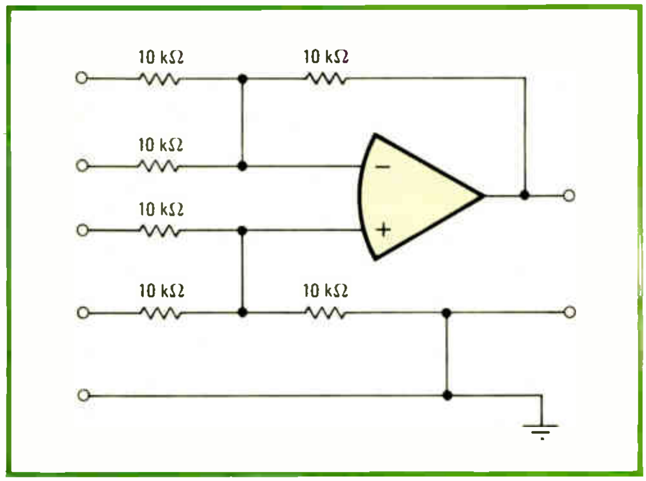
To facilitate such trimming, features called top hats and trim tabs (Fig. 6a) are added to the layout of a thin-film resistor network. The trimming is performed on them. The top hat has greater effect and is therefore used for coarse trim. The trim tab has significantly less effect and is used for fine trim.

An L cut

It may appear that considerable latitude exists for both the shape and size of the cut made on the top hats and trim tabs. However, it can be demonstrated theoretically and proven in practice that trimming methods can have a significant impact on resistor stability and reliability. In fact, an L-shaped cut has much greater effect than does a straight cut (Fig. 6b).

Laser trimming is usually computer-controlled and automatic, a big advantage considering the large number of networks on each wafer. In the automated operation, defective chips (those that cannot be trimmed to the desired values) have an X burned into them. This mark allows them to be readily recognized and culled later during visual inspection.

A useful byproduct of computerized operation is the tabulation of measurement and yield statistics. If trimming is not required, automatic probing, measurement, and inking of defective networks is done instead. After



8. Thin- vs metal-film. For this typical operational amplifier resistive network with its 0.01% ratio accuracy and its 2-ppm/°C tracking, bulk- or metal-film discrete resistors would cost about $35 versus $10 or less for a standard thin-film monolithic resistive network.

laser trimming and testing, the borders between the many networks on each substrate are scribed, and the chips are broken apart by pressure. The individual chips are loaded into waffle packs for microscopic inspection, typically by 100× magnification. Those chips with scratches or other blemishes are removed. For military requirements, the inspection is performed in accordance with MIL-STD-883A, method 2010.

Networks in unpackaged chip form are often used by hybrid-IC manufacturers. The trimming is frequently done after the chip has been incorporated into the IC. It can be based on the performance requirements of the completed circuit, thereby taking variations in other components into account.

For those users that require packaged networks, chips can be mounted in TO cans, flat packs, or DIPs by eutectic or epoxy die attachment. Wires are connected between the chip pads and the interior terminations of the package leads. Aluminum ultrasonic or gold thermocompression bonding of the same type used in the packaging of monolithic ICs is employed. After vacuum bake to eliminate any traces of moisture, the package is hermetically sealed.

Manufacturing precautions must be observed and procedures followed to avoid network damage such as permanent resistance shifts that can result from the high temperatures encountered in bonding and other packaging operations. Labor and materials constitute the largest share of packaged-network manufacturing costs.

Cost factors

Wafer-manufacturing costs are essentially independent of the particulars of the mask patterns. Consequently, the cost of resistor chips is primarily a matter of how many can be contained on the wafer and what kinds of yields can be obtained. A good rule of thumb is: the more chips per wafer, the lower the cost per chip.

Networks of smaller total resistance require less metal film, use less chip area, pack more chips per wafer, and so cost less. Similarly, more terminations per network mean more bonding pads per chip, a larger chip, fewer chips per wafer, and therefore produce a higher cost per chip. Power rating and required trim range also affect chip size and cost.

Actually, doubling the size of the chip produces less than half the number of chips and more than doubles the cost per chip. A major factor is the very small imperfections in the original silicon wafers. Larger chips with fewer total chips per wafer will have a higher percentage of defective, less usable wafer area. Another way to look at this is to realize that the larger the chip, the greater the likelihood of an imperfection being included in it. In the extreme, a one-chip-per-wafer design that occupies the whole wafer would have a 0% yield because the imperfections would have to be part of the chip.

Custom charges

Another cost factor is nonrecurring charges for custom networks. Although a customized network can be produced for a nominal one-time charge (typically $2,000 to cover special masks, the trim program, probe cards, and so on), standard designs (Fig. 7) can satisfy many requirements.

Furthermore, it is frequently possible to adapt an existing design, particularly where the manufacturer's original judicious inclusion of trim tabs and top hats allows alteration of resistor values to meet a wide range of requirements. In some cases, it may only be necessary to modify the bonding-pad mask in order to tap the network at a different location. Thin-film resistor manufacturers now have substantial libraries of mask sets, and it behooves a prospective user to discuss his custom requirements with manufacturers before freezing his resistor specifications.

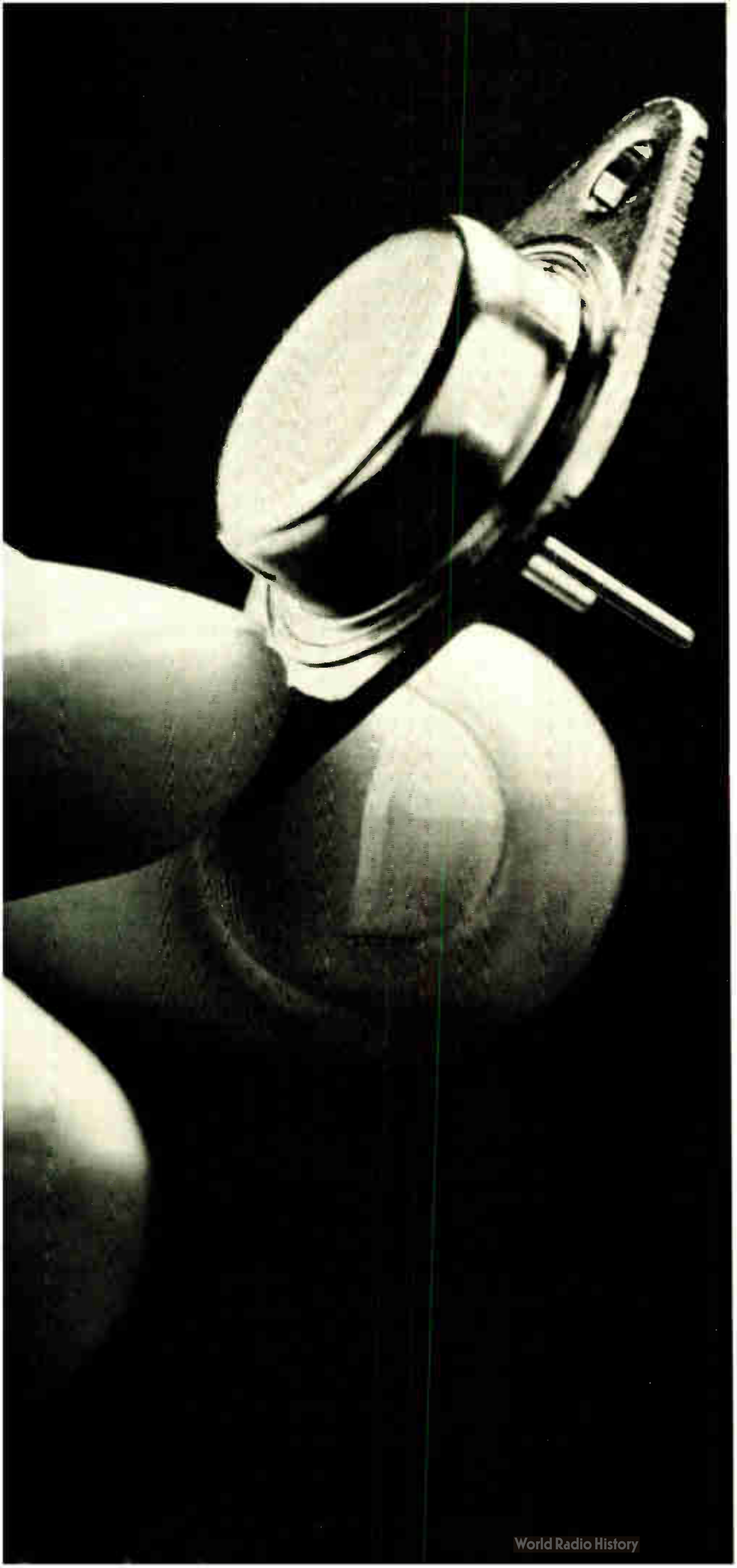
The economic benefits of using monolithic thin-film resistor networks can be demonstrated by considering a thin-film net versus discrete bulk-film resistors in the construction of the typical operational-amplifier circuit shown in Fig. 8, which is based upon 0.01% ratio accuracy and 2 ppm/°C tracking. In hundreds, standard thin-film monolithic resistors for this circuit would cost about $10 versus $35 for a bulk-film network.

Thin vs bulk-film resistors

With the thin-film network, the circuit's gain accuracy can be controlled by simply specifying the ratio tolerance. In contrast, with discrete resistors, the gain precision can only be assured by specification of tight absolute tolerances, which costs extra. In addition, the monolithic network, by virtue of being packaged in a single DIP, can be assembled into a printed-circuit board with less labor and, in fact, may be used with automatic insertion equipment.

The future may be expected to bring improved materials and processing that will facilitate the creation of networks with better absolute accuracies, reduced temperature drift, and increased long-term stability. Higher sheet resistivity will make possible greater total network resistance and smaller chip size which, in turn, will reduce chip costs.

Further work will reduce costs of packaging networks. Finally, costs will come down as quantities continue to grow and further economies of scale are realized. □



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Designer's casebook

Photodiode and op amps form wideband radiation monitor

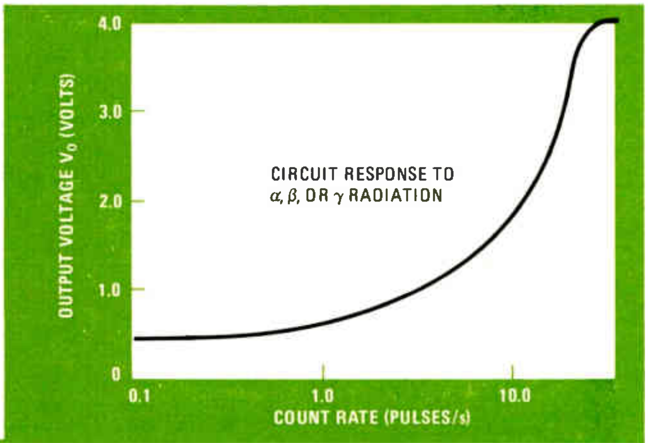
by Grzegorz Hahn
Institute of Nuclear Research, Swierk, Poland

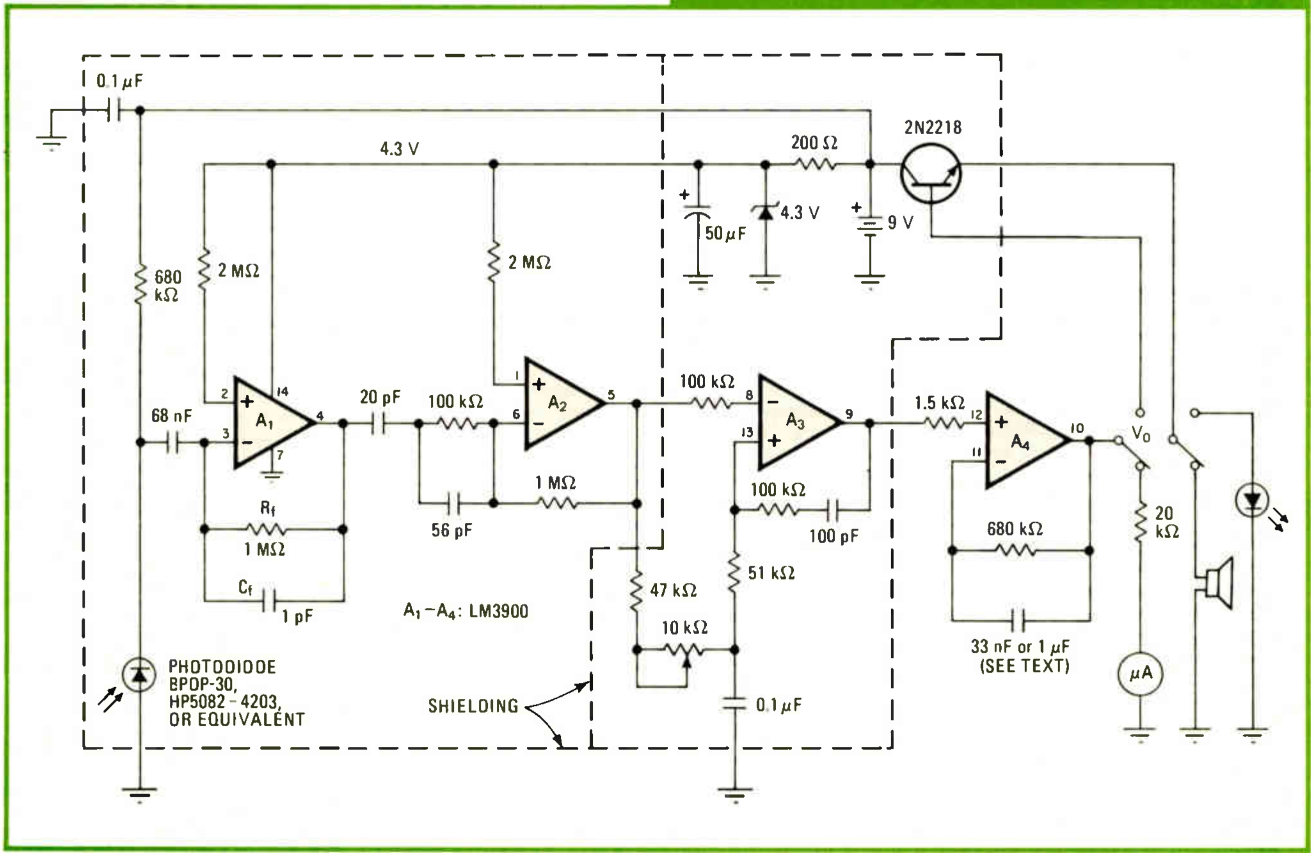
A sensitive radiation monitor may be simply constructed with a large-area photodiode and a quad operational amplifier. Replacing the glass window of the diode with Mylar foil will shield it from light and infrared energy, enabling it to respond to such nuclear radiation as alpha and beta particles and gamma rays.

The general circuit is shown in Fig. 1. The HP-5082-4203 device is a p-i-n photodiode, called that because there is a thin layer of undoped, or intrinsic, material between the p and n type regions of the diode. The intrinsic material acts to lower junction capacitance, so that the device has a higher frequency response than a standard photodiode, making possible the detection of beta particles and gamma rays (alpha particles could be detected with a standard photodiode).

As a consequence of the p-i-n semiconductor structure, the device bandwidth is large. Hole-electron pairs, and thus charge (Q), can be accumulated across the photodiode by all forms of ionizing radiation. When the junction is shielded from visible and infrared light, the photodiode output is a function of the nuclear-type radiation only.

The junction charge generated by the ionizing radiation is $Q = \Delta E/\epsilon$, where ϵ is the ionizing constant of





1. Energy count. Broadband characteristics of p-i-n photodiode enables it to respond to α, β, and γ radiation when pn junction is shielded from visible and infrared wavelengths. Op-amp circuit amplifies and integrates pulses for meter or loudspeaker. Circuit has uniform response to radiation, independent of energy class.

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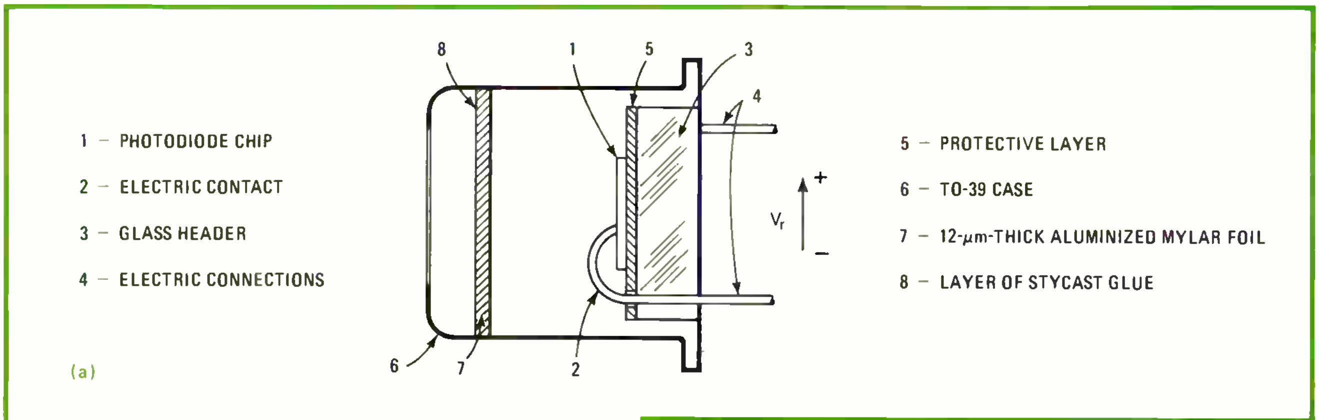
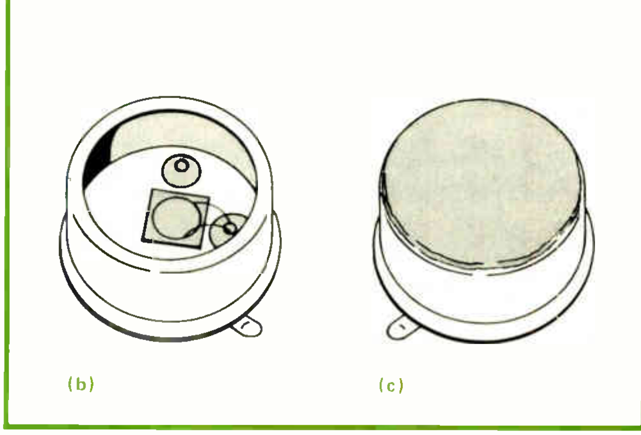




2. Adaptation. Glass window of photodiode (a) must be removed and replaced by opaque material to shield pn junction from light. Top of photodiode case is first cut out (b) by turning lathe, then layer of aluminized Mylar foil is secured in place (c) with Stycast glue.

silicon (3.66 electronvolts at 300 K), and ΔE is the energy stored across the active region of the photodiode. The output voltage from integrator A_1 is thus:

$$V = (Q/C_f)\,(1 - e^{-t/R_fC_f})$$

where t is measured from the instant ΔE appears across the junction and R_fC_f is the time constant of the integrating network. A_2 is a quasi-Gaussian filter that shapes the pulse in order to inprove the signal-to-noise ratio of the small output signal at A_1. A_3 generates a rectangular pulse with a width proportional to the input amplitude for every signal that exceeds a threshold set by the user.

The threshold control is used if a radiation alarm circuit is desired (indicating maximum limits have been exceeded) or if it is necessary to discriminate against hash in high-noise environments. It should be noted that A_3 is in principle a current discriminator and that its temperature-drift coefficient is probably lower than that of conventional voltage discriminators, which are often used in radiation monitors.

A_4 integrates the output of A_3 in order to drive a microammeter. A 1-microfarad capacitor is used in the integrating network. A lower value, say, 33 nanofarads, will make it possible to drive a small loudspeaker (50-hertz output signal) or light-emitting diode.

Figure 2 illustrates the procedure used to replace the photodiode's glass window with a 10-micrometer-thick aluminized Mylar foil. The photodiode shown here is the BPDP-30, a European make, but most photodiodes made in the U. S. are very similar.

As shown in Fig. 2b, the top of the TO-39 case containing the window must be cut away with a turning lathe. Care should be taken not to touch the pn junction within. Sharp edges are then filed smooth with care. The new window is then secured to the edges of the device by means of black Stycast glue (available from Emerson and Cuming Inc., Canton, Mass.). Figure 2c is a view of the completed diode.

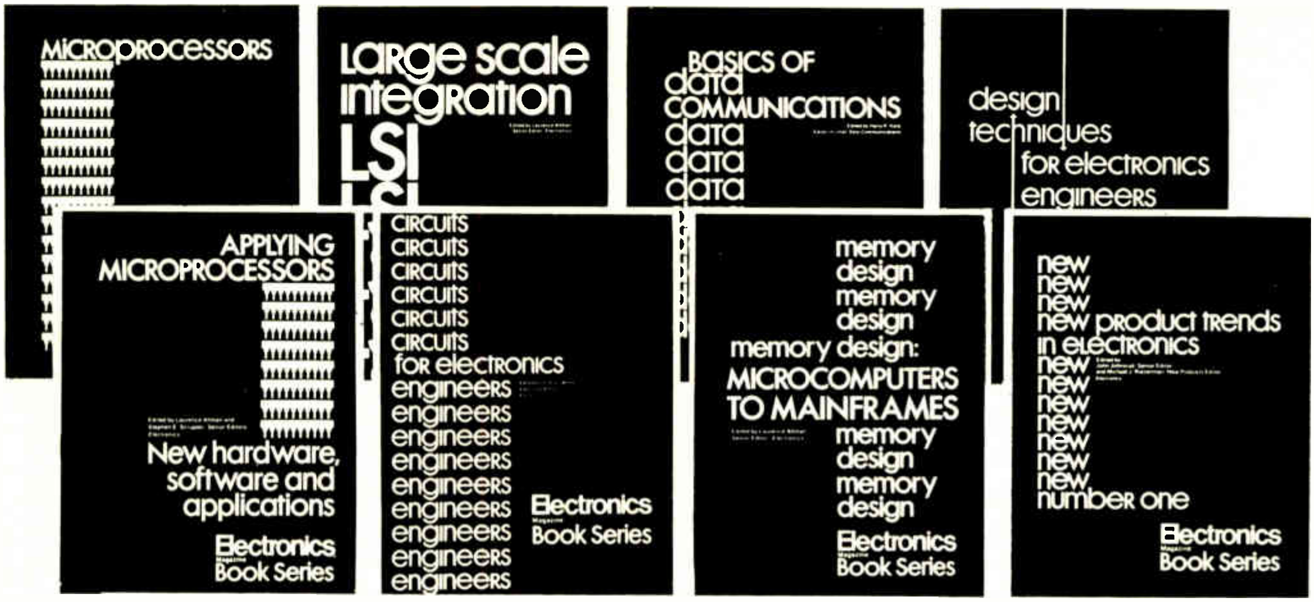
The circuit response is seen in the upper part of Fig. 1. Note that this device is a radiation monitor, as opposed to a radiation meter, and so cannot distinguish between α, β, and γ radiation. Because of the photodiode's wide bandwidth, each energy class generates the same output voltage for a given radiation intensity. Thus the monitor is intended for use where an *a priori* knowledge exists of the type of energy to be encountered. □

Vehicle-intruder alarm has automatic set/reset switching

by M. B. Horan
Derby, England

Providing fully automatic operation at negligible stand-by current, this low-cost burglar alarm for automobiles will sound the horn if any door is opened. No alarm-set switch is required on the body of the automobile: there is a built-in time delay between the opening of the door and the sounding of the alarm, which gives the driver time to activate the ignition circuit and so disengage the alarm. Resetting the circuit requires only that the driver open a car door before the ignition key is removed, thereby engaging the alarm circuit.

