SEPTEMBER 2, 1976

WESCON: MICROPROCESSORS DOMINATE THE BIG SHOW / 114
Designing low-cost fiber-optic data-transmission systems / 94
How to use the new 4,096-bit RAMs effectively / 103

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Circle 900 on reader service card
Let's talk about a way for you to save hours in microprocessor SOFTWARE DEBUGGING

HP's 1600S Logic State Analyzer, in the MAP mode, lets you examine the unique "fingerprint" of every logic system.

In the TABLE mode, the 1600S displays up to 16 lines of code, with their sequential relationships in familiar logic notation.

I mean many hours of savings if you've ever heard this problem: You've just finished your prototype microprocessor-based system, made the preliminary checks on the hardware, and loaded the program in RAM. You hit the start button. Everything's running smoothly, then wham! You're out of business. Things are out of sequence and the system is doing things you never intended. Now you could be in for hours—or even days—of troubleshooting.

But let me tell you about a much faster way to spot software problems... with HP's 1600S Logic State Analyzer. This instrument lets you look inside your operating circuit—right on the buses and qualifier lines—and see program implementation. That's the fastest way I know to locate software problems in operating circuits.

Actually, the 1600S gives you two ways to view program flow:

Mapping. This is a dynamic view of your system's operation... a pattern of dots and lines that are unique for each program. Each dot is a specific data word. It's location indicates binary magnitude, and its brightness indicates relative frequency of occurrence.

You might call the map a personal fingerprint. It's different for every program. With a little practice, you can easily spot a suspicious pattern and locate the word or group of words that could be the trouble source. Then you simply position a cursor over the word in question and push a front-panel switch to go to the Table display mode.

Table. The CRT now gives you a display of word flow using the word you selected as the trigger point. It displays up to sixteen 32-bit words at one time... in familiar One's and Zero's. You can look at events leading up to, surrounding, or following the trigger word. And even delay up to 99,999 clock cycles beyond the trigger point to view events anywhere in your program.

Suppose your problem is an erroneous data word that causes an unwanted jump. Mapping helps you spot the jump, and the Table mode lets you quickly compare each data word leading up to the jump with your written program.

That's just a simple example. HP's 1600S Logic State Analyzer, priced at $7100*, can speed more complex software debugging problems too. We'd like to tell you more.

And HP has arranged a number of seminars to make that possible. Find out how to attend one in your area by calling your local HP field engineer. He can also supply you with complete spec sheets and application notes detailing the use of mapping for troubleshooting minicomputer and microprocessor systems. You'll discover an exciting new concept in digital troubleshooting.

*Domestic U.S.A. price only.

Address for Electronics/September 2, 1976

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Introducing HP's 3455A DVM—a microprocessor controlled DVM with high resolution and computational capability for the lab plus high speed and good noise rejection for systems use...complete with true r.m.s. ac to 1 MHz, dc and ohms for $3,200*. HP's new high-speed microprocessor gives the lab user:

5½ or 6½ digit resolution. Choose from the normal 5½ digit mode or the High Resolution 6½ digit mode for >1 part per million resolution...ideal for trimming, matching and balancing in the Standards lab. Wide bandwidth ac readings are always displayed with 5½ digit resolution.

Math capability. Enter constants into memory and you can offset readings, take ratios or scale a measurement to give direct readout in engineering units. Or, display percent error from a standard value in memory to speed calibration and inspection tasks.

But the microprocessor is also control oriented to give the systems user:

Fast reading. Read at rates up to 24/sec on dc ranges, up to 12/sec in the fast ac mode and up to 12/sec on ohms ranges. You get this high dc speed with >60 db normal mode noise rejection at line related frequencies.

Easy programming. Program by pushing front-panel buttons. That's right, program-code knowledge is not required. In the Binary Program Mode, the HP-IB (HP's implementation of IEEE's 488-75) compatible 3455A automatically monitors front-panel control settings and reports their status to the controller, speeding and simplifying instrument programming. Front-panel indicators give complete instrument status at all times.

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And for both lab and systems:

Microvolt sensitivity and high accuracy. Read directly from thermocouples and other low-level sources...with >140 dB CMR. On dc you have 1 µV sensitivity, 10 µV on ac. and HP's Auto Cal provides dc accuracy of ±0.005% of reading + 1 digit) for 90 days by automatically measuring reference constants and digitally correcting readings. A test function signals out of tolerance constants and identifies the constant for rapid repair.

Plus convenient features and options. Choose either 2-wire kΩ or 4-wire kΩ measurements. Switch select 50 or 60Hz operation...front or rear panel inputs. And for $200 less ($3,000) you can substitute an average ac converter for the r.m.s. converter. Once you see the 3455A, you'll know it's the right system or lab DVM decision. Ask your local HP field engineer for all the details.

*Domestic U.S.A. price only.

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Circle 2 on reader service card
Highlights

Cover: Making a-d conversions faster, 89
High-resolution analog-to-digital conversion no longer needs to slow the work of digital multimeters and voltmeters. A new error-correcting technique permits the subtraction, as well as addition, of correction values to successive results in the conversion process. The result is conversion in as little as a tenth of the time of previous instruments.

Cover is by Art Director Fred Sklenar.

Professional-activities plan draws boos, 67
Reaction to the revised professional-activities plan of the Institute of Electrical and Electronics Engineers is not overwhelmingly enthusiastic. The focus of the complaints is the apparent lack of action in the plan’s five goals.

Standard hardware is key to optical systems, 94
Off-the-shelf cables and components make fiber-optic transmission systems a practical reality. An experimental system demonstrates the low cost and high performance possible, while pointing to cost-effective improvements for large operating systems of the future.

Wescon may be standing room only, 114
It could look like the 1960s at the Sept. 14–17 Wescon in Los Angeles, where the show will be the biggest in at least six years. The ubiquitous microprocessor will dominate both technical program and exhibits. Our Wescon overview and program guide is followed by a sampling of new products at the show.

And in the next issue ...
A master-slave arrangement of processors forms a universal microcomputer-development system... more about the 8500A microprocessor-based test system... how to analyze the performance of fiber-optic transmission links.
Publisher’s letter

"An engineer can always make a circuit work," says Joe Reedholm, "but it takes time to make it work consistently well in products coming off the assembly line." The circuit for the high-speed analog-to-digital converter, described by Reedholm and Riekus Koeman of John Fluke Manufacturing Co. in the article on page 89, is no exception.

Reedholm, who has just moved to Keithley Instruments, discussed the idea of incorporating bidirectional error correction to the a-d converter in a digital multimeter with his engineering group at Fluke early in 1972. "It looked like we could gain conversion speed with no increase in sensitivity to noise," he says. After some initial talks, Koeman began a feasibility study, and by mid-1973 he had proven that the circuit worked, that it could be built—but that it was costly to implement.

These early circuit designs, however, did not include microprocessor control, and when low-cost one-chip devices became available, the bidirectional error-correcting technique became economically feasible. Two more Fluke engineers then became involved in the project. Dean Ballard, who now is a consultant to Fluke, designed the microprocessor-controlled version of the circuit. Bob Hatch, whose article on the flexible module-and-bus structure of the 8500A multimeter will appear in the next issue, developed the intelligent instrument itself.

By the middle of 1975, they had proved out the unit's basic design, but some bugs remained. For example, stray capacitances were causing nonlineairities, and Ray Kletke, project manager for power sources and calibrators, was called in. Kletke's experience with precision circuits helped in making such corrections as keeping leads short to minimize the effects of dielectric absorption.

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Candidates should have at least a BSEE and substantial engineering experience. If you're interested, send résumé and salary requirements to: Executive Editor, Electronics, 1221 Avenue of the Americas, New York, N.Y. 10020.

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- logic level on-off
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- 50°C rating (uprating for lower temperature)

BLOCK DIAGRAM OF THE RMK SWITCH-MODE POWER SUPPLY

AVAILABLE OUTPUT RATINGS FOR THE KEPCO RMK MODELS

<table>
<thead>
<tr>
<th>Volts</th>
<th>5V</th>
<th>9V</th>
<th>12V</th>
<th>15V</th>
<th>24V</th>
<th>SIZE</th>
<th>WGT.</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amps</td>
<td>10A</td>
<td>6A</td>
<td>5A</td>
<td>4A</td>
<td>2A</td>
<td>2 5/6&quot; x 5 5/8&quot; x 7 1/2&quot;</td>
<td>3.0 lbs.</td>
<td>$210.00</td>
</tr>
<tr>
<td>Amps</td>
<td>20A</td>
<td>10A</td>
<td>8A</td>
<td>8A</td>
<td>4A</td>
<td>3 3/8&quot; x 5 5/8&quot; x 8 1/4&quot;</td>
<td>4.75 lbs.</td>
<td>$299.00</td>
</tr>
<tr>
<td>Amps</td>
<td>30A</td>
<td>16A</td>
<td>12A</td>
<td>12A</td>
<td>6A</td>
<td>4 1/8&quot; x 5 5/8&quot; x 8 3/4&quot;</td>
<td>5.25 lbs.</td>
<td>$399.00</td>
</tr>
</tbody>
</table>

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ask him to show you the clean layout, the cool operation,
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are designed to operate in the stringent environment required by aerospace systems — MIL-STD-810B and MIL-STD-461A for electromagnetic interference.

RELIABILITY — MTBF (mean time between failures) as calculated in the MIL-HDBK-217 handbook can be expected in excess of 50,000 hours at 100°C for all of these power modules. The hours listed under the photos above are the MTBF figures for each of the models shown. Additional information on typical MTBF’s for our other models can be obtained by phoning or writing to us at the address below.

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- 400\(\text{VDC}\) to DC
- 28 VDC to DC
- 28 VDC to 400\(\text{VDC}\)
- 12-28 VDC to 60 \(\text{VDC}\)

Please see pages 1037-1056 Volume 1 of your 1975-76 EEM (ELECTRONIC ENGINEERS MASTER Catalog) or pages 612-620 Volume 2 of your 1975-76 GOLD BOOK for complete information on Abbott Modules.

Send for our new 60 page FREE catalog.

<table>
<thead>
<tr>
<th>abbott transistor</th>
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<tbody>
<tr>
<td>IN STOCK</td>
</tr>
<tr>
<td>28 VDC to DC</td>
</tr>
<tr>
<td>(55,463 Hrs.)</td>
</tr>
<tr>
<td>Model C95D</td>
</tr>
<tr>
<td>28 VDC to 400</td>
</tr>
<tr>
<td>(61,387 Hrs.)</td>
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<tr>
<td>Model S3D</td>
</tr>
<tr>
<td>400 VDC to DC</td>
</tr>
<tr>
<td>(56,148 Hrs.)</td>
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<tr>
<td>Model W5D</td>
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Readers’ comments

Feerst can’t lead

To the Editor: I disagree with the premise in your July 22 article “Who will lead the IEEE into change?” [p. 78] that the presidential election is a contest among three candidates of equal leadership ability but with differences in platform and style. I have serious questions about Irwin Feerst’s ability to lead or responsibly represent the Institute of Electrical and Electronics Engineers.

Past leadership in the IEEE is the only meaningful measure I know to predict future performance. The board-nominated candidates, Robert Saunders and Robert Briskman, and the petition candidates, Robert Rivers and Carleton Bayless, each have an impressive record of leadership within the IEEE. But Feerst’s record only includes a short-lived membership on the professional-activities committee of Long Island. His complete alienation from all levels of IEEE leadership will make it impossible for him to achieve any substantial progress toward professional goals within the organization.

Although you may be accurate in your reporting, readers may derive the over-simplified impression of abrasive Feerst, idealistic Rivers, and affable Saunders. You describe Feerst as abrasive, but he is also abusive. His scapegoat tactics, confrontation politics, and flamboyant actions make good copy, but poor presidential material.

You describe Rivers as given to “elaborate analysis and lists of ideal goals,” but he is an activist on behalf of professional activities. You do not mention his positive record of achievements in promoting professionalism within the IEEE. In 1971 he advocated the changes in the constitution which paved the way for the U.S. activities board, where he plays a strong role in addition to his activities as a technical director.

You describe Saunders as an “affable educator,” but he is also an eminent consultant for industry and government. His leadership ability in bringing together diverse elements for constructive action has been demonstrated in his activities on
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\[ \frac{1}{2} \text{LSB max. over temp.} \]

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Readers' comments

behalf of the educational-activities board and as vice president for regional activities.

Thelma Estrin

The IEEE ballots are scheduled to be mailed by Sept. 1 and must be returned by Nov. 1.

Competition must be limited

To the Editor: Your editorial “Legis­lating competition out of telecommunications” [June 10, p. 10], although based on reported facts, concluded with the hope “that Congress will reject limitations on telecom­munications competition.” This hope is unreasonable in its comprehensive nature.

Much experience and other evidence has shown that unlimited competition is bad—not good—in the public-service field, which includes telecommunications. The problem for Congress will be to establish, in the public interest, the specific limitations on competition, rather than whether there will be competition. Certainly there will be competition among telecommunica­tions companies in the future at least to the degree it has existed in the past.

The primary goal of Congress while establishing the future limitations on competition will be to enable full realization in the U.S. of the best attainable telecommunication services at the least cost consistent with fair treatment of the employees, stockholders, and customers of the telecommunications companies. Limited competition will be only one of many factors involved in realizing this goal.

Henry H. Abbott

Correction

In the Designer's Casebook “One-op-amp oscillator keeps sine-wave amplitude constant” [June 24, p. 107], the thermistor is model 32A3 from Victory Engineering Corp.
Meet Model 7115, the industry's first microprocessor-based digital multimeter. It does what no conventional DVM could hope to do:

**Automatic zero/self calibration.** Using its computing power and built-in memory, Model 7115 continually calibrates itself against drift and component aging. Similarly, it detects and corrects for zero drift and offset error. Result: accurate readings all the time!

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**High-speed autoranging.** A rapid new S-D autoranging technique finds the correct range, goes there immediately and reads. It's not only a big improvement for bench use, but systems users can now use autoranging.

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THE PRICE OF OPTICAL ENCODERS JUST PLUMMETED.

News update

Scientific Micro Systems of Sunnyvale, Calif., wanted to get into the single-chip microprocessor business. The designers at the company, a subsidiary of Corning Glass Works, considered the alternatives open to them and decided to take the shortest route to the market: they simply “unbundled” their MicroController System. The bipolar unit has been offered as part of a controller on a printed-circuit board. So last summer [Electronics, Aug. 21, 1975, p. 26], SMS began to offer the Schottky TTL microprocessor as a separate part in a 48-pin dual in-line package.

The move was a success, says the company, pointing to sales of thousands of the single-chip device. The part now runs at 250 nanoseconds instead of the 300-ns time that was originally specified, and SMS is offering asynchronous as well as synchronous devices. But the price is still $90 in quantities of 100 or more.

In the year since he took over as president of Dumont Oscilloscope Laboratories, John Carter has led the firm away from its sole product line, oscilloscopes for the military [Electronics, Aug. 21, 1975, p. 14]. The firm has broadened its offerings with a digital multimeter produced under the DeForest Electronics trade name [Electronics, April 29, p. 160], as well as the year-old line of commercial scopes.

“The best mover we have right now is the 100-megahertz-bandwidth commercial scope [model 1100P],” says Carter, “and we’re trying to come up with a line of low-cost test equipment to complement the DMM.” Soon to be introduced is a 10-megahertz scope with a 3-inch screen, and a frequency counter is on the drawing boards.

Progress on the new lines has been steady, but not as fast as expected because, admits Carter, “we don’t have the biggest engineering department in town.” But encouraging sales of the DMM—$8,000 in the first three months—have convinced Carter that the firm can be successful in the commercial market.
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A slow start for IEEE's professional activities

The Institute of Electrical and Electronics Engineers is still struggling to get an effective, generally acceptable professional activities program off the ground. The members at large, to judge by their initial reaction, are still far from satisfied with the five-goal 1976 program plan developed by the institute's 16-member U.S. activities board. In fact, their generally critical reception of the plan is yet another illustration of the basic problem: the poor communications that exist between the membership and its current leadership.

Although it was a good—if quite obvious—idea to circulate the details of the plan to the general membership, and to publish them in the institute's magazine, Spectrum, we have to agree with many members who are wondering why more of them weren't given a chance to participate in forming the plan in the first place.

One critic, more harshly, feels that the U.S. activities board has effectively shut out members till now. "The board went into a secret laboratory to invent a new profession—engineering—and upon emerging is surprised the results have no resemblance to the real world," he says.

His assessment may be too severe, but it's still a reading of the grass-roots sentiment on how the IEEE operates. Its perception is that communications between those at the top is excellent, but somewhere between membership and leadership there's an open circuit.

The board, chaired by James H. Mulligan Jr., a professor at University of California, admittedly includes six appointed members at large, as well as six regional directors, three technical-division directors, and some assistants from IEEE's headquarters staff. But despite Mulligan's efforts, the feeling seems to be widespread that the board is still really not representative of the average engineer, who is, after all, the one with the most at stake in the planned professional-activities program.

Part of the problem may be that comments on the plan were solicited only from section chairmen and chairmen of local professional-activities committees, which vary enormously in quality and interest. But if the IEEE is to overcome the disenchantment and, even worse, the apathy of many of its members, a way must be found to give those members who will be most affected by projected programs greater participation in planning them. There needs to be much more input to headquarters “establishment” from the membership at large.
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Electronics / September 2, 1976

Circle 13 on reader service card
People

Rockwell, Motorola organize for auto-electronics business

"I recognize clearly that electronics people cannot define automotive firms' functional needs," says Motorola's Willard E. Hauth Jr. And at Rockwell International, H.A. Beall observes, "It's more difficult for us to understand how an auto company works than for them to understand our microprocessors." These two statements, made by officials in new posts at semiconductor houses seeking to expand sales of "under-the-hood" electronics to auto firms, sum up the principal problems facing them.

To bridge what they say has been a gap in communications between the two industries in the past, both Motorola Inc.'s Semiconductor group and Rockwell's Microelectronic Device division have made organizational changes to focus their efforts. They are trying roughly the same approach, pulling together into a single organization people and jobs that previously had been dispersed.

Hauth has been named program manager for Motorola's Automotive Electronics Systems group in Phoenix, and Beall has been appointed business director of Rockwell's Automotive LSI and Subsystems group in Anaheim, Calif.

Potential. Both predict the auto industry is close to becoming an important customer for microprocessor-based systems. But Beall's group has a big head start on Motorola and the rest of the industry. Its 10-bit processor will be the computing element for General Motor's Misar (microprocessed sensing and automatic regulation) system [Electronics, Aug. 9, p. 43]. Misar, the first such equipment planned for production models, is scheduled for the 1977 Oldsmobile Toronado.

How Rockwell won this bellwether contract taught some lessons that Beall says will help future programs with the auto makers. "You need a dedicated team working closely on a day-to-day basis with its engineering counterparts over a period of years," he explains. But the going gets tough when it comes to contractual terms and the stringent qualification, environmental, and life tests the equipment must pass, he says. And there's no hurrying things because of the auto industry's product-development philosophy that "a step at a time cuts risks on very large dollar investments."

Motorola's Hauth is aware of this too, and of the close working relationship that's required. "You have to understand their problems so well you can offer alternative ways of solving them."

To the top. Hauth and Beall came to their present posts by opposite paths. Hauth, from the auto industry, joined Motorola as operations manager for sensors late last year.
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People

after a long career with General Motors, most recently as director of research and development for the AC Spark Plug division. There, he was involved in microprocessor-oriented programs, in the development of digital instruments, and the electronic antiskid system for trucks.

Beall has been rising through corporate ranks at Rockwell ever since he came there 20 years ago out of college. He was in aerospace work until 1970, and in 1974, he became director of industrial electronics.

Although the auto industry's need for the efficiency of electronic systems is spurred by what Hauth calls the "combined crunch of Federal standards for emission control and gas mileage," developments are being held back by the Government, the two men claim. Congress must agree on the final standards for emissions and mileage so that designers of electronic engine-control systems will have a steady target. "Until our customers, the auto firms, find out what the standards will be, they can't tell us what to build," Beall points out.

Beall's operation has a staff of about 25 people, primarily engineers, divided between advanced and product development. In Phoenix, Hauth has an 11-person effort, an "engineering group that serves as a technical interface with our automotive customers, drawing on all Motorola areas of expertise."

Economics is it. In looking at the market, Beall terms "economics the driving force" for electronic systems. "Computational capacity of the chip is no problem," he says. "And we are working on ways to use it to take more of the load off the sensors." Sensors still need the biggest improvements, he says, since they are still mostly analog and more expensive than the auto companies like.