The alarm has been designed using complementary-metal-oxide-semiconductor logic, because it is inexpensive, rugged, reliable, and available, requires only a few



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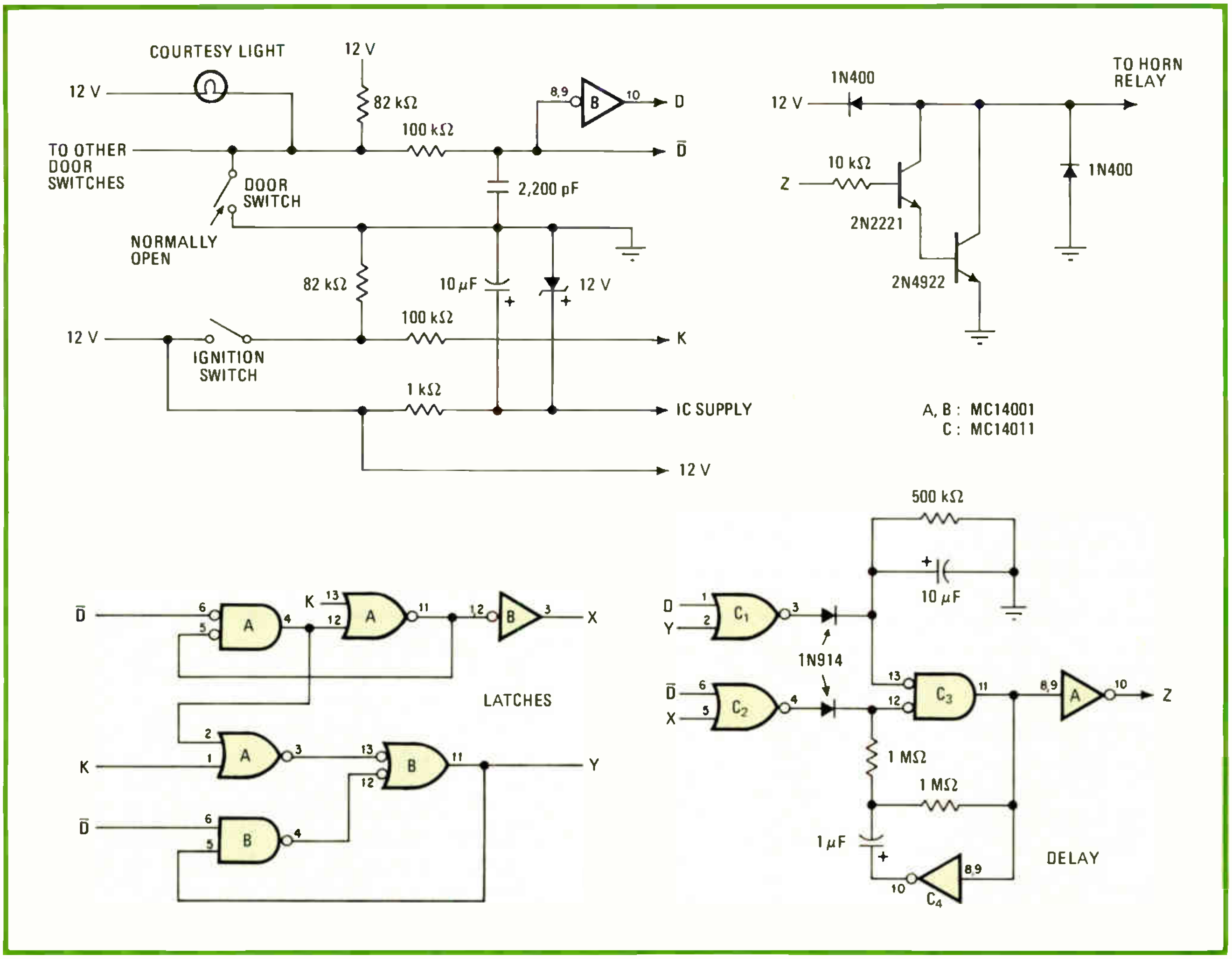


Invisible sentry. Automobile burglar alarm sounds car horn if any door is opened. Five-second-delay circuit enables user to disengage alarm just by turning on ignition. Alarm is reset by opening car door before ignition circuit is disengaged.

microwatts of power, and has good noise immunity. The circuit is simple, as the figure shows. Only six connections are required to interface it with the auto—two for the ignition, two for the door switches, and two for the horn relay.

The circuit must distinguish between several asynchronous events encountered in normal operation and store their present states so that:

- The horn will sound approximately 5 seconds after the time any door is opened, provided the ignition switch is not engaged.
- Once the horn sounds, it will continue to do so, independent of the position of any door.
- The alarm can always be reset by engaging the ignition switch.
- If the door is opened with the ignition on, and then the ignition is turned off and the door subsequently closed within 5 seconds, the horn will not sound.

In order to perform these tasks, the circuit implements the function:

$$Z = (D+Y)(\bar{D}+X)$$

where $X = K+DX$, $Y = K+DX+\bar{D}Y$, and K is true high for ignition switch-on, D is true high for an open door, and Z is true high for detection of an intruder.

Implementing the logic for the condition where one is entering the vehicle is simple. The equation given becomes more involved, however, because the circuit must allow the operator to leave the auto while setting the alarm without triggering the horn. The logic to implement this fourth condition is controlled by two latches, one of which generates the secondary variable X and the other generating Y. X is set high, also allowing Y to be set high when the condition occurs. Latch Y remains high, ready to reset on the opening of any door. Latches X and Y and the door signal are then gated to preset the alarm signal.

The alarm-gating signal (Z) is actually generated once the 1-microfarad capacitor in the delay oscillator discharges below gate C_3's logic-1 point, about 5 seconds after the X signal arrives at C_2. The inverting-gate astable multivibrator, C_4, modulates the horn at 1 hertz to enhance effectiveness as an alarm signal. Other components are included in the circuit for protection against switching transients. □

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.

Variable-persistence storage CRT achieves high writing speed

Adding a magnifying image-projection lens allows 1,800-cm/μs rate and 100-MHz bandwidth without reduced display

by Van Harrison,* Paul Carnahan, and James F. Haley, *Hewlett-Packard Co., Colorado Springs (Colo.) Division*

☐ The variable-persistence storage oscilloscope is a versatile and useful instrument for capturing and analyzing transient or anomalous electronic events. But the conventional storage tube at its heart has a writing speed and contrast that restrict its use to relatively low-frequency signals or pulses with long rise times, unless certain design tradeoffs are made.

A new design, however, the 1744A expansion storage cathode-ray tube, achieves a writing speed of more than 1,800 centimeters/microsecond. Using this tube, a variable-persistence storage scope can capture low-duty-cycle, high-speed pulses or waveforms with an equivalent bandwidth of 100 megahertz, as well as attain extremely high single-shot trace resolution. Up to three channels of such waveforms can be analyzed in either the variable-persistence or the automatic-storage mode.

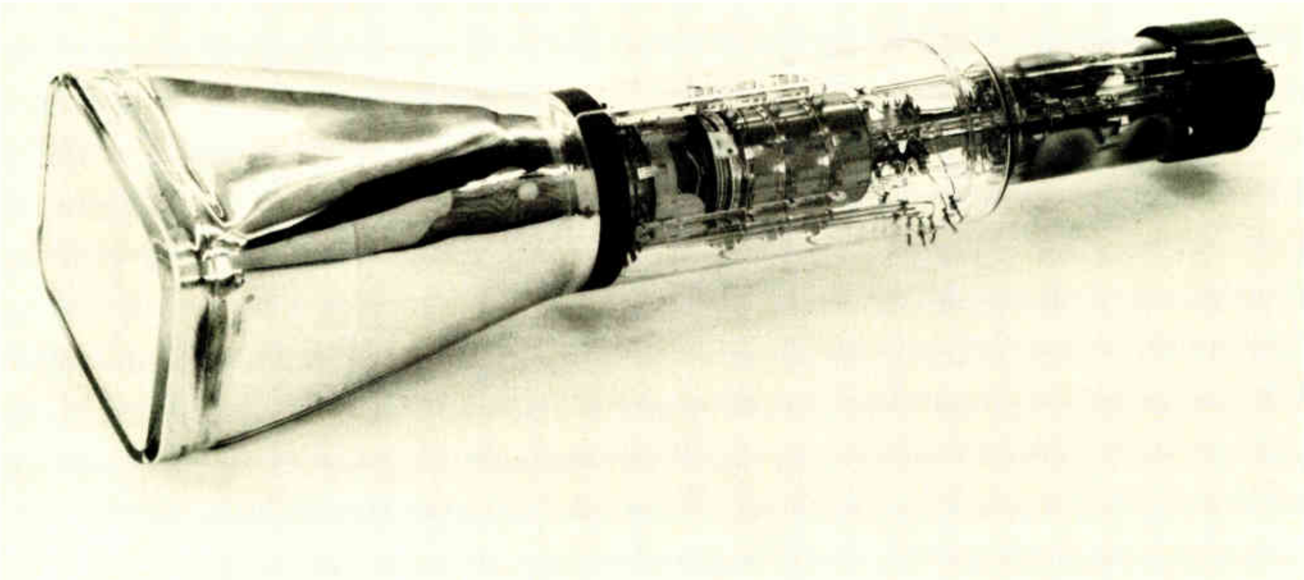
The new tube (Fig. 1) uses a static-electric-field crossover lens to expand the image before it is displayed on a conventional phosphor screen. The active display area is about 10 times larger than the image written on the storage surface and the CRT's writing speed is increased by the same factor.

*Now with ADR Corp., Phoenix, Ariz.

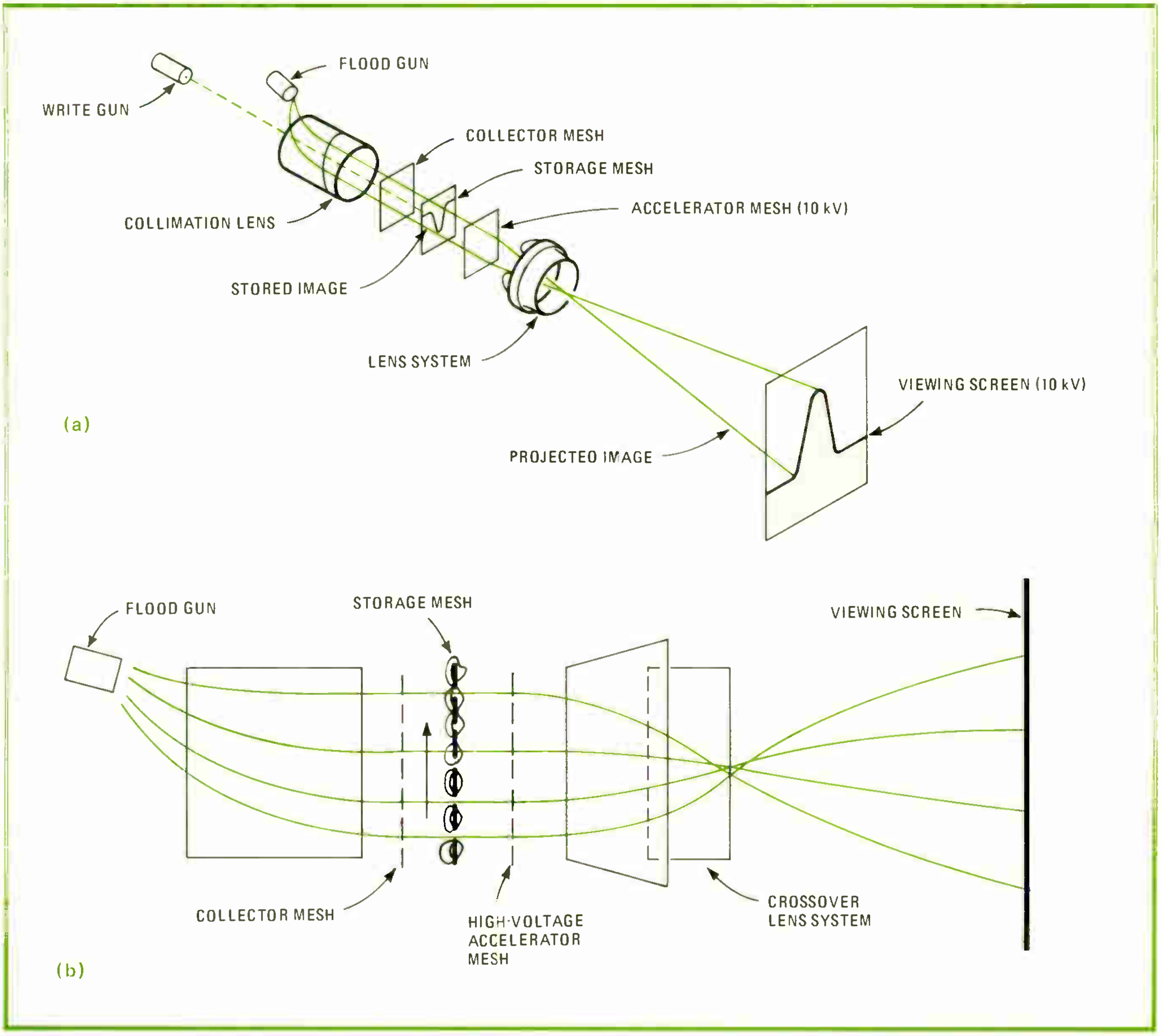
How does it work?

The expansion storage CRT is similar to the older variable-persistence type except for the region between the storage mesh and the phosphor viewing screen. In the conventional tube, the storage mesh is next to the screen. In the expansion tube, a high-voltage mesh is placed in front of the storage mesh to accelerate the flood-gun electrons transmitted through the stored image (Fig. 2a). The electrons are then directed through a newly developed crossover lens system to the phosphor screen, forming well-defined trajectories (Fig. 2b). The crossover lens inverts and expands the stored image before it reaches the screen.

The storage mesh is about 1/10 the size of the viewing



1. Expansion storage. Newly developed CRT has a computer-refined lens system. Used in an oscilloscope, it offers fast writing capability, variable persistence, full-screen display, and 100-MHz bandwidth for observing fast and single-shot waveforms.



2. More parts. The internal geometry of the expansion storage CRT (a) is more complex than that of conventional storage tubes. Crossover lens inverts and expands the stored image by a factor of 10 before it reaches the phosphor viewing screen. Writing speed is increased by the same amount. Flood-gun electron trajectories (b) must be precisely controlled for optimal CRT operation.

screen, in contrast to other storage meshes, which are the same size as the screen. Thus the image to be viewed is magnified 10 times. In a given interval, a display spot moves 10 times farther on the phosphor screen than it does on the storage mesh. Consequently, the crossover lens system increases the writing speed by the same factor of 10.

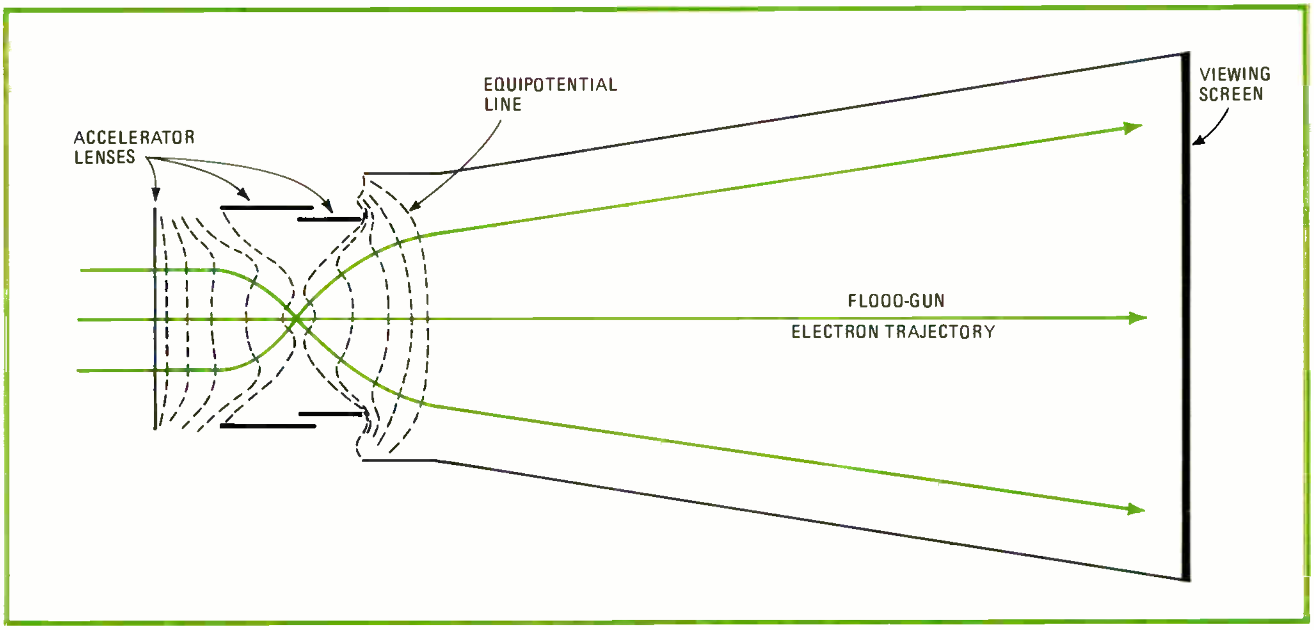
The lens system acts by means of the electrostatic fields formed in the region between the final accelerator mesh and the viewing screen. The effect of these fields on flood-gun electrons can be understood by observing the pattern formed by the region's equipotential lines, which are influenced by the accelerator mesh (Fig. 3).

The electrons leaving the accelerator mesh travel almost parallel to the axis of the tube at a relatively high speed. The crossover lens is held at a voltage that is lower than the potential of the accelerator mesh, and the lower voltage causes the electron beam to decelerate and bend toward the axis of the CRT. Other electrons, coming from various locations on the storage mesh, are also forced to converge along the axis of the tube near the center of the lens area.

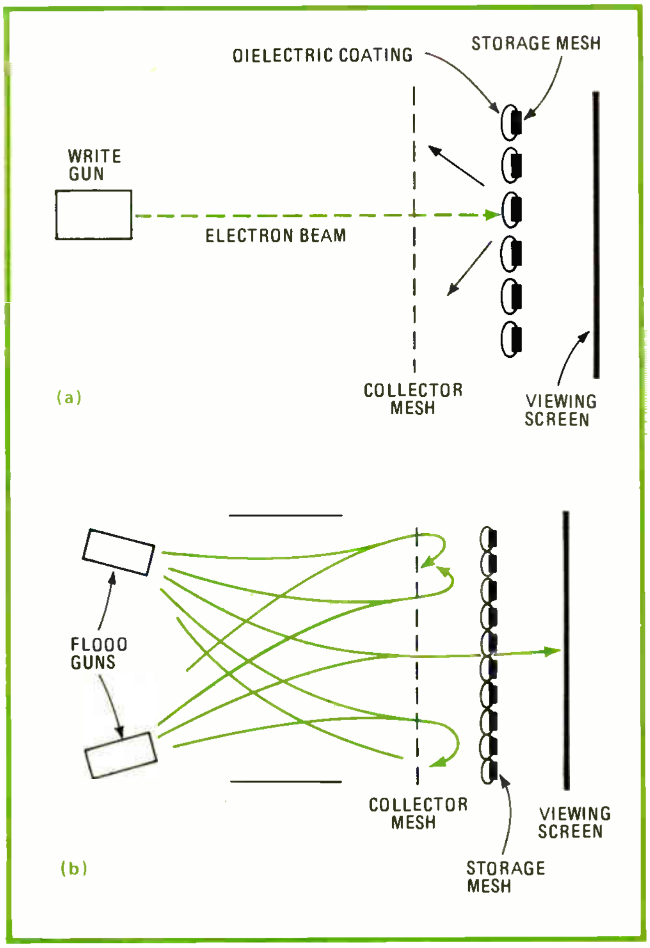
Restoring the electrons

On the screen side of the crossover region, the electrons are once again presented with an acceleration field that causes them gradually to regain their initial speed and bends them toward the field lines that are normal to the equipotential contours on this side of the region. When the voltages on the lens are properly adjusted, an inverted real image from the storage mesh is produced on the screen.

The quality of the image formed depends primarily on the aberrations introduced by the lens system. The main problem encountered in designing the lenses was the definition of the shapes of the electrodes for the



3. Equipotentials. Accelerator mesh helps define the electron trajectories for minimum picture distortion. The equipotential lines must also form specific curves so as to properly accelerate and decelerate the electrons, especially in the crossover region.