Both officials say they have a number of programs going with various auto firms but decline to discuss them specifically. At any rate, "since only a few of them eventually hit, you have to be prepared to make an investment for the long run," Beall says.
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Circle 19 on reader service card
Meetings


WESCON—Western Electronic Show and Convention, IEEE, Los Angeles Convention Center, Los Angeles, Sept. 14 - 17.


22nd Annual Holm Seminar on Electrical Contacts, Illinois Institute of Technology and IIT Research Institute, Pick-Congress Hotel, Chicago, Sept. 21 - 23.

Semicon/East 76, Semiconductor Equipment and Materials Institute (Golden Gate Enterprises, Santa Clara, Calif.), Nassau Veterans' Memorial Coliseum, Uniondale, N.Y., Sept. 21 - 23.


Quality Testing Show, American Society for Nondestructive Testing (Columbus, Ohio), Shamrock Hilton Hotel, Houston, Tex., Sept. 28 - 30.
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Golden Opportunity
Pushbutton Switches!
General Instrument is about to introduce the most ambitious electrically alterable read-only memory yet—an 8,192-bit chip-erasable device. (GI and McDonnell Douglas' Nitron division are the only U.S. suppliers of commercial Earoms.) The Hicksville, N.Y., company expects to supply samples of the nonvolatile part in September and put it into production by year's end. Manufactured with GI's metal-nitride-oxide-semiconductor process, the ER 2800 is erased by applying a voltage to the package pins. It should not be confused with the Intel's 2708 avalanche-injection type of erasable memory, which is erased with ultraviolet light.

Brian Cayton, ROM marketing manager, says specifications of the ER 2800 will be similar to those of GI's ER 2401 4,096-bit part. Reading takes 2 microseconds at p-channel voltage levels; writing and erasing take a respective 10–20 milliseconds and 100 ms at 28 volts. These figures qualify the new Earom for use in small memory systems in point-of-sales equipment or automatic dialers, say, and as core-replacements for the military—all applications where the ER 2800's erasability and nonvolatility matter a lot and its slowness matters less. For faster applications, GI will begin selling samples of a 650-ns 4-kilobit part, the ER 3400, by the end of the year.

At the same time, Japan's Nippon Electric Co. will add an 8-kilobit Earom to its line of programable ROMs that includes 1- and 2-k Earom devices. Unlike GI's nitride process, the avalanche-injection technique used by Nippon is based on standard polysilicon MOS technology, and unlike Intel's uv-erasable device, this one is electrically erasable. The new part, designated µPD 458D, has a minimum read access time of less than 500 nanoseconds, making it the fastest commercially available anywhere. The device, to be introduced in sample quantities in November, will be priced at $100 in small quantities.

Two commercial semiconductor divisions of McDonnell Douglas Corp. are pushing into the microprocessor-control business. A three-chip, 16-bit processor serves as the computing element for an advanced numerical-control system. These three chips are the first large-scale MOS devices to come from the Actron division in Monrovia, Calif., which designed them as part of a $1 million-plus research program, and the Nitron division in Cupertino, Calif., which manufactures them.

Consisting of a 16-bit controller and two 8-bit slices serving as arithmetic units, each processor can handle up to 200,000 instructions per second,
E-H Research Laboratories Inc. in Oakland, Calif., is getting out of the data-logger/acquisition-systems business—which it entered last year through acquisition of Data Graphics Inc. of San Antonio, Texas. The move follows the appointment of Richard Kirk by the board of directors to replace E-H president Jack Hubbs. The new management, which plans to concentrate E-H's activities on programmable instruments and digital logic recorders, decided that the return on investment from data-acquisition systems didn't justify the expense required to develop a viable product line to compete with companies like Doric Scientific, John Fluke, and Esterline.

"We decided we couldn't handle that many different markets," says E-H marketing vice president Domenic Norcia. "Data systems fragment our markets and product line too much, and it would have been too expensive to support all of them."

Being dropped are the recently introduced model 7000, a remotely controllable data logger, base-priced at $5,200 for a 100-channel system that is expandable to 1,000 channels, as well as a microprocessor based data logger that was in development. Former Data Graphics president John Peddie, who had been named to head a new Data Systems division of E-H, has resigned. Also leaving E-H are about a dozen former Data Graphics employees who teamed with more than 20 E-H employees to man the now-defunct division.
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Circle 28 on reader service card
Significant developments in technology and business

Two-way link teams up the E-2C and F-14

Digital data exchanged automatically includes radar inputs from fighters and orders from commanders.

Using an early-warning aircraft as a flying headquarters to command fighter interceptors has been difficult in the past because voice communications could be jammed or misunderstood, says Capt. Frank Roth, program manager at the U.S. Navy's E-2C Project Office in Washington. "But with the new two-way data link" between the E-2C AEW Hawkeye and the F-14A Tomcat fighter, "that's a problem that hardly exists any more," he asserts.

Moreover, the new digital link augments the "eyes and ears" of the E-2C with its ability to communicate with more than 30 F-14s. Both aircraft are built by Grumman Aerospace Corp., Bethpage, N.Y.

Uhf link. The fighter's radar automatically feeds such data as range and azimuth of potential enemies to one of several on-board computers. The data is encoded and transmitted via a time-division-multiplexed ultra-high-frequency data link to the E-2C. Also included automatically is data on the state of the fighter itself—for example, its remaining fuel and ammunition stores.

Once received aboard the E-2C, target information is processed, correlated, and presented on cathode-ray-tube screens to battle-control officers who decide how the threat is to be met. Their orders to the fighter pilots are transmitted back to the fighters via the data links. And by including information processed by the E-2C, the combat pilot can get a full 360° representation of the battle area—never before possible. Additionally, the data can be sent to shipboard Navy and Marine tactical data systems, for integration into still higher levels of command.

The two-way link for the E-2C/F-14A team represents the first time that AEW aircraft could command and control the fighters as well as receive target and other information from sensors aboard the fighters. Previously, there had been a one-way data link only to transmit command data from the E-2A, an earlier version of the E-2C, to the McDonnell-Douglas Corp. F-4 Phantom fighter.

The heart of the two-way link is the AN/ARC-158 uhf communications system supplied by Collins Radio Co., Cedar Rapids, Iowa. Typically, officers aboard the E-2C select the most appropriate of the F-14s (in terms of such things as position relative to target, fuel state, weapons complement) and vector the fighters to their targets by means of

Electronic review

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coded data messages. Once in contact with the enemy, the F-14 takes control, and the fighter presses the attack, relying on its own system inputs. Upon completion of the attack, the E-2C resumes control, vectoring the F-14 to rendezvous with a tanker aircraft for refueling, if necessary, or to a landing site.

Extended range. "Equally important," as a result of using the two-way link," Roth continues, "is the extension of the E-2C's radar range. And the number of fighters that can be controlled simultaneously is many more than could be done with voice communications." While the surveillance capabilities of the E-2C exceed those of the F-14 (250-plus miles vs 100-plus miles), the fighter has its own forward-looking multitarget tracking capability.

With its AWG-9 Phoenix missile system, the F-14 can engage as many as six targets simultaneously with guided missiles. Thus, with the E2C's ability to control upwards of 30 F-14s via two-way link, "the maximum number of simultaneous target engagements possible has been increased an order of magnitude," says James McManus, AEW future-systems program manager at Grumman.

The E-2C/F-14A team has already stacked up an enviable record during fleet exercises in the Mediterranean, McManus continues. In a recent exercise called Operation Lafayette, 12 F-14s, operating in concert with four E-2Cs, detected and intercepted all 91 flights made against the carrier John F. Kennedy. No "attackers" penetrated the carrier's inner defense perimeter, and another 38 aircraft not involved in the mock raid also were intercepted successfully.

Hybrids

Makers offer standard circuits as promise for high-volume brightens

A surge in demand from manufacturers of telecommunications, medical, and industrial equipment is changing the emphasis in hybrid technology from short-run custom designs to high-volume lines of standard products.

Hybrid technology has traditionally been used mostly for military applications because the armed forces are willing to pay the premium for special functions in relatively small volume. But recent developments in production techniques are making it economical to turn out large numbers of hybrid circuits for prices that could otherwise only be met with combinations of standard monolithic ICs and discrete components.

Modern methods. Taking advantage of newer production methods involving such things as automatic laser trimming and testing, General Instrument Corp.'s Hybrid division in Hicksville, N.Y., is joining companies like National Semiconductor Corp. and Beckman Instrument Inc.'s Helipot division to make hybrids as standard products.

Cheaper. These devices are being turned out at prices much lower than custom hybrids, and they are competitive with discrete designs. "We have many commercial and industrial firms coming to us for hybrids because they want to put 16 times the functions in the same-size or smaller-size equipment," says Allan C. Bahr, GI's director of communications products.

National, in Santa Clara, Calif., entered the standard active-filter market last fall with basic building-block filter circuits—a universal active filter and a generalized impedance converter [Electronics, Dec. 11, 1975, p. 124]. It has since developed 14 hybrid active filters for tone-receiver systems, and these modules are available as individual modules or on assembled cards for telephone central-office equipment.

In Fullerton, Calif., Beckman followed suit with a family of 13 hybrid tone-receiver modules and card assemblies [Electronics, April 1, p. 123] which, like the General Instrument and National units, are compatible with Bell-System equipment.

Return. The payoff could be huge indeed. "The standard hybrid business will be $50 million to $100 million within the next three to five years," estimates Beckman's hybrid-microcircuits manager, Richard Snyder.

General Instrument's Bahr is equally sanguine. He predicts, "In the very near future, our standard hybrid business will surpass that of our custom business," which was slightly less than $10 million this year. "We'll easily do a $15-million-plus business within three years, just for standard telecommunications products, even if we don't crack Western Electric," which has its own hybrid-assembly operation for Bell.

Trimmer. Resistor on hybrid circuit is trimmed on General Instrument's production line by YAG laser from Korad Corp.
National probably has the most experience with the market by virtue of its earlier entry. “Most of the activity for our universal filters and generalized impedance converters is coming from the telecommunications industry,” says Dennis Dauenhauer, National’s hybrid-product marketing engineer. “But there’s a lot of interest from many other areas.” These include security systems and medical electronics.

Dauenhauer says orders are coming in quantities of 10,000 to 30,000 pieces, primarily from independent telephone-equipment manufacturers who don’t have their own assembly operations. Such orders are considered prototype quantities, and orders for hundreds of thousands of devices are in the offing, Bahr claims.

Filters. General Instruments’ new standard line includes more than 60 hybrid active filters for switching and multiplexing systems, tone receivers, and modems—three segments of the telecommunications industry that it’s targeting as its primary market. Penetration into a fourth segment—voice transmission over radio—will begin in late September when the firm is to sample a hybrid tone-squelch system that will replace electromechanical and discrete-component subsystems used in transceivers.

Do-it-yourself. Heath Co.’s game kit, which will sell for about $50, plays four games on a black-and-white TV display.

the receiver hook up the video and sound inputs, power supply and ground. The game also includes an intermediate-frequency “defeat” circuit that turns off the broadcast video and sound signals.

All the connections except those for sound are made by clipping the wires to the i-f board connector. And all five are terminated in a connector on the back of the set so that the game’s control box can be moved easily from set to set.

Remote control. The black-and-white Sportscreen, which has its own sound and on-screen scoring, will play ping pong, squash, hockey, and a one-person practice game. It uses two remote-player control boxes wired to a central control unit that sits atop the set. “The GI chip could also provide a pair of target games that we’re not presently using,” Brockway says. Paddle size, ball speed and rebound angle, and volume are chosen by the players. The ball may be served manually or automatically.

Johnson doesn’t rule out making future game kits that would use TV-antenna hook-ups and require FCC approval.

“We can’t become involved in modifying other manufacturers’ TV

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Consumer

Heath adds game for TV receivers

After watching scores of games makers scurry to the Federal Communications Commission for type approval of new video games, Heath Co. sat back and developed a game not subject to any such regulations.

The Benton Harbor, Mich., manufacturer of do-it-yourself electronics kits designed its game to bypass entirely the television set’s antenna terminals, the interface that is regulated by the FCC because it can be a source of radio-frequency interference. Instead, Sportscreen, as it’s called, is designed to be hooked directly into the TV circuitry, and it can be played with any solid-state television receiver Heath has ever had on the market.

Customer knowhow. “We’re able to do it because our customers have built their own sets, so they know where everything is,” points out vice president William E. Johnson. Once the back of the set is off, it takes only about three minutes to hook up the game with five alligator clips, he says.

However, it takes five or six hours to assemble the game kit, built around a chip from General Instrument’s Microelectronics division. Savings for labor and parts—the game uses the TV set’s power supply, for example—will allow Heath to tag the four-game Sportscreen at $54.95 (by mail, $49.95) when it’s available in October in the company’s retail stores.

Besides GI’s n-channel, metal-oxide-semiconductor chip, the kit’s single printed-circuit board holds a reference crystal and a second integrated circuit that works as an oscillator, and associated discretes. “We use a pass transistor and a series resistor as a regulator to accommodate the different voltages the game will see from our 15 different solid-state TV models,” says Roger Brockway, chief engineer for Heath’s consumer products.

Five wires to different points in

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Electronics/September 2, 1976
sets, so there would be no other way to do it," he says. Some parts of those kits would have to be preassembled for type approval.

Companies

Costs, financing too much for Datran

Last week's demise of specialized common carrier Data Transmission Co. (Datran) in Vienna, Va., seemingly is a case of either too much too soon or not enough too late.

Post-mortems by data-communications industry observers and Datran officials indicate the firm invested much more in its digital switching system and microwave transmission network than its market share justified. Moreover, financing did not arrive in time to complete the system's original concept of totally digital communications lines owned outright by Datran. Also late were Government rulings that might have prevented American Telephone & Telegraph Co. from offering certain digital data transmission rates that the FCC's law judges found in June to be unlawful, unreasonably low, anti-competitive, predatory, and designed specifically to eliminate Datran.

Facilities. Founded originally as a University Computing Co. subsidiary in 1968, Datran was to provide the Dallas-based data-processing-services firm (now Wyly Corp.) with transmission facilities. It was then expanded to offer the same services to a data-communications marketplace. However, that market—Datran attracted 150 to 200 customers—never came even close to generating revenues to cover Datran's front-end costs that totaled upwards of $100 million. In 1975, for example, when Datran's revenues reached about $1 million, it posted a $14 million loss.

The big losers, in addition to Wyly Corp. ($45 million), are Haeffner Holding AG of Switzerland (about $50 million), Bechtel Co. (about $4 million), which constructed the system's microwave towers, and Nippon Electric Co., which supplied the microwave radios, time-division multiplexers, and other equipment.

"Datran was a very different kind of common carrier," says telecommunications consultant Harry Newton of New York City. "It stressed state-of-the-art technology and took numerous gambles in building an all-digital data communications network," as opposed to other specialized carriers which concentrated on voice communications. For instance, Datran installed the first-ever electronic data switch [Electronics, Dec. 12, 1974, p. 91].

As originally conceived, Datran's network was entirely digital, an alternative to the Bell System's analog telephone net. It was also to have cost less while providing higher transmission rates and lower average setup times. "But many potential users, wondering if Datran would stick around, opted to play it safe and stay with Bell," says Newton.

Expensive. Unfortunately for Datran, the tremendous cost of installing dedicated digital loops forced it to lease some analog lines from other carriers. The mix of lines meant Datran needed a lot of modems—typically four per connection, instead of the two required by other specialized carriers.

John Guttenberg, a former Datran vice president, says about $30 million more was needed for such things as remote switching units to eliminate some of the leased channels.

But money, as well as customers, was always hard to come by. Says Guttenberg, "AT&T could cause a wait-and-see attitude to take place up and down the market spectrum, whether it was the market for customers, capital, or regulatory decisions."

Just how AT&T's posture affected Datran may be answered in the $285 million law suit Wyly has filed against AT&T, charging it with violation of Federal antitrust laws.

Terminations. Datran, which inaugurated services in early 1974, grew to have about 1,000 data links in 22 cities. By late last week it expected to discontinue all services and had terminated all but a handful of about 250 employees, down from a peak of 300 at the year's start. And it was meeting with other carriers that could serve its customers.

Datran leaves an estimated $1.1 billion market to be shared by survivors such as MCI Communications, Southern Pacific Communications—and AT&T. William G. McGowan, chairman of MCI, doesn't expect Datran's departure to affect his operations significantly since only about 7% of its 14,000 circuits is used for data communications. A spokesman for AT&T in New York says the firm has no plans to take over any of Datran's transmission facilities or routes "and neither do we intend to solicit any of Datran's customers." Ironically, Datran was the largest customer for AT&T's digital data system, outside of the company's own organization.

Microwaves

Fine geometry improves transistors

In their drive toward higher frequencies with even higher gains, while keeping noise low, makers of silicon bipolar microwave transistors have worked themselves into a double bind. Geometries of microwave transistors must be tiny because of the frequencies at which they operate—the higher the frequency, the finer
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Electronics/September 2, 1976

Circle 33 on reader service card
the geometry of the emitter "fingers." But, as the devices get smaller, the current density becomes enormous, and capacitive effects grow, decreasing gain. What's more, as thermal and injection-current effects increase, noise increases.

However, engineers at Hewlett-Packard Co.'s Microwave Semiconductor division appear to have found a way out of this bind. They have developed a technique that enables them to make submicrometer emitter fingers without sacrificing device gain or yield, and yet minimize the noise figure. Without pushing the limits of their process, engineers at the Palo Alto, Calif., division have built, and are producing in volume a 4-gigahertz device—the HXTR-6101—that has an associated gain of about 9.0 to 9.5 decibels and a typical noise figure in the 2.3- to 2.7-db range.

In contrast, competitors like Avantek Inc., TRW Semiconductor, Microwave Semiconductor Corp., Texas Instruments, Nippon Electric Co. and Fujitsu Ltd. are getting for comparable 4-GHz silicon transistors under development associated gains ranging from about 7.5 to 8 db and typical noise anywhere from 2.7 to 3.5 db.

Complex. The HP technique, involving a combination of ion implantation, local oxidation, computer-aided design and a proprietary self-aligning process, is complex but effective. Craig Snapp, section manager for bipolar transistors at HP, says highly reproducible emitter-to-emitter spacings of 5 micrometers and emitter widths of about 0.7 µm can be achieved by using conventional contact lithography and hard-surface oxidized chrome photo masks.

"Transistors with this fine a geometry have previously been fabricated," says Snapp, "but usually with processes requiring projection-mask aligners, electron-beam lithography, or lateral-diffusion techniques, none of which are associated with high-volume production."

Keys to the fine geometries are the use of ion implantation and a self-alignment technique that simultaneously defines the emitter and base-contact windows in a silicon-dioxide layer, he says. In conventional devices, by contrast, a combination of diffusion and ion implantation is used in the fabrication of the emitter and base fingers.

Combined with the self-alignment technique, this eliminates one of the most critical alignments and, thus, two major sources of noise in silicon bipolar transistors: thermal noise arising in the base-spreading resistance and shot noise in the injection of current across the emitter-base junction.

Increasing gain. To improve the gain of their devices, Snapp found he had to minimize the effects of the collector-base junction capacitance and the collector-base bonding-pad capacitance. "The first was achieved partly as a side product of improving the noise characteristics," he says. Another factor was the closer placement of the interdigitated fingers of the emitter.

To reduce the collector-base bonding-pad capacitance, a relatively thick oxide is formed by a local-oxidation/ion-implantation combination that uses a silicon-nitride cap to prevent the formation of oxide in the base region during a thermal-oxidation cycle.

Family. The HXTR-6101, says Snapp, is the first in a family of linear microwave power-amplifier elements extending from as low as 0.4 GHz to as high as 8 GHz. Experimental noise figures on 1.5 GHz devices, he says, range from 1.45 dB to 1.5 dB, with an associated gain of 15 dB. At the high end, around 6 GHz, devices have been fabricated with 3.9-db noise figures and 7.5-db associated gain.

Microprocessors

Intel eases use of high-level language

"For the first time, microcomputer designers have access to the more powerful software techniques developed in the past 10 years," says Intel Corp.'s Paul Rosenfeld, software product manager for microcomputer systems. "And they do not add appreciable extra complexity to the [software] development process."

Enhancements. Rosenfeld is talking about the modular approach to programming and the use of a high-level language, both of which are groundbreaking features of an enhanced software package for Intel's Intellec microcomputer-development system [Electronics, May 25, 1975, p. 95]. Called the ISIS-II, the package will be introduced at the Wesccon meeting in Los Angeles later this month.