4. Old system design. The older direct-viewing storage system has a simpler design. Relative positive charge is held on the storage mesh dielectric coating (a). Later it is either purposely erased or allowed to fade into the background. Flood-gun electrons help to form the viewing-screen image in the variable-persistence mode (b). They also erase the images written by the write gun.

elements. These electrodes had to be easily producible, use voltages that could be readily generated by the instrument, and cause minimal distortion of the projected image.

Initially, in order to work out the design, experimental tubes with different lens shapes were built. This trial-and-error approach produced surprisingly good results and in fact yielded the basis of the final design, which was refined using an in-house computer program. The model set up by the program allowed the direct calculation of the effects of different lens shapes on the various electron trajectories.

A new write gun also had to be designed, because the crossover lens expands the trace width as much as it expands the image, and the wider trace can cause distortion. Therefore the initial spot had to be made small enough not to cause such problems when magnified. In addition, the write beam had to have a very high current density so that the writing speed would not have to be reduced. The resulting gun has a spot size at the viewing screen of less than 0.002 inch typically and less than 0.02 in. maximum when expanded under high-drive single-shot conditions.

Why the old method isn't good enough

In other variable-persistence storage cathode-ray tubes, the image is retained on a dielectric-coated storage mesh positioned behind the phosphor writing screen (Fig. 4a). To store a picture, a write gun writes on the dielectric surface with a high-energy electron beam. Energy from the write-gun electrons frees secondary electrons from the dielectric coating, and thus the written areas on the surface facing the write gun become relatively positively charged.

These secondary electrons are gathered by a collector mesh located between the storage mesh and the write gun. The secondary charge established by the write gun then remains stored on the dielectric coating of the

How much writing speed is required

Writing speed is a key specification in selecting a storage oscilloscope. It is defined as the highest spot velocity that produces a visible trace on the cathode-ray-tube viewing screen. This spot velocity has a maximum vertical (V_y) and a maximum horizontal (V_x) component. The maximum spot velocity is equal to the square root of the sum of the squares of these two values.

The writing speed required to display only the sweep base line is calculated by dividing the scope face calibration (centimeters per division) by the sweep rate (nanoseconds per division). The result is in centimeters per microsecond, which is most useful because storage scopes have storage writing speeds in microseconds.

Although this example does not cover all cases and calculating the writing speed for complex waveforms is difficult, it is practical enough to allow a first approximation of the sweep speed for the purpose of selecting an oscilloscope.

When the variable persistence feature is used, the writing speed also directly affects the speed with which the light output is enhanced. For example, if an oscilloscope with a variable-persistence writing speed of 100 cm/μs is to display a 25-megahertz signal with a 4-cm on-screen amplitude, a single-shot writing speed of about 600 cm/μs is required. However, for a low-duty-cycle repetitive signal, a 100-cm/μs variable-persistence writing speed allows the signal to be displayed after it is integrated about six times. With a variable-persistence writing speed of 5 cm/μs, it would take about 20 times as long to obtain a viewable display.

storage mesh until it either is erased or fades into the background.

To display a stored image with this system, a pair of flood electron guns is used (Fig. 4b). The flood guns emit low-energy electrons that either go through the positively charged, written areas of the storage mesh or are repelled from the negative, unwritten areas. These electrons are collimated with a lens system set up so that they strike the storage surface at right angles. Resolution is thereby optimized, and the display image is the same size as the image on the storage mesh.

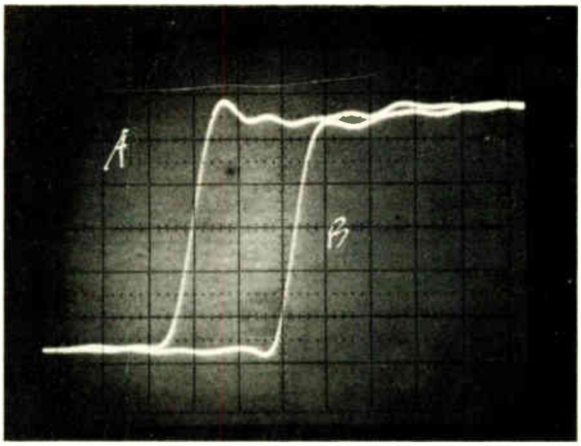
The flood-gun and write-gun electrons add to form the image on the viewing screen in the variable-persistence mode. However, in the single-shot or storage mode, only the flood-gun electrons striking the phosphor are visible. When desired, the flood guns erase the images written by the write gun.

Solving some problems

The writing speed obtainable is proportional to the product of the beam current and the secondary emission ratio of the dielectric coating on the storage mesh divided by the storage-mesh capacitance. Therefore, to get higher writing speeds, either the secondary emission ratio or the beam current must be increased, or the storage-mesh capacitance must be reduced.

The secondary emission ratio of the dielectric coating is a physical property of the material, and the only way to increase it is to employ very expensive and hard-to-use, exotic materials. Obviously, that is not practical. As for the beam current, the guns in most storage CRTs are at the limit of their current-density producing abilities, and thus there is no way to increase this current while maintaining other important CRT parameters.

The storage-mesh capacitance can be varied to increase the writing speed of the CRT, but reducing it also reduces the viewing time proportionally, making the instrument less useful. However, this problem can be got around by transferring the written image from a high-speed, low-capacitance storage-mesh to a low-speed high-capacitance one. This approach allows CRTs to be made with very high single-shot writing speeds and very long viewing times. The one disadvantage for the user is that he cannot have a high-speed variable-persistence writing rate in a continuous operating mode.



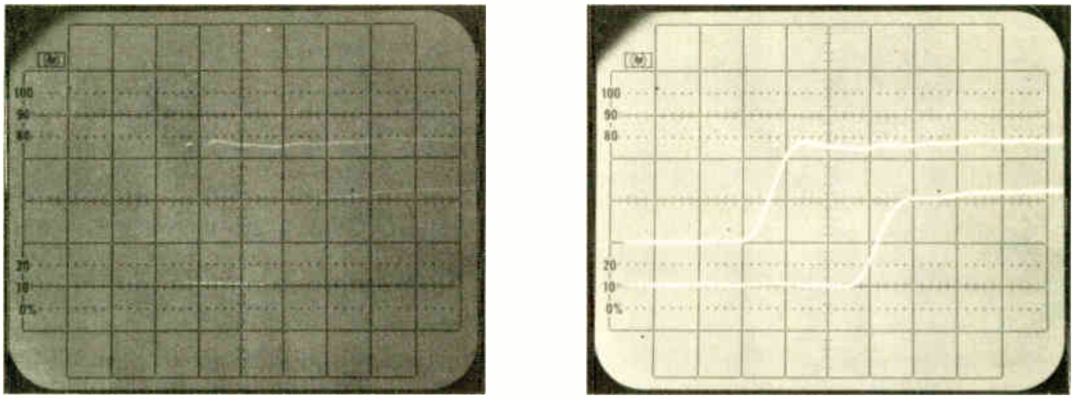
5. Data and clock. Curves A and B represent typical device clock and data signals, respectively, with a horizontal scale of 5 nanoseconds per division for both. The bright picture allows the time interval between the two to be determined by direct observation.

The 1744 high-speed variable-persistence storage scope, made possible with the new cathode-ray tube, is useful for displaying such signals as radar pulses, glitches and noise pulses in digital systems, nonperiodic, hard-to-trigger-on data streams, tone-burst signals, and X-ray signals, which would be impossible or difficult for conventional storage oscilloscopes to handle.

What a high-speed storage scope can do

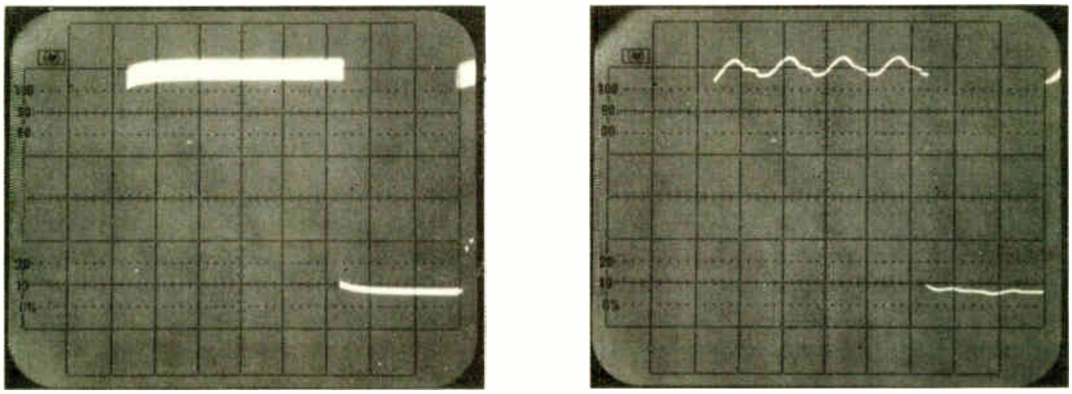
If the signal is one that can be repeated manually—for example, by pressing a button that makes a signal appear—then the high-speed variable-persistence feature can optically integrate it over several sweeps to obtain a bright, high-contrast display. In this mode and for all low-repetition-rate applications where fast transitions occur, variable persistence leads to high contrast in less time than conventional storage oscilloscopes require.

The high writing speed also extends the capacity of the instrument to capture, store, and display nonrepeti-



(a) (b)

6. Better contrast. Conventional picture (a) has little contrast. Variable-persistence picture (b) is much easier to see. Same waveform with variable persistence stands out from the background. Horizontal scale is 5 ns/division in both cases.



(a) (b)

7. Better noise. Noise waveform shapes are readily observed with the 1744 oscilloscope. Triggering on the signal causes noise smearing in a conventional display (a). With the new CRT, the noise is not distorted (b), since the automatic-erasing and variable-persistence features eliminate smear and jitter. Conventional triggering on the signal, rather than on the noise (which is far harder to do), is still possible.

tive waveforms. When the automatic-erasing feature is used, the instrument can display fast nonperiodic and complex waveforms while filtering out unwanted signals for easier viewing.

Consider, for example, a typical clock pulse that generates a data pulse in some device. The oscilloscope is set up in the dual-channel auto-erasing mode (Fig. 5). The data pulse occurs about once every 200 milliseconds, making it very hard to view on a conventional storage scope, since the data-generating device under test has a 3-nanosecond set-up time.

With the high-speed storage scope, the leading edge of this pulse can be easily seen. The time between the leading edge of the data pulse and the clock pulse can be measured by direct observation even in the 10-ns range. For the pulses shown, the measured time is about 12 ns, which easily exceeds the device specification of 3 ns.

Low-duty-cycle signals with fast edges can also be made more readily viewable. The photograph in Fig. 6a was taken in the minimum-persistence mode, which results in performance similar to that of a nonstorage oscilloscope. The high-speed variable-persistence feature provides a much brighter display (Fig. 6b).

High-speed automatic erasure is also helpful when noise or some other asynchronous signal couples into a pulse or digital waveform. With a nonstorage oscilloscope, triggering on the pulse causes the noise to smear. The smear is displayed as a thick, solid line (Fig. 7a) with no information content. With a conventional storage scope, it may be possible to see the noise, depending on its frequency and type. But with high-speed variable persistence and auto-erasure, it is unnecessary to attempt to trigger on the noise in order to see its waveform (Fig. 7b). □

High-level languages ease microcomputer programming

Closer to English than assembly language, they shorten the time needed for development and debugging

by J. Lynn Saunders and Larry E. Lewis,* *Tektronix Inc., Beaverton, Ore.*

☐ High-level languages are to assembly- or machine-language programming what integrated circuits are to discrete logic—they collect small, related elements into neat modules. The benefits, too, are similar. Just as the hardware designer needs fewer components to build a system, the programmer thinking in a high-level language needs fewer lines of code to make a system go.

Such languages are not the perfect solution for all programming problems. They require a lot of memory, for example, and in the case of microcomputers, that was economically impractical till quite recently. But now they can often be used to cut expensive microcomputer-firmware development time, especially if their user is aware of the languages' strengths and weaknesses.

Advantages are many

The number of statements a programmer writes per unit time is a good measure of his or her productivity. But the number of machine instructions produced from a statement can vary all the way from 1 to a high of about 12. In general, the higher the level of the statement, the greater the portion of the task the statement executes, and the fewer the statements that are required. For a constant statement rate, then, high-level languages decrease coding time.

When thinking in an HLL rather than an assembly language, the mind is free of such detailed and tedious tasks as keeping track of what each accumulator holds. The programmer can focus on the problem to be solved rather than on the idiosyncracies of the machine.

For one thing, modern HLLs use so-called friendly instructions that closely parallel the English language. Mnemonics like IF, THEN, ELSE; DO, WHILE; REPEAT, UNTIL; and CASE, OF are obvious to the programmer and ease the task of translating thoughts into a language the computer can understand.

For another, friendly keywords also make programs easier to understand because HLL source statements are easier to read than an assembly-language source listing. This greatly reduces the need for comments and may also eliminate the flow-charting phase of the development process. Indeed, one way to evaluate a language's performance is to see how easily the programmer's peers can read his code. The HLL code can be understood with

FRIENDLY SUBROUTINE

```
           PROCEDURE /PROGRAM.ENTRY/

  V          VAR
  V          BINARY*8:KEYCODE
  V          LOGICAL*8:STEPMODE,QEMPTY
  V          ENDV

  C          CON
  C          BINARY*8:STEPKEY/13H/
  C          ENDC

  E          EXT
  E          PROCESS.COMMAND,DISPLAY.INSTRUCTION
  E          GET.KEYPUSH,DISGARD.KEYPUSH,QTEST
  E          ENDE

  R          REPEAT

  R            IF NOT STEPMODE THEN
  RI           PROCESS.COMMAND(STEPMODE)
  RI           ENDI

  R            IF STEPMODE THEN
  RI           DISPLAY.INSTRUCTION
  RI           GET.KEYPUSH(KEYCODE)

  R              IF KEYCODE=STEPKEY THEN
  RII            DISGARD.KEYPUSH
 -RII            ELSE
  RII            STEPMODE=FALSE
  RII            ENDI

  RI           ENDI

  R          QTEST(QEMPTY)
  R          UNTIL QEMTPY OR STEPMODE
  R          ENDR

           RETURN
           END.
```

1. Easy to read. This subroutine is part of a program for scanning the keyboard and illuminating the display of a front-panel controller. It is written in a high-level language called Tesla, an Algol derivative similar to Pascal. With few comments, this language is relatively simple to understand even without prior exposure to it.

Larry E. Lewis is now the director of software at Futuredata Computer Corp., Los Angeles, Calif.

The pros and cons of assembly and high-level languages . . .

High-level languages designed especially for microcomputers are very much in the cards these days. But this wasn't always the case. For a long time the high cost of memory restricted microcomputer-system programmers to assembly language.

Assembly-language programming is the most basic form of firmware development. It consists of learning a particular processor's mnemonics and composing a program in accordance with the operations they perform. The assembly process can then be handled in one of two ways: by machine or by hand.

Besides translating mnemonics and data into binary machine code, a software assembler automatically builds a symbol table and assigns addresses to appropriate routines and data tables, not to mention flagging errors that hand assembly may often overlook. Also, because an assembler is part of a development system or general-purpose computer, bells and whistles like extended macro capabilities, linking of relocatable code blocks, and hard copy are generally available. In short, the benefits of a machine assembler are such that hand assembly is only practical for small systems in limited editions.

One distinct advantage of assembly-language programming is its efficiency. The assembly-language instructions are so intimately related to the machine code (in fact, there is a one-to-one correspondence) that the clever programmer can often develop programs with minimal execution times and memory requirements. Indeed, a few applications can be dealt with only by coding in assembly language. These include problems with very intricate timing requirements or cost sensitivity, such as the inability to allocate more than one small read-only memory to run an entire system.

Developing firmware with a high-level language, however, is much more convenient. Routines written with an HLL are shorter, more portable, and closer in form to English. One HLL instruction may produce as few as one or as many as a dozen assembly-language instructions. In general, a particular HLL instruction will not always compile into the same set of machine code. This is because at the time of compilation, the contents of the various registers and stack/memory pointers will be differ-

few or no comments, as Fig. 1 makes clear.

Moreover, errors are proportional to the number of instructions written. Since HLLS produce more machine code per instruction, there will be fewer errors to debug. More than half of the errors associated with hand-coded assembly-language programs can be eliminated using the compiler of the HLL. For example, keeping track of what is in each index register is an activity that may produce errors in assembly-language coding, but is performed automatically by an HLL compiler.

Structured and portable

Block-structured HLLS with rich control features allow and even encourage the designer to use block-structured programming techniques in solving a particular problem. Such a modular design reduces development costs and improves program reliability.

Some HLLS available for microprocessor firmware development are similar to programming design languages. Many programmers are successfully implementing the flow-chart phase of the firmware design process with the aid of these PDLS, since they are essentially the same, in keywords and structure, as the HLL used in the coding phase. The translation is a trivial one, and the programmer feels he has a machine that executes his flow charts.

Using a high-level language to develop firmware means the product designer can check a design sooner. A myriad of products now on the market are microprocessor-based, but they have unproven user interfaces. It is very important to check out these interfaces early in the design stages, and HLLS make this possible.

HLLS are much less machine-dependent than assembly languages. Hence, code written in a HLL is inherently more portable than that written in assembly language. Utility routines, such as stack and queue manipulators, floating-point math packages, and number-conversion packages, are common to many projects, so that in the long run, portability turns out to be cost-effective.

ROM CONTENTS CHANGE

Original version	Version 2	Version 3	Version 4	Version 5	Version 6	Version 7
ROM A	new		new			
ROM B	new					
ROM C	new					
ROM D	new					
ROM E	new					
ROM F	new		new			
ROM G	new	new				
ROM H	new					
ROM J	new		new			
ROM K	new			new		new
ROM L	new					
ROM M	new					
ROM N	new		new			
ROM P	new			new		
ROM Q	new		new		new	
ROM R	new					
Changes	16	1	5	2	1	1
Total changes — 26						

2. Maintenance. It is not true that once the read-only memories have been programmed, the listings can be discarded and the disk-files expunged. Shown here are the revisions demanded for a typical set of ROMs over a span of two years. Because high-level languages are easier to read and write, maintenance is less arduous.

The idea that "once the read-only memories are programmed, the maintenance is over" is simply not true. Figure 2 shows a number of ROM packages that have undergone seven releases in two years of production. Obviously, then, it cannot be assumed that once the product is in production, the software task is complete. Life-cycle costs for firmware products are similar to those for software products. Maintenance is as important in firmware as it is in software, and that maintenance is simplified when the programming medium is a HLL.

. . . for microcomputer programming

ent and a certain amount of "cleaning up" is required before meaningful assembly-language instructions are generated.

A growing number of microprocessor development system manufacturers and software houses are offering high-level languages for firmware development. Besides the well-known general-purpose languages like Basic, Fortran, and Cobol, there are dedicated languages such as Intel's PL/M and Zilog's PL/Z. Many semiconductor manufacturers are taking a good hard look at Pascal, known for its data-handling versatility and block structure.

Forth Inc., in Manhattan Beach, Calif., offers microForth and miniForth as software design tools. The Forth language is one of many attempts to reduce the memory requirements and enhance the speed of high-level languages.

Traditionally, HLLs have needed mass-storage devices, like disks. With the expansion in size of solid-state read-only memories, however, many high-level languages are finding their way onto chips, and this is just the beginning. National Semiconductor now has three versions of Basic on a chip. Rudy Langer, a manager of microprocessor systems and software at National, feels that with the availability of integrated interpreters, systems can be put together that actually execute Basic instructions at the board level. One ROM would hold the interpreter, another the instructions. With the addition of one inexpensive integrated circuit (the interpreter), Basic instructions could be executed on the spot, if the system could hack the lower speed, as many can.

There is also serious talk about a standard high-level language for microcomputers. A universal language would forestall dependence on a particular hardware vendor and help control the rising cost of software development. The language chosen should be general-purpose and self-documenting and have flexible data-handling and input/output capabilities. The two leading contenders appear to be Pascal and C, a structured language developed at Bell Labs in Murray Hill, N. J. Proponents of C like its data-structuring capabilities. A variety of constructed data types can be declared, manipulated, pointed to, and dimensioned by the user in C, they say. **J. G. Posa**

BEWARE OF INEFFICIENT CODE

(a)

```
 1        PROCEDURE /TEST2/

 2   V      VAR
 3   V      ADDRESS*16:COPYFROM,COPYTO
 4   V      CHAR*8:DISPLAY(10)
 5   V      BINARY*8:COPYLEN
 6   V      ENDV

 7   C      CON
 8   C      CHAR*8:READYMSG(10)/'READY
 9   C      ENDC

10   E      EXT
11   E      COPY
12   E      ENDE

13        COPYFROM=READYMSG(5)
14        COPYTO=DISPLAY(10)
15        COPYLEN=10
16        COPY(COPYFROM,COPYTO,COPYLEN)
17        RETURN
18        END.
```

(b)

```
41                          *
42                          *********  13      COPYFROM=READYMSG(5)
43                          *
44   0000  C6   05          TEST2              LDA B   #5
45   0002  4F                                  CLR A
46   0003  FB   0013  1                        ADD B  1+LIS.0004
47   0006  B9   0012  1                        ADC A    LIS.0004
48   0009  F7   0001  0                        STA B  1+COPYFROM
49   000C  B7   0000  0                        STA A    COPYFROM
50                          *
51                          *********  14      COPYTO=DISPLAY(10)
52                          *
53   000F  C6   0A                             LDA B   #10
54   0011  4F                                  CLR A
55   0012  FB   0015  1                        ADD B  1+LIS.0002
56   0015  B9   0014  1                        ADC A    LIS.0002
57   0018  F7   0003  0                        STA B  1+COPYTO
58   001B  B7   0002  0                        STA A    COPYTO
```

3. Before optimizing. Being unable to recognize constant subscripts, the compiler here produced less than optimal code. The high-level source lines—13 and 14 in (a)—each produced six assembly-language instructions in the object code (b), three times the necessary amount.

A programmer needs to become familiar with the type of code the HLL produces in order to employ those constructs that produce efficient code and avoid those that do not. An HLL compiler can be thought of as a sophisticated assembler with an extensive, predefined macroinstruction capability. The task of learning any particular compiler is simplified if it produces assembly-language object code and can also furnish a listing with the corresponding assembly statements embedded in the source code. The form of listing produced is important: there is a need for assembly-type mnemonics that depict the code produced from a particular construct (as shown in Figs. 3b and 4b) immediately after the construct, with clear indications of the associated physical addresses and their contents. A block nesting indicator for each executable source statement is also useful.