Until now, any designer who wished to modularize his microcomputer's software has been able to use high-level languages for the job only with difficulty. To link the program modules and assign them correctly to memory addresses, the designer has been forced to conform to very
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detailed cross-reference specifications. ISIS-II, however, which has a disk-based operating system, includes both linker programs and locater programs that work with a resident compiler for the high-level PL/M language. A new macro-instruction assembler and a library manager complete the package.

Intel's original Intellec system has become a model for in-circuit emulation systems, which stand in for the microprocessor during the design and development of associated hardware and software.

The approach gives the engineer a lot of freedom in prototyping a microcomputer system, and the addition of a high-level language and modularization is a step that will undoubtedly be followed by other major suppliers of microprocessors.

PL/M was originally developed by Intel for its earlier 8008 microprocessor. But before ISIS-II the language could be compiled for the 8080 chip only on a large 32-bit computer. The new PL/M compiler is compatible with the earlier PL/M cross-compiler but was rewritten from scratch, according to Rosenfeld. It makes multiple passes through the Intellec system and requires 65 kilobytes of memory.

Modular programing has the same advantages for the design of microcomputer-based systems as for computer- and minicomputer-system design. It enables the programmer to write separate subroutines for common tasks, debug them separately, and then—in the case of ISIS-II—use linker and locater software aids to stitch them together into a larger program. And, with the ISIS-II library manager, the routines can be stored on disk and easily withdrawn when needed.

New bus. The key to linking these new elements together according to Rosenfeld, is to establish language specifications for a "software bus." These work like the standard specifications that allow a hardware bus to be connected to all hardware modules meeting the standards. Similarly, standard specifications for a software bus permit its interconnection to program modules.

News briefs

Fairchild takes on Mostek 4-k RAM
Mostek Corp., the acknowledged leader in sub-200-nanosecond 4,096-bit random-access-memory chips, has chosen Fairchild Semiconductor as its second source for its 16-pin MK 4027. Mask and process exchanges between the two manufacturers should insure close conformity of specifications between the hard-to-build depletion-mode polysilicon devices. The deal continues the companies' already close association—Mostek, in turn is Fairchild's only second source in the U.S. for the popular F-8 microprocessor system.

Add-on memory maker recalls employees
Cambridge Memories Inc. has been able to recall 80 of 350 laid-off workers by selling its leasing operations to pay off $13 million of its $16 million debt [Electronics, Aug 5, p.38]. Yet to come is its decision whether to sell all or part of its Poughkeepsie, N.Y., plant for making n-channel metal-oxide-semiconductor memories. The Bedford, Mass., company had sales of $11.6 million for the six months ending Feb. 28, while during the same period it lost $604,000.

Peterson resigns to make way for Penisten...
Valentine E. Peterson, who was serving as interim president of American Microsystems Inc., Santa Clara, Calif., succeeding Bernard T. Marren, has resigned. He makes way for Glenn E. Penisten, former head of Datran (see p. 32), who had been elected president and chief executive earlier.

... as Signetics names Sharp to head Logic division
U.S. Philips Corp.'s Signetics subsidiary in Sunnyvale, Calif., has named Steven J. Sharp general manager of its Logic division. Formerly the division's advanced technology manager, Sharp replaces Norman J. Miller, who becomes president of U.S. operations for ITT Semiconductor, based in Woburn, Mass.

The locator program then takes over and adjusts the memory addresses of the linked programs so that each resides in nonconflicting sections of memory. The program can then be executed. With the linker and locater, a software library can be built up of basic routines and drawn upon whenever it's needed. Users who have the Intellec system now will be sent the ISIS-II package, which includes linker, locater, library manager, and macro assembler and requires 32-k memory. But the PL/M compiler will be sold separately.

Air-traffic control

System under test at O'Hare Airport detects dangerous aircraft wakes

Aircraft attempting to land in the turbulent wake of planes touching down ahead of them can encounter dangerous buffeting. To warn airtraffic controllers of the presence of these wake vortices, as they're called, the Department of Transportation's Systems Center has installed a wake advisory system at Chicago's O'Hare International Airport and is now in the process of testing it. The hope is also to increase the number of landings (and take-offs) by safely shortening the separation between landing aircraft.

Wake vortexes are the tube-shaped trails of turbulent air churned up by the plane's wings and flaps. They can remain in the approach corridors so long after a
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Monolithic Memories

Monolithic Memories

Electronics/September 2, 1976

Circle 37 on reader service card
large jet like a Boeing 707 has 
landed that a single-engine plane 
may have to keep a 6-mile distance 
from the 707 when coming in 
behind. And until now, air-traffic 
controllers have had no way to 
detect the air disturbance. Instead, 
they simply used extremely conser­

<table>
<thead>
<tr>
<th>Problems accompany move to 40 channels</th>
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Afraid of being stuck with unsold 
citizens' band receivers, several U.S. 
manufacturers are offering to update 
their units to operate over the 40 
channels that will go into service on 
Jan. 1. But the modification may not 
be easy and may even be impossible 
at an acceptable price.

Much depends on how the channel 
frequencies, in the 27-megahertz 
range, are generated and whether or 
not the sets meet Federal Communications 
Commission requirements. 
The few transceivers that generate 
their carriers with phased-locked 
loops and synthesizers will be easy 
to modify. Inserting a new read-only-
memory integrated circuit that gen-
erates the digital code to program 
the synthesizer will do the trick.

| Crystal sets. But most of the sets 
imported from Japan and other 
offshore suppliers that are sold by 
a large number of U.S. firms generate 
frequencies with crystal synthesiz-
ers—as many as 14 crystals are 
required for the present 23 channels. 
To convert these sets, manufacturers 
would either have to switch to 
phased-locked loops or add more 
crystals, both relatively expensive 
modifications.

Still other problems will remain, 
however, even after the number of 
frequencies is increased. The FCC, in 
ruling for the 40-channel class D 
service [Electronics, Aug. 19, p. 34], 
wants all modified sets to meet new 
and more demanding specifications 
that put a tighter lid on spurious 
radiations from the CB transmitters 
and receivers.

The circuit boards in most off-
shore sets have no shielding, and it 
may be difficult to add to prevent 
radiation from the chassis. Also, a 
front-end filter may be needed to 
prevent local-oscillator radiation 
from leaking out the antenna.

The U.S. set makers now offering 
to modify their 23-channel sets
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include Hy-Gain Electronics Corp., Lincoln, Neb. and the California firms of SBE Inc., Watsonville, Communications Power Inc., Mountain View, and Pathcom Inc.'s Pace Communications division, Harbor City. They'll modify already owned or yet to be purchased sets at fees that range from $25 to $95. But not all the companies are, in general, offering to modify all their models—probably only the ones that are easiest to update.

**Lower prices.** For the consumer, however, prices are dropping. Some manufacturers forecast that, by Christmas, 23-channel sets will be priced at only $49.95, as the scramble goes on to get rid of crystal-synthesized sets already in inventory and others committed to be shipped from Japan. For some big-name-brand radios prices have already been cut from $159 to a low of $99.

But major U.S. manufacturers do agree on one thing. They predict that the cheap 23-channel sets will fade out and that top-of-the-line 40-channel models, many operating with single-sideband transmissions of generally longer range, will dominate the marketplace until the FCC opens a so-called class E service in the very-high-frequency range about 1979. And they think sales of CB radio will remain at the current level of about 750,000 sets a month for two or three more years.

**Companies**

Rockwell shifts product emphasis

Rockwell's Microelectronic Device division is emphasizing production of integrated circuits and products with higher potential profits than the minuscule margins of the division's former mainstay, calculators.

That is the immediate result of the first big change made by Donald R. Beall, who took over as president of Rockwell Electronics Operation in Anaheim, Calif., late this spring from Donn L. Williams [Electronics, May 13, p. 36]

Even though production of calculators and consumer-electronic products remains the largest operation in the division, managers have also been assigned responsibility for large-scale-integrated circuits applied to microprocessors, modems, and automotive products. This assignment of accountability comes as no surprise, since Beall had favored clear definition of responsibilities for product-line managers when he headed Rockwell's Collins Radio group, which he turned around to profitability.

**Timing.** Although Beall had been expected to make structural changes in the billion-dollar Electronics Operations, which includes Collins, some sources had thought he would give priority to the Autonetics group, which is more than five times larger than the Microelectronic Device division.

One reason for the timing, one source says, is that vice president and general manager of the Microelectronic division, Charles V. Kovac, had had the reorganization already planned when Beall assumed command. Williams had previously turned thumbs down on the proposal, wanting to keep tight central-management control.

Although the four new organizations will not be separate profit centers, each will have its own product-planning, design engineering, marketing, and financial sections. All will share such common functions as production, design engineering, quality assurance, sales, and personnel.

**Leaders.** Heading the organizations are: H.A. Beall (see p. 14), automotive LSI and subsystems; D.R. Barnhart, calculator and consumer electronics; Alan Secor, microprocessor LSI and subsystems; and D.P. Del Frate (former director of marketing for the entire Microelectronic Device division), modem LSI and subsystems.

In a statement, Kovac said the move "culminates a three-year diversification plan, during which substantial business" was generated in the non-calculator and consumer areas.
### ELECTRONIC ORGANS / FREQUENCY DIVIDERS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
<th>PART NUMBER</th>
<th>MAXIMUM FREQUENCY</th>
<th>POWER SUPPLIES</th>
<th>PACKAGE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MASTER FREQUENCY GENERATOR</td>
<td>Generates a complete octave of musical frequencies</td>
<td>AY-1-0212</td>
<td>1.5 MHz</td>
<td>+12, GND</td>
<td>16 DIP</td>
<td>250 kHz minimum frequency</td>
</tr>
<tr>
<td>TOP OCTAVE GENERATOR</td>
<td>Generates top octave scale</td>
<td>AY-3-0214</td>
<td>4.5 MHz</td>
<td>+10 to +16, GND</td>
<td>16 DIP</td>
<td>12 outputs, 50% duty cycle</td>
</tr>
<tr>
<td>PRIORITY LATCHING NETWORK</td>
<td>Establishes priority level of 13 latch inputs/outputs</td>
<td>AY-1-1313</td>
<td>20 kHz</td>
<td>GND, -12, -27</td>
<td>40 DIP</td>
<td>Stackable for expanded latching/priority function</td>
</tr>
<tr>
<td>RHYTHM GENERATOR</td>
<td>Generates 6 rhythms, drives 8 instruments</td>
<td>AY-5-1315</td>
<td>10 kHz</td>
<td>GND, -15</td>
<td>18 DIP</td>
<td>Resets for coupling chords to rhythm, 32 beat pattern. Mask programmable</td>
</tr>
<tr>
<td>CHORD GENERATOR</td>
<td>Produces major, minor, 7th chords, walking bass</td>
<td>AY-5-1317A</td>
<td>50 kHz</td>
<td>GND, -15</td>
<td>40 DIP</td>
<td>Mixed outputs, sustain, top key priority</td>
</tr>
<tr>
<td>PIANO KEYBOARD</td>
<td>Electronically simulates piano operation and sound</td>
<td>AY-5-1350</td>
<td></td>
<td>GND, -10, -27</td>
<td>40 DIP</td>
<td>12 keys per unit, loudness proportional to key press velocity</td>
</tr>
<tr>
<td>FREQUENCY DIVIDERS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 stage</td>
<td>AY-1-5051</td>
<td>1 MHz</td>
<td>GND, -13, -27</td>
<td>10 TO</td>
<td>Arranged 2+1+1</td>
<td></td>
</tr>
<tr>
<td>5 stage</td>
<td>AY-1-6721/5</td>
<td>1 MHz</td>
<td>GND, -13, -27</td>
<td>10 TO</td>
<td>Arranged 3+2</td>
<td></td>
</tr>
<tr>
<td>6 stage</td>
<td>AY-1-6721/6</td>
<td>1 MHz</td>
<td>GND, -13, -27</td>
<td>12 TO</td>
<td>Arranged 3+2+1</td>
<td></td>
</tr>
<tr>
<td>7 stage</td>
<td>AY-1-2006</td>
<td>50 kHz</td>
<td>GND, -12, -27</td>
<td>14 DIP</td>
<td>Arranged 2+1+1</td>
<td></td>
</tr>
<tr>
<td>216 divider Counter/Divider</td>
<td>Operation is a function of current through a resistor from ( V_{CC} ) to injection input.</td>
<td>AY-9-1000</td>
<td></td>
<td></td>
<td>8 TO, 16 DIP</td>
<td>Crystal/RC oscillator input; divide by 2^16, 2^15, 2^14, 2^13, 2^12, or 2^7</td>
</tr>
</tbody>
</table>

### TELECOMMUNICATIONS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
<th>PART NUMBER</th>
<th>POWER SUPPLIES</th>
<th>PACKAGE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PUSH BUTTON TELEPHONE DIALER CIRCUIT</td>
<td>Converts push button input to rotary dial pulses</td>
<td>AY-5-9100</td>
<td>SEE DATA SHEET</td>
<td>18 DIP</td>
<td>Programmable timing, one-call memory, optional redial and access pause capability</td>
</tr>
<tr>
<td>REPERTORY DIALLER</td>
<td>Stores ten telephone numbers</td>
<td>AY-5-9200</td>
<td>SEE DATA SHEET</td>
<td>16 DIP</td>
<td>Complements AY-5-9100 to enable storage of up to 22-digit telephone numbers. Stackable</td>
</tr>
<tr>
<td>COINBOX CIRCUIT</td>
<td>Controls the operation of a standard pay telephone</td>
<td>AY-5-9300</td>
<td>SEE DATA SHEET</td>
<td>24 DIP</td>
<td>Up to 3 coin denominations recognized, 16 selectable coin value ratios</td>
</tr>
<tr>
<td>DUAL TONE MULTI-FREQUENCY GENERATOR</td>
<td>Generates MF/Tone telephone frequencies</td>
<td>AY-3-9400</td>
<td>+5, GND</td>
<td>14 DIP</td>
<td>With a low cost ceramic resonator, generates 12 tone pairs</td>
</tr>
<tr>
<td>C-MOS CLOCK RECEIVER</td>
<td>Receives 2-phase clocks from a single power supply</td>
<td>AY-5-9500</td>
<td>SEE DATA SHEET</td>
<td>14 DIP</td>
<td>Generates 2-phase clocks for AY-5-9100 &amp; AY-5-9200</td>
</tr>
<tr>
<td>MULTI-FREQUENCY RECEIVER</td>
<td>Detects and converts MF/Tone telephone frequencies</td>
<td>AY-5-9800</td>
<td>SEE DATA SHEET</td>
<td>28 DIP or 40 DIP</td>
<td>Many programmable features provide wide applications</td>
</tr>
</tbody>
</table>

### DATA COMMUNICATIONS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
<th>PART NUMBER</th>
<th>REPLACES (PIN-FOR-PIN)</th>
<th>BAUD RANGE</th>
<th>MAX. FREQ.</th>
<th>TEMP. RANGE</th>
<th>POWER SUPPLIES</th>
<th>PACKAGE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>UART/1*</td>
<td>Complete 5-8 bit serial, parallel, or analog interface</td>
<td>AY-3-1015</td>
<td></td>
<td>0 to 30 kb</td>
<td>480 kHz</td>
<td>0 to 70</td>
<td>+5, GND</td>
<td>40 DIP</td>
<td>1, 1.5, or 2 stop bits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1AY-6-1013</td>
<td></td>
<td>0 to 20 kb</td>
<td>320 kHz</td>
<td>55 to +125</td>
<td>+5, GND, -12</td>
<td>40 DIP</td>
<td>1 or 2 stop bits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AY-5-1013</td>
<td></td>
<td>0 to 30 kb</td>
<td>480 kHz</td>
<td>0 to 70</td>
<td></td>
<td>40 DIP</td>
<td>1 or 2 stop bits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AY-5-1013A</td>
<td></td>
<td>0 to 40 kb</td>
<td>640 kHz</td>
<td>0 to 70</td>
<td></td>
<td>40 DIP</td>
<td>1 or 2 stop bits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AY-3-1014A</td>
<td></td>
<td>0 to 30 kb</td>
<td>480 kHz</td>
<td>0 to 70</td>
<td>+5 to +14, GND</td>
<td>40 DIP</td>
<td>1, 1.5, or 2 stop bits</td>
</tr>
<tr>
<td>RANDOM ACCESS MULTIPLEXER</td>
<td>Multiplexes 16 channels, current, voltage, or analog interface</td>
<td>AY-5-1016</td>
<td></td>
<td>0 to 70</td>
<td>2 MHz</td>
<td>55 to +125</td>
<td>+5, GND, -12</td>
<td>40 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1AY-6-4016</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>40 DIP</td>
<td></td>
</tr>
</tbody>
</table>

*For future release.

*Also available with MIL STD 883 screening (add suffix TX to part number)
COUNTERS / DIGITAL METERS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
<th>PART NUMBER</th>
<th>MAX. COUNT FREQUENCY</th>
<th>DISPLAY CURRENT</th>
<th>POWER SUPPLIES</th>
<th>PACKAGE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 DIGIT COUNTER</td>
<td>Counts &amp; decodes one decade to BCD outputs</td>
<td>MEM 1056BCC</td>
<td>1.0 MHz</td>
<td>—</td>
<td>GND, +13, −27</td>
<td>24 DIP</td>
<td>BCD outputs.</td>
</tr>
<tr>
<td>1 DIGIT COUNTER/ DISPLAY DRIVER</td>
<td>Counts &amp; decodes one decade to 7-segment outputs</td>
<td>MEM 1056</td>
<td>1.0 MHz</td>
<td>1.0 mA</td>
<td>GND, +13, −27</td>
<td>24 DIP</td>
<td>7-segment outputs</td>
</tr>
<tr>
<td>4 DIGIT COUNTER</td>
<td>Counts, stores &amp; decodes four decades to BCD outputs</td>
<td>AY-5-4057</td>
<td>500 kHz</td>
<td>—</td>
<td>+5, GND, −12</td>
<td>16 DIP</td>
<td>BCD outputs</td>
</tr>
<tr>
<td>4 DIGIT COUNTER/ DISPLAY DRIVER</td>
<td>Counts (up or down), stores &amp; decodes four decades to 7-segment outputs</td>
<td>AY-5-4007</td>
<td>600 kHz</td>
<td>25 mA/V</td>
<td>+5, GND, −12</td>
<td>24 DIP</td>
<td>BCD outputs, true/complement control</td>
</tr>
<tr>
<td>3½ DIGIT DVM CIRCUIT</td>
<td>DVM logic incorporating dual ramp integration</td>
<td>AY-5-3507</td>
<td>40 kHz</td>
<td>6 mA</td>
<td>GND, −15</td>
<td>18 DIP</td>
<td>Range to 1999, 7-segment outputs</td>
</tr>
<tr>
<td>3½ DIGIT DVM CIRCUIT</td>
<td>DVM logic incorporating single ramp integration</td>
<td>AY-5-3500</td>
<td>200 kHz</td>
<td>6 mA</td>
<td>GND, −7.5, −15</td>
<td>28 DIP</td>
<td>3 ranges: 999, 1999, 2999 Dual polarity, BCD &amp; 7-segment outputs</td>
</tr>
<tr>
<td>4½ DIGIT DVM CIRCUIT</td>
<td>DVM logic incorporating dual ramp integration</td>
<td>AY-3-3550</td>
<td>400 kHz</td>
<td>2.5 mA</td>
<td>+5, GND</td>
<td>40 DIP</td>
<td>Auto-range, auto-zero, auto-polarity, 7-segment/BCD outputs, counter mode.</td>
</tr>
<tr>
<td>10 BIT D/A CONVERTOR</td>
<td>Ladderless D/A converter</td>
<td>AY-5-5053</td>
<td>SEE DATA SHEET</td>
<td>—</td>
<td>+5, GND, −12</td>
<td>24 DIP</td>
<td>employs stochastic techniques</td>
</tr>
<tr>
<td>A/D CONVERTOR</td>
<td>With AY-5-5053, performs A/D with transmitter facility</td>
<td>AY-5-5054</td>
<td>SEE DATA SHEET</td>
<td>—</td>
<td>+5, GND, −12</td>
<td>24 DIP</td>
<td>For use in remote sensing applications</td>
</tr>
</tbody>
</table>

MICROPROCESSORS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>PART NUMBER</th>
<th>INTERNAL REGISTER ADD</th>
<th>CLOCKS FREQUENCY/ MICROCYCLE</th>
<th>INTERFACE</th>
<th>POWER SUPPLIES</th>
<th>PACKAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 BIT</td>
<td>CP1600</td>
<td>3.6 µs</td>
<td>2/3.3 MHz/ 600 ns.</td>
<td>TTL</td>
<td>+12, +5, GND</td>
<td>40 DIP</td>
</tr>
<tr>
<td></td>
<td>*CP1600A</td>
<td>2.4 µs</td>
<td>2/5 MHz/ 400 ns.</td>
<td>TTL</td>
<td>+5, GND</td>
<td>40 DIP</td>
</tr>
<tr>
<td>8 BIT</td>
<td>PIC1640</td>
<td>1 µs</td>
<td>1/4 MHz/1/µs</td>
<td>TTL</td>
<td>+5, GND</td>
<td>40 DIP</td>
</tr>
<tr>
<td></td>
<td>PIC1650</td>
<td>5.5 µs</td>
<td>1/720 kHz/694 ns.</td>
<td>TTL or high level (open drain)</td>
<td>+5, GND, −12</td>
<td>40 DIP</td>
</tr>
<tr>
<td>INPUT/OUTPUT BUFFER</td>
<td>IOB1680</td>
<td>—</td>
<td>—</td>
<td>TTL</td>
<td>+5, +12, GND</td>
<td>40 DIP</td>
</tr>
<tr>
<td>DUAL D/A CONVERTER</td>
<td>DAC1600</td>
<td>—</td>
<td>—</td>
<td>TTL</td>
<td>+5, +12, GND</td>
<td>40 DIP</td>
</tr>
</tbody>
</table>

**NEW**

General Instrume nt offers a "total product family" approach to microprocessor circuits including the circuits described here plus a full complement of semiconductor circuits. PC modules, prototype development hardware, extensive software support and comprehensive documentation.

RANDOM ACCESS MEMORIES

<table>
<thead>
<tr>
<th>BITS/ MODE</th>
<th>MEMORY ORGANIZATION</th>
<th>PART NUMBER</th>
<th>REPLACES (PIN-FOR-PIN)</th>
<th>ACCESS TIME/ CYCLE TIME</th>
<th>POWER SUPPLIES</th>
<th>PACKAGE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1024/ STATIC</td>
<td>256 x 4</td>
<td>RA-3-4256A</td>
<td>—</td>
<td>500ns/500 ns.</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td>Power down mode</td>
</tr>
<tr>
<td>RA-3-4256B</td>
<td>—</td>
<td>RA-3-4256A</td>
<td>—</td>
<td>650ns/650 ns.</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td>Power down mode</td>
</tr>
<tr>
<td>RA-3-4256C</td>
<td>—</td>
<td>RA-3-4256B</td>
<td>—</td>
<td>650ns/650 ns.</td>
<td>+5, GND</td>
<td>22 DIP</td>
<td>Differential outputs</td>
</tr>
<tr>
<td>4096/ STATIC</td>
<td>4096 x 1</td>
<td>RA-3-4200</td>
<td>SEMI 4200</td>
<td>215ns/400 ns.</td>
<td>+12, +5, GND, −5</td>
<td>22 DIP</td>
<td>TTL output</td>
</tr>
<tr>
<td>RA-3-4402</td>
<td>SEMI 4402</td>
<td>RA-3-4200</td>
<td>SEMI 4200</td>
<td>200ns/350 ns.</td>
<td>+12, GND, −5</td>
<td>22 DIP</td>
<td>Differential outputs</td>
</tr>
</tbody>
</table>

*For future release.*
## Electrically Alterable Read Only Memories

<table>
<thead>
<tr>
<th>Bits</th>
<th>Organization</th>
<th>Part Number</th>
<th>READ Access Time</th>
<th>Erase Time</th>
<th>Write Time</th>
<th>Power Supplies</th>
<th>Package</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>512</td>
<td>32 x 16</td>
<td>ER2050</td>
<td>4µs</td>
<td>100ms</td>
<td>100ms/16 Bit Word</td>
<td>+5, -29</td>
<td>28 DIP</td>
<td></td>
</tr>
<tr>
<td>1024</td>
<td>256 x 4</td>
<td>ER1105</td>
<td>2µs</td>
<td>100ms</td>
<td>10ms/4 Bit Word</td>
<td>+12, -12</td>
<td>24 DIP</td>
<td></td>
</tr>
<tr>
<td>1400</td>
<td>100 x 14</td>
<td>ER1400</td>
<td>3.4 µs</td>
<td>20 ms</td>
<td>20ms/14 Bit Word</td>
<td>-35</td>
<td>8 TO</td>
<td></td>
</tr>
<tr>
<td>4096</td>
<td>1024 x 4</td>
<td>ER2401</td>
<td>2µs</td>
<td>100ms</td>
<td>10ms/4 Bit Word</td>
<td>-5, -14, -24</td>
<td>24 DIP</td>
<td></td>
</tr>
<tr>
<td>8192</td>
<td>2048 x 4</td>
<td>ER2800</td>
<td>2µs</td>
<td>100ms</td>
<td>20ms/4 Bit Word</td>
<td>-5, -14, -24</td>
<td>24 DIP</td>
<td></td>
</tr>
</tbody>
</table>

### Description
- For future release.

## Read Only Memories

<table>
<thead>
<tr>
<th>Description</th>
<th>Bits</th>
<th>Organization</th>
<th>Part Number</th>
<th>Replaces (Pin-For-Pin)</th>
<th>Access Time</th>
<th>Clocks/ Voltage</th>
<th>Power Supplies</th>
<th>Package</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Purpose</td>
<td>1024</td>
<td>256 x 4</td>
<td>RO-7-1024/4</td>
<td>—</td>
<td>1µs (typ.)</td>
<td>STATIC</td>
<td>+5, GND, -12</td>
<td>16 DIP</td>
<td>RO-6 versions avail. for -55° to +125°</td>
</tr>
<tr>
<td></td>
<td>128 x 8</td>
<td>RO-7-1024/8</td>
<td>—</td>
<td>1µs (typ.)</td>
<td>STATIC</td>
<td>+5, GND, -12</td>
<td>24 DIP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>512 x 4</td>
<td>RO-7-2048/4</td>
<td>—</td>
<td>1.5µs (typ.)</td>
<td>STATIC</td>
<td>+5, GND, -12</td>
<td>24 DIP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>256 x 8</td>
<td>RO-7-2048/8</td>
<td>—</td>
<td>1.5µs (typ.)</td>
<td>STATIC</td>
<td>+5, GND, -12</td>
<td>24 DIP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2560</td>
<td>512 x 5</td>
<td>RO-3-2560</td>
<td>—</td>
<td>450 ns.</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>18 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4096</td>
<td>512 x 8</td>
<td>RO-3-4096</td>
<td>—</td>
<td>500 ns.</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>22 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5120</td>
<td>512 x 10</td>
<td>RO-3-5120</td>
<td>EA4000</td>
<td>500 ns.</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8192</td>
<td>2048 x 4</td>
<td>RO-5-8192</td>
<td>AMI58665 TLM54000</td>
<td>1.2µs (typ.)</td>
<td>2/TTL</td>
<td>+5, -12</td>
<td>24 DIP</td>
<td></td>
</tr>
<tr>
<td>New</td>
<td>16384</td>
<td>4096 x 4</td>
<td>RO-3-16384</td>
<td>AMI58999</td>
<td>1µs</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2048 x 6</td>
<td>RO-3-8316A</td>
<td>AMI5831A</td>
<td>850 ns.</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RO-3-8316B</td>
<td>AMI5831B</td>
<td>450 ns.</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RO-3-9316A</td>
<td>AMI58316E</td>
<td>850 ns.</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>RO-3-9316B</td>
<td>AMI58316F</td>
<td>450 ns.</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>32766</td>
<td>4096-8</td>
<td>RO-3-9332</td>
<td>850 ns.</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>24 DIP</td>
</tr>
</tbody>
</table>

### Note
- All Read Only Memories are mask-programmable

## Keyboard Encoders / Character Generators

<table>
<thead>
<tr>
<th>Description</th>
<th>Bits</th>
<th>Organization</th>
<th>Part Number</th>
<th>Replaces (Pin-For-Pin)</th>
<th>Access Time</th>
<th>Clocks/ Voltage</th>
<th>Power Supplies</th>
<th>Package</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keyboard Encoder</td>
<td>2376</td>
<td>88 x 3 x 9</td>
<td>AY-5-2376</td>
<td>SMC KR2376</td>
<td>10-100 KHz Scan Rate</td>
<td>1/TTL or INT. OSC</td>
<td>+5, GND, -12</td>
<td>40 DIP</td>
<td>2 key rollover. 88 keys, 3 modes</td>
</tr>
<tr>
<td></td>
<td>3600</td>
<td>90 x 4 x 10</td>
<td>AY-5-3600</td>
<td>SMC KR3600</td>
<td>10-100 KHz Scan Rate</td>
<td>1/TTL or INT. OSC</td>
<td>+5, GND, -12</td>
<td>40 DIP</td>
<td>2/N key rollover. 90 keys, 4 modes</td>
</tr>
<tr>
<td>Character Generator</td>
<td>2240</td>
<td>64 x 5 x 7</td>
<td>RO-5-2240S</td>
<td>MK2302 FSC1257</td>
<td>1µs (typ.)</td>
<td>1/TTL for Scanning</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td>5-7 char. col. out. on-chip scanning</td>
</tr>
<tr>
<td></td>
<td>2560</td>
<td>64 x 8 x 5</td>
<td>RO-3-2513</td>
<td>SIG2513</td>
<td>450 ns.</td>
<td>STATIC</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td>5 x 7 characters, row output</td>
</tr>
<tr>
<td></td>
<td>5184</td>
<td>64 x 9 x 9</td>
<td>RO-5-5184</td>
<td>—</td>
<td>5µs (typ.)</td>
<td>1/TTL for Scanning</td>
<td>+5, GND</td>
<td>24 DIP</td>
<td>9-9 char. on-chip left/right scanning</td>
</tr>
</tbody>
</table>

### Note
- All Keyboard Encoders and Character Generators are mask-programmable

## Static Shift Registers

<table>
<thead>
<tr>
<th>Bits</th>
<th>Organization</th>
<th>8º to 7º Part No.</th>
<th>7º to 0º Part No.</th>
<th>Operating Freq. Range</th>
<th>Input/Output</th>
<th>Clocks/ Voltage</th>
<th>Power Supplies</th>
<th>Packages</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>VARIABLE</td>
<td>SS-5-1032</td>
<td>SS-6-1032</td>
<td>DC-1 MHz</td>
<td>TTL</td>
<td>1/TTL</td>
<td>+5, GND, -12</td>
<td>16 DIP</td>
<td>6 S/R's arranged 1-1-2-4-8-16</td>
</tr>
<tr>
<td></td>
<td>DUAL 16</td>
<td>SS-5-1211</td>
<td>SS-6-1211</td>
<td>DC-2 MHz</td>
<td>TTL</td>
<td>1/TTL</td>
<td>+5, GND, -12</td>
<td>16 DIP</td>
<td>Set control dual input selector</td>
</tr>
<tr>
<td>64</td>
<td>QUAD 16</td>
<td>SS-5-1211</td>
<td>SS-6-1212</td>
<td>DC-2 MHz</td>
<td>TTL</td>
<td>1/TTL</td>
<td>+5, GND, -12</td>
<td>8/14 DIP, BTO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DUAL 50</td>
<td>SS-5-2050</td>
<td>SS-6-2050</td>
<td>DC-1 MHz</td>
<td>TTL</td>
<td>1/TTL</td>
<td>+5, GND, -12</td>
<td>14 DIP</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>QUAD 25</td>
<td>SS-5-4025</td>
<td>SS-6-4025</td>
<td>DC-1 MHz</td>
<td>TTL</td>
<td>1/TTL</td>
<td>+5, GND, -12</td>
<td>14 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DUAL 64</td>
<td>SS-5-2064</td>
<td>SS-6-2064</td>
<td>DC-1 MHz</td>
<td>TTL</td>
<td>1/TTL</td>
<td>+5, GND, -12</td>
<td>14 DIP</td>
<td></td>
</tr>
<tr>
<td>128</td>
<td>QUAD 32</td>
<td>SS-5-4032</td>
<td>SS-6-4032</td>
<td>DC-1 MHz</td>
<td>TTL</td>
<td>1/TTL</td>
<td>+5, GND, -12</td>
<td>14 DIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DUAL 100</td>
<td>SS-5-2100</td>
<td>—</td>
<td>DC-2 MHz</td>
<td>TTL</td>
<td>1/TTL</td>
<td>+5, GND, -12</td>
<td>14 DIP</td>
<td></td>
</tr>
<tr>
<td>256</td>
<td>DUAL 128</td>
<td>SS-5-2128</td>
<td>—</td>
<td>DC-2 MHz</td>
<td>TTL</td>
<td>1/TTL</td>
<td>+5, GND, -12</td>
<td>8/14 DIP, BTO</td>
<td></td>
</tr>
</tbody>
</table>

### Note
- All Keyboard Encoders and Character Generators are mask-programmable

* Available in Europe as part number SS-7-216 (16 lead plastic DIP only)
## CALCULATORS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
<th>PART NUMBER</th>
<th>PACKAGE FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8 DIGIT BASIC</strong></td>
<td>4 functions and percent key.</td>
<td>C-683</td>
<td>Accumulator and 4 key memory</td>
</tr>
<tr>
<td></td>
<td>4 functions, percent key, one-key or multi-key memory.</td>
<td>C-685</td>
<td>Accumulator and Grand Total Memories.</td>
</tr>
<tr>
<td><strong>8 DIGIT ALGEBRA</strong></td>
<td>4 functions, percent key, (x^2, \sqrt{x}, 1/x, +/-), one-key or multi-key memory, choice of 20 to 29 keys.</td>
<td>C-689</td>
<td>Accumulator, item counter, and four-key independent memory.</td>
</tr>
<tr>
<td><strong>9 DIGIT BASIC</strong></td>
<td>4 functions and percent key.</td>
<td>C-693</td>
<td>Snooze alarm, individual digit drive.</td>
</tr>
<tr>
<td></td>
<td>4 functions, percent key, one-key memory.</td>
<td>C-694</td>
<td>Snooze alarm, dupplexed digits.</td>
</tr>
<tr>
<td></td>
<td>4 functions, percent key, multi-key memory.</td>
<td>C-695</td>
<td>Snooze alarm, dupplexed digits, sleep-time, timeswitch, battery standby capability.</td>
</tr>
<tr>
<td><strong>9 DIGIT SCIENTIFIC</strong></td>
<td>Basic 4 functions, scientific notation, (\sin, \cos, \tan, \arcsin, \arccos, \arctan, ) memory, square root, pi, natural logs, (1/x, e^x, ) memory exchange, degrees and radians, exponent range (\pm 99), choice of 19 to 35 keys.</td>
<td>C-696</td>
<td>Operates directly from a 3.58 MHz crystal.</td>
</tr>
<tr>
<td>All the above plus: 0 to 10(^9) degree trig range, (\log_{10}, 10^x), extended digit accuracy of transcendental constants, choice of 21 to 38 keys.</td>
<td>C-697</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All the above plus: two levels of parenthesis, (x^2, %), +/-, choice of 24 to 41 keys.</td>
<td>C-698</td>
<td></td>
<td></td>
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</tbody>
</table>

The C-500/C-600 series are pin-for-pin compatible chips designed to fit in the same basic PC board. All have automatic constant in 4 functions, floating decimal, on-board oscillator, single power supply, and drive LED segments or fluorescent displays directly. All are in a 28 lead DIP.

## CLOCKS / CLOCK RADIOS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
<th>PART NUMBER</th>
<th>DISPLAY TYPE</th>
<th>FLASHING SECONDS</th>
<th>ZERO BLANKING</th>
<th>50/60 Hz OPERATION</th>
<th>PACKAGE FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4 DIGIT</strong></td>
<td>12/24 hour clock</td>
<td>AY-5-1200A</td>
<td>7-SEGMENT FLUORESCENT</td>
<td>✓</td>
<td>✓</td>
<td>4 DIP</td>
<td>Direct fluorescent display drive.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AY-5-1202A</td>
<td>7-SEGMENT FLUORESCENT</td>
<td>✓</td>
<td>✓</td>
<td>4 DIP</td>
<td>Direct fluorescent display drive.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AY-5-1203A</td>
<td>BCD OUTPUTS</td>
<td>✓</td>
<td>✓</td>
<td>4 DIP</td>
<td>See AY-5-8320 TV circuit.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AY-5-1204A</td>
<td>7-SEGMENT FLUORESCENT</td>
<td>✓</td>
<td>✓</td>
<td>4 DIP</td>
<td>Direct fluorescent display drive.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AY-5-1224A</td>
<td>BCD OR 7-SEGMENT LED</td>
<td>✓</td>
<td>✓</td>
<td>16 DIP</td>
<td>Zero blanking in 12 hour mode only.</td>
</tr>
<tr>
<td><strong>4 DIGIT WITH ALARM AND DIRECT DISPLAY DRIVE</strong></td>
<td>12 hour clock, 24 hour alarm</td>
<td>CK3000</td>
<td>7-SEGMENT PLASMA</td>
<td>✓</td>
<td>✓</td>
<td>40 DIP</td>
<td>Snooze alarm, individual digit drive.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CK3100</td>
<td>7-SEGMENT LED</td>
<td>✓</td>
<td>✓</td>
<td>40 DIP</td>
<td>Snooze alarm, individual digit drive.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CK3200</td>
<td>7-SEGMENT PLASMA</td>
<td>✓</td>
<td>✓</td>
<td>28 DIP</td>
<td>Snooze alarm, dupplexed digits.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CK3400</td>
<td>7-SEGMENT LED</td>
<td>✓</td>
<td>✓</td>
<td>28 DIP</td>
<td>Snooze alarm, dupplexed digits.</td>
</tr>
<tr>
<td><strong>4 DIGIT AUTOMOBILE CLOCK</strong></td>
<td>12 hour clock</td>
<td>CK3300</td>
<td>7-SEGMENT LED</td>
<td>✓</td>
<td>✓</td>
<td>28 DIP</td>
<td>Snooze alarm, dupplexed digits, sleep-time, timeswitch, battery standby capability.</td>
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</tbody>
</table>

*For future release.*

## CALCULATOR / CLOCK MODULES

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION (SEE ABOVE)</th>
<th>PART NUMBER</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8 DIGIT CALCULATOR</strong></td>
<td>Same as C-683D</td>
<td>M-683</td>
<td>Self-contained module which requires only the addition of a keyboard and battery to produce a working calculator.</td>
</tr>
<tr>
<td></td>
<td>Same as C-685D</td>
<td>M-685</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Same as C-689D</td>
<td>M-689</td>
<td></td>
</tr>
<tr>
<td><strong>4 DIGIT CLOCK RADIO</strong></td>
<td>Same as CK3300</td>
<td>M-3300</td>
<td>Self-contained module which requires only the addition of switches and a power source to produce a working clock.</td>
</tr>
</tbody>
</table>
## RADIO / TELEVISION