Once the compiler's output is executed, its performance can be evaluated. By selectively optimizing critical paths in assembly language, it is possible to increase efficiency substantially, especially in terms of speed. An effective way to document this is to enclose the inefficient code in comment delimiters, so that the enclosed code becomes the comment describing what the assembly-language statements do, as shown in Fig. 4.

Optimize by hand

Thus, if a loop contains 20% of the code but uses up 80% of the execution time, it would probably be wise to re-code parts of that loop by hand in assembly language. Programs typically spend rather more than 90% of their

HAND-CODE CRITICAL PATHS

```
13      # COPYFROM=READYMSG(5) #

14  A  ASM
15  A                 LDX   #READYMSG+4
16  A                 STX   COPYFROM
17  A        ENDA

18      # COPYTO=DISPLAY(10)

19  A  ASM
20  A                 LDX   #DISPLAY+9
21  A                 STX   COPYTO
22  A        ENDA
```

(a)

```
                         *********   13   # COPYFROM=REA YMSG(5) #
                         *
                                          ENTRY      TEST2
                                          SECTION CODES
                         *
                         *********             14     ASM
                         *
                 0000  2 TEST2            EQU    *
0000   CE        0004  1                  LDX  #READYMSG+4
0003   FF        0000  0                  STX  COPYFROM
                         *
                         *********   18   # COPYTO=DISPL Y(10) #
                         *********             19     ASM
                         *
0006   CE        0000  0                  LDX  #DISPLAY+9
0009   FF        0002  0                  STX  COPYTO
                         *
                         *********             23     COPYLEN=10
                         *
000C   C6        0A                       LDA B   #10
000E   F7        000E  0                  STA B   COPYLEN
                         *
```

(b)

4. After optimizing. Original inefficient HLL instructions were enclosed in comment delimiters (for documentation purposes) and hand-coded in assembly language. Note that only two instructions were really necessary, and that both ROM space and execution time were reduced.

SHORTER DEVELOPMENT TIME

	Job 1	Job 2	Job 3	Job 4	Job 5	Job 6
Language used	Assembly				High-level	
Number of functions	10	9	13	45	35	40
Stored program ?	no	no	no	yes	yes	yes
Editing 1 (1)	–	–	–	yes	yes	yes
Editing 2 (2)	–	–	–	yes	no	no
Algebraic calculations?	no	no	no	no	yes	yes
RAM space (bytes)	128	512	1 K	1.5 K	1 K	1.5 K
ROM space (bytes)	4 K	12 K	12 K	20 K	16 K	20 K
Development time (man months)	10	22	22	42	11	9
Design time (man months)	4	8	7	18	5	4
Coding time (man months)	4	7	8	11	4	3
Debug time (man months)	2	7	7	13	2	1

5. Firmware. Shown above are the attributes of six typical firmware-development projects. Probably the most important difference between the use of assembly language and a high-level language is the development time, which is 25% to 20% shorter with the HLL.

time executing rather less than 10% of their code.

Tailoring utility routines to the task at hand and writing them in assembly language can save much time and space. Figure 5 summarizes the attributes of six firmware development projects; the sixth job is similar to the fifth and used some common design coding time. Here, "number of functions" is a measure of the overall complexity of the task implemented and correlates with the ROM image size. "Stored program?" indicates whether or not the task supports programs definable by the user—some kind of memory management is implied. "Editing 1" is an indication of whether or not simple editing (say, deleting from and adding to the end of the user program) is allowed, whereas insertions and deletion within the program are permitted by "Editing 2."

In Fig. 5, the number of functions required by the third, fourth and fifth projects are similar. However, the development time of the HLL programs is one fourth to a fifth that of the assembly programs. The space efficiencies are about the same. It is unnecessary to compare time efficiencies, because all tasks operate with similar timing constraints and all met the design requirements imposed at product conception.

If an HLL is used for firmware development, a handle on the physical address space is necessary. Certain absolute addresses like interface ports and common areas with assembly-language routines need to be easily accessible. Ideally, procedures should be able to access global variables across their boundaries, whether written in assembly language or an HLL. If the compiler produces assembly code as object code, many of these criteria are met. The resulting modules can be easily linked into one firmware module.

Seeing the big picture

The examples used by many evaluaters of HLLs are too simple to measure accurately how well the HLL will handle a task where modularity and structure are forced on the programmer. The structure of a firmware module longer than 1,000 statements is practically impossible to comprehend as a whole. Yet to make global optimizations, such understanding is critical. This threshold of comprehension loss is reached sooner when writing in assembly language. When coding in an HLL, however, much more of the overall problem can be recalled.

Most benchmark routines assume the programmer uses the full power of the language without knowledge of the type of code it produces. In reality, much more efficient code can be produced by intelligent use of the HLL—by keeping in mind the things it does well and the things it does poorly. An efficiency increase of 30% can be realized in just two weeks if this time is spent learning the HLL's strengths and weaknesses. □

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Boosting op amps' roll-off extends range of active filters

by C. A. J. van der Geer
FOM Institute for Plasma Physics, Jutphaas, the Netherlands

The upper frequency limit of a low-pass active operational-amplifier filter can be extended by making use of the op amp's roll-off. By simply cascading a number of op amps that have been individually compensated, the effect of roll-off (gradual loss of gain beyond the flat portion of its mid-frequency amplitude curve) is reduced, and a filter having at least 10 times the maximum cutoff frequency of conventional units can be obtained. The high-order filter response is almost identical to that of a maximally flat (Bessel) filter.

The method used to achieve optimum response will be best understood by observing the op amp's open-loop transfer function. The open-loop response without internal compensation is approximately:

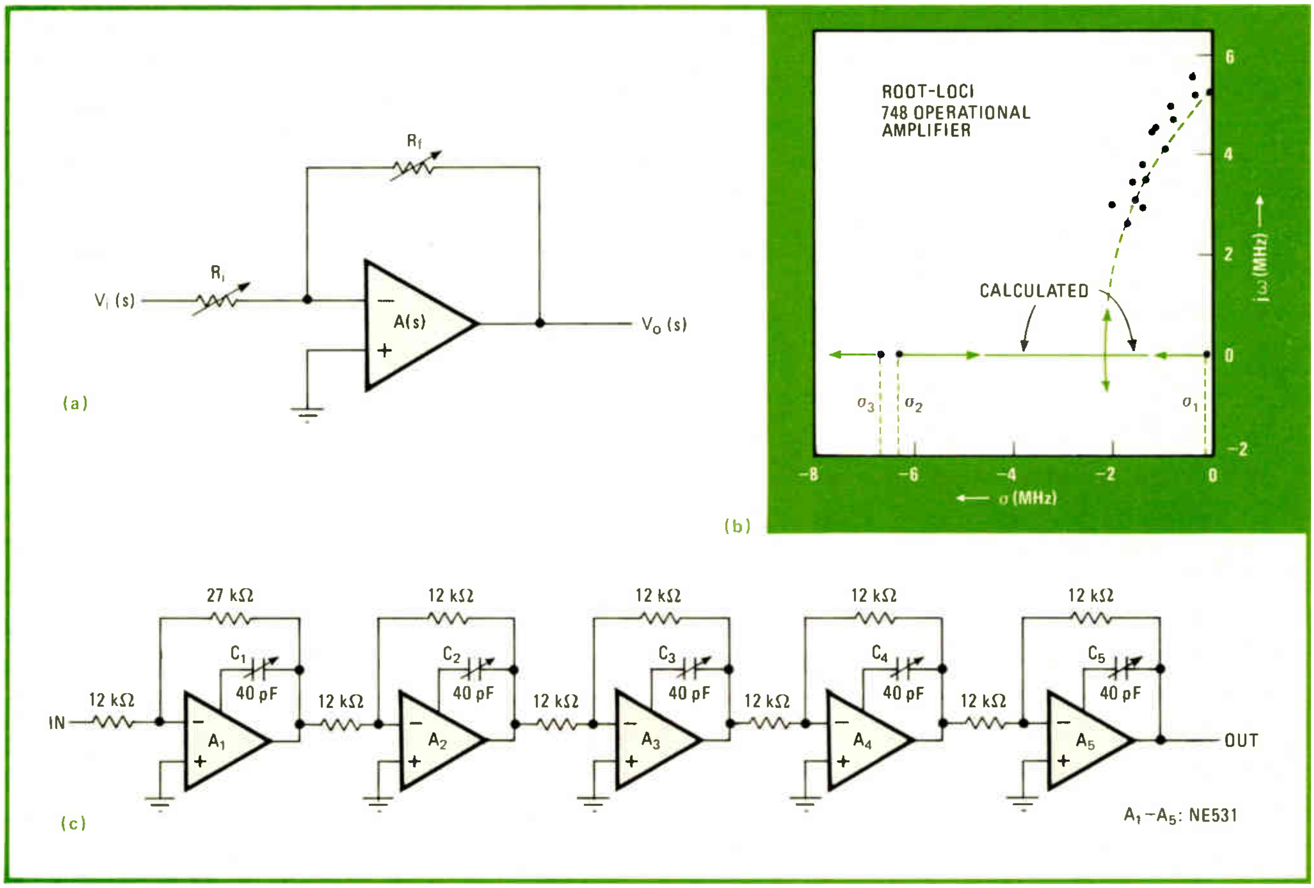
$$A(s) = A_o\left[\frac{\sigma_1\sigma_2\sigma_3}{(s-\sigma_1)(s-\sigma_2)(s-\sigma_3)}\right]$$

where A_o is the low-frequency gain and σ_1, σ_2, and σ_3 are the open-loop poles, or the break points, in the frequency-response curve.

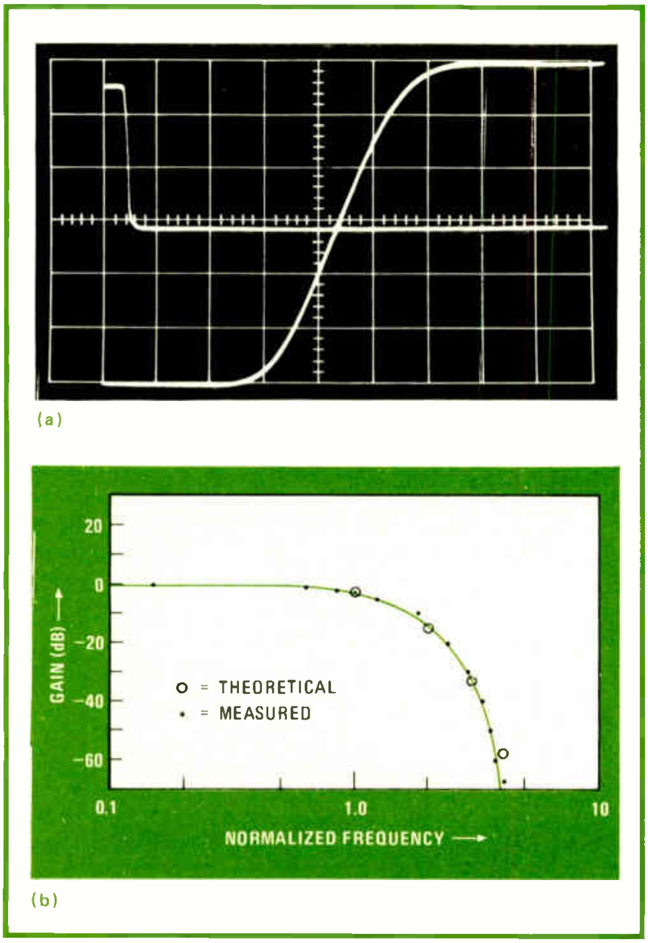
When negative feedback is applied without external compensation to the op amp in its standard inverting configuration (Fig. 1a), the closed-loop function becomes:

$$\frac{V_o(s)}{V_i(s)} = \frac{-A(s)}{1+\beta[1+A(s)]}$$

where β equals the ratio of the feedback resistor, R_f, to the input resistor, R_i. The resistive feedback neither introduces new poles or zeros in A(s) nor cancels them, but it does alter their location in the s-plane. When the feedback is gradually increased from zero to infinity by decreasing the input resistor to zero, the poles of the closed-loop function depart from σ_1, σ_2, and σ_3 and follow a particular trajectory, terminating in the zeros of A(s). These trajectories are the root loci, examples of which are shown in Fig. 1b, one for each of the closed-



1. Pole position. Adding negative feedback (a) to op amp alters pole-zero location in s-plane, enables plot of root loci (b) when feedback is gradually increased. Root loci resemble Gaussian low-pass filter curves, and suitably compensated op amp filter (c) can duplicate response at an upper frequency limit far beyond that of conventional active filters by boosting roll-off, which becomes more than 60 dB per decade.



2. Response. Filter is optimized by adjusting filter's compensating capacitors for the rise time required (large curve) using a step input (negative-going pulse). On plot of normalized frequency response (b), op-amp filter closely matches theoretical 10th-order Bessel filter.

loop poles of a 748 op amp. Only the root loci for the positive values of $j\omega$ are shown.[1]

The root loci resemble the curves on which the poles of the Gaussian family of filters are situated,[2] and these curves may be virtually duplicated if several cascaded op-amp stages are set so that their individual root loci align in a pattern that makes possible a circuit response well above the normal passband of one op amp. In essence, this technique allows the combining of stagger-tuning with the boosting of the individual high-frequency responses of each amplifier.

The overall response of the filter can be extended by varying each op amp's compensating capacitor in order to move the location of the individual poles. Of course, the poles can also be moved by changing the ratio of feedback-to-input resistors as mentioned, but the former method is more practical because it is easier to trim the circuit when the amplifier gain is held constant.

Figure 1c shows a 10th-order low-pass filter, built with 561 op amps, having a gain of about 2 and a 1-megahertz cutoff frequency (at which point the output voltage is −3 dB down from its peak value). The roll-off is more than 60 dB per decade. The gain of any filter built using this technique should be above unity to ensure minimum difficulty in trimming the circuit.

Figure 2a shows the response of the filter for a step input. The scope's time base is set at 200 nanoseconds per division. For optimum response at a given cutoff frequency, the trimmers C_1–C_5 are adjusted in sequence to obtain the rise time required. The normalized frequency response is plotted in Fig. 2b. The circles represent the corresponding points for a theoretical 10th-order Bessel filter. □

References
1. S. S. Hakim, "Feedback Circuit Analysis," Iliffe Books Ltd., London, 1966.
2. A. I. Zverev, "Handbook of Filter Synthesis," John Wiley and Sons Inc., New York, 1967.

Extending the range of an intermodulation distortion test

by Don Feeney
TRW Semiconductors, Linear RF Products, Lawndale, Calif.

More often than not, a system's intermodulation distortion is characterized by its third-order intercept value, the most widely accepted figure of merit for indicating the linearity of a system. Even though IMD is extremely difficult to measure accurately and with repeatability when low signal levels are introduced into the device under test, precise measurements can be made at levels as low as 100 decibels below the desired carrier (input-signal) point. The secret is to add a tunable bandpass filter to the measuring system and to reduce the nonlinearities inherent in the test system, thus making it possible to determine third-order intercept values of up to +50 dBm, which is more than 20 dB above that of most measuring systems now in use.

Third-order intermodulation products are generated as shown in part (a) of the figure. Consider two signals, f_1 and f_2, that are applied to the input of a device that has a nonlinear transfer function. If the output power is equally distributed at both frequencies and the frequencies are close together, equal power-distortion products will occur at $2f_1 - f_2$ and $2f_2 - f_1$.

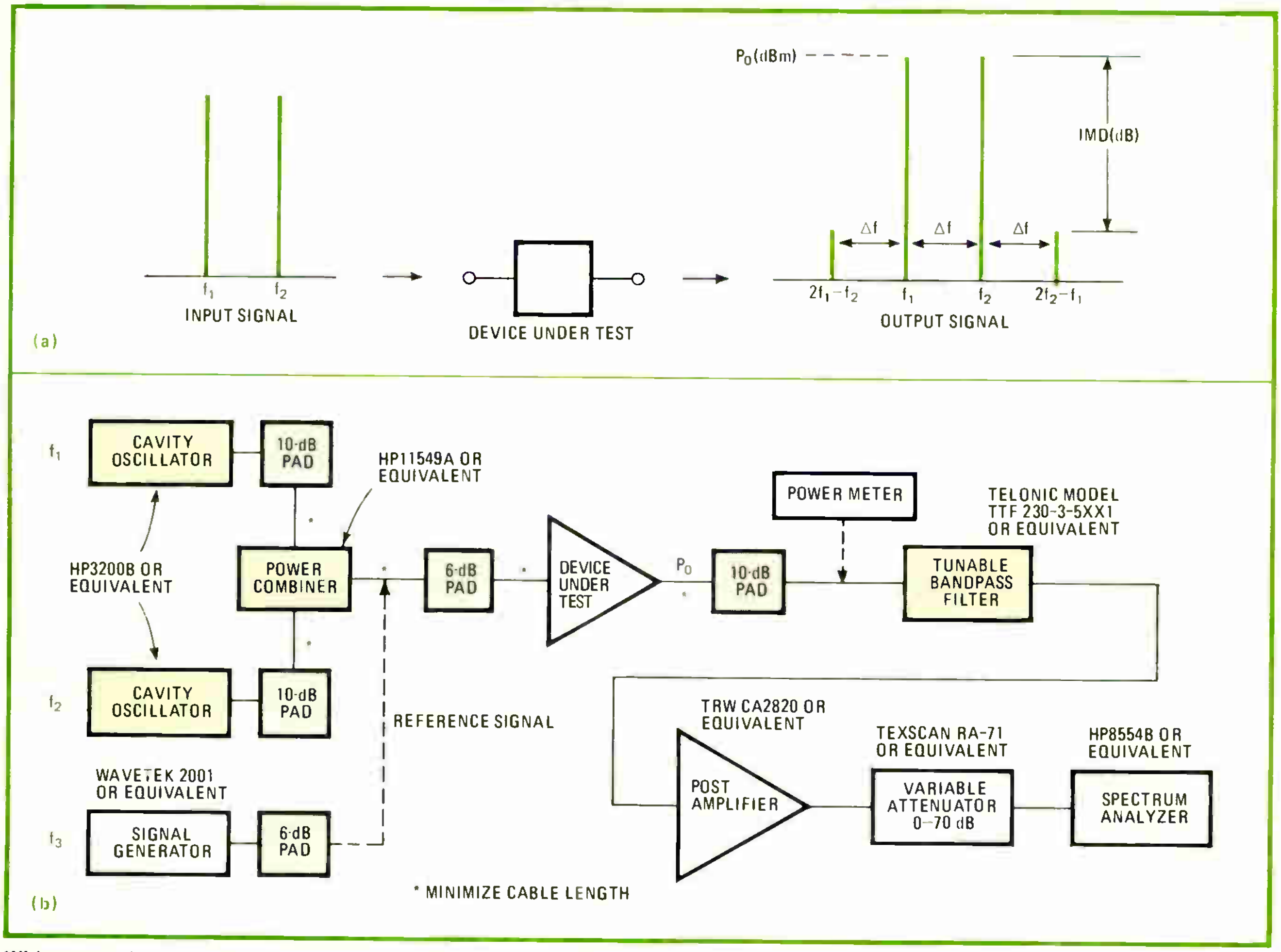
The magnitude of these unwanted products, expressed in decibels below the output P_0, is defined as the system IMD. The third-order intercept may then by found by its defining equation:

$$I = P(\text{dBm}) + \text{IMD}(\text{dB})/2 \qquad (1)$$

where IMD is the third-order product produced by the I intercept value, measured in decibels.

An IMD setup having wide dynamic range is shown in (b). In this case, measurements are performed at 30 to 500 MHz, although the guidelines set forth here will allow accurate measurements at any frequency.

The first step in measuring IMD and thus securing the third-order intercept of a device is frequently the most difficult to attain—that of combining two input tones to the device under test without introducing distortion or



Wide range. Intermodulation distortion is created if two input frequencies pass through a nonlinear device (a). System measures IMD over wider range than standard setups by using cavity oscillators to reduce harmonic generation, tunable bandpass filter for rejection of IM components not measured against f_1 or f_2 ($2f_2-f_1$ or $2f_1-f_2$, respectively), and power-splitter for linear combiner of f_1 and f_2. Pads (6 dB and 10dB) offer isolation between system elements. With setup, measurements of IMD can be made at levels 100 dB below carrier.

spurious responses. For fixed-input-frequency setups, filters can be employed to eliminate harmonics generated by f_1 and f_2. If the input frequencies are variable, cavity oscillators should be used instead of sweep generators, because the latter's harmonic content is too high.

The best method for combining the two signals linearly is to use a resistive power combiner as shown, so that the composite signal generated will be virtually clean (no nonlinearities). To reduce third-harmonic distortion between the f_1 and f_2 generators, 10-dB attenuator pads should be used between the cavity oscillators and the power combiner. Using both the pads and the combiner guarantees a broadband input source with constant characteristic impedance facing the device under test. As the requirement for a broadband resistive source of constant impedance also applies to the load for the test device, it is wise to use a 10-dB attenuator here, as well.

The system's measuring range is improved by placing a five-pole bandpass filter in the postamplifier chain. Having a bandwidth of less than Δf, this filter rejects unwanted signals f_1, f_2, their harmonics, and $2f_2-f_1$ when measuring IMD at $2f_1-f_2$, thus eliminating strong but unwanted signal responses that tend to limit the dynamic range of (that is, densensitize) the test system.