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
<th>PART NUMBER</th>
<th>POWER SUPPLIES</th>
<th>PACKAGE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV RECEIVER FREQUENCY COUNTER/DISPLAY</td>
<td>Counts &amp; displays MW, SW, and VHF frequencies</td>
<td>AY-5-8100</td>
<td>GND, -17</td>
<td>28 DIP</td>
<td>4½ digit display; MW 2999 KHz, SW 29.995 MHz, VHF 299.95 MHz, 0 to 99 FM channel indication (European standard), 7-segment outputs.</td>
</tr>
<tr>
<td>TV RECEIVER FREQUENCY COUNTER/DISPLAY WITH 4 DIGIT CLOCK</td>
<td>Counts &amp; displays AM/FM frequencies with a 12 hour clock</td>
<td>AY-3-8110</td>
<td>+5 to +12, GND</td>
<td>28 DIP</td>
<td>Easy time set controls, low power consumption, on-chip intensity control.</td>
</tr>
<tr>
<td>TV CHANNEL/TIME DISPLAY SERIES</td>
<td>Various circuits in series to display channel numbers on TV screen with some additional features to display time.</td>
<td>AY-5-8300 SERIES</td>
<td>+18, GND</td>
<td>14 DIP or 24 DIP</td>
<td>Selection of display position on screen, automatic display recall, BCD time inputs (see AY-5-1203A clock circuit).</td>
</tr>
<tr>
<td>TV REMOTE CONTROL</td>
<td>Transmitter</td>
<td>SAA 1024</td>
<td>9V BATTERY</td>
<td>16 DIP</td>
<td>Power on/off output, 16 TV channel selection (5 spares), 3 analog outputs.</td>
</tr>
<tr>
<td>TV REMOTE CONTROL</td>
<td>Receiver</td>
<td>SAA 1025</td>
<td>SEE DATA SHEET</td>
<td>16 DIP</td>
<td></td>
</tr>
<tr>
<td>TV REMOTE CONTROL</td>
<td>Transmitter</td>
<td>*AY-5-8410</td>
<td>GND, -15</td>
<td>—</td>
<td>23 channels, either local control at receiver or remote control.</td>
</tr>
<tr>
<td>TV REMOTE CONTROL</td>
<td>Receiver</td>
<td>*AY-5-8411</td>
<td>9V BATTERY</td>
<td>—</td>
<td>63 channels with error-detection.</td>
</tr>
<tr>
<td>TV REMOVE CONTROL</td>
<td>Transmitter</td>
<td>*AY-5-8450</td>
<td>9V BATTERY</td>
<td>16 DIP</td>
<td>18 ultrasonic control frequencies, interfaces directly with a 5-6 matrix keyboard.</td>
</tr>
<tr>
<td>TV REMOVE CONTROL</td>
<td>Receiver</td>
<td>*AY-5-8460</td>
<td>GND, -18</td>
<td>18 DIP 24 DIP</td>
<td>Interfaces directly with OMEGA 10 digit keyboard inputs plus 1 analog control, fine tune up/down, and recall function.</td>
</tr>
<tr>
<td>2 CHIP TV DIGITAL TUNING SYSTEM</td>
<td>2-8-2000 control circuit: accepts direct or remote inputs to control and program system.</td>
<td>ECONOMEGA</td>
<td>+12, GND</td>
<td>40 DIP</td>
<td>16 programs, 14 bit accuracy with coarse and fine tune.</td>
</tr>
<tr>
<td>2 CHIP TV DIGITAL TUNING SYSTEM</td>
<td>Memory circuit: see ER1400 description on Pg. 6.</td>
<td></td>
<td>+12, -24</td>
<td>8TO</td>
<td>100-14 bit memory</td>
</tr>
<tr>
<td>4 OR 5 CHIP TV DIGITAL TUNING SYSTEM</td>
<td>Control circuit: accepts keyboard or remote inputs to control and program system.</td>
<td>OMEGA®</td>
<td>+12, GND</td>
<td>40 DIP</td>
<td>Scan mode or search mode may also be selected.</td>
</tr>
<tr>
<td>4 OR 5 CHIP TV DIGITAL TUNING SYSTEM</td>
<td>Display circuit: displays selected channel number.</td>
<td></td>
<td>+12, GND</td>
<td>40 DIP</td>
<td>Decodes and drives BCD or LED displays.</td>
</tr>
<tr>
<td>4 OR 5 CHIP TV DIGITAL TUNING SYSTEM</td>
<td>D/A convertor circuit: converts output to coarse and fine tunable outputs.</td>
<td></td>
<td>+12, GND</td>
<td>40 DIP</td>
<td>14 bit accuracy for precise varactor tuning.</td>
</tr>
<tr>
<td>4 OR 5 CHIP TV DIGITAL TUNING SYSTEM</td>
<td>Memory circuit: see ER1400 description on Pg. 6.</td>
<td></td>
<td>+12, -24</td>
<td>8TO</td>
<td>100-14 bit memory</td>
</tr>
<tr>
<td>4 OR 5 CHIP TV DIGITAL TUNING SYSTEM</td>
<td>Optional channel selector interface circuit permits preset favorite channel selection.</td>
<td></td>
<td>+12, GND, -24</td>
<td>40 DIP</td>
<td>Up to 20 channels; pre-set and/or customer selection.</td>
</tr>
</tbody>
</table>

*For future release.

**OMEGA and ECONOMEGA are trademarks of General Instrument Corporation.**

## TV GAMES

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
<th>PART NUMBER</th>
<th>POWER SUPPLIES</th>
<th>PACKAGE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>BALL &amp; PADDLE I</td>
<td>Add-on for TV sets, 6 games tennis, squash, hockey (soccer), pelota, rifle shooting 1 &amp; 2</td>
<td>AY-3-8500</td>
<td>9V BATTERY</td>
<td>28 DIP</td>
<td>4 two-person and 2 one-person games. Automatic scoring (displayed on TV screen), realistic sounds, visually defined playing area, 525 and 625 line standards.</td>
</tr>
<tr>
<td>BALL &amp; PADDLE II</td>
<td>Add-on for TV sets, 5 advanced games of tennis, squash, soccer, hockey and practice</td>
<td>AY-3-8500-1</td>
<td>—</td>
<td>40 DIP</td>
<td>2 or 4 player, on-screen scoring, color or black &amp; white, 2-axis player motion.</td>
</tr>
<tr>
<td>BATTLE</td>
<td>Add-on for TV sets, 2 games: tank fight, tank battle with strategy</td>
<td>AY-3-8710</td>
<td>9V BATTERY</td>
<td>40 DIP</td>
<td>2 player tank battle games with limited ammunition and destructible barriers, on-screen scoring and realistic battle sounds.</td>
</tr>
<tr>
<td>PROGRAMMABLE GAMES</td>
<td>Add-on for TV sets, multiple games to be announced</td>
<td>AY-3-8800 SERIES</td>
<td>+12, -5, GND, -3</td>
<td>40 DIP</td>
<td>Single person and 2 person interactive games using programmable microcomputer.</td>
</tr>
</tbody>
</table>

*For future release.

## APPLIANCE TIMERS

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>FUNCTION</th>
<th>PART NUMBER</th>
<th>POWER SUPPLIES</th>
<th>PACKAGE</th>
<th>FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLOCK TIMER</td>
<td>24 hour programmable repeatable on/off time switch with 24 hour clock</td>
<td>AY-5-1230</td>
<td>GND, -17</td>
<td>28 DIP</td>
<td>50 Hz input (60 Hz option on request), BCD or 7-segment direct fluorescent display drive outputs, zero blanking, 24 hour display (12 hour option on request).</td>
</tr>
<tr>
<td>COUNT-DOWN TIMER</td>
<td>Keyboard programmable count-down timer with 99 min/99 sec capability</td>
<td>*CT 7000</td>
<td>GND, -15</td>
<td>40 DIP</td>
<td>60 Hz input, drives 4 digit display, end-of-count audio output.</td>
</tr>
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Circle 50 on reader service card

Electronics/September 2, 1976
Bill would protect engineers from wage-busting tactics that most commonly affect those working for large contractors at Huntsville, Cape Kennedy, and similar places. The measure, HR 15228, was drafted by the IEEE and introduced by Frank Thompson (D., N.J.) and James Corman (D., Calif.) as an amendment to the Service Contract Act of 1965. It has been referred to committee.

The bill is aimed at situations where a company wins a contract by underbidding the company that holds it. When engineers and other professionals already on the project seek jobs with the new contractor, they are forced to accept pay or benefits cuts.

Grumman Aerospace Corp. in Bethpage, N.Y., is working on an all-weather attack version of its basic F-14 Tomcat air-superiority fighter, called the A-14. If procured by the U.S. Navy, the new craft would replace aging A-6 aircraft in the fleet inventory. Approximately $9 million worth of electronics goes into each F-14, so additions to the Tomcat production line in the form of A-14s would create a windfall for subcontractors.

United Technologies' Norden division in Norwalk, Conn., has, under contract to Grumman, developed a flyable brassboard of a synthetic-aperture radar to be flown on the F-14 to prove an attack capability. The experimental radar is expected to increase the stand-off distance and accuracy of radar-guided weapons systems employed on the F-14.

While America's television manufacturers await resolution of a jurisdictional dispute over which Federal agency gets to hear charges of dumping against Japanese color-television manufacturers [Electronics, July 22, p. 42], new figures attest to the scope of the foreign inroads into the U.S. market. Electronics Industries Association computations show that imports of color receivers in the first half of the year skyrocketed 151% higher than a year earlier.

The last 18 months have seen a 50% drop in the average price of photovoltaic cells intended for use as sources of electrical current in rural areas. That's the report of officials at the Energy Research and Administration Development, elated over a fall to $15 per watt from $30 or more. The lower figures are quoted in bids responding to a recent 130-kilowatt procurement request; the higher came in an earlier 46-kW purchase. ERDA will soon announce that it has signed contracts worth $2.3 million.

The biggest winner is Spectrolab Inc., with a $718,000 contract for 40 kW. ERDA will pay less to Sensor Technology of Chatsworth, Calif.—$512,000 for 40 kW—because the Sensor cells are more efficient and therefore can produce more electricity with less surface area. Other winners: 30 kW from Solarex Corp., Rockville, Md., $519,000; 15 kW from Solar Power Corp., Wakefield, Mass., $349,000; and 5 kW from M4 International Inc., Arlington Heights, Ill., $139,000.

The success of the silicon solar-cell program has led ERDA to gear up its next effort—improving the efficiency of advanced compounds in other technologies that can generate electricity directly from the sun. Next year,
ERDA will release requests for proposals for three cadmium-sulfide projects and seven other projects to improve solar-array concepts. And ERDA's Sandia Laboratory in Albuquerque, N.M., soon will release requests for proposals for photocell systems using optical concentrators to increase the intensity of ultraviolet sunlight [Electronics, Aug. 19, p. 69].

Two Government agencies have agreed to review the proposal of an electronics-company executive to organize a "science court" that would take debates over nuclear power and environmental quality away from lawyers and nontechnical judges. Arthur Kantrowitz, chairman of the Avco-Everett Research Laboratory, persuaded the National Science Foundation and the Commerce Department to consider the proposal at a debate scheduled Sept. 19 to 21.

The Federal Communications Commission will not drop a request for an evidentiary hearing, as requested by Satellite Business Systems to hasten review of its domestic-satellite system proposal. The proposed system, which would pit SBS' partner, IBM Corp., against AT&T, Western Union, and RCA, includes use of small dish antennas for point-to-point communications and would have the system bypass local telephone companies. SBS is worried that a prolonged FCC review—which could take four more years—would give its competitors additional time to become entrenched in the embryonic field.

The off-again, on-again, procurement of 41 patrol planes for the U.S. Coast Guard is on again, and it is expected to result in at least a $200 million contract to one of five bidders. Falcon Jet, Grumman, Lockheed, Rockwell, and VFW Fokker submitted acceptable bids, says the Coast Guard, which is promising a decision by the end of the year. More than $20 million worth of special sensor hardware also will be purchased. An earlier procurement was challenged in Congress because competitors claimed that the specifications favored the Rockwell plane.

The Air Force Systems Command has given General Electric a contract to develop a production capability for a militarized version of its 4-kilobit static MOS random-access memory, for use in a new aircraft cockpit display. The new hardware would replace the 1-kilobit static RAM used in the virtual-image display being flight-tested on the F-111 and F-4. Delivery of prototype hardware is expected by January 1978.

NASA, anxious to add to the list of hundreds of innovations that have been transferred from the space program to private industry, has scheduled a conference on biomedical instrumentation. It will be held at the University of Connecticut in Storrs on September 21... A Commerce Department study of the effect of increased telephone installation charges on requests for new installations and disconnections shows, not surprisingly, that those requests decrease.
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Five tough questions to ask our 8080A competitors.

1. Do you have an 8K Electrically Erasable PROM? You know, like NEC Microcomputer's μPD458 that's compatible with 2708's but can be erased in 1 minute, programmed in 80 seconds, only needs two voltages for reading and programming, has conventional packaging, a guaranteed data retention time of 10 years, and an access time of 450/650ns, making it the first practical non-volatile RAM storage.

2. Do you have a Universal Synchronous Receiver/Transmitter Data Communications Controller? You know, like NEC's μPD379 with SDLC capacity up to 50K baud.

3. Do you have a 450ns 16K ROM? You know, like NEC's μPD2316A that's pin compatible with other 2316As but has the speed to match the 8080A.

4. Do you have a Floppy Disk Controller? You know, like NEC's μPD372 that can control up to four IBM 3740-compatible drives.

5. Do you have a Tape Cassette Controller? You know, like NEC's μPD371 that can control up to two cassette drives with International Standard Data Format.

Go ahead, ask any competitor you like. What you'll find is that if you want these super 8080A peripherals, you'll simply have to come to NEC.

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NEC Microcomputers, Inc., Five Militia Drive, Lexington, MA 02173. 617-862-6410.
There's a saying in Italy, where we come from, that goes something like this: "between saying and doing there's a sea in the middle". OK, may be it doesn't sound too great in English, but in Italian it does and it rhymes as well!

Now, the particular "sea" in our case is just this: TDA 2002 was invented and patented by SGS-ATES; we were the first to produce it and we're already delivering it - in fact, we've been mass-producing the TDA 2002 since the beginning of 1976. Now we hear that somebody else is going to launch a similar product on the market... in 1977. That's good, but for the moment let's talk about

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Typical application circuit.
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Electronics / September 2, 1976
Toshiba scores first in Japan with 8-bit microcomputer chip

Toshiba scored points against its Japanese semiconductor-maker competitors last month when it went to market with the country's first 8-bit microcomputer on a chip. Although the chip—the T3444—will turn up first in controllers for data-processing hardware like floppy disks, data cassettes, and intelligent terminals, Toshiba foresees a wide spread of applications.

The price for the chip in quantity is a low $24, so Toshiba expects to sell it to producers of hardware like data loggers, heating controls, microwave cookers, and even video games, as well as to makers of data-processing equipment.

For their money, buyers will get in a 42-pin ceramic package a chip with an arithmetic/logic unit, a random-access memory, a read-only memory, and input/output ports. The ROM, mask-programed for each specific application, can hold up to 256 24-bit words. The RAM capacity is a modest 16 words by 8 bits. The clock and transistor-transistor-logic I/O drivers are not on the chip. Although the T3444 has less capability than the Intel 8080A, it is much faster.

Long instructions. Modest, too, at first glance, is the ALU's set of 14 instructions, far fewer than the 50 or more instructions used in popular 8-bit general-purpose microprocessor chips. But this drawback is offset by high speed; clock cycles as fast as 1.25 microseconds are possible because of its n-channel silicon-gate-MOS technology with enhancement driver and depletion load.

What's more, the 24-bit instruction words in the microprogram increase the apparent speed because execution of the first instruction in the ROM is followed by branching to execute the instruction in the register. In effect, the equivalent of two instructions is executed during one clock cycle.

The instructions, designed for efficient processing, include a cyclic code. As a controller, the T3444, operating at a maximum clock rate of 800 kilohertz, can control a floppy disk with data speeds up to 800 kilobits per second.

Microprogramming. To make microprogramming and system debugging easier for T3444 users, Toshiba has developed a simulation board built with some 120 TTL packages (the chip is completely TTL-compatible), including two 4-bit-slice ALUs from Texas Instruments. There are enough sockets for field-programmable ROMs so that designers can try out alternative microprograms. The TTL packages on the board duplicate the chip functions internally as well as externally. For that reason, Toshiba has included on the board a 42-pin socket with the logic levels of the chip. As with the chip itself, the board has neither a clock nor the four TTL I/O drivers that have to be outboarded.

Around the world

British associative processor to work with disks

A design group at Brunel University in Uxbridge, Middlesex, England, has designed an associative processor around an array of large-scale-integrated memory and supporting LSI transistor-transistor control logic. The processor combines the potential cheapness of LSI with the speed of associative processing to yield a flexible terminal base for text processing.

The so-called Micro-App, patented by the government's National Research Development Corp., could be used in local editing terminals for such applications as quick retrieval of documentary information stored in disk files. Only dedicated associative memories like the Micro-App could load and unload information at disk speeds. Even with buffering, general-purpose microprocessors can't handle the common transmission rate of 5.5 microseconds per byte.

Brunel has designed two Micro-App memories, one a 16-word-by-16-bit version on a chip of 169 by 118 mils. That version has minimum read-cycle and write-cycle times of 40 and 120 nanoseconds, respectively, and power dissipation is 307 milliwatts. Estimated cost after development is about $1 each in quantity.

Hitachi simplifies video-disk laser pickup

The Hitachi Central Research Laboratory has miniaturized and simplified the laser pickup for an experimental video-disk system developed by Philips of the Netherlands. Hitachi claims its experimental pickup, which is only a twentieth as large and requires only a fraction of the power, is interchangeable with the Philips assembly for disks built to the same specifications. Instead of employing the usual helium-neon-gas laser, Hitachi turned to a buried-heterojunction injection laser. The pickup, together with its mount, occupies a cube only about 1 centimeter on a side; in contrast, typical low-power gas lasers, which also require large high-voltage power supplies, are about 25 cm on a side.

Simplicity is achieved by transmitting a single beam through mirrors and lenses for automatic focusing, tracking, and video-signal pickup with the aid of servo motors. Experimental laser pickups developed by Philips put out about 1 milliwatt—twice as much as the Hitachi product. The buried heterojunction laser has an active region about 1 micrometer square. This tiny radiant area simplifies focusing the beam as a spot 1.6 µm in diameter on the video disk and reduces the input current required to achieve lasing. In the experimental unit, the laser provides the 0.5-mW output with an input current of only 10 milliamperes.
Tiny jumpers and connector versatility.

Your imagination is the key to the range of uses you can find for Cambion connector products. Take the tiny jumpers that mate with spring-loaded receptacles. These are being used extensively as low-cost, trouble free circuit switches because engineers recognize the advantages they provide. And, they got a bonus in terms of long-life—the jumper switches have been tested for more than 50,000 cycles (insertions/extractions).

Color coding and positive position indication are two more features of this one product group that demonstrate connector versatility. And that's only a part of the Cambion connector line.

To become better connected, ask for the Cambion connector catalog by writing: Cambridge Thermionic Corporation, 445 Concord Avenue, Cambridge, Ma. 02138. In Los Angeles, 8703 La Tijera Blvd., 90045.

Send for newest catalog 747A
Electronic gear controls cleansing of Amsterdam water

Amsterdam, which has always lacked enough clean ground water, is turning to electronic equipment to control purification of water from the highly polluted Rhine River for drinking. A new purification and supply system, which can handle Amsterdam’s drinking water demand for some 90 million cubic meters a year, is being officially opened Sept. 2 by Prince Claus, a member of the Dutch royal family. In the system, nearly $3 million worth of electronic gear from Philips Gloeilampenfabrieken continuously monitors and measures water quality during filtration. Several Philips P800 minicomputer systems scan hundreds of measuring points, perform the necessary calculations, and determine any alarm conditions.

U. S. Navy tests British display for aircraft pilots

A helmet-mounted head-up symbolic display for aircraft pilots has been delivered by Marconi-Elliott Avionic Systems Ltd. to the U.S. Navy for testing, and the company says other military services are also considering it. Symbols are generated for the pilot by a tiny matrix of light-emitting diodes mounted inside a standard flying helmet with a modified sighting visor. He views the symbols either through the visor or an eyepiece. The helmet also contains a prismatic optical system, energizing electronics, and an umbilical cord that connects the array to data and power sources in the cockpit.

The low-power LED matrix, made by GEC Hirst Research Centre, is claimed to be the first that is bright enough and has enough resolution for helmet displays. Consisting of 20 by 23 LED elements on a 0.3-millimeter pitch, it puts out 10,000 foot-lamberts.

Stereo attachment measures profiles of semiconductors

The tiny dimensions of semiconductor chips can be measured precisely by an experimental stereoscopic attachment for scanning electron microscopes. The device, developed at the Hitachi Central Research Laboratory, enables a Hitachi electron microscope to provide a vertical resolution of 300 angstroms, along with the microscope’s horizontal resolution of 30 angstroms—adequate for measuring the thicknesses of metal patterns, field oxide, and most other vertical deposits on semiconductors except the thin gate oxide.

The three-dimensional effect is achieved by making two black-and-white images of the chip, differing about 10° in rotation about a single axis, and by storing the two in memory tubes. These images are reproduced alternately at a field rate on a television monitor. Two optically active crystal shutters, synchronized with the field rate, alternately open and close to show different images to the left and right eyes.

French firm aims at U. S. market for fiber optics

A French fiber-optics company hopes to enter the United States market later this year to cash in on the growing demand for optical communications systems, optoelectronic proximity detectors, and endoscopes. The Fort Group of Paris, which has already sold endoscopes to three North American airlines to inspect the interiors of jet engines, is looking for an American distributor or licensee. The company manufactures fiber-optic systems, as well as the fibers. It makes more than 2,000 types of endoscopes and controls more than 90% of the French endoscope market.
SAW oscillators become synthesizers for mobile radios

Problems with temperature and reliability that have prevented surface-acoustic-wave (SAW) oscillators from penetrating the market for hand-held and mobile radiotelephones apparently have been solved by Edinburgh University’s department of electrical engineering. The group employs phase-control techniques on delay-stabilized SAW oscillators so that the more rugged modules consume less power than conventional crystal oscillators that use frequency multiplication.