For those not familiar with the procedure, IMD and third-order intercept are found as follows:

- Set channel spacing to the desired Δf (6 megahertz for the system shown in the figure).
- Set reference signal f_3 to $2f_1-f_2$.
- Using a power meter, set P_0 to the desired output power level for each of the three sources independently. Connect only one source at a time.
- With f_3 connected, tune the bandpass filter to f_3. With the variable attenuation at 30 to 50 dB, set a reference level on the spectrum analyzer. Make sure the postamplifier is not in compression by inserting 30 to 50 dB of additional attenuation. One should then observe 30 to 50 dB of signal reduction on the spectrum analyzer.
- Apply f_1 and f_2. Decrease attenuation in the variable attenuator to bring the signal within range of the analyzer. Add the change in attenuation to the value of suppression as read on the analyzer to obtain IMD.
- Adjust f_3 and filter to $2f_2-f_1$ and repeat all steps. IMD should be within 3 dB of the first measurement.
- Calculate the third-order intercept from Eq. 1. □

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Engineer's newsletter

One way to mate ECL and TTL

It's often convenient to mate transistor-transistor logic with some unique emitter-coupled-logic functions such as the MC1648 vhf oscillator or the MC12002 analog mixer. Vernon P. O'Neil of Motorola Inc.'s Discrete Semiconductor division says that if system speed requirements are not too high, there is a convenient IC for transforming ECL levels into TTL levels—the MC3486 line receiver. **Using the complementary ECL outputs as the input to the line receiver transforms them into TTL inputs**—and with the added advantage of three-state output.

Alternatively, if the speed of the MC3486 would limit the performance of the system, then use the built-in ECL/TTL converter of the MC12000 digital mixer, which operates at frequencies above 40 MHz. Both the MC 3486 and the MC12000 operate from a single 5-v supply.

A teach-yourself trainer in logic for technicians

Do you have to train technicians and production personnel in combinational or sequential digital logic based on standard gates and flip-flops? At \$69.95, the Broder model 100 Logic Trainer appears to be a simple, low-cost method. It comes in a plastic box 9 3/16 by 4 3/4 by 1 9/16 inches in size with a series of eight switches on its left side. Across from the switches is a liquid-crystal horizontal-bar indicator. The circuitry is powered by an internal battery.

To operate it, you put a "problem" card in a cavity between the switches and the readout. The card indicates the necessary logic switches and the bar position for a proper solution of its logic configuration. The user simply has to program the indicated switches to force a logic 1 at the card's output to turn on the correct bar indicator. No wiring or IC manipulation is required. A manual, 40 problem cards, and a 9-v battery are included. For additional information, contact L. J. Broder Enterprises Inc., 3912 Darvany Dr., Dallas, Texas 75220, or call (214) 357-7763.

What's a Kelvin contact?

Wherever high-current, low-voltage measurements have to be made, Kelvin contacts are needed. But most engineers either have forgotten or don't know the technique for making measurements with them. So Sage Enterprises has put out a technical brief, TB 7801, describing **the application and theory of Kelvin contacts in some detail.** For a free copy, write to Sage Enterprises, 1080 Linda Vista Ave., Mountain View, Calif. 94043.

Tektronix to teach about microprocessors

Tektronix Inc. is setting up four permanent training centers in microprocessor design and development. Two are already in operation in Rockville, Md., and Santa Clara, Calif., and the others will open in Boston and Dallas next October and January.

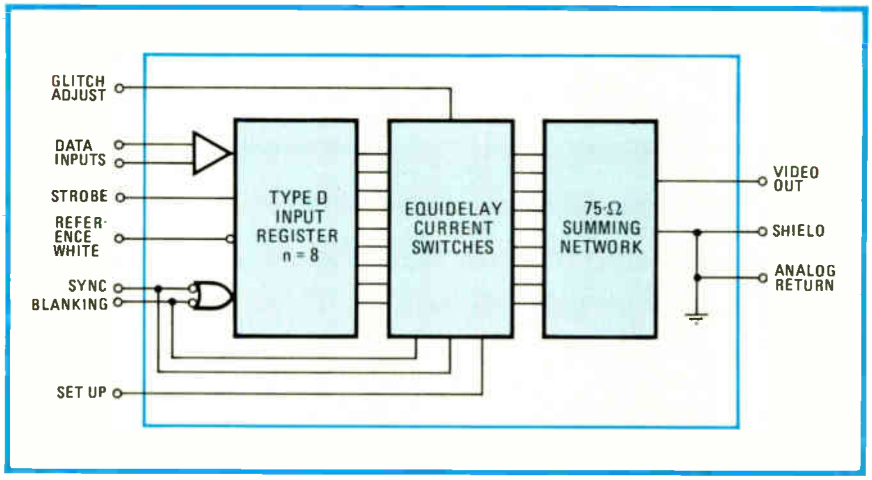
Scheduled to run altogether 65 times through June 1979, the courses are: **a microprocessor design workshop (five days for \$595) and a microprocessor development lab workshop (three days for \$395).** The longer one will focus on software development and system integration for the 8080 and 6800 family microprocessors; it takes the designer from flow charts to debugging and emphasizes hands-on experience with the Tektronix 8002 microprocessor development lab. The other makes use of the firm's 8002 development system.

First courses at the centers are scheduled for Aug. 21, Sept. 11, and Sept. 25. For more information, contact Tektronix, P. O. Box 500, Beaverton, Ore. 97077, or call (503) 644-0161. **Jerry Lyman**

D-a subsystem runs at 100-MHz

Glitch-free 8-bit video module includes composite sync and blanking inputs; sells for $85

by Pamela Hamilton, Boston bureau



As a 100-MHz digital-to-analog converter that sells for $85 in 100-piece quantities, the MP8308 is impressive enough. But the 8-bit module goes further—it is a complete video subsystem that accepts standard video control inputs and interfaces directly with 75-Ω cable on its ouput. And on top of all that it comes in a fully shielded package measuring only 2 by 3 by 0.35 inches.

"When this project finally gelled, we'd decided we didn't want to build just another high-speed d-a converter," comments Matthew Mahoney, group manager for a/d/a modular products. "We wanted a complete subsystem, instead." Most high-speed, or video, d-a converters have to be connected to a deglitcher to avoid sudden changes in the output signal caused by slight differences in the switching time of their current switches. But by carefully matching the switching times of its switches, the designers of the MP8308 have avoided the need for deglitching entirely, according to Mahoney.

The glitch-adjust terminal in the block diagram may suggest that glitch-free operation requires user trimming. Actually, the terminal may be left open provided the negative supply voltage is exactly −5.0 v. The terminal allows trimming of the delay of the most-significant-bit switch to accommodate voltages from −4.75 to −5.5 v.

No ringing. Interfacing a d-a converter to a 75-Ω transmission line usually necessitates the use of an output buffer amplifier with its related problems of overshoot, settling time, and ringing. The designers of the MP8308 cleverly avoided this problem by eliminating the amplifier. Their R-2R resistive summing network has an impedance of 75-Ω all by itself, making extra matching circuitry unnecessary.

Adds Mahoney: "As a byproduct—because you're looking into a resistive network—the device is very flexible. It's very easy to add on other resistive levels. For example, you can make the signal brighter or darker with additional resistors." The output is compatible with EIA standards RS-170 and RS-343A and will drive high-resolution monitors directly.

Two versions of the converter are offered: the 100-MHz unit, whose data inputs must be driven by emitter-coupled logic, and a transistor-transistor-logic unit with a maximum update rate of 40 MHz. Both versions contain eight ECL type D flip-flops, but the TTL device includes TTL–ECL translators in its input data lines. Both units use TTL control signals; the ECL version requires ECL signals only on its input data lines.

Both converters require nominal power supplies of ±5 v. The ±5-v supply can vary by 5% from nominal and must be capable of delivering 25 mA for the ECL converter and 50 mA for the TTL. The −5-v supply may vary from −4.75 to −5.5 v and must supply 300 mA to the 100-MHz converter and 400 mA to the 40-MHz device.

The MP8308 has a full-step settling time, to within one least significant bit, of 7.5 ns, typical. Rise and fall times (10% to 90%) are a maximum of 4 ns, but typically 3 ns. Operating temperature range is 0° to 55°C.

The device will be used mainly in graphic display systems of the raster-scan Z-axis-modulation type. For multicolor displays, multiple converters can be used.

The $85 price applies to the ECL unit. The TTL version sells for $89. Production quantities are expected to be available in October, according to the company.

Analogic Corp., Audubon Road, Wakefield, Mass. 01880. Phone Dick Ferrero at (617) 246-0300 [338]

Packaging & production

System performs complete tests

Combined analog and digital unit does both in-circuit and functional testing

Electronics manufacturers can reduce warranty and manufacturing costs, increase productivity, and reduce excess inventory by exploiting the capability of the 3060A board test system. It can perform both advanced in-circuit component measurements and board-level functional stimulus-response tests. This improvement in testing efficiency not only allows the checking of boards to a high confidence level in a single operation, it also minimizes board handling and eliminates the need for two separate test systems.

Moreover the functional testing provided by the 3060A is not only digital. The system can check out a digital-to-analog converter as easily as it can a board full of straight transistor-transistor logic.

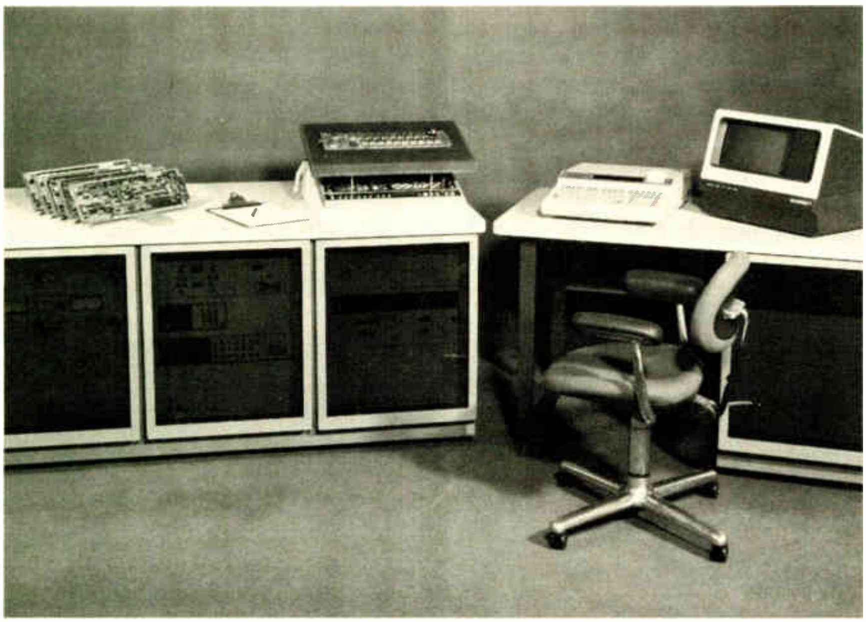
Functional tests are performed using the same bed-of-nails fixture used for in-circuit component testing, so they are greatly simplified and speeded up. The response of internal circuit nodes is available, eliminating the guided probe.

Testing with the 3060A follows a logical sequence, which minimizes both the stress placed on the board and the testing time. First, in-circuit testing verifies that discrete components, such as diodes and resistors, are correctly loaded and are within specified tolerances. Accurate in-circuit tests are not possible without isolation of each tested part from the effects of parallel components.

To do this, the 3060A uses the simple guarding found in other systems, extended guarding to remove the effects of lead length and relay contact resistance, and accuracy enhancement to remove the effects of scanner thermal offsets. Phase-synchronous detection also enhances measurement capability by separating the impedance contributions of parallel resistive and reactive elements.

The 3060A has two separate digital testing modes: static pattern testing and dynamic signature analysis. Static pattern testing is best for combined digital and analog circuits, such as the d-a converter.

Signature analysis adds the capability of testing large-scale integrated circuits, including microprocessors, at full operating speed (up to 10 MHz). In addition, a portable HP 5004A signature analyzer can be used to troubleshoot these same boards when the product requires service in the field.



To eliminate programming problems—often the most troublesome part of an automatic test system—HP uses High-Level Programming Language (HPL), which provides immediate feedback when errors occur. It also allows on-line editing to reduce programming time.

The system software package also includes a special Board Test Language (BTL) and an in-circuit program generator (IPG). IPG automatically generates the in-circuit portion of the program, prints out the finished program in BTL, and generates a fixturing map for faster programming.

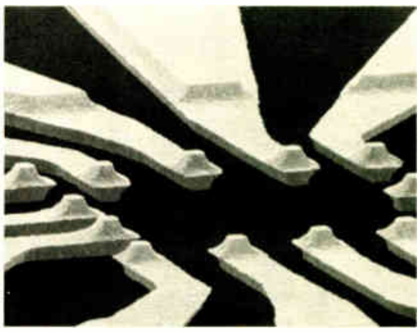
The U.S. price for the 3060A starts at $74,000. Deliveries will begin in September.

Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif. 94304 [391]

Tape takes bumps out of wafer preparation

Automated production of integrated circuits has involved the use of microinterconnect tapes or film carriers for some time [*Electronics*, Dec. 25, 1975, p. 61]. But the process has until now required an extra wafer-processing step before the tape and the chip could be joined; a metal bump had to be added at the interconnect point to prevent the pad from collapsing when normal thermocompression or alloy-type bonding was used.

This step, which added to produc-



tion costs and reduced chip yield, can now be eliminated by using an 11-mm microinterconnect tape. The tape has a 1.3-mil-high bump etched on the tip of each 1.3-mil-thick lead. A few mils from the bump, the lead is thickened to 2.6 mils to improve lead rigidity.

The 2-oz single-layer copper tapes are supplied on reels and are at present available either bare or gold- or nickel-plated, to complement the metallurgy used in wafer manufacture. For unplated 11-mm, nontestable bumped tape, large-quantity orders result in a price of less than 1 cent per unit for a standard pitch. Making tapes from purchaser's artwork takes about five weeks.

Dyna-craft Inc., a division of National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. Phone Dick Presby at (408) 739-6321 [393]

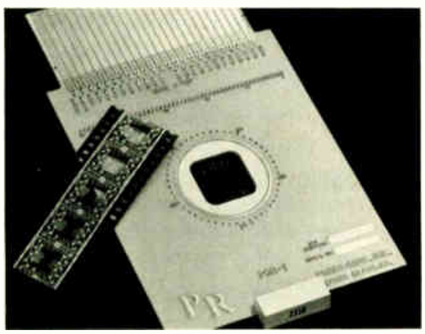
Card specified by user probes ICs on film carriers

A probe card developed by Probe-Rite permits automatic testing of integrated circuits on continuous film carriers. Testing does not damage the film substrate. The card can be used with standard or specially designed probing equipment and has gold-plated probes.

Cards are configured to the user's specification and are identified according to the chip for which each is intended.

Prices for the cards begin at $60 and are available two weeks after receipt of order.

Probe-Rite Inc., 2725 Lafayette St., Santa Clara, Calif. 95050. Phone (408) 249-1255 [395]



Microcomputers & systems

Unit controls communications

Single-board computer frees system bus from long-winded conversations

Hanging more processors onto a microcomputer-based system may add some computing power, but it often yields headaches as well. The reason: it's hard to get the microprocessors to talk to each other, and when they do, they take up valuable time on the system bus. Now, Intel Corp. is about to announce a new single-board computer that not only solves those problems but can function as either an off-bus processor for communications slaved to one or more master processors or as a stand-alone communications controller.

"You can look at it two ways, as an intelligent slave or as a single-board computer with I/O on it," declares Gary G. Sawyer, SBC 80 product manager, OEM Microcomputer Systems division, Aloha, Ore. Called the iSBC 544, the single-board computer employs a dual-port random-access memory of 16,384 bytes and a three-bus architecture, which it shares with the newly introduced 80/30 single-board microcomputer. Together, these two features mean that the 544 performs all of its processing of communications traffic off the system bus, so that "it doesn't occupy system time," according to Craig Kinnie, project manager for board products.

The buses are the dedicated processor bus with its own input/output and read-only-memory and programmable ROM section, the system bus, and the dual-port bus for access to the 16 kilobytes of RAM. The dual-port bus is governed by an "arbiter" circuit "which determines which of the first two can access the dual-port bus," Kinnie explains.

The significance of the 544 is that "for the first time a user has intelligence built into a slave device," declares Sawyer. "He now has the capability to offload a bus master to perform communications activities locally on the board." He adds that the 16 kilobytes of dual-port RAM "minimizes the need for dedicated RAM boards."

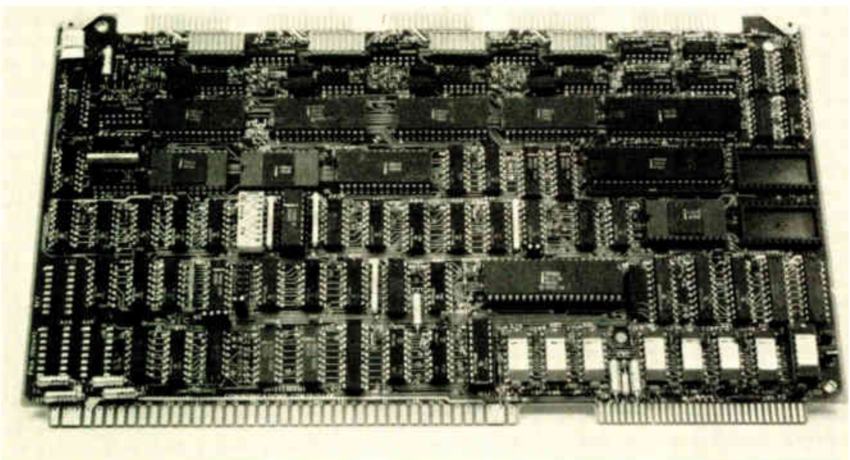
Kinnie emphasizes the functional density" of the 544, noting that it packs "a lot of power in one card" measuring 6.75 by 12 inches. Powering the SBC is a 2.6-MHz version of Intel's popular 8085A 8-bit microprocessor. The communications board contains four programmable synchronous or asynchronous serial channels, capacity for up to four kilobytes of PROM or eight kilobytes of ROM, four programmable baud rate generators, three interval timers a programmable interrupt control, a 10-bit input/output interface compatible with a Bell 801 automatic calling unit, and an interface control for auto-answer/auto-originate modems.

Specifications seem powerful, too. Sawyer says that the processor speed is 1.45 μs for the fastest executable instruction, which is the way Intel specifies its single-board computers. The synchronous baud rate ranges from 4.8 kHz to 56 kHz, and the asynchronous baud rate ranges from 75 Hz to 19.2 kHz. Temperature range is 0° to 55°C, and the unit requires power supplies of +5 and −12 v dc.

As an intelligent slave, the 544 could be used as a front-end processor or terminal multiplexer in a system controller, perhaps by the 80/30 microcomputer board. The 544 would handle the communications chores such as format control, code conversion, data-link control, error checking, data compression, and protocol management without bothering a bus master such as the 80/30 or disturbing the system bus. In its stand-alone mode, it may act as an intelligent terminal controller, connecting one or more dumb terminals to a data link and providing the required buffering, code conversion, and data link control functions.

The 544 is expected out later in August. For pricing information, contact local Intel sales office.

Intel Corp., OEM Microcomputer Systems Division, 3065 Bowers Ave., Santa Clara, Calif. 95051 [371]



Single-board display has control system, too

The first members of a family of low-cost, self-contained alphanumeric display subsystems, the MTX-A2 and MTX-B2, are based on an intelligent single chip that controls both display and keyboard functions. Known as the alpha chip, it permits the complete display subsystem, including the controller, display drivers, and alphanumeric light-emitting-diode displays, to be contained on a single printed-circuit board that measures 8 by 3.25 inches.

The MTX display boards interface directly with an 8-bit bidirectional data bus or input/output port, so they can be directly connected to microprocessors such as the 8080A and the 6800. The MTX-A2's display consists of 16 five-by-seven-dot-matrix LEDs that are 0.3 in. high, whereas the MTX-B2 uses the two 16-character rows of 14-segment, 0.5-in.-high LEDs for its display.

The on-board alpha chip offers 22 commands for display manipulation, including clear-display, blink, shift, rotate, and cursor manipulation commands. It can control scanning and debouncing of up to 64 keys.

Each display requires a single 5-V, 800-mA power supply. The column-driver voltage can be varied between 2 and 6 V to change the display intensity or to decrease power consumption.

All mounting hardware and a red filter are included with the single-board units. Prices begin at $280 for a single 16-character display, and quantity discounts are available. Delivery time is two to four weeks.

Matrox Electronic Systems Ltd., P. O. Box 56, Ahuntsic Sta., Montreal, Que. H3L 3N5. Phone (514) 481-6838 [373]

Operating system helps clean out bugs

The Micromonitor operating system CDP18S831, tidily known as MOPS, is a software package of enhanced debugging techniques ranging from simple terminal-Micromonitor dialog to hands-off system testing for users of the Cosmac Micromonitor CDP18S030. The Micromonitor is a self-contained debugging tool usable with any system based on the CDP1802 microprocessor. It permits real-time, in-circuit debugging of hardware and software problems.

MOPS adds to the performance of the Micromonitor by allowing users access to the processing and storage capabilities of a Cosmac development system II equipped with a floppy-disk drive. The software package consists of a diskette, a universal

asynchronous receiver/transmitter module, connecting cable, and a user's guide with several examples of MOPS application. In single quantities, it is priced at $350 in the U. S.

RCA Solid State Division, P. O. Box 3200, Somerville, N. J. 08876. Phone (201) 685-6380 [374]

Software for 6500 family debugs at assembly level

A stand-alone debugging system for the 6500 microprocessor family, the DB/65 comes with a programmable read-only memory in which its monitor program resides, 2 kilobits of random-access memory, and an emulation cable. Sockets are provided for adding 6 kilobits of RAM.

With the PROM-resident monitor, users may examine and modify memory and registers, set breakpoints, load memory, trace history by exercising a single instruction at a time, and write memory-protection blocks by keeping the write line high.

The system also features automatic symbolic disassembly that, after a user-program halt, displays the next instruction in assembly language with symbols inserted for the label and operand fields. Thus, the programmer can debug the system at the same level at which it was created.

The DB/65 may be loaded from a System 65 or similar system via the parallel input port—a 4-K program can be loaded in about 5 seconds—or from the serial port.

It is priced at $1,450, with delivery from stock to 60 days. Purchasers must specify the type of system, available RAM, and starting address.