The basic module, consisting of a SAW delay line, an electrically variable phase-shift circuit, and a feedback amplifier, produces a stable oscillation at a single frequency that can be modulated to obtain a desired frequency. By adding digital dividers to the modules, the group can synthesize many frequencies for multichannel operation at very-high and ultrahigh frequencies. Because the basic module can be added to a conventional reference oscillator, the group predicts a large retrofit market. The project, funded by the British Science Research Council and Hewlett-Packard Ltd., is being closely watched by British manufacturers.

Germans install independent net to fight crime

West German police are installing their own communications network to enhance cooperation between police precincts and intensify the fight against crime. The hierarchical network, which transmits both speech and video signals at voice frequencies, uses a Siemens automatic main exchange system at Wiesbaden, headquarters of West Germany’s Federal Criminal Offices. Subordinate exchange systems, located in the country’s various provinces, are supplied by other communications-equipment companies. Besides speech, the network transmits telephotos, fingerprints, and documents in support of crime evidence, as well as pictures of wanted criminals and the scenes of crimes.

Toshiba offers 1-k nonvolatile RAM at core price

A refinement of an earlier design has enabled Toshiba in Japan to offer a 1,024-bit nonvolatile static random-access memory with four times the capacity of one it introduced last year. The RAM, which can also be used as an electrically alterable read-only memory, is priced at $13. The price per bit is competitive with small magnetic-core memories used to prevent loss of memory contents during power failure because of the relatively high production volume of 20,000 units a month and a projected volume of twice as many next year.

Toshiba’s device is a conventional p-channel silicon-gate MOS RAM backed up by electrically alterable metal-nitride-oxide-semiconductor transistors in each cell. It can retain memory contents with the power off for a minimum of a year. The memory, arranged as 256 words by 4 bits, comes in an 18-pin ceramic package. Compatible with transistor-transistor logic, it has a maximum read-access time of 1,500 nanoseconds, typical read-access time of 800 ns, maximum power drain of 600 milliwatts, typical power drain of 400 mW, and maximum write-cycle time of 1,000 ns.

Addendum

Philips of the Netherlands plans to begin construction in December of a $50 million plant in Taiwan to make color-television picture tubes. The company is to supply $22 million. The plant will employ 800 people when construction is completed in two years near a Philips factory in Chupei that is already manufacturing parts for black-and-white TV sets.
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And TI's new low prices prove it.

**SR-56**
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An SR-52 is a better way.


If you have the time, you work them out. Or, you get in line for computer time, then wait. So, more often than you'd like to admit, you rely on your intuition. Make an educated guess. Or do some ball-park figuring.

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Because personal programmables help you cope with more data, explore with more insight, far more successfully than ever before. You make better decisions, chosen from more options—better decisions founded on a broader data base. More decisions. Faster. On the spot.

A card programmable that offers outstanding capability at an extremely attractive price. Without compromising quality.

TI's advanced technology and manufacturing know-how are the keys to the SR-52's exceptional value.

You can process data or perform complex calculations automatically. Load the card and put its contents into program memory. Key variables directly into the program— or into the 20 data memory registers (up to 60 in certain cases). Run a program as often as needed. Change values of variables as often as you desire.

Program memory and data registers in abundance. Data recording, too. The SR-52's 224-step program memory uses merged prefixes, so each step can hold two keystrokes. With this capability the SR-52 can handle programs you may have thought required a computer. Although the basic 20 data registers are usually more than adequate, you can use up to 40 additional registers. (28 in program memory, the 10 pending operations registers, and 2 more.) And you can record up to 28 data registers onto blank magnetic cards. Read them back in later.

Computer-like branching. The SR-52 offers seven types of unconditional branching. And 10 conditional branches each with three ways to address: absolute, label, or indirect. That's 37 different branch-

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Circle reader service number 200

At a new low price:

Circle reader service number 200 $299.95*

Due to the difficulty of photographing calculator readouts, displays represented in this brochure are simulated.
ing instructions. Five flags can be set, cleared, or tested from the keyboard or within a program. You also get 10 user-defined keys.

**Direct or indirect access to all data memories.** Store numbers directly in any memory register. Or, store a number in a data memory specified by any other register (indirect addressing). Add, subtract, multiply, divide directly within all registers. Exchange display with memory.

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**Basic Library of 22 programs included.** Put them to work right away: math, statistics, finance, electrical engineering, and others. You also get a 96-page Basic Library manual. Each prerecorded program card is supported with sample problems, user instructions and program listings.

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**Develop, write and record your own programs.** Programming is just logical thinking. You can do it. Using the programming manual with the handy coding form and user instruction tablet, you’ll be writing programs in just a few hours. More than likely you won’t be able to write optimum programs straight-off. Programs which run the fastest and use the fewest steps. However, you can begin writing programs that work. Press LRN to store each keystroke. Press it again and the SR-52 has learned your program. It’s ready to RUN. Record your program on a blank magnetic card, and make it part of your personal library to use again and again. As your programming knowledge develops, you’ll discover how this skill magnifies your professional capability. Better decisions will be as near as your SR-52.

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**Share programs with your colleagues through PPX-52.**

There may be times when you need a complex specialty program. But you’d like the convenience of having a ready-made program that’s not a bother to obtain. This is where TI’s Professional Program Exchange (PPX) can be of enormous help. Here’s how it works:

As a member you’ll be able to turn to the section of your PPX-52 Catalog that serves your discipline. With hundreds of user-submitted programs available, there’s a good chance the one you need is there. Order it, and put it to work on receipt.

What you get is a program developed, tested and submitted by one of your professional peers. Likewise, when you develop programs you may submit them for possible inclusion in the Exchange for others to use.

PPX-52 is for SR-52 owners who want to increase their professional contribution and efficiency. The annual membership fee of $15 entitles you to a Catalog, updates, and a subscription to the PPX-52 newsletter. Plus, your choice of three programs. Order more programs as you need them—$3.00 each.
TI's unique Algebraic Operating System makes the calculator part of the solution.
Not part of the problem.

With the introduction of the SR-50 slide rule calculator a few years ago, Texas Instruments had a choice: algebraic entry or Reverse Polish Notation (RPN). TI chose algebraic entry because it's the most natural and easiest to use. Now, with the new programmable calculators, TI takes another major step forward in power and ease of use—the unique Algebraic Operating System.

AOS is more than just algebraic entry. It's a full algebraic hierarchy coupled with multiple levels of parentheses. This means more pending operations, as well as easy left-to-right entry of expressions—both numbers and functions.

Pending operations let you compute complex equations directly. For example, a seemingly simple calculation like this:

\[ 1 + 3 \times \left[ 4 + \frac{5}{\left(7 - \frac{2}{9}\right)} \right] = ? \]

contains six pending operations as it's written. A TI calculator with full AOS easily handles it just as it's stated, left-to-right. You don't have to rearrange the equation, or remember what's in the stack as with RPN.

**Compare the SR-52 & SR-56 with other programmables in their class.**

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<td>•</td>
<td>Fractional part</td>
<td>•</td>
<td>•</td>
<td>Program flags</td>
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<td>Additional special memories</td>
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<td>38</td>
<td>Trig functions &amp; inverses</td>
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<td>•</td>
<td>Decrement &amp; skip on zero (loop)</td>
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<td>Indirect memory addressing</td>
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<td>Hyperbolic functions &amp; inverses</td>
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<td>Conditional branching instructions</td>
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<td>30</td>
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<td>Exchanging x with t</td>
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<td>•</td>
<td>Deg/min/sec to decimal deg &amp; inverse</td>
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<td>•</td>
<td>Unconditional branching</td>
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<td>Fixed decimal option</td>
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<td>Deg to rad conversion</td>
<td>•</td>
<td>•</td>
<td>Indirect branching</td>
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<td>Calculating digits</td>
<td>12</td>
<td>12</td>
<td>Polar to rectangular conversion</td>
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<td>•</td>
<td>Editing; Step, Backstep</td>
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<td>-</td>
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<tr>
<td>Angular mode Deg/Rad</td>
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<td>•</td>
<td>Mean, variance &amp; standard deviation</td>
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<td>•</td>
<td>Nop</td>
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<td>Grad angular mode</td>
<td>•</td>
<td>•</td>
<td>&amp; inverse</td>
<td>-</td>
<td>-</td>
<td>Single step execution</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Digits displayed (mantissa + exponent)</td>
<td>10 + 2</td>
<td>10 + 2</td>
<td>-</td>
<td>-</td>
<td>Pause</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

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Waldbieser Engineering Terra Haute

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Richard D. Binkhorst, M.D.
Ophthalmic Surgeon
New York City

“Calculating a gas pipeline network for 200 homes under construction takes hours of tedious work. I developed a program for my SR-52. It makes all the necessary iterations—and gives me pressures and flow rates. Now I do in less than two hours the same work that used to take 10.”

Carlos de León
Consulting Engineer
Diseño Ingeniería y Técnica en Gas, S.A.
Mexico City

“I wrote a program which I use in designing overhead bridge cranes. It calculates the moment and the maximum deflection on the beams that carry the trolley. I plug in the section’s modulus and moment of inertia. Then the bending stresses and deflection are calculated for me. I wrote another program that I use in designing column footings. A programmable gives me the capability to analyze several setups very rapidly and come up with a good solution.”

Biddle W. Worthington, Jr.
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Professional program gets few cheers

Grass-roots reaction to the IEEE U.S. activities board's 1976 program plan ranges from lukewarm approval to disappointment

by Gerald M. Walker, Associate Editor

If the IEEE is having second thoughts about asking members to comment on its proposed professional-activities plan, it could be forgiven. For the plan, drawn up in January and revised in July, is being greeted with less than wild enthusiasm.

A sampling of those who have read the plan [Electronics, Aug. 5, p. 32] shows a typically unfavorable reaction. The prime complaint, even among members who praise the plan's five general goals, is that there is an apparent lack of action in those goals, which are subdivided into individual tasks (see "The plan in brief," p. 68).

The reactions were generated by what is for the IEEE an unusual step. When the revised plan was ready, James H. Mulligan Jr., the society's vice president of professional activities and chairman of its U.S. activities board, decided to circulate it among section and professional-activities committee chairmen. In a covering letter, he asked for written suggestions by Aug. 31. Those comments will be placed before the 16-member U.S. board at its Sept. 10-11 meeting for consideration in formulating the 1977 plan.

Most of those section leaders who have studied the program want a closer meeting of the minds. "Why," typically complains a Midwest member, "do they wait until after the program is completed to ask the 'grass roots' for its opinions? Why didn't they ask us before?"

More specifically, "the program does not meet the needs of West Coast members," declares J. G. Hoagland, chairman of the Orange County section of the Los Angeles Council. There is a "big discrepancy" between what members want and expect and what the program talks about, he adds. He blames this on the makeup of the U.S. activities board. "Too many academics and pseudo-academics. It's another series of studies on top of studies, which is the academic approach," he says.

Response. In contrast, Myron Ross, acting professional activities chairman of the Boston-area IEEE, observes, "The activities board seems to be trying to respond to the members' needs, at least to some of the expressed desires of Boston-area members." Section chairman Allan Schell points out that he is more concerned with local professional activities than with the national plan. "I'm convinced that if the sections don't generate programs on the local level that are somewhat analogous to the national program, then they are remiss."

Meanwhile, an official's view was expressed by Joel B. Snyder, Region 1 PAC chairman and a member of the activities board's steering committee and its controller, who claims that the board has tried to modify existing programs and develop new programs to address each of seven previously stated "needs of engineers" adopted by the executive committee.

Estimating his views on the overall program as falling between that of "rabid fanatics and rabid conservatives," Snyder says, "To my thinking, the program is a very ambitious one. But, considering our limited financial position, the program is, perhaps, too ambitious."

Snyder considers the bulk of the 24 tasks previously adopted to be responsive to the needs of engineers. "In general, the tasks under the five goals are needed by engineers; in some cases, immediately; in others, it's more of a long-range thing. Unfortunately, some of those things needing immediate attention can't be accomplished overnight."

Criticism. One of the most outspoken critics of the plan, Robert Bruce, PAC chairman for the Long
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Island section, complains, “I don’t think the board deliberately set out to squander over $1 million of our dues, but this plan accomplishes the same thing.”

Bruce lists these criticisms:

- Employer cooperation in career maintenance (task I-e) does not cope with the core of the EE’s problem—oversupply. There is no mention in the plan about controlling the quantity and quality of engineers directly.
- Affirmative action for senior engineers (task II-b) also misses the mark by failing to put teeth in the proposal, such as maintaining a black list of undesirable employers, as do other professional organizations. This comment also applies to the employment guidelines (task II-d)—no teeth, no blacklist.
- Standard occupational titles (task II-g) could work against the engineer by “pinning him to a board like a butterfly.” These titles could narrow an EE’s chances of finding employment and may not reflect his true talents either.

Suggestions. Somewhat disappointed by the final plan, James Nawrocki, chairman of the Santa Clara, Calif., professional-activities committee, notes, “The program looks more like a program goal than a program plan.” He has submitted several suggestions to the board. In one, Nawrocki says, “They ought to work on task IV-a (communications). The board has been active in ‘upward communication,’ but has been short on ‘downward communication’ to members.”

He recommends that the IEEE inaugurate an employer-evaluation survey, such as the Santa Clara chapter plans to initiate, and rate local firms as good, poor, and bad for engineers. Nawrocki, who believes that the USAB will heed the will of the members, is also concerned about what the institute is doing and not doing about describing the drawbacks of the EE career to students, women, and minorities.

George F. Kujawski, PAC chairman for the Metropolitan Los Angeles Council, is lukewarm on the plan. “While the program addresses all the proper areas and identifies the problems, it is not as specific as it could be,” he says. Most of all, it lacks a sense of urgency in accomplishing certain tasks.”

The plan in brief

The U.S. Activities Board’s revised 1976 program plan is a well-organized document done in outline format. Here are the contents, with the amounts budgeted for each goal:

- Goal I ($201,300): Improvement in financial and economic benefits for members. Tasks are pension coverage, portable benefits, employment rights under Government contracts, patents rights of employed inventors, and employer cooperation in career maintenance and development.
- Goal II ($158,900): Improvement in career conditions and opportunities. Tasks include employment assistance, affirmative action for senior engineers, career centers, extension of work on employment guidelines, manpower reports, forecasting engineering-manpower requirements, standard occupational titles, and a data base for manpower planning.
- Goal III ($31,900): Improvement in professional status. Tasks are professional identification, professional qualification, and matters of ethical concern.
- Goal IV ($225,800): Improvements in Government relations and other interfaces. Tasks cover contributions to Government decision-making, participation in technical projects related to professional activities in the United States, continuation of congressional fellowships, and the U.S. intersociety legislative advisory project.
- Goal V ($114,100): Improvement in communicating USAB aims, activities, and accomplishments. Tasks are communication among IEEE members, with employers of IEEE members, with other societies and professions, and with Government bodies.
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and then some.
Big Three follow different routes

Now that microprocessor has made debut in GM car, Chrysler plans to expand linear applications, but Ford will wait

by Larry Armstrong, Midwest bureau manager

The microprocessor has made its long-awaited debut in autos, and Detroit's Big Three all expect microprocessors to be widely used for engine control by 1980. However, Chrysler and Ford are taking different paths toward that goal, while GM has started with its announcement that some 35,000 Oldsmobile Toronados will be equipped with a microcomputer from Rockwell International to handle ignition timing and spark regulation [Electronics, Aug. 19, p. 43].

Electronic ignition systems have been installed on cars by all manufacturers for several years now, and spark advance has become the function that's ripe for the switch to electronics. General Motors came down heavily in favor of digital microprocessors in its first attempt to handle spark advance with electronics. Chrysler plans to expand its linear sparking system, first shipped in January, to nearly all eight-cylinder engines in its 1977 models, an estimated 400,000 to 500,000 units. And Ford, while not lagging in microprocessor development, has decided that relying on electromechanical devices, at least this year, is a better idea.

GM's Delco-Remy, working on a system in competition with Delco Electronics, a sister division, opted for PAC—for programmable automotive controllers—from Rockwell's Microelectronic Device division to use in the Toronado. First shown a year and a half ago [Electronics, March 6, 1975, p. 36], PAC is a 10-bit p-channel MOS central processor, coupled with a 1,024-by-10-bit read-only memory programmed to the customer's specifications. Besides preprogrammed instructions, the ROM chip also holds data curves for table look-up, and the CPU chip interpolates between points on the curves.

Chrysler has elected to stand by its successful discrete electronic-spark computer, which is used with a "lean-burn" engine [Electronics, April 3, 1975, p. 38]. About 100,000 copies of the analog system have been sold as options on 400-cubic-inch engines this year. Chrysler was able to meet Federal emission-level requirements without using catalytic converters or so-called EGR (exhaust-gas-recirculation) techniques.

This year, however, as emission limits have been pushed another step downward, Chrysler has had to return the catalyst. It is standard equipment on 360-, 400-, 440-, and will be optional later this year on the 318-cubic-inch 1977 engines. However, these cars operate without the additional drag of EGR.

Chrysler engineers are at work to eliminate the catalytic converter with a version of the spark computer that will meet the mandated lower nitrogen-oxide levels. "As the environmental limits get more severe, this is still somewhat speculative," points out Earl W. Meyer Jr., assistant chief engineer for engine electrical engineering at Chrysler in Detroit. But the firm has completed 50,000-mile durability tests on a 400-in.³ engine equipped with the advanced system; after the data is submitted to the U.S. Environmental Protection Agency, the system without the converter will probably be offered as an option.

 Differences. "The differences are just calibration changes," Meyer says. "We run a little leaner fuel-air ratio and try to overcome it with a
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more dynamic spark-advance schedule." Also, later this year, Chrysler will replace more than half the components in the system with three custom integrated circuits; National, RCA, and Texas Instruments are building two each.

Chrysler is in the process of switching from analog to digital electronics, and the firm has long said that its first use of microprocessors will be for electronic fuel metering. "It's a natural step that will be used in combination with the lean-burn engine," Meyer says. "An electronic fuel system simply operates leaner than a carburetor can." He predicts that microprocessors will be installed in Chrysler 1979 or 1980 models, although there's talk around Detroit that the firm's first microprocessor-based fuel system might show up during the 1978 model year.

Less cost. "We could do it in custom linear ICs every bit as reliably, but the microprocessor gives us a certain flexibility from model year to model year as calibrations and features change," he says. "More important, we can do it at a reduced cost."

Chrysler defined equations for its linear designs and handed the package to RCA and Texas Instruments. "The products that both companies are proposing are evolutions of their standard microprocessors," Meyer says. "But it became clear, for economy and reliability reasons, that the devices had to have some custom concepts in them, so they will be automotive microprocessors."

RCA's is an 8-bit CMOS device; TI's is part of its 16-bit 9900 family. "We need at least 8 bits, and we have enough computing capability with 8 bits," Meyer says. "But bit length also entails tradeoff with the input/output circuits. Some would argue that it's better to have more powerful processors and memories so that custom inputs and outputs could be simpler and more general."

Ford, in a splashy introduction last fall, unveiled an electronic spark advance of its own, called computer-controlled timing (CCT). CCT, built primarily of complementary MOS by Aeronutronic Ford and Motorola's Automotive Products division, was later postponed and then quietly sacrificed for a more conventional electromechanical sparking system. "It met our performance and reliability requirements, but alternate means were giving us better fuel economy," comments Robert S. Oswald, manager of electronic subsystem and component design at Ford in Dearborn, Mich. Ford claims that the system is still in the development stages, but an insider contends that it's a less capable system than those from GM and Chrysler.

Ford first. But Ford was one of the first to design a microprocessor, a custom 12-bit chip built by Toshiba in 1972. "Even though we've worked with ours longer, and have more confidence in it, and more experience with it," Oswald says, "we're not committed to it. It's 1972 architecture, and we're not going to be casting our lot in with what would be classed today as obsolete." Even so, the industry expects to see Ford introduce limited numbers of the Toshiba system in cars at the top of its line, simply to get on-the-road experience with electronics.

Ford is expected to go out this month with a set of specs for its next generation CCT, this one microprocessor-based. And Ford's criteria for the Toshiba design still apply. "It has to be a single chip and give us sufficient accuracy to do calculations for engine control without going to double precision," Oswald says. "And it can't be a word processor; it should be oriented to the control task, with hardware multiply-and-divide and bit-manipulation capability."

Ford is considering the use of microprocessors for total engine control: ignition, spark, EGR, fuel metering, and several associated on/off functions for switches and solenoids. The company set up a task force a little over a year ago to formalize the application of electronic engine controls. "We picked the R&D systems and put them into a production program," says Melvin F. Sterner, who heads the task force. "We thought it was an aggressive program then, and it's even more so now. We've moved the timetable up within the past year."
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Six commercial versions are available: in the TO-5, the standard CA3140T and the premium types CA3140AT and CA3140BT; the CA3140S, CA3140AS and CA3140BS are the DIL-CAN versions of the TO-5. Also available is the chip version—CA3140H. The CA3140 series is available processed to all levels of MIL-M-38510/883.

**Send for 13 useful circuits.**

To show you how useful the CA3140 is, we’ve designed it into 13 typical circuits. To get these circuits plus other information, contact your RCA Solid State distributor. Or RCA.

Write: RCA Solid State. Box 3200, Somerville, N.J. 08876; Ste Anne de Bellevue H9X 3L3, Canada; Sunbury-on-Thames, U.K.; Fuji Bldg., Tokyo, Japan.

**Low circuit cost**

The CA3140 needs no external compensating circuitry. It is characterized for low-cost TTL systems requiring operation at 5 V and maintains operation down to 4 V. Its wide bandwidth—1.5 MHz unity gain—makes possible low-cost video and audio circuits. For low-cost sample and hold and other data acquisition systems, it offers fast settling time: 1.4 μs typ. to 10 mV. When it's driving power transistors, the output swings to within 0.2 V of the negative supply, eliminating the need for level-shifting circuitry.

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**CA3140 vs. 741 at a glance**

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**Basic Function Generator**

The CA3140 gives 1,000,000:1 range, single control when used as a buffer readout for the integrating capacitor in this basic function generator. The RCA data sheet (File No. 957) tells you how to build this circuit.
Memories

Conferees close in on 16-k standards

But Jedeck committee may be beaten to the punch by whichever RAM that can be supplied in volume demanded by users

by Bernard Cole, San Francisco bureau manager

Take heart: the great battle over latches in 16-kilobit RAMs—and other less important, but related, skirmishes—may soon be resolved.

In a series of meetings to be sponsored by the Joint Electron Device Engineering Council over the next few months, vendors and users will attempt to extend the agreement on 16-k RAM pinouts that was completed about a year ago [Electronics, June 12, 1975, p. 80] to cover at least two additional levels of standardization: latched or unlatched outputs, plus timing and control—64- or 128-cycle refresh and other related functions. The first discussion on those points took place on Aug. 10.

But, even if the attempts fail, a number of forces already set in motion in the 16-k marketplace may force the issue. Depending on how fast most vendors get to market with their 16-k RAMs, the standards may be set by supply and demand—what's available in volume. Right now, Intel Corp. and its latched 2116 part are in front. But if a number of other vendors arrive in the marketplace with unlatched 16-k parts reasonably quickly, the standards may be set by them.

Latched or unlatched. So far, the only available latched device is Intel's 2116, which appeared in sample quantities in December. But such major suppliers as Texas Instruments, which began showing samples of its unlatched 4070 in April, and Mostek Corp. with its 4116, as well as Motorola Semiconductor, Fairchild Semiconductor, and National Semiconductor, all have opted for unlatched versions. Others, including Advanced Micro Devices Inc., Advanced Memory Systems Inc., and American Microsystems Inc., are investigating both options, and they could go either way, although the momentum at this point is building toward the unlatched approach.

David House, Intel's memory-applications manager, says his company chose the latched output for the 16-k RAM on the basis of compatibility with existing 4-k RAMs. "Our surveys show that a majority of our customers—as many as 60% or 70%—want the output latch," he says. "Besides, if a user doesn't want it, he can just use the column-address strobe to disable it."

But, says Jeffrey Kalb, National's director of memory-components operations, "the 16-k is basically a new part, and we shouldn't be constrained by its predecessor." More important, he says, an on-board latch simply slows down the part. He points out that Mostek, for one, hasn't seen anything slower than 200 nanoseconds so far, compared to the 2116's access time of 250 to 350 ns.

House, however, counters with the observation, "Again, the majority of the market, we feel, is not in the high-speed area." Moreover, in a systems environment, he says, much of the speed differential between a latched and nonlatched part disappears.

In a nonlatched output device,
data output is valid only during the time both the column address and row address clocks are active and each memory cycle can be maintained as a separate entity. Latched outputs, on the other hand, hold the data output valid into the succeeding memory cycle and need an extra cycle to clear the latch, thus adding to the cycle time of the memory system.

Refresh. Besides having latched outputs, Intel's part is the only one that can be refreshed in either the 64- or 128-cycle, 2-microsecond modes. All other current designs require a 128-cycle refresh only, a limitation chosen because in the 64-cycle refresh mode the user must strobe both row and column addresses—in other words, he must change the on-cycle timing in the system to take advantage of the shorter refresh time. And that causes higher power dissipation.

House's response to this criticism is that 64-cycle refresh is an advantage to users because it provides greater utilization of memory than the 128-cycle approach. “Most customers I've talked to don't want the memory tied up for too long in refresh, where it can't be accessed,” he says. The cost in power for the 64-cycle option, says House, has been overstated. “The increase is only 10% to 20% during the refresh cycle,” he says, “and only 1% to 2% added average power.

Derrell Coker, applications engineer at Mostek, is one who believes the marketplace may decide the standard before any committee does, and he has his own view of what that will be. “The winner will be the source that can supply a 16-k RAM that will be able to fit into everyone else's socket and also has the most device margin,” he says. “In other words, the guy with the fastest part with the lowest power, good power-supply tolerances, and input and output levels.”

Intel, however, has one powerful counter-argument left—availability. Although some users aren't entirely happy with the approach the Santa Clara, Calif., company has taken, they are buying it because the 2116 is the only device being shipped in volume—perhaps as many as 2,000 parts per month.

Electronics/September 2, 1976

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Electronics / September 2, 1976
Minicomputers

Shortage of field technicians looms

DEC is working with two-year colleges on minicomputer technology programs as other makers also push recruiting

by Pamela Leven, Boston bureau

Minicomputer makers are beginning to worry about a growing shortage of field-service technicians as the industry expands and a traditional source of such personnel—the military—shrinks. Most of the manufacturers are intensifying talent hunts and training programs, none perhaps as much as Digital Equipment Corp., the industry's sales leader.

DEC expects its sales to top $1 billion a year by 1980, compared with $736.3 million in the fiscal year that ended July 3. To service that growing product base, DEC figures it will need an additional 2,000 junior technicians. In what the company hopes will eventually be an industry-wide effort, it is helping public and private two-year colleges establish programs that will result in associate degrees in minicomputer-service technology. Donald Palko, coordinator of minicomputer technology for DEC's educational services, says that graduates of the program who are hired and receive further training from DEC should fill about 30% of the jobs. The rest will come from other schools, other companies, and DEC's own training program at its Maynard, Mass., headquarters.

The college courses, built with curriculum advice and materials from DEC, as well as discounted equipment in the laboratories, will cover the "principles, fundamentals, and concepts of computers; they will not go into specifics on product lines," says Palko.

Ron Lund, assistant coordinator for the program, adds, "The idea behind the program is to bring the students into the industry at a predetermined level of competence in state-of-the-art training. Now, they come to us with very high and very low states of preparedness."

DEC is relying on its service managers in the field to point out candidate schools in areas where potential DEC sales increase and customer-service needs are expected to be greatest. So far, three schools are offering mini-tech programs: Bucks County Community College in Pennsylvania, Daniel Hale University in Chicago, and Franklin Institute in Boston. Lund says another 10 to 15 schools have programs in the developmental stages.

As the giant in the minicomputer industry, DEC has the resources to create a successful college-level-degree program—and is using them. DEC offers participating schools much of the material the company uses in its in-house training program, DEC Tech. This support includes state-of-the-art equipment at discount prices for students' hands-on experience, documented curriculum materials, and audio-visual instruction aids.

Teaching teachers. Faculty members get as much attention from DEC as the students. Lund says that two instructors per school are offered tuition-free courses at the DEC educational-services program in Maynard. In two intensive summer sessions, instructors take four weeks of software courses and six weeks of hardware. Lund estimates that, with tuition fees at $500 per course, each school receives $10,000 worth of training. "If we were to market the entire mini-tech program, we'd set the price for each school at between $500,000 and $750,000," says Lund.

DEC expects to benefit financially in the long run from its program. The company figures that each graduate is ready to enter the final product-specifics phase at DEC Tech, or approximately the last three weeks of the 13-week course. Lund estimates that the elimination of about 10 weeks of training saves DEC $7,500 to $10,000 in student technicians' salaries, travel, and housing. If the mini-tech program produces the expected 600 junior technicians by 1980, DEC will have saved $4.5 million to $6 million a year.

By 1980, DEC plans for about 60 schools to have established mini-tech programs, with about 48 producing graduates for final product training.

What other companies are now doing depends on how they view future demand. At Data General Corp., Joanna Flint, field-personnel representative, considers the technician shortage a problem of quality rather than quantity. "There's going to be a lot of competition for the same top people," she comments. But she agrees with DEC's approach, saying, "It is inevitable that companies are going to have to tell..."
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Probing the news

schools what they want the schools to produce, so it's logical that they have input into the curriculum of the schools.”

The minicomputer maker, in Southboro, Mass., has intensified its search for qualified candidates by recruiting at two-year colleges and technical institutes in a manner similar to its college-level head-hunting for engineers. Data General then sends such technical-school graduates through an additional year to 18 months of intensive training at its regional facilities to teach them electronics and minicomputer theory and give them hands-on experience with products.

Joseph Rechner, customer service vice president at Interdata Inc. in Oceanport, N.J., agrees with Flint. “There aren’t as many ideal candidates today to fill customer engineering positions as there were five years ago,” he says. “Businesses like ours must take less trained and less qualified candidates and supplement their knowledge with additional training.”

For several years, Interdata, a subsidiary of Perkin-Elmer Corp., has been cultivating relationships with technical schools around the country. The firm offers “generous discounts” on equipment and provides teaching aids and curriculum consulting to the selected schools.

Costal calm. West Coast minicomputer firms say they're not worried about an impending technician shortage, although firms around Los Angeles agree that DEC is probably correct in its assessment of a shortage somewhere down the line. They note, however, that DEC has the resources to provide technical assistance to schools that smaller computer makers can not hope to match.

At Hewlett-Packard Co.'s Computer Services division, Will Houde says he expects no problems attracting technicians and does not plan to participate in any outside training programs. “We’ll leave the business of education up to the colleges,” he says. “We tell them what they need to do and what kind of people are marketable.”
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Use of this bidirectional error-correcting technique increases the speed at each stage of the conversion because the measurement at any stage does not have to be very precise. An imprecise reading is being corrected during the succeeding step of the conversion, while higher-resolution readings are being processed.

The speed with which an analog signal can be converted to digital form is the most important factor that limits the operating speed of measurement instruments such as DVMs and DMMs. Especially in instruments designed for use in systems, as opposed to bench instruments, a prime requirement is to combine a short measurement period with high resolution.

Indeed, the first commercial application of the bidirectional error-correcting technique is a 5½-digit multimeter, model 8500A [Electronics, Aug. 19, p. 117]. In this instrument, a microprocessor controls the timing, parallel a-d conversion, and accumulation of error-correction results. The microprocessor directs the sequence of steps taken by the converter, such as setting the polarity of its voltage reference.

Although the success of the technique does not depend on the microprocessor, inclusion of the device within the instrument makes possible a great deal of flexibility in configuring the instrument, as well as the addition of functions such as calculating ratio values, correcting for offset and calibration errors, and averaging readings. By averaging readings, for example, the microprocessor improves the instrument’s performance, since it can combine the vastly reduced response to line-related noise of dual-slope integrating conversion with the high speed and resolution of cyclic conversion.

Converting cyclically

Cyclic a-d converters provide a direct conversion of a dc voltage to a digital value by successively:
1. approximating and digitally storing the approximation of an unknown voltage,
2. setting a d-a converter’s output to this value,
3. amplifying the difference between the d-a output and the unknown dc voltage,
4. storing the amplified difference (remainder) on a capacitor,
5. disconnecting the unknown voltage and the capacitor from the converter,
6. reconnecting the capacitor to the converter so as to treat its voltage as an unknown voltage, and
7. repeating all the previous steps (using another capacitor as a storage element) until enough d-a conversions have been made to achieve the desired resolution.
A cyclic converter can perform steps 1 through 4 virtually simultaneously (Fig. 1). Blocks G and H form a classic control loop that amplifies the difference between the unknown voltage and the output from the d-a converter.

The control logic, in conjunction with the discriminator, controls the output of the d-a converter so that the voltage to be stored on capacitors C1 and C2 and scaled by K is within the subtracting range of the d-a circuit. Steps 5 and 6 would be accomplished by rotating both S1 and S2 from position A to position B and repeating steps 1 through 4. The voltage stored on C1 and scaled by K would be treated in the same fashion as the unknown voltage was treated. Capacitor C2 would then store the amplified difference, or remainder.

Repeating steps 5 and 6 to generate more resolution would require switching S1 from B to C, switching S2 from B to A, and repeating steps 1 through 4. As much resolution as desired can be generated with the cyclic process by continually repeating steps 5, 6, and 1 through 4. While there are no limits as to achievable resolution, practical limitations are set by errors caused by such factors as thermal noise, imperfect d-a converter linearity, dielectric absorption, and leakage. The practical limits of resolution are quite high: the 8500A has achieved repeatable measurements with a resolution of 1 part in $4 \times 10^6$.

Without concern for the means of implementing the various functions that would be required, consider the example of a four-decade cyclic a-d converter that has a full-scale dynamic range of +16 v. Assume that an input of +11.045 v must be measured.

Within the converter, assume that G approaches infinity and $H = \frac{1}{10}$, so that a signal at S2 is equal to exactly 10 times the difference between the unknown voltage and the d-a output voltage. It is further assumed that $K = 1$ and that the d-a can output, in 1-v intervals, all voltages in the band between 0 v and +15 v.

To further simplify the example, it is assumed that the amplifier G has an infinite output-voltage range and that the discriminator is itself an a-d device whose least significant bit is equivalent to +10 v and whose most significant bit is equivalent to +80 v.

During the first cycle, the initial conditions include a d-a converter output of 0 v, S1 and S2 are set to A, and therefore $V_1 = 11.045$ v. This would produce a $V_o$ of 110.45 v, and the a-d would digitize this value and present it to the control logic as 110 v. The control logic would then act on that 110 v by dividing it by 10, setting the d-a output to be equal to the resultant 11 v, and storing the 11 v number in memory. As a result of the d-a converter's output going to 11 v, $V_0$ would then be equal to $10(11.045 v - 11.000) = 0.45$ v. Capacitor C1 would be charged to 0.45 v.

**Continuing the process**

During the second cycle, the initial conditions include a d-a converter output of 0 v, S1 and S2 are set to B, and therefore, $V_1 = 0.45$ v. Under these conditions, $V_o = 4.5$ v, which would be digitized as 0 v. The d-a converter's output would be set to 0 v, and a value of 0.0 v would be stored. $V_o$ would be uncharged, and capacitor C2 would be charged to 4.5 v.

During the third cycle, the initial conditions include a d-a output of 0 v, S1 is set to C, and S2 is set to A; therefore, $V_1 = 4.5$ v. Then, $V_o = 45$ v, which would be digitized as 40 v. The d-a converter would be set to 4 v, and a value of 0.04 v would be stored. $V_o$ would equal $10(4.5 v - 4 v) = 5 v$, and C1 would be charged from 0.45 v to 5 v.
During the last cycle, the initial conditions include a d-a converter output of 0 V, S₁ and S₂ are set to B, and, therefore, V₁ = 5 V. The value of V₆ is then 50 V, which would be digitized as 50 V, and a value of 0.005 V would then be complete, and the converter would be ready to begin another conversion. The final converted value would be the sum of the values stored during each cycle, or

Vₙ = 11 V + 0.0 v + 0.04 V + 0.005 V = 11.045 V

**Limiting speed**

A novel approach to increasing the speed of cyclic converters relies on digital logic to perform arithmetic operations. A microprocessor provides this capability at very low cost.

What are some of the speed limitations of cyclic converters? To get at that answer, it helps to break up the time required for each cycle into two main components—decision time and settling time.

Decision time is the time required for a converter to decode and act on the value at which the d-a converter's output must be set, reducing the amplified difference between this output and the input voltage to a level within the dynamic range of the d-a converter. Settling time is the time required for the converter to store, within the error limits as implied by the converter's resolution, the amplified difference between the d-a converter's output and the input voltage.

At the end of each decision time, a d-a converter output is subtracted from the unknown voltage, and the remainder is less than the converter's full-scale output. Such a process is in itself an a-d conversion whose resolution is equal to the maximum difference that the process allows.

That sequence illustrates how a cyclic converter sequentially processes, first, the input voltage, and then, the remainder voltage from each previous cycle, through the same a-d converter process.

**Making decisions**

The cycle-decision time is the time required for the single-cycle a-d conversion process. For the simplistic example illustrating how a cyclic converter works, the discriminator functions as the entire single-cycle a-d process. (It is practical to use a separate limited-resolution a-d converter for the approximation process, but it is easier to have the cyclic converter itself operate directly on the input voltage.) In order to achieve the minimum decision time, the a-d converter would be implemented as a parallel converter whose output could directly drive the d-a conversion circuit. If minimum decision times were not necessary, a slower successive-approximation a-d converter might be used.

Precision cyclic converters are not limited in speed by the decision times, but are, instead, limited by settling times. For the 22-bit converter used in the 8500A, such limitations as those caused by printed-circuit-board materials, frequency compensation, and storage capacitors prevent first-cycle settling times of less than 150 microseconds. Subsequent cycles have shorter settling times because the required accuracy of the remainder.
The remainder would then be added, the digitized remainder to the accumulator.

accumulating logic be capable of subtracting, as well as addition, and it would be necessary only that the converter would allow precision analog subtraction and output (compared to the input voltage). A bipolar d-a converter's output to inhibit such influences from setting the d-a converter too high in value. Conceptually, the cyclic device can produce an accurate remainder, regardless of whether or not the d-a converter's output is greater than the input voltage. Proper operation would be maintained if it were possible to digitize the positive or negative remainder that resulted from too small or too large a d-a converter output (compared to the input voltage). A bipolar d-a converter would allow precision analog subtraction and addition, and it would be necessary only that the accumulating logic be capable of subtracting, as well as adding, the digitized remainders to the accumulator.

The capability to subtract from, as well as add, remainders to the accumulator is referred to as bidirectional error correction. The concept of bidirectional error correction can be illustrated by the example given earlier with the further assumption that the control logic sets the d-a converter's output to +12 during the first cycle. The remainder would then be

\[ 10(11.045 \, \text{v} - 12 \, \text{v}) = -9.55 \, \text{v}. \]

On the second cycle, the a-d converter would digitize -95.5 v to be -90 v, the d-a converter would be set to -9 v, and -0.9 v would be stored. The remainder would be

\[ 10(-9.55 \, \text{v} - 9 \, \text{v} = -5.5 \, \text{v}. \]

On the third cycle, the -50 v would be digitized, -0.05 v would be stored, and the d-a converter set to -5 v. On the final cycle, -50 v would be digitized and stored as -0.005 v. The final converted value would be

\[ V_{\text{in}} = +12 \, \text{v} - 0.9 \, \text{v} - 0.05 \, \text{v} - 0.005 \, \text{v} = +11.045 \, \text{v}. \]

If enough error correction is provided in the conversion process, the cyclic converter functions as a precision sample-and-hold with a very small aperture time. Thus, a cyclic a-d converter can be used as a sampling converter and can provide information on higher-frequency signal components than implied by its maximum conversion rate.

**Successive approximation**

Setting times are the predominant factors in fast recirculating-remainder a-d conversion times. A successive-approximation approach, which does not drastically affect the conversion rate, is therefore used during the decision times. The successive-approximation a-d device makes use of the precision elements in the cyclic converter and employs a polarity detector as a discriminator.

As shown in Fig. 2, the precision d-a converter is made up of a switchable voltage reference and a 5-bit voltage ladder consisting of switches S1 through S5 and resistors R0 through R4. Reference voltages of ±7 v ensure that the reference voltages depend only on the reference amplifier and not the ancillary circuitry in the reference supply. A voltage ladder is used instead of a current ladder so that the loop gain around amplifier A will stay constant, regardless of the setting of the digital-to-analog converter.