Computer Applications Corp., 413 Kellogg, Ames, Iowa 50010. Phone (515) 232-8181 [375]

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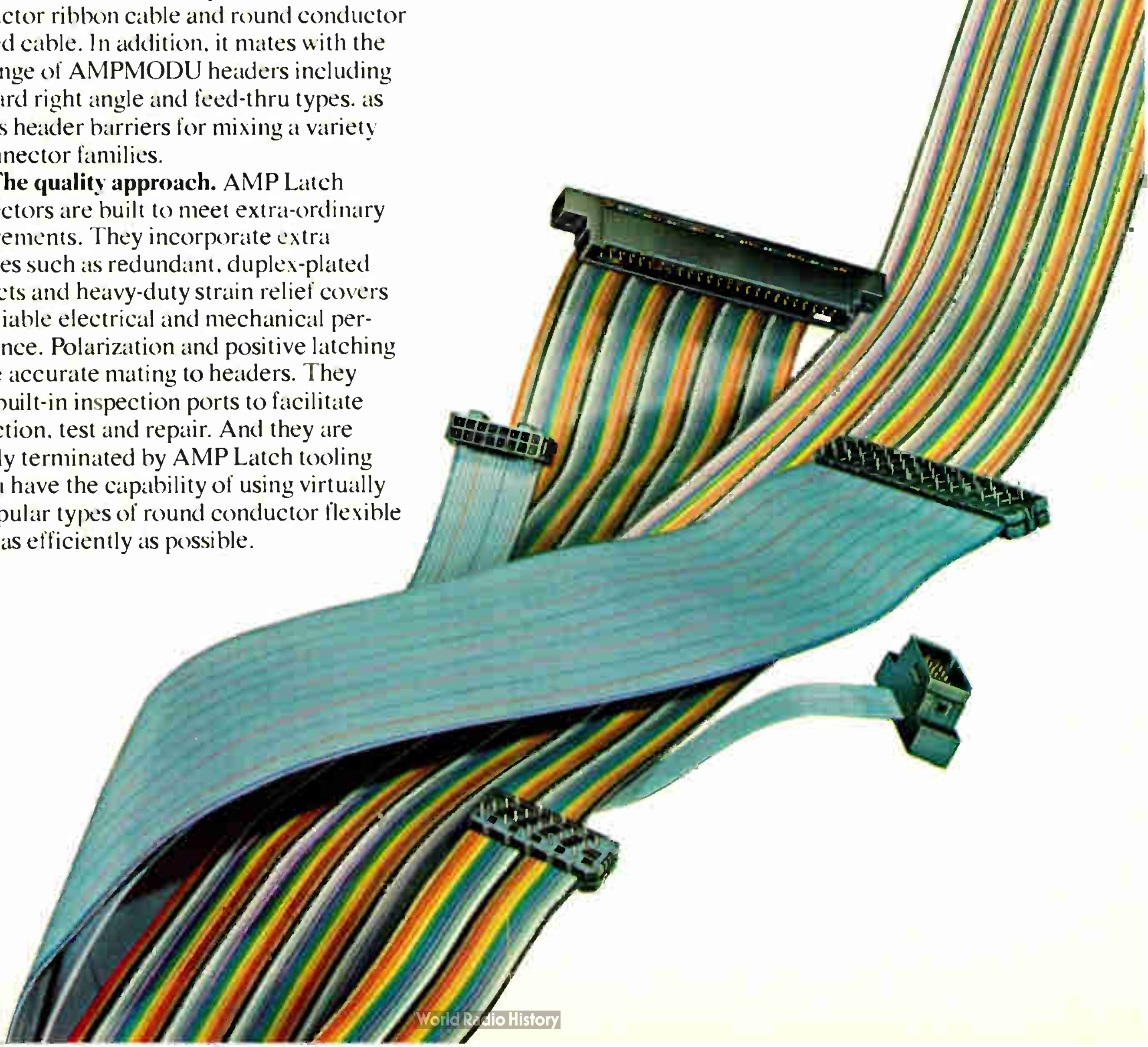


New products

Instruments

Meter measures up to 1 farad

Battery-powered 10-range instrument resolves 0.1 pF; sells for $120

Designers and field-service personnel to whom low cost is more important than programmability or other special features will appreciate the model 820 digital capacitance meter. Priced at only $120, the four-digit instrument has 10 ranges, from 999.9 pF to 999.9 mF. Its maximum error is 0.5% of full scale plus one count up to 100 μF, increasing to 1.0% of full scale plus one count from 1 mF to 1 F.

Weighing only 1.51 lb complete with four standard C cells, the 820 is as useful in the field as it is in the laboratory. Although it is not a precision instrument, its measurement uncertainty is much less than the tolerance of most capacitors. It is therefore useful for matching capacitors in critical applications, spot checking for quality assurance, measuring the capacitance of complex series-parallel networks, and simply identifying unmarked components.

A pair of front-panel lead-insertion jacks makes possible fast in-out testing of small components. For connection to large capacitors or circuits, there is also a pair of standard banana jacks.

Readings on the four-digit light-emitting-diode display stabilize within 300 ms for capacitance values up to 1,000 μF; above that value, the required time increases to a maximum of 35 s at 1 F.

Available accessories include a rechargeable battery pack, a charger, and a carrying case.

B&K Precision, 6460 West Cortland Ave., Chicago, Ill. 60635. Phone (312) 889-9087 [351]

3½-digit multimeter spans 50 kHz, resolves 10 μV

Although it sells for only $365, the model 3030A multimeter is a 3½-digit instrument that offers such unusual features as true-rms measurements out to 50 kHz, resolutions of 10 μV, 10 nA, and 10 mΩ, and direct readout in decibels. The 3.5-lb portable instrument measures ac and dc voltage, ac and dc current, and resistance. Its ac capabilities, however, are what really set the 3030A apart from the pack.

The meter has four ac modes—average, peak, rms, and decibel. A front-panel control allows the user to set the decibel reference level. Frequency response in the average mode extends from 50 Hz to 110 kHz; for peak readings, it goes from 20 Hz to 20 kHz; and for rms measurements, it covers 20 Hz to 50 kHz. Maximum crest factor for full-scale inputs in the rms mode is 3 over the full frequency range.

Both ac and dc voltage functions are served by six ranges, from 20 mV full scale to 1,200 V. Similarly, there are six current ranges, from 20 μA full scale to 2 A. The seven resistance ranges are broken into two overlapping groups: the low scales, which go from 20 Ω full scale to 2 MΩ, use an excitation voltage of 200 mV; the high ranges (2 kΩ to 20 MΩ) use 2 V. The benefit is easy in-circuit measurements on diodes and transistors. Available options include a $45 internal rechargeable battery pack.

Ballantine Laboratories Inc., P. O. Box 97, Boonton, N. J. 07005. Phone (201) 335-0900 [354]

High-speed unit analyzes five logic families

The Scanmaster 5700B is a high-speed logic analyzer for in-circuit troubleshooting of 14- and 16-pin digital integrated circuits. Users can select the appropriate high and low threshold levels for any of these logic families: complementary-metal-oxide-semiconductor (5, 10, 12, and 15 V), high-threshold, resistor-transistor, transistor-transistor, and diode-transitor logic.

Two operating modes are provided. In the fast-scan mode, the unit checks the threshold status of each pin in sequence, stopping only when a particular pin's logic level is out of tolerance. If that should occur, the pin number and logic condition are displayed; also, use of a hand-held probe enables the logic

New products

level to be displayed by an on-panel digital voltmeter. If no level fault is detected, the scan cycles to the last pin, and light-emitting diodes display the logic status of each. The manual mode allows each pin to be checked individually.

The probe may also be used as a pulser to inject a signal of appropriate amplitude and width, and the analyzer can be used with an oscilloscope or recorder to further display or retain data. In addition, static or dynamic failures can be stored in the unit's memory.

Priced at $1,295, the 5700B is deliverable in 30 days.

Information Scan Technology, 1725 Rogers Ave., San Jose, Calif. 95112. Phone Tony Lee at (408) 292-7196 [355]

4½-digit panel meter offers BCD output option

A 4½-digit panel instrument with 100- or 10-μv sensitivity, the AN2574 can be optionally configured with a word-programmable, three-state output in binary-coded decimals that lets it converse with, say, a microprocessor. Its data can be multiplexed onto a single set of data bus lines in 4-, 8-, 12-, 16-, or 20-bit words, along with information from other units.

The unit features 1,000-MΩ differential input impedance, autozero, and autopolarity. Capable of a ±20,000 count, it has a resolution of within 0.005% and an accuracy of within 0.01% of the reading ±1 digit. When operating from either 110- or 220-v ac lines, it has a ground-to-line isolation of 1,400 v.

In quantities of 100 or more, individual AN2574s cost $99.

Analogic Corp., Audubon Road., Wakefield, Mass. 01880. Phone (617) 246-0300 [356]

Components

Touch switches behave better

Keyboard and position sensor designed for the ungrounded and the "hard-of-touching"

After three years of intensive research, Touch Activated Switch Arrays Inc. has triumphed with a $49 solid-state keyboard and a touch-activated solid-state control module called the Ferenstat. Both new products feature the company's pioneering micro-proximity touch-sensor technology.

Touch-activated switches are currently found in elevators, point-of-sale terminals, and a variety of control panels. But they are often unreliable. Many will not switch on unless the operator is electrically near ground. Others have been damaged by users pushing them too hard. Still others may react when it is an adjacent switch that has been touched.

In the Ferenstat's touch-activated array, "the sensors are 1/16 inch apart," says Ferenc Ledniczki, TASA president. "Yet there's no interaction problem and the user can be floating in space but still activate the switch." Both the Ferenstat and keyboard are sealed and covered with a durable, polycarbonate plastic, so that "even ham-fisted button pushers can't damage them," Ledniczki quips.

A Ferenstat module converts finger motion along its 7-inch sensor surface into a series of logic-state changes, or counts, proportional to how far the finger has traveled and in which direction—up or down. It is a way to convert the human hand's motion into a digital format for use by a computer or process controller, for example.

The Ferenstat's designers arranged its 105 touch sensors so that they are in seven successive groups of 15 sensors each. Individual sensors from each group are connected in parallel to form 15 parallel output lines. These, in turn, form the input to a parallel-load shift register that outputs parallel data to a pattern-comparison motion detector, and the same data in serial form to a serial-load shift register.

To accept the data from the parallel-load register, the serial-load register must load its contents from a previous transfer into the motion detector, where it is compared with that of the parallel-load register. Thus, outputs from the parallel-load register indicate present position pattern and those from the serial-load register, the previous position pattern.

At the outset, with no finger on the surface, the outputs of the present and previous position registers are all in a low state. When a user

places his finger anywhere on the surface, some of the sensors in one or two of the seven groups will change to a high state, but if the finger does not move, this new pattern will not be shifted to the parallel outputs of the present-position register.

With the finger in motion, however, shifting will take place, and the comparison circuitry will see a difference between the inputs from the present- and the previous-position registers. The rate of the change and the order in which sensors are being activated determine the rate and count direction—up or down—of the Ferenstat's output.

The first 28-pin Ferenstat models will be available in sample quantities at the end of August; they are identical except for the output format. One will use a quadrature output like that of a shaft encoder, others will have a count output plus an up/down output pin. These samples will cost $125, but Ledniczki believes prices could eventually fall to between $5 and $10 for large-volume orders.

TASA's touch-activated ASCII keyboard will also be available at the end of August, in sample quantities, for $49, according to Ledniczki. Here, too, with large orders, keyboard prices may drop to below $15, he says.

Unlike a push-button switch keyboard, there is absolutely no tactile feel with this keyboard. It would not be useful, therefore, for an electric typewriter, but Ledniczki feels that for data entry—where the user enters only one or two characters, looks up at the CRT screen, then enters a few more—this tactile lack is no handicap. In any case, there is no present technology that enables a push-button keyboard manufacturer to make as reliable a keyboard at as competitive a price. That fact, rather than the TASA keyboard's utility, is likely to generate interest, especially among the manufacturers and users of such equipment as home computer terminals.

Touch Activated Switch Arrays Inc., 2346 Walsh Ave., Santa Clara, Calif. 95050. Phone (408) 247-2301 [341]

For instrumentation amplifier programmable is a 4-bit word

The term "programmable" in programmable-gain instrumentation amplifiers is taking on a new meaning. Whereas it once referred exclusively to gain selectability obtained through external resistors, it is now beginning to mean the ability to control gain directly with a simple logic word.

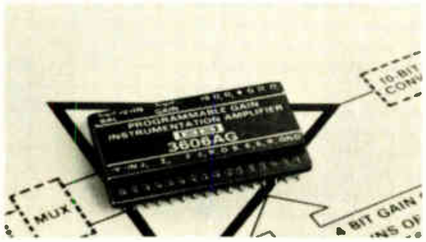
The latest example of this linguistic switch is the 3606 instrumentation amplifier, which offers 11 binary gains from 1 to 1,024 selected by a 4-bit transistor-transistor-logic-level word. When used in a microprocessor-controlled data-acquisition system with a 10-bit analog-to-digital converter, a system resolution of 1 ppm is achievable.

As an instrumentation amplifier alone, the unit's specifications are very respectable. Maximum gain nonlinearity is 0.01% even at its highest gain, maximum gain error is 0.02%, and maximum gain drift is 10 ppm/°C. Common-mode rejection is a minimum of 110 dB, and input resistance is 10 GΩ.

For gains of 1 and 1,024, the maximum input offset voltages are 2 mV and 22 μV, respectively. Change in offset voltage is limited to a maximum of 25 mV for any gain change without external adjustment, but with two simple offset adjustments, the change is limited to 2 mV.

The amplifier is housed in a ceramic or metal 32-pin dual in-line package that measures only 1.75 by 1.15 by 0.23 in. For quantities of 100 and up, unit prices begin at $51.50.

Burr-Brown Research Corp., P. O. Box 11400, International Airport Industrial Park, Tucson, Ariz. 85734. Phone Dennis Haynes at (602) 746-1111 [343]



New products

Data acquisition

Converter needs little power

12-bit hybrid d-a unit with internal reference consumes only 150 mW

In the hotly contested 12-bit digital-to-analog converter market, companies scrambling for position candidly admit engaging in product gamesmanship to seek an edge, if only for a few months until the competition comes up with a counterploy. The latest example is Beckman Instrument's complementary-metal-oxide-semiconductor 12-bit converters, which are low-power pin-for-pin replacements for what is probably the most popular d-a converter—Burr-Brown's DAC-80.

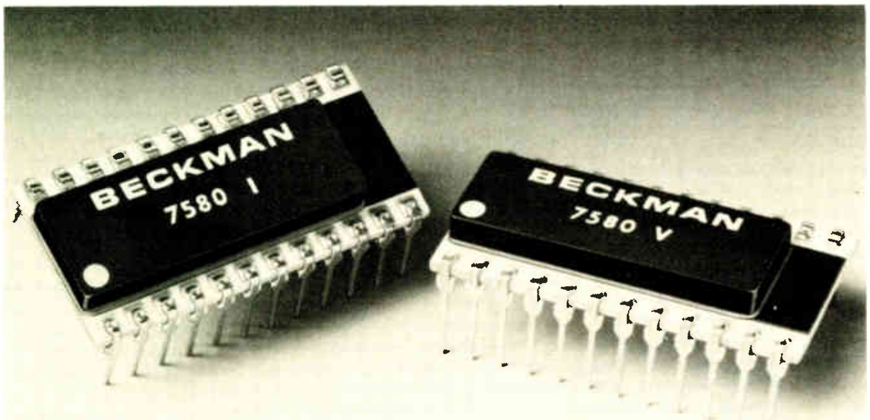
"There's no question the C-MOS converter has an advantage," claims Lyle F. Pittroff, who manages the Beckman Advanced Electro-Products division's hybrid microcircuit lines. "Our model 7580 uses only 150 mw typically, against 800 mw. For process-control uses, where the big market is, C-MOS can go to back-up power, which is not possible with the DAC-80."

Two versions of the 7580 are offered: the 7580I current-output model and the 7580V voltage-output unit, which includes an output buffer amplifier. Both units operate from ±12-v to ±17-v power supplies; neither requires +5 v or −5 v, thus providing isolation from the logic supply, according to Pittroff. Both models have an internal reference and both can be driven by either transistor-transistor or C-MOS logic.

The current-output 7580I has a typical settling time of 2 μs, whereas the 7580V requires 25 μs because of its buffer amplifier. Pittroff terms these times "ideal for most applications in industrial and process control, test instrumentation, machine-trol, and computer numerical controls." Only one such application, he says, needs a faster settling time than 25 μs—driving the deflection circuitry of a cathode-ray-tube display, but this function seldom occurs in industrial systems.

To keep their power dissipation low, the new converters use a proprietary C-MOS switch design combined with a thin-film R-2R ladder network. The switches were used previously in two earlier d-a converters: the 7545 multiplying converter and the 7546, a general-purpose unit. When an ac signal is applied to their reference input, the new converters can operate as four-quadrant multipliers.

In industrial applications, Pittroff explains, linearity is the critical parameter. Nonlinearity should not exceed ¼ least significant bit, he says, for proper operation of feedback control systems. Typically, both of his new units meet this requirement over the range from 0° to 70°C. Their guaranteed maximum nonlinearity is half an LSB. The units are also guaranteed to be monotonic over temperature. Power-supply rejection is within 0.002% of full scale/%v for both supplies. The offset is trimmed to less than 0.02%.



The 7580V is priced at $15.90 each for 1,000 or more units, the 7580I at $14.90. These prices, Pittroff says, are "competitive with [that of] the DAC-80, since our intent is not to bomb the price, but to offer improved performance." Delivery of either 7580 model is from stock to our weeks.

Beckman Instruments Inc., Technical Information Section, Advanced Electro-Products Division, 2500 Harbor Blvd., P. O. Box 3100, Fullerton, Calif. 92634. Phone (714) 691-0841 [381]

12-bit monolithic C-MOS d-a converter needs no trimming

In making precision digital-to-analog converters, be they hybrid or monolithic, manufacturers generally find it necessary to trim the units' resistor ladder networks to meet the converter accuracy and linearity specifications. How best to perform this adjustment—with zener zapping or laser trimming—is the subject of lively controversy in the industry. Proponents of each technique point out that the other has long-term stability problems.

The engineers at Micro Power Systems think that both sides may be right, so they have come up with a monolithic 12-bit converter that needs no trimming at all. The key to the operation of the complementary-metal-oxide-semiconductor circuit is a combination of highly uniform film deposition with special etching and contacting procedures. But "even with perfectly matched resistors, errors in the solid-state switches could ruin the linearity," explains John M. Caruso, project manager for the new model 7621. So his unit incorporates an improved switch design as well.

The resulting d-a converter is a current-output device with a settling time of about 2 μs and a power consumption of 20 mw. Its full-scale drift temperature coefficient is no more than 2 ppm/°C. These specifications are similar to those of competitive converters like Analog Devices' model 7541. The price of $21 each for quantities of 100 or more is also similar.

The difference, if any, is in long-term stability. According to its detractors, laser trimming of resistor networks leads to long-term stability problems because the heat of the laser beam alters the composition of the material along the trimming path. Laser-trimming devotees point out that zener zapping—using junction shorting to adjust resistor values by removing individual resistive elements from series arrays—is subject to self-healing. When that happens, the junction short caused by the reverse-bias or zener-trimming technique becomes resistive with the passage of time.

Production of the new converters is scheduled for late September.

Micro Power Systems Inc., 3100 Alfred St., Santa Clara, Calif. 95050. Phone (408) 247-5350 [382]

Automatic a-d systems lets desktop unit do the thinking

The GMAD-3/HP-9825A analog-to-digital conversion system can interface with Hewlett-Packard's 9825A desktop computer to provide such automatic functions as gain control of any channel or group of channels, digital addressing of channels by the computer, repeat channel addressing for multisignal averaging and special functions, and timing control with verification of function. The system is available with 12-, 13-, 14-, or 15-bit resolution, has signal conversion errors as low as 0.01%, and provides a 20-μs conversion time. With as many as 16 input channels, the system can be bought for less than $19,000.

Preston Scientific Inc., 805 E. Cerritos Ave., Anaheim, Calif. 92805 [384]

Semiconductors

Fast rectifiers protect V-FETs

Ion-implanted devices block up to 100 V, recover in 20 ns

The advent of vertical-groove metal-oxide-semiconductor field-effect transistors as fast power-switching devices has raised an important design question: how does one cope with ever-present transient voltages that could damage the gates? The diodes that normally do this job are either too slow or, in the case of Schottky rectifiers, incapable of blocking more than about 40 v.

A solution offered by Solid State Devices is its HSR-2-52 series of ion-implanted rectifiers, which have a typical reverse-recovery time of 15 ns (20 ns maximum) and blocking-voltage ratings from 20 to 100 v dc. "We see their use as gate clamps as a significant market," says Arnold N. Applebaum, president. "In such applications, where FETs are being contemplated for phased-array antennas, several thousand of them will be needed." The key requirement in this sort of application is for the rectifier to be faster than the device it is protecting.

But protection isn't the only application Applebaum envisions for the miniature 6-A devices. They can be useful wherever the intent is to speed transistor switching. Inverter power supplies are a major possibility, he says.

Manufactured with the company's patented Epion ion-implantation process, the rectifiers are packaged in modified TO-18 transistor cases with a diameter of 0.23 in. and a height of 0.15 in. Key specifications include a maximum forward-voltage drop of 825 mV at a junction temperature of 100°C and a maximum reverse leakage current of 20 μA. In comparison, Applebaum says, conventional high-speed rectifiers have typical reverse-recovery times of 30 to 50 ns and forward drops of about 1 v. Reverse leakage current is typically about the same.

Another important feature of the new rectifier series is its inherent radiation resistance. This results from the low minority-carrier lifetime, which in turn is a consequence of the units' narrow junction width of less than 1 μm. Moreover, the small size of the rectifiers—70 mils square—also contributes to radiation tolerance, the company says.

As with most high-power-density devices, the secret behind the performance is in the packaging. As Applebaum explains, the dice in the HSR-2-52 series are eutectically bonded to the modified TO-18 case, which, along with one lead, serves as a high-current anode. Then the other two leads, normally attached to the emitter and the base of a transistor, are ultrasonically bonded in parallel to the chip with 10-mil wires; together they constitute the cathode. The resulting large contact areas contribute to the low forward-voltage drop. The entire diode is hermetically sealed.

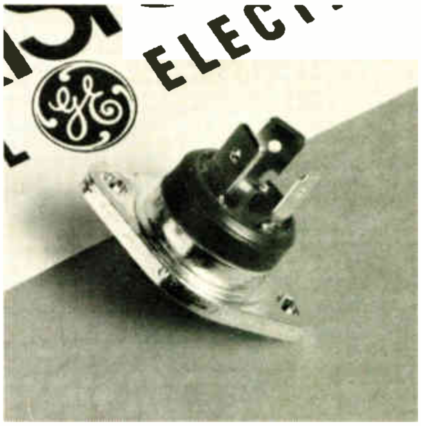
The series consists of seven devices with maximum repetitive reverse voltages from 20 to 100 v and maximum rms voltages from 15 to 70 v. For all seven units, the average half-wave rectified current rating is 6 A, with nonrepetitive surges to 125 A. Operating temperature range is −55° to +175°C.

Production of the new diodes is particularly suitable for highly automated techniques, and the company expects to be turning out large quantities. Present prices, for lots of 100 to 999 pieces, begin at $1.90. Delivery time is four weeks.

Solid State Devices Inc., 14830 Valley View Ave., La Mirada, Calif. 90638. Phone (213) 921-9660 [411]

Inexpensive triacs block up to 600 V

To increase production speed for appliances and industrial goods while reducing their assembly costs, the manufacturer of the SC160 triac has packaged the thyristor in a cleverly modified TO-3 case. With its electrically isolated package, the unit can be directly riveted or screwed onto a heat sink without extra insulation. Furthermore, the device provides "fast-on" terminals that accept slip-on connectors, eliminating the need for soldered connections.



Dubbed the Econopower, the SC160 responds to a need for a low-cost ac power control unit in a mechanically rugged package. It is fabricated using a glass-passivated pellet to provide low leakage and stable blocking life. The pellet subassembly, with copper metallization directly bonded by a patented process, is encapsulated with epoxy to ensure ruggedness.

The unit is rated for a current of 25 A rms and voltages as high as 600 v. In quantities of 10,000 or more, individual SC160s cost $2.78.

General Electric Co., Semiconductor Products Dept., Building 7-49, Syracuse, N. Y. 13221 [413]

Switching regulators offer increased power efficiency

A pin-for-pin replacement for SG-1524 regulators, the XR-1524 family of pulse-width-modulating regulators is based on a monolithic chip that includes an internal voltage regulator, error amplifiers, an RC oscillator, pulse-steering flip-flops, and output driver transistors. These transistors can be used in either

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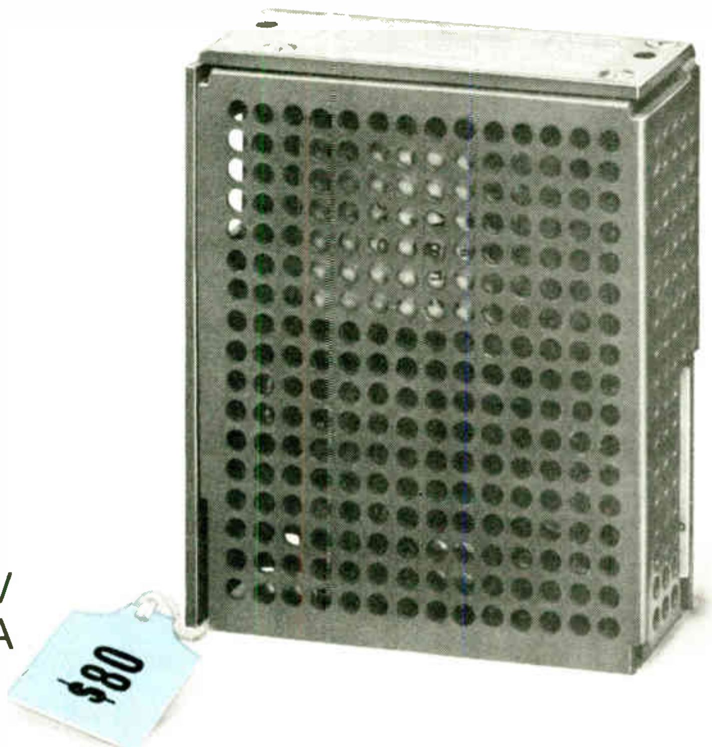

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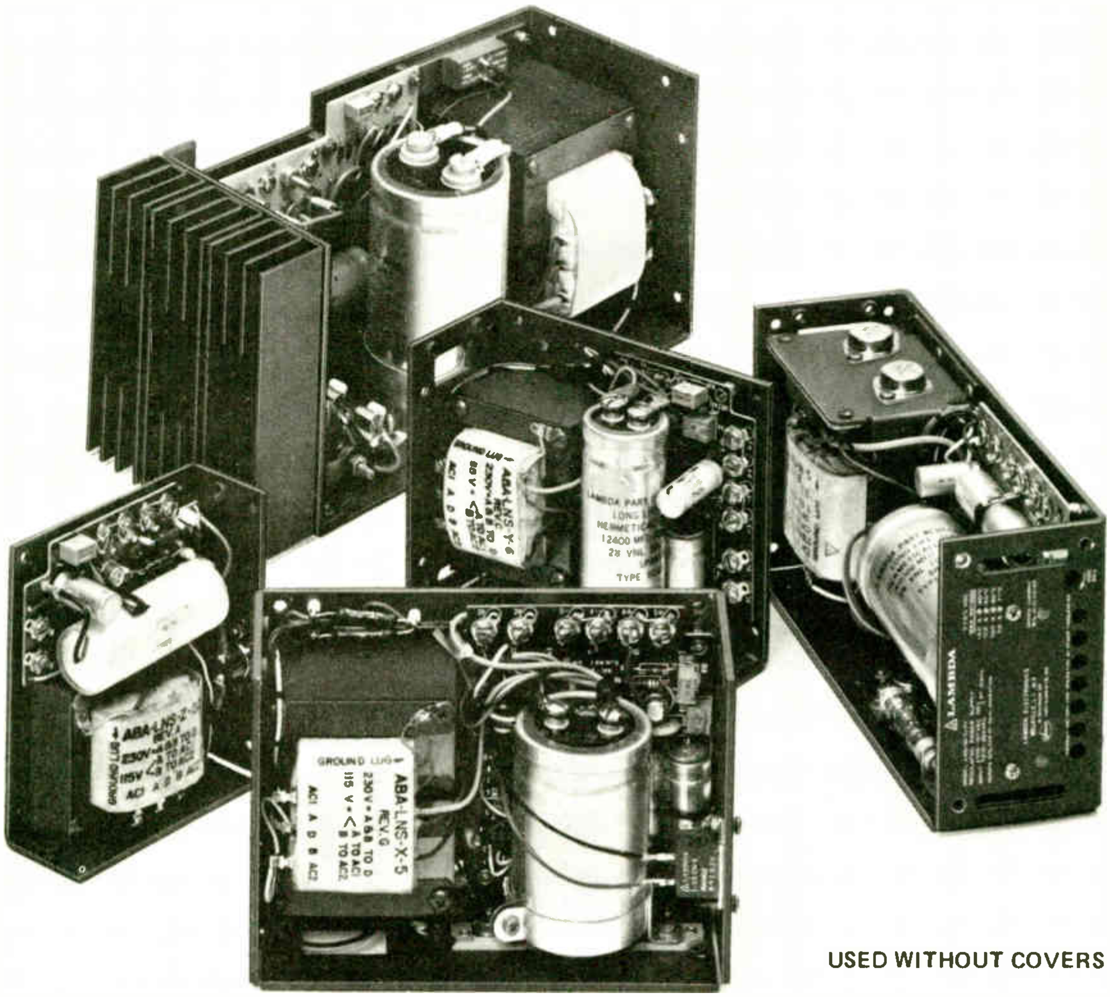

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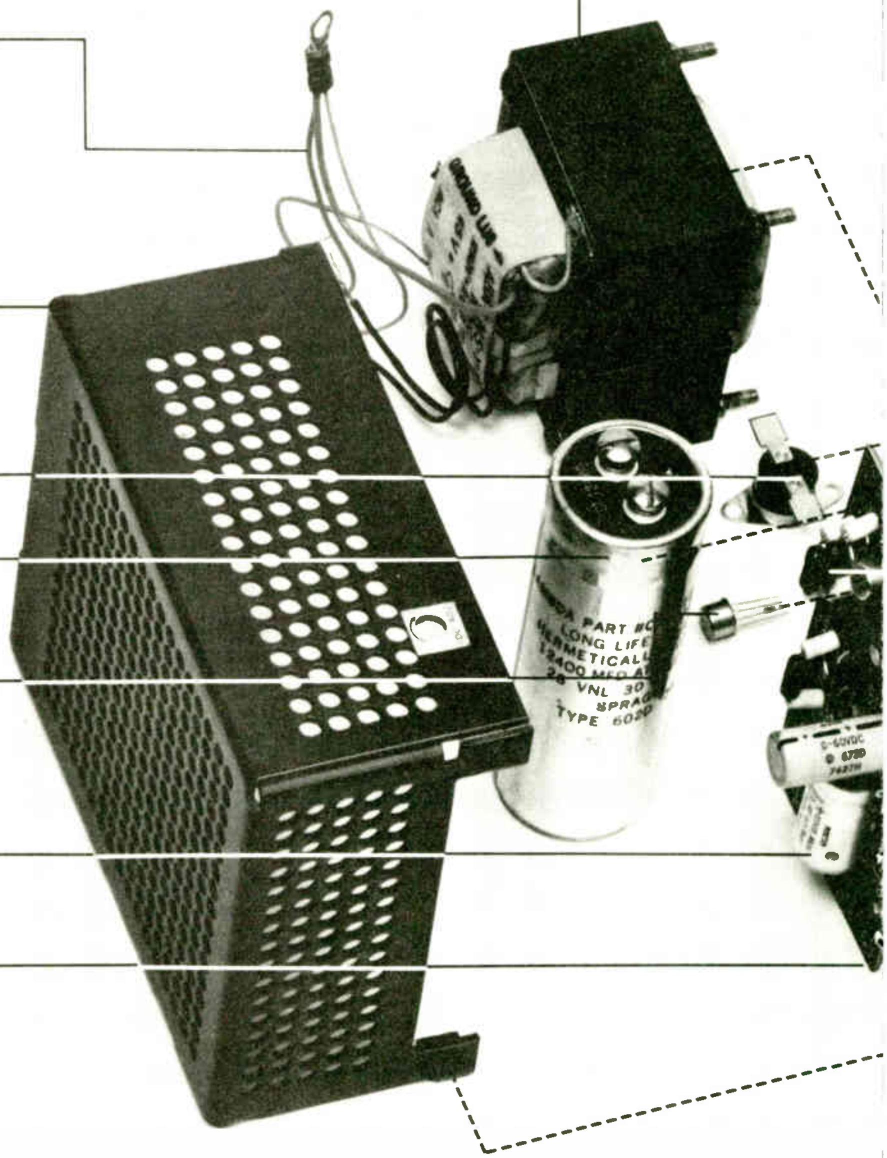

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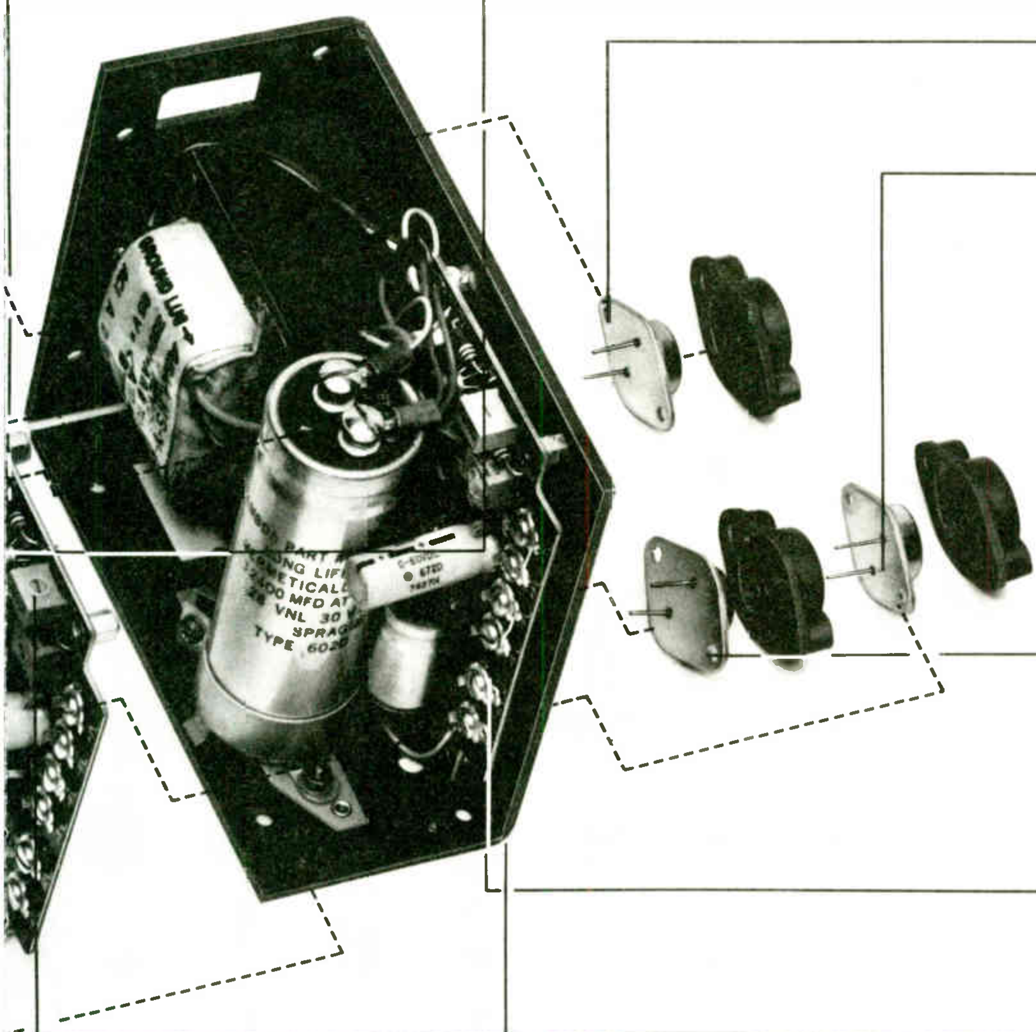

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VOLTAGE AND CURRENT RATINGS

DUAL OUTPUT

5 VOLTS ± 5% ADJ, 9V-12V ADJ

MODEL	REGULATION (LINE OR LOAD)	RIPPLE (RMS)	VOLT. VDC.	(1)MAX CURRENT AMPS AT 40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS(2) (INCHES)	PRICE
LND-X-MPU (3)	0.1%	1.5	5±5%	7.0 (5.95)	6.0 (5.11)	4.7 (4.0)	3.2 (2.72)	X	7 x 4 7/8 x 2 7/8	$172
			9–12	1.2 (1.02)	1.1 (0.94)	1.0 (0.85)	0.8 (0.68)			
LND-P-MPU (3)	0.1%	1.5	5±5%	14.0 (13.3)	12.2 (11.59)	10.0 (9.5)	7.5 (7.13)	P	11 x 4-7/8 x 4-13/32	245
			9–12	2.5 (2.38)	2.2 (2.09)	1.8 (1.71)	1.35 (1.28)			

± 15 VOLTS TO ± 12 VOLTS ADJ — DUAL TRACKING

MODEL	REGULATION (LINE OR LOAD)	RIPPLE (RMS)	VOLT. VDC.	40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS (INCHES)	PRICE
LND-Z-152	0.15%	1.5	±15 to	0.6 (0.54)	0.55 (0.5)	0.45 (0.41)	0.3 (0.27)	Z	4 7/8 x 4 x 1 3/4	$ 85
			± 12	0.6 (0.54)	0.55 (0.5)	0.45 (0.41)	0.3 (0.27)			
LND-Y-152	0.1%	1.5	± 15 to	1.4 (1.20)	1.2 (1.02)	0.9 (0.77)	0.6 (0.51)	Y	5 5/8 x 4 7/8 x 2 5/8	120
			± 12	1.2 (1.02)	1.1 (0.94)	0.8 (0.68)	0.5 (0.43)			
LND-X-152	0.1%	1.5	± 15 to	2.5 (2.13)	2.1 (1.79)	1.6 (1.37)	1.1 (0.94)	X	7 x 4 7/8 x 2 7/8	150
			± 12	2.3 (1.96)	1.9 (1.62)	1.4 (1.2)	0.9 (0.77)			
LND-W-152	0.1%	1.5	± 15 to	3.3 (3.0)	3.1 (2.8)	2.6 (2.34)	2.0 (1.8)	W	9 x 5 x 2 7/8	170
			± 12	3.1 (2.8)	2.8 (2.52)	2.3 (2.07)	1.6 (1.44)			
LND-P-152	0.1%	1.5	± 15 to	5.3 (5.04)	4.7 (4.47	3.9 (3.71)	2.9 (2.76)	P	11 x 4-7/8 x 4-13/32	240
			± 12	4.6 (4.37)	4.0 (3.80)	3.3 (3.14)	2.5 (2.38)			

SINGLE OUTPUT

5 VOLTS ± 5% ADJ

MODEL	REGULATION (LINE OR LOAD)	RIPPLE (RMS)	(1)MAX CURRENT AMPS AT 40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS(2) (INCHES)	PRICE
LNS-Z-5-OV	0.15%	1.5	3.0 (2.7)	2.7 (2.4)	2.3 (2.1)	1.7 (1.5)	Z	4 7/8 x 4 x 1 3/4	$ 80
LNS Y-5-OV	0.1%	1.5	6.0 (5.4)	5.1 (4.6)	4.2 (3.8)	3.1 (2.8)	Y	5 5/8 x 4 7/8 x 2-5/8	115
LNS X-5-OV	0.1%	1.5	10.0 (8.5)	8.9 (7.6)	7.3 (6.2)	5.3 (4.5)	X	7 x 4 7/8 x 2 7/8	140
LNS W 5-OV	0.1%	1.5	14.0 (11.9)	12.2 (10.4)	10.0 (8.5)	7.5 (6.4)	W	9 x 5 x 2-7/8	175
LNS-P-5-OV	0.1%	1.5	22.0 (20.9)	19.5 (18.53)	16.5 (15.68)	13.0 (12.35)	P	11 x 4-7/8 x 4-13/32	220

6 VOLTS ± 5% ADJ

MODEL	REGULATION	RIPPLE	40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS	PRICE
LNS Z-6	0.15%	1.5	2.5 (2.25)	2.2 (2.0)	1.9 (1.7)	1.4 (1.3)	Z	4 7/8 x 4 x 1 3/4	$ 75
LNS Y 6	0.1%	1.5	5.6 (5.0)	4.9 (4.4)	4.0 (3.6)	2.9 (2.61)	Y	5 5/8 x 4 7/8 x 2 5/8	110
LNS-X-6	0.1%	1.5	9.5 (8.1)	8.4 (7.15)	7.1 (6.0)	5.0 (4.25)	X	7 x 4 7/8 x 2 7/8	130
LNS W 6	0.1%	1.5	13.0 (11.0)	11.2 (9.5)	9.3 (7.9)	6.8 (5.9)	W	9 x 5 x 2 7/8	165
LNS-P-6	0.1%	1.5	20.5 (19.48)	18.1 (17.2)	15.3 (14.54)	12.0 (11.4)	P	11 x 4-7/8 x 4-13/32	200

12 VOLTS ± 5% ADJ

MODEL	REGULATION	RIPPLE	40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS	PRICE
LNS Z-12	0.15%	1.5	1.7 (1.55)	1.6 (1.45)	1.5 (1.4)	1.3 (1.2)	Z	4 7/8 x 4 x 1 3/4	$ 75
LNS Y-12	0.1%	1.5	4.0 (3.6)	3.5 (3.15)	2.9 (2.6)	2.2 (2.0)	Y	5 5/8 x 4 7/8 x 2 5/8	110
LNS X 12	0.1%	1.5	6.5 (5.5)	5.5 (4.7)	4.5 (3.8)	3.3 (2.8)	X	7 x 4 7/8 x 2 7/8	130
LNS-W-12	0.1%	1.5	8.5 (7.2)	7.2 (6.1)	5.9 (5.0)	4.2 (3.6)	W	9 x 5 x 2 7/8	165
LNS-P-12	0.1%	1.5	14.0 (13.3)	12.4 (11.8)	10.0 (9.5)	7.3 (6.94)	P	11 x 4-7/8 x 4-13/32	200

15 VOLTS ± 5% ADJ

MODEL	REGULATION	RIPPLE	40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS	PRICE
LNS Z-15	0.15%	1.5	1.4 (1.3)	1.3 (1.62)	1.2 (1.1)	1.0 (0.9)	Z	4 7/8 x 4 x 1 3/4	$ 75
LNS Y-15	0.1%	1.5	3.4 (3.1)	3.1 (2.8)	2.6 (2.35)	2.0 (1.8)	Y	5 5/8 x 4 7/8 x 2 5/8	110
LNS X 15	0.1%	1.5	5.5 (4.7)	4.8 (4.1)	3.9 (3.35)	2.8 (2.4)	X	7 x 4 7/8 x 2 7/8	130
LNS W 15	0.1%	1.5	7.7 (6.55)	6.7 (5.7)	5.5 (4.7)	3.8 (3.15)	W	9 x 5 x 2 7/8	165
LNS-P-15	0.1%	1.5	12.0 (11.4)	10.6 (10.1)	8.5 (8.1)	6.3 (6.0)	P	11 x 4-7/8 x 4-13/32	200

20 VOLTS ± 5% ADJ

MODEL	REGULATION	RIPPLE	40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS	PRICE
LNS Z 20	0.15%	1.5	1.0 (0.69)	0.85 (0.77)	0.65 (0.59)	0.45 (0.41)	Z	4 7/8 x 4 x 1 3/4	$ 75
LNS Y-20	0.1%	1.5	2.7 (2.45)	2.5 (2.25)	2.0 (1.08)	1.3 (1.2)	Y	5 5/8 x 4 7/8 x 2-5/8	110
LNS X 20	0.1%	1.5	4.4 (3.75)	3.6 (3.1)	2.6 (2.2)	1.6 (1.4)	X	7 x 4 7/8 x 2 7/8	130
LNS W 20	0.1%	1.5	6.1 (5.2)	5.2 (4.4)	4.2 (3.6)	3.0 (2.6)	W	9 x 5 x 2 7/8	165
LNS-P-20	0.1%	1.5	10.0 (9.5)	8.9 (8.46)	7.5 (7.13)	5.5 (5.23)	P	11 x 4-7/8 x 4-13/32	200

24 VOLTS ± 5% ADJ

MODEL	REGULATION	RIPPLE	40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS	PRICE
LNS-Z-24	0.15%	1.5	0.9 (0.81)	0.75 (0.68)	0.6 (0.55)	0.4 (0.36)	Z	4 7/8 x 4 x 1 3/4	$ 75
LNS-Y-24	0.1%	1.5	2.3 (2.1)	2.1 (1.9)	1.7 (1.5)	1.1 (1.0)	Y	5 5/8 x 4-7/8 x 2-5/8	110
LNS-X-24	0.1%	1.5	3.8 (3.25)	3.2 (2.75)	2.4 (2.0)	1.4 (1.62)	X	7 x 4-7/8 x 2 7/8	130
LNS-W-24	0.1%	1.5	5.4 (4.6)	4.6 (3.9)	3.7 (3.1)	2.5 (2.1)	W	9 x 5 x 2-7/8	165
LNS-P-24	0.1%	1.5	9.0 (8.55)	8.0 (7.6)	6.7 (6.37)	5.0 (4.75)	P	11 x 4-7/8 x 4-13/32	200

28 VOLTS ± 5% ADJ

MODEL	REGULATION	RIPPLE	40°C	50°C	60°C	71°C	PKG SIZE	DIMENSIONS	PRICE
LNS Z-28	0.15%	1.5	0.8 (0.75)	0.65 (0.6)	0.5 (0.45)	0.35 (0.32)	Z	4 7/8 x 4 x 1 3/4	$ 75
LNS Y 28	0.1%	1.5	2.0 (1.8)	1.8 (1.65)	1.5 (1.35)	1.0 (0.9)	Y	5 5/8 x 4 7/8 x 2 5/8	110
LNS X 28	0.1%	1.5	3.4 (2.9)	2.9 (2.5)	2.2 (1.5)	1.2 (1.0)	X	7 x 4-7/8 x 2 7/8	130
LNS-W 28	0.1%	1.5	4.7 (4.0)	4.0 (3.4)	3.2 (2.75)	2.2 (1.9)	W	9 x 5 x 2-7/8	165
LNS-P-28	0.1%	1.5	8.0 (7.6)	7.1 (6.75)	6.0 (5.7)	4.5 (4.28)	P	11 x 4-7/8 x 4-13/32	200

NOTE:
1. Rating in Parenthesis for LN Series when cover is used
2. Dimensions include cover
3. Includes OV protection on both outputs (5V OV trip point is 6.6 ± .2V fixed; 9—12V OV trip points is 13.7 ± .4V fixed)

SPECIFICATIONS OF LN SERIES

DC Output

Voltage range shown in tables

Regulated Voltage

regulation, line	0.1% (0.15% for LN-Z)
regulation, load	0.1% (0.15% for LN-Z)
ripple and noise	1.5mv RMS, 5mV pk-pk with either positive or negative terminal grounded.
temperature coefficient	0.03% /°C
remote programming resistance	200 ohms per volt nominal
remote programming voltage	volt per volt

AC Input

line	105-127 VAC, 210-254 VAC (by transformer tap change) 47-440 Hz. Consult factory for operation at frequencies other than 57-63 Hz.
Efficiency (Typical)	30%-5V and 6V models, 42% 12V and 15V models, 49%-20V, 24V and 28V models. 42% for LN duals except LND-MPU which are 34%.

Ambient Operating Temperature Range

Continuous duty from 0° to +71°C with corresponding load current ratings for all modes of operation.

Storage Temperature Range

–55°C to 85°C

Overload Protection

Electrical

External overload protection, automatic electronic current limiting circuit limits the output current to a preset value, thereby providing protection for the load as well as the power supply.

Thermal

Thermostat — automatically reset when overtemperature condition is eliminated.

Overshoot

No overshoot on turn-on, turn-off or power failure.

Overvoltage Protection

Overvoltage protection module crowbars output when trip level is exceeded — standard on all 5V models and both outputs of models LND-X-MPU and LND-P-MPU. For other models see back cover.

Input and Output Connections

Heavy-duty screw terminals on printed circuit board.

DC Output Controls

Simple screwdriver adjustment over the entire voltage range.

Tracking Accuracy (Dual Tracking Models Only)

3% absolute voltage difference, 0.2% change for all conditions of line, load and temperature.

Remote Sensing

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

Mounting

Three Mounting surfaces, three mounting position. One mounting position for LN-P models.

Convection Cooled

No external heat sinking or forced air required.

Transformer

MIL T-27C, Grade 6, Electrostatic shield; 4000 VAC input/output isolation.

Isolation Rating

Minimum 10 Megohm isolation from DC to ground at ground at 1000 VDC.

Fungus Proof

No fungi nutrient material used

Military Specifications

The LNS series has passed the following tests in accordance with MIL STD 810C

1) Low Pressure – Method 500.1, Procedure I.
2) High Temperature – Method 501.1, Procedure I & II.
3) Low Temperature – Method 502.1, Procedure I
4) Temperature Shock – Method 503.0, Procedure I.
5) Temperature – Altitude – Method 504.1, Procedure I. Class 2 (0°C operating)
6) Humidity – Method 507.1, Procedures I & II.
7) Fungus – Method 508.1, Procedure I
8) Vibration – Method 514.2, Procedures X & XI
9) Shock – Method 516.2, Procedures I & III

MIL I-6181D – Conducted and radiated EMI with one output terminal grounded.

Physical Data

Package Model	Weight Lbs. Net	Weight Lbs. Ship	Size Inches
LN Z	3	3 1/4	4 7/8 x 4 x 1 3/4 (w/cover)
			4 7/8 x 4 x 1 5/8 (w/o cover)
LN Y	5	5 1/2	5 5/8 x 4 7/8 x 2 5/8 (w/cover)
			5 5/8 x 4 7/8 x 2 1/2 (w/o cover)
LN X	7 3/4	8 1/4	7 x 4 7/8 x 2 7/8 (w/cover)
			7 x 4 7/8 x 2 3/4 (w/o cover)
LN W	9	9 1/2	9 x 5 x 2 7/8 (w/cover)
			9 x 4 7/8 x 2 3/4 (w/o cover)
LN P	14	15 1/2	11 x 4-7/8 x 4-13/32 (w & w/o cover)
LND-P	15-1/2	17	11 x 4-7/8 x 4-13/32 (w & w/o cover)

Finish

Gray, Fed. Std. 595 No. 26081.

UL/VDE

Designed for listing in UL Recognized Components Index.

Designed for listing in VDE Index.

Accessories

Overvoltage protectors (standard on 5V models and models LND-X-MPU and LND-P-MPU).

Guaranteed for 5 Years

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

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New products

single-ended or push-pull modes to increase power transfer efficiency.

Two or more units may be interconnected and synchronized in master-slave fashion for use in complex power-control systems, and the output stage is protected against shorting or overload.

The three members of the family, the XR-1524, the XR-2524, and the XR-3524, are intended for application in military, industrial, and commercial switching power supplies or dc-dc converters. Prices begin at $4 each in quantities of 100 or more and decrease with large orders. Delivery is from stock.

Exar Integrated Systems Inc., 750 Palomar Ave., Sunnyvale, Calif. 94086. Phone (408) 732-7970 [414]

Free-floating SCR survives the heat with less fatigue

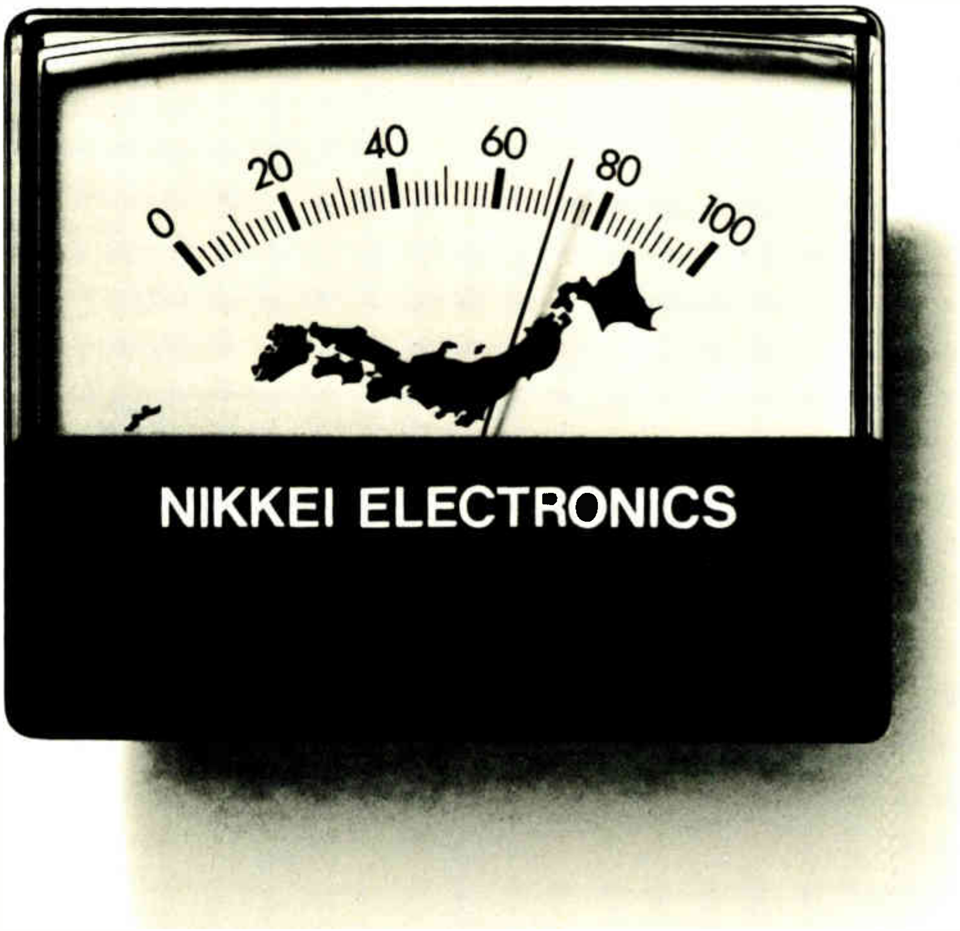
By allowing the heart of their silicon controlled rectifiers to "float" within the package, designers of the 174, 176, and 179 series have produced SCRs with better thermal fatigue characteristics and consistent thermal impedances of only 0.14°C/W.

The 174 family consists of phase-control devices rated at 275 A rms; blocking voltages ranging from 100 to 1,400 V in 100-V increments are available.

The 176 and 179 families comprise fast-turn-off inverter SCRs rated at 235 and 275 A rms, respectively. SCRs of the 176 family can be furnished with blocking voltages from 700 to 1,200 V and turn-off times of 30 to 40 μs, while those of the 179 group are available with blocking voltages between 100 and 600 V and turn-off times of 10, 15, and 20 μs. Both the 176 and the 179 series can withstand surge currents of 4,500 A.

Typical units within the 174, 176 and 179 series are priced at $84.55, $73.25, and $62.40 each, respectively, in quantities from 10 to 99. Small quantities are available now.

FMC Corp., Semiconductor Products Division, 800 Hoyt St., Broomfield, Colo. 80020. Phone Art Connolly at (303) 469-2161 [415]



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Products newsletter

Motorola enters codec market

Taking dead aim at the needs of Ma Bell, **Motorola's Semiconductor division, Phoenix, Ariz., has developed a one-chip coder-decoder (codec) that operates off a single 5-V supply and dissipates between 50 and 100 mW.** The commercial version of the complementary-MOS unit is designated the MC14406; the military, the MC14407. Both have a power-down capability that cuts consumption to less than a milliwatt.

Look for a compatible monolithic active filter from Motorola by the first quarter of 1979. It will be housed in a 16-pin dual in-line package and will also be fabricated in C-MOS.

Microcomputer board gets dual-port memory

A three-bus architecture in Intel Corp.'s new iSBC 80/30 one-board microcomputer gives it dual-port access to a whopping 16,384 bytes of on-board RAM. **Previous SBC one-board designs lacked the dual-port bus that allows data exchange with external devices via memory.** Useful for multiprocessing, the new bus structure also has an ulterior motive— interconnection of 8-bit boards and a 16-bit family to come.

Ink-jet printer mechanism offered without electronics

Manufacturers of printers and other original equipment who want to take advantage of Silonix Inc.'s drop-on-demand ink-jet printing technology without buying a complete printer can now purchase the mechanism less the electronic control board and power supply. **The full printer sells for $2,495, but the OEM parts are available in 500-piece quantity for $500,** according to the Sunnyvale, Calif., company.

Analog dividers grow more accurate

A monolithic IC analog voltage divider from Analog Devices, Norwood, Mass., promises to make life easier for people who are dissatisfied with the performance of analog multipliers in the division mode. The two-quadrant model AD535K has **a maximum divider error of 0.5% over a denominator range of 10:1 with no external trimming.** Over a denominator range of 50:1 the error may be 2%. The unit sells for $24 in hundreds.

Second-source coming for DEC LPS-11

A single-board laboratory system for Digital Equipment Corp.'s PDP-11 minicomputers will soon be available from Data Translation, Natick, Mass. **The DT1711-LPS is a second source for the DEC LPS-11 system and should sell for about half the price.**

Correcter reduces time-base errors

Time-base errors in instrumentation tape recorders **can be reduced by from 8 to more than 20 times, depending upon tape speed, regardless of the type of recorder being used.** The digital time-base correcter that performs this feat is called the Tymcor 1000. It sells for less than $7,000 and is available from Bancomm Corp., Palo Alto, Calif.

Chip set designed for speech synthesis

A pair of 40-pin digital ICs from Telesensory Systems Inc., Palo Alto, Calif., will work with standard memories and digital-to-analog converters to form the heart of a speech synthesizer. Specifically designed to simulate the human vocal tract, **the chip set differs from a recent speech-synthesizing chip that "plays back" from read-only memories in that it is completely programmable, offering a wide range of "voicings."**

Classified section FOR ENGINEERING/TECHNICAL EMPLOYMENT OPPORTUNITIES

PROJECT ENGINEER

Continued, rapid growth of north suburban Chicago manufacturer of telecommunications equipment creates an opportunity for a results-oriented individual with a minimum of 3 years experience in analog and digital design. Any exposure to 8080 or Z80 microprocessors is a definite plus. Projects will involve telecommunication circuit designs from conception to completion. Required B.S.E.E. or equivalent in addition to above experience.

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Responsibilities will include the designing of analog control circuits for a rapidly growing family of industrial controls products. Initial assignment will be implementation of cost reduction of present product line. Subsequent assignments will include product design responsibilities extending from conception through production of new analog interface modules for TI's industrial controllers. BSEE and up to 3 years' experience required.

Sr. Digital Design Engineer

Responsible for hardware design of industrial controllers and peripheral products extending from the product's definition stage into and through the pilot production phase. Requires BSEE/MSEE with 4-7 years' experience in TTL circuit design, microprocessor-based design and software design.

Digital Design Engineer

Responsibilities to include the designing of various digital subsystems in TI's industrial controls product family and will extend from circuit design, prototyping, worst case analysis through pilot production of new products and engineering support for existing product line. Requires BSEE with up to 3 years' experience in TTL circuit design and microprocessor related design. Software design experience extremely desirable.

Design Engineer (Hardware & Software)

Responsibilities to include designing and developing as part of a team working on "state-of-the-art" real time operating microprocessor systems, utility routines and communication routines. Knowledge and understanding of top down design a real advantage. BSEE/Computer Science required, MSEE/Computer Science desirable. Must have 2-5 years' related experience.

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Systems Test Engineer

Designing computer-based test equipment to be used by manufacturing to test microprocessor-based industrial controls products. Responsibilities include executing both hardware and software designs associated with all test stations. Requires a BSEE/Computer Science with a working knowledge of computer architecture, 8080, Z-80, 990 microprocessors, software and digital design.

Process Engineers

Responsible for general manufacturing engineering duties connected with the production of industrial controls product lines. Duties include cost reduction, yield/quality improvement, equipment and process design. Requires BSME or EE with up to 5 years of experience.

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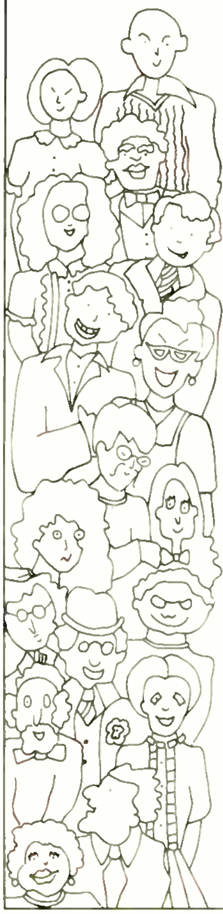

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DESIGN SUPPORT

Electrical Engineers at various levels to maintain, modify and assist the current production of electrical designs in various product lines.

EQUIPMENT DESIGNERS

For Physical design of Proprietary Products. Equipment Designers must have knowledge of electro-mechanical packaging and/or printed circuit board layout. No degree necessary.

other openings at LENKURT

SEMICONDUCTOR TEST ENGINEER

We seek an Engineer with a BSEE (or equivalent) and 2-5 years experience testing and evaluating low and high frequency semiconductor components such as Diodes, Transistors, Linear and Digital Integrated Circuits. Knowledge of component failure analysis, Sentry II programming and some circuit design experience is desirable. (Job # HM-007)

TEST EQUIPMENT ENGINEER

Position requires experience in analog and digital circuit design, preferably in the area of test equipment. Some programming background desirable. Ability to convert engineering test requirements into finished production test equipment.
You must be able to analyze existing test facilities and processes, and design and implement cost effect improvements. BSEE or equivalent experience required. MSEE preferred. (Job # JC1)

SENIOR TEST ENGINEER

Responsibilities include the ability to test and troubleshoot thick film circuit hybrids, evaluate yield data and take corrective action in hybrid assembly operations. The engineer should have experience with computer controlled laser trimming and be capable of programming and evaluating of hybrid test equipment and complete controlled laser systems for functional trimming.
The position requires an Electrical Engineering degree or equivalent with 3-5 years manufacturing experience. (Job # MCK2)

INDUSTRIAL: METHODS IMPROVEMENT

Responsibilities include methods improvement, equipment selection, facilities layout and work flow, materials handling and packaging, computer applications to manufacturing problems and solution of production problems during new product introduction. Electronic assembly experience desirable. Minimum BSIE or equivalent with 1-2 years experience desired. (Job # MCK1)

STAFF ENGINEER, TOOL & MACHINE ENGINEERING

BSME and 8 years of experience or Professional Manufacturing Engineer in the field of Electronics Manufacturing. Responsibilities include tool design for sheetmetal and small machined parts, the design of process and assembly equipment used for electronics manufacturing, and the design of unsophisticated production machines including electrical and air-hydraulic controls. (Job # HL1)

PROJECT ENGINEER

Be responsible for analyzing contract orders for Microwave and Multiplex Systems. Determine exact details of equipment required to meet the contractural obligations. This includes office requirements for power, antennas, towers, and other ancillary equipment. This effort requires performing varying amounts of System Engineering, scheduling, contract interpretation and direct customer contact. BSEE degree desirable (or an AA degree with equivalent experience.) Technical experience in the following areas: Microwave Radio, Multiplex, Supervisory and Control and Switching Systems. Will consider some recent graduates for junior or entry level positions. (Job # GM 2)

SENIOR SYSTEMS ENGINEER

Determine the proper configuration of radio, FDM or PCM multiplex and data equipment to meet customers' communications requirements. System problems such as electrical interfacing with existing networks, calculation of channel signal-to-noise ratios, and analysis of potential microwave radio interference situations will be solved. BSEE or equivalent degree and some experience required. (Job # RW1)

TRANSMISSION ENGINEER

Utilize topographic and other maps to select radio repeater sites, determine tower heights and antenna equipment needed to meet customers' communications requirements. You will also calculate system noise performance, predict radio propogation reliability and analyze potential microwave interference situations. BSEE or equivalent degree and 0-2 years experience required. (Job # RW2)

FIELD SERVICE ENGINEER

BSEE (or equivalent Telecommunications Electronics experience) You will work closely with Development Engineers and troubleshooting with customers via telephone or in the field. Position requires responsible person, capable of exercising good judgement in customer relations and able to make independent decisions as necessary. 20% travel involved. (Job # TI 4)

MICROCIRCUIT PROCESS ENGINEER

Position will include development and evaluation of thick and thin film materials and processes plus the development of microcircuit packaging techniques for semiconductors used in telecommunications equipment. Applicant should have BS/Chemistry, Chemical Engineering or Material Science. Experience in microcircuit technologies required. (Job # BW2)

ENGINEERING WRITER

This position requires a strong electronics background plus working knowledge of microwave radio for telephone systems. Min 2 years experience in writing commercial instructions, manuals or engineering level documents. (Job # FF-3)

SYSTEMS ANALYST

Bachelor's degree plus 1-5 years experience in analysis and design of computerized business information systems. Experience in data base/data communications-oriented applications for a manufacturing company desired. Must have sound knowledge of business functions and have strong verbal and written communications skills. (Job # SL1)

ANALYST PROGRAMMER

To work in an IBM 370-148 SVS environment. Must have indepth knowledge of COBOL, JCL, utilities, etc. BS or BA degree preferred, AA acceptable or related work experience. (Job # EC1)

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TECHNICAL TRANSLATOR

As an experienced free lance technical translator I speak English and French Electronics fairly well. So, for technically accurate translations contact:

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An established Conn. based company in pleasant suburban surroundings seeks an Engineer or Physicist for work on research development and testing of fiber optics circuit components.

The position will involve the design and development of E/O receiver and transmitter modules as well as the development of new products and applications in optical fiber communication systems.

B.S. Degree with 2-5 years related experience in optics or electro optics is desired.

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August 3, 1978

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■ For more information of complete product line see advertisement in the latest Electronics Buyers Guide
• Advertisers in Electronics International
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