The polarity-detector output is used by the control logic to determine whether or not the d-a converter has been set to a value that causes the remainder to change polarity. The standard successive-approximation sequence is followed by the control logic; the logic increases the d-a converter's output each time the polarity doesn't change, and it attempts a lower d-a converter output when the polarity does change.

Summing resistor Rs determines the dynamic range of
the fast recirculating-remainder a-d converter. In the 8500A, \( R_S \) was selected to be 10/7 of the value of \( R_o \), the most-significant-bit resistor in the d-a conversion circuit, so that 10 \( V \) at the input would exactly correspond to the
nulling current that could flow through the most-significant-bit resistor. The result is that the a-d device produces a binary output whose MSB is equivalent to 10 \( V \). As 21 magnitude bits are created by the fast recirculating-remainder converter, the least significant bit is equivalent to 20 \( \times 2^{21} \mu V \).

Feedback resistor \( R_{FB} \) and remainder-summing resistor \( R_R \) are connected so that the voltage-drift characteristics of the two illustrated voltage followers are reduced by the loop gain around \( A \).

The feedback resistor has a value of 16\( R \), and, together with amplifier A, provides a remainder that is 16 times the difference between the d-a converter's output and the unknown. Thus, even though the resolution is 5 bits, the digitized remainders are added to or subtracted from the accumulator after having been divided by 16. The a-d conversion process, in going through its five cycles, generates a total of 25 bits; however, since the
remainder gain is 24 instead of 25, the conversion word length is not 25 bits, but is, instead, 21 bits.

The logic that is part of the a-d converter and physically removed from the 8500A's microprocessor consists of control latches whose outputs directly drive the field-effect-transistor switching equivalents of \( S_6 \) through \( S_9 \), a 5-bit bipolar successive-approximation-logic circuit whose outputs drive the d-a converter, and interface circuitry for communicating directly with the microprocessor via a control/data bus.

The control latches are loaded directly from the control/data bus, thus providing the microprocessor with
means to directly control switches \( S_6 \) through \( S_9 \). An attempt was made to design all of the a-d logic functions into the microprocessor, thereby reducing the control-logic cost even further, but the speed limitations encountered were not deemed worth the cost reductions.

### Averaging the readings

In addition to high conversion rates, digital multimeters for system applications must have high rejection of line-related noise and ripple. Dual-slope integrating a-d conversion is often employed specifically for its noise rejection. In such converters, the input signal is integrated during the line period, and the result is discharged at a constant rate. The discharge time is then proportional to the input signal (Fig. 3).

If the integrated period is reduced below the line period in order to increase conversion speed, the advantage of line-frequency-noise rejection is reduced. The decision circuit that determines the end of a discharge period also tends to cause inaccuracies at higher discharge rates.

An alternate approach was taken in the model 8500A. The microprocessor contains a phase-locked loop so that the conversion can be synchronized to the line frequency, whether it is 50 or 60 Hz, and a reading may be started every \( 1/4 \) of a clock period. By averaging readings that are taken over the line period, the effects of line-related noise and harmonics do not appear in the result (Fig. 4).

In the averaging mode, the noise behavior of the 8500A is similar to that of a dual-slope integrating meter, while attaining twice the conversion rate.

The availability of a microprocessor within the instrument makes it possible to add many other functions. The ratio of two input signals can be measured, for example, by processing each signal independently, then dividing the results. In contrast, conventional voltmeters make ratio measurements by replacing the internal a-d converter reference with the external input signal. Since the operation of the a-d converter is optimized at the internal reference voltage, the accuracy is considerably less in the ratio mode. By computing ratios and not changing the internal reference, full performance is maintained in the ratio mode.

The ohms-measurement circuitry is similarly affected by microprocessor control. In conventional digital voltmeters, the ohms function is achieved by driving a highly regulated current through the unknown resistor, and the voltage across that resistor is measured. In the 8500A, ohms values are calculated from three voltage measurements (Fig. 5). But, since the value of the internal reference voltage does not influence the result, any contribution to inaccuracy by this source is eliminated.

The microprocessor also eliminates the need for a zero-adjusting trimming potentiometer, and readings may be made at any preselected offset from zero by storing a reference voltage and subtracting it from the reading. Setting zero, which compensates for external thermal EMFS as well as internal zero drift, requires only that the measuring leads be shorted outside of the instrument, and the zero button be pushed. This function operates only in the most sensitive range. Offsets may be any value within scale, in any range, and in any function.

The microprocessor also makes corrections within the instrument to compensate for drift away from calibration or for scaling. Gain-correction values may be determined for every range and stored in an optional non-volatile memory, and the microprocessor can correct readings by applying the appropriate gain-correction factors. This compensation greatly reduces the time the instrument—and the system in which it operates—would otherwise be unavailable for use because it is undergoing calibration.

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Fiber-optic data transmission: a practical, low-cost technology

Efficient fiber-optic communications links are put together with standard off-the-shelf optical and electronic components

by Hermann Schmid, General Electric Co., Binghamton, N. Y.

Designers have long been intrigued by the practically gigahertz bandwidth and the immunity to electromagnetic interference that lightweight optical fibers offer for reliable transmission of all kinds of data. But the question foremost in their minds has always been, “Is it practical?” Next comes, “Are enough low-cost, high-performance components available to make such systems technologically feasible?”

The answer to both questions is an unqualified “Yes.” Formost applications, the technology exists, and for many applications, off-the-shelf fiber-optic cables and components are available from several manufacturers at reasonable cost. And, obviously, as optical-fiber hardware is developed further and more systems begin using it, costs will drop even more.

Consider this fact: right now, the cost per channel for a 10-meter link in a relatively simple multichannel system with a bandwidth from direct-current to 10 megahertz is $30, including the cable (see Table 1). However, a design that uses a maximum of off-the-shelf components could drop per-channel costs to a couple of dollars.

How can anyone be so positive? It has been proven. To determine the feasibility of a basic fiber-optic system, General Electric engineers last year set up an experimental system. They replaced an 11-channel shielded twisted-pair cable with a fiber-optic link, including electro-optic interfaces to carry digital data between two flight-control computers. The system, though large and expensive, was workable and showed great promise of efficiency and economy. And, as usual in such experimental setups, numerous deficiencies in the technology and the components became readily apparent.

Eliminating all possible shortcomings in the experimental system, the engineers designed a 16-channel system. However, for the sake of economy, only three channels of the system were prototyped. In comprehensive tests, the performance proved to be better than had been expected, and it is economical.

Experience in building and testing the systems is pointing up the desirable criteria, as well as pitfalls, in fiber-optic design. What’s more, test results suggest additional improvements that should be cost-effective in large operating systems of the future.

Getting started

Figure 1 shows the most basic fiber-optic link—it needs only three key components. The transmitter can use either a light-emitting or laser diode, which is modulated by a digital waveform. The modulated light

1. Basic fiber-optic system. The transmitter portion uses a light-emitting diode modulated by a TTL driver. The modulated light travels over the fiber cable to the receiver, where a p-i-n photodetector converts the light signals back into the original digital waveform.
beam is then coupled into the optical-fiber cable to carry that information to the receiver portion of the system. In the receiver, an inexpensive p-i-n photodetector converts the modulated light signals into photocurrents that reproduce the original digital waveform. The amplifier converts the current into a voltage needed to drive transistor-transistor logic.

However, in any practical system, these basic components must be configured to meet the individual system's requirements. To do this, several questions, although seemingly straightforward, must be dealt with. Here are some that should be resolved early:

- What type of system is needed? Will the link be used only point-to-point, or to supply multiple locations?
- Will it be used for short- or long-distance communications?
- Will the link be used for one-way or two-way communications?
- Will data be multiplexed over a single channel or carried over parallel channels?
- What bandwidth is needed?
- Should the system be dc- or ac-coupled?

Another important consideration is whether or not the fiber system will replace existing electrical cabling or be used in a completely new application. This choice sets the constraints on the system and determines the amount of freedom the designer has. A replacement system, for example, must use the power-supply voltages and space available in the existing system.

An important initial consideration is the environment in which the system must operate. Temperature, humidity, dust, shock, and vibration—these are only a few of the factors that should ultimately determine which integrated circuits are selected, how the connectors and housings are sealed, and whether plastic or hermetically sealed components should be used.

Finally, the mechanical arrangement of the system must be chosen. Such items as how the cables are terminated, where connectors are located, and where the electronic and optical components are placed in relation to the connectors must be firmed up.

For instance, putting the connections at the natural interface between cable end and the transducer in the

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**TABLE 1: COST PERFORMANCE FIGURES**

<table>
<thead>
<tr>
<th>System performance</th>
<th>Cost per channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity of 16-channel fiber-optic links</td>
<td>$5.00</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>6.00</td>
</tr>
<tr>
<td>dc to 10 MHz</td>
<td></td>
</tr>
<tr>
<td>Cable length</td>
<td>6.00</td>
</tr>
<tr>
<td>10 meters</td>
<td></td>
</tr>
<tr>
<td>Temperature range</td>
<td>0.75</td>
</tr>
<tr>
<td>-55°C to +70°C</td>
<td></td>
</tr>
<tr>
<td>Cost of 10 meters of cable is about $10.</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** Costs were based on price lists of April 1976.
system requires that the male optical-fiber connector terminate the fiber cable and that the female connector, fastened to the equipment housing, contain all the necessary system components. Although this configuration demands a more complex connector assembly initially than if the electronic components were mounted on a board inside the equipment, it allows direct replacement of the electrical cables and connectors with fiber-optic types without having to cut the cable and introduce two additional interfaces.

Once these questions have been resolved, choosing the type of cable must be considered. It's not always true that a more expensive lower-loss single-fiber cable is a better choice than a higher-loss bundle type. In selecting a cable, cable losses must be weighed against coupling losses in the connections between fiber and photodetector and the fiber and light-emitting-diode source. For example, for the relatively short distance of about 10 meters, the lower-loss cable (less than 1 decibel, as opposed to 5 dB for the bundle) appears the better choice. But what isn't obvious at first is the difference in coupling loss. If the smaller-diameter cable were selected, the loss would be far greater—7 dB, compared with only 4 dB for the higher-loss cable.

Making the feasibility model

Surprisingly, when all system losses are tallied, the system using the higher-loss cable edges out the lower-loss cable system by about 3 dB. The system loss over the 10-meter length is 13 dB for the higher-loss cable.

In the feasibility model, the fiber cable was terminated at both ends by the male half of a modified connector. The female half, mounted on the transducer-interface units, contained the actual transmitter and receiver modules. The optical components used in the transducer units were hybrid circuits packaged in TO-5 cans. Additional circuitry provided compatible logic levels and an electrical-output connector assured direct replacement without changing the system. Both interface units measured about 4 by 5 by 6 inches and contained the 5-volt and 12-V supplies, as well as all electronic circuitry needed to replace the coaxial cable in the system.

The initial system left much to be desired. It had a data rate of only 5 MHz, was large, dissipated 1 watt per channel, and worst of all, the small quantity cost was $300 per channel. Although it demonstrated that optical coupling between computers was possible, it underscored the point that, if fiber optics were to prove competitive with existing techniques, much still had to be done.

Adapting existing components

At first, the only possible way to get the necessary high-density packaging and high reliability at low cost appeared to be hybrid large-scale integration. Multiple optoelectronic transducers on chips for the receiver and transmitter could be packaged in a single DIP, which would be plugged into the female portion of the multi-channel optical connector. The male connector, would terminate the fiber cable (Fig. 2). A metalized rubber seal would keep the light beams apart and keep out the dust, moisture, and electromagnetic interference.

The idea was workable, but the cost of developing all the necessary custom hybrid circuits was too high. An
alternate, more practical, solution was found: off-the-shelf ICs and a modified electrical connector. That design goal for the 16-channel connector/transducer assembly was accomplished with the system shown in Fig. 3, in which all off-the-shelf components would be standard ICs with medium-scale ICs, LED light sources, and photodiodes. An ITT Cannon type DRA-50R miniature electrical connector was modified so that the male half of the connector would terminate the cable, and the female half would house the transducer assemblies. Only the front shells of the connector would be used, and everything else would be altered.

The plastic spacer separates the bundles and aids in alignment. A spring-loaded latching mechanism holds the ferrules containing the fibers in place, while pushing them forward to ensure longitudinal alignment between the sources and photodiodes when the connector halves are mated. A pliable O-ring on each ferrule keeps humidity and dust away from the fiber ends. When all the fiber bundles had been inserted into the connector body, a modified cover was pushed over the terminated cable and attached to a mechanical support on the back of the male connector body to protect the fibers.

In this 16-channel design, the female half of the connector would house two pc boards containing the LEDs, photodiodes and ic drivers or amplifiers. Standard ICs packaged in DIPs, together with a few discrete components of the transmitter and receiver circuits, would occupy the rest of the board space. Also, an electrical connector would interface with existing link equipment.

When the boards were in place, all 16 diodes would protrude through the front holes in the connector shell and, when mated, would be properly positioned with the terminated optical-fiber bundles. Alignment of the diodes and the fiber bundles would be assured by the closely machined tolerance of connector assemblies.

The 16-channel transmitter board would use 16 LEDs along with the same number of 68-ohm current-limiting resistors to ensure safe operation and long LED life. Two quad two-input Schottky NAND gates would switch the current of all eight LED sources.

Figure 4 shows the drive circuit for one channel. The rather large beam of light from the gallium-arsenide edge-emitting LED is focused by an internal lens into a much narrower beam of 30° to hold the total coupling loss to about 7 dB in coupling the 1 milliwatt of infrared light output into the 0.045-inch fiber bundle. The power dissipation per channel, consumed almost entirely by the LEDs, is normally 250 mW.

The switching time, which includes the propagation delay of the drive circuit and the turn-on time of the LED, is typically 12 nanoseconds. This is more than adequate to handle a rate of 10 MHz.

The eight-channel receiver board would contain eight photodiodes, two Motorola emitter-coupled-logic line receivers, two high-speed quad comparators that would function as amplifiers, and several resistors and capacitors. In addition, to keep dissipation low, the 8-V negative supply voltage needed for the MECL circuits would be generated by the series regulator mounted on the pc board. The receiver then would need only the same two voltages as the transmitter.

In each receiver (Fig. 5 shows a single channel) the p-i-n photodiodes would convert 10 microwatts of light power at the end of the 10-meter length of fiber bundle (approximately 1% of what would be emitted from the LED) into a 50-microampere photocurrent. The MECL line receiver (actually a quarter of a MC 10115) would be connected as a transimpedance amplifier. Also,
with a feedback resistance of 10 kilohms, the input of the MECL line driver would be sufficiently low to provide the needed current-to-voltage conversion and still maintain sufficient gain.

The output of the amplifier would produce a 50-millivolt peak-to-peak swing with 10 μW of input power. The output is directly coupled into the positive input terminal of one of the comparators (four channels are served by a single MC 3430). The negative input of the comparator would be biased to the dc level of the line-receiver output in order to set the dc level of the comparator to midpoint of the output-voltage swing. The comparator would provide TTL-compatible signals with maximum fanout of 10.

Since the receiver would be dc-coupled, it could handle signals from dc through 10 MHz. This capability is important if the system is being designed for unknown data formats. Power dissipation per channel is about 300 milliwatts.

Although the schematic of the receiver is quite straightforward, the circuit layout is not. To faithfully reproduce a 10-MHz square wave, the circuit must be capable of handling frequencies at least 10 times higher. Not only do the logic circuits have to be selected with this requirement in mind, but also careful attention must be focused on layout of components and grounding because even the shortest lead length contributes unwanted parasitic capacitance and inductance.

In addition, the p-i-n photodiode has a rise time of 15 ns, sufficient to follow the 10-MHz square-wave input. The diode, which is housed in a standard TO-46 package, is optimized at a wavelength of 900 nm and designed by the manufacturer to interface directly with the 0.045-inch diameter of the fiber bundles.

The receiver could operate at significantly lower light-input levels and over greater temperature extremes (from -55°C to +125°C) if ac coupling were used between the transimpedance amplifier and the comparator. However, this type of coupling would limit the minimum data rate to about 10 kHz with a capacitor of reasonable size.

To demonstrate the practicality of the 16-channel concept, the three-channel breadboard developed by General Electric and built by Spectronics Inc. (Fig. 6) was tested. The smaller unit on the left with only one IC is the transmitter and the larger unit with three ICs is the receiver. They are connected by a medium-loss (less than 0.5 dB per meter) optical-fiber cable containing three bundles of 285 fibers each.

Putting together a prototype

To assure minimum parasitics and maximum operating speeds, rf techniques were used to build both the transmitter and receiver. Instead of using the standard type of pc board, from which most of the metalization has been removed, leaving only the narrow interconnecting lines and small component mounting pads, most of the metalization is left on the board to form a large ground plane. And rather wide metal interconnect lines are tailored for minimum length to reduce lead inductance between the transmitter NAND gate and the LEDs and between the receiver amplifier and the photodiodes. Moreover, parasitic capacitances and inductances are kept to a minimum by soldering the discrete components directly to the line receiver.

It is also important to properly ground the transducer assembly to the connector case when the pc board and frame are screwed directly to the connector housing. The three-bundle, 10-meter fiber cable is contained in a flexible convoluted Teflon duct to limit the minimum bend radius of the cable to protect the individual fibers of the bundle against breakage.

Both ends of the cable were prepared as before, and, for convenience, each bundle was terminated with available TO-18 lens caps. This provides greater tolerance of both axial and longitudinal misalignments, but at the expense of an additional 6-db loss in both input and output coupling. However, because the lenses better focus the available light, connector halves separated as much as ¼ inch can still provide adequate signal transmission over the initial 10-meter cable.

Both cable ends are terminated in a modified miniature electrical connector, ITT Cannon's DAM-3W35. These small connectors could easily accommodate the TO-18 cans containing the LEDs and photodiodes.

Promising performance

The breadboard performed with adequate safety margins at -55°C, 25°C, and 70°C (see Table 2). Specifically, six parameters of major importance were monitored over the temperature extremes. The worst-case pulse rate of 10 MHz still allows a 10-MHz square wave to be transmitted with minimum distortion over the 10-meter fiber-optic link, even at 70°C, with nominal supply voltages. With a non-return-to-zero bit stream, a 20-MHz bit rate would be possible.

The most critical of the power-supply voltages is the 5-V transmitter supply. The LED is least efficient at high temperatures, but even at 70°C, transmitter output is
sufficient to maintain proper waveforms. The total delay time between the TTL input at the transmitter end is typically 120 ns, and the TTL output at the receiver varies little over the temperature range. Half this delay is the propagation delay in the fiber cable.

Measuring the analog swing of the MECL line driver and the resulting crosstalk in the temperature chamber would have been difficult because any leads hooked to it would have changed the results. But in testing the entire system, including the cable, in a temperature chamber, data rates remained equal or better than 10 MHz.

The breadboard, when dc coupled, cannot operate over the full temperature range of -55°C to 125°C because of the drift of both amplifier and comparator circuits. However, an ac-coupled version using a 50% duty cycle, as provided by a Manchester code, should easily handle that temperature range, because, in this type of operation, the effect of transimpedance-amplifier drift is eliminated.

The most difficult problem with a dc-coupled system is to keep the drift over temperature small, compared to the amplitude of the pulse signal. To minimize the drift, the MECL bias voltage was connected to the noninverting input of the comparator, thus forcing the comparator to track the dc component of the MECL amplifier over its temperature range.

Looking ahead

The proposed 16-channel fiber-optic transmission link is only a start. Several possible improvements should increase performance and efficiency in smaller, lower-cost versions. These improvements could be made in most parts of the system, but the key is to combine as many of the functions as possible in future systems.

In the receiver section, for instance, the separate ICs could be integrated in a single IC so that only two are necessary for the entire 16-channel setup. These circuits would include both quad amplifier and quad comparator, as well as the series regulator needed for the MECL bias voltage. What's more, including an automatic-gain-control circuit on the same chip would minimize the effects of using different cable lengths.

The size of the connector could be reduced or its form factor could be changed by arranging the photodiodes in one of two ways. By mounting four or eight photodiodes in a single package with 0.1-inch channel spacing, all 16 channels could be set in a single 1.6-in. row or two rows 0.8 in. long.

And, of course, mass-fabrication techniques such as casting or molding plastic materials for ferrules and covers would drastically cut costs. Metal housings, however, might be needed to shield the electronic portion in environments with severe electromagnetic interference. Also minimizing the need for precision dimen-

<table>
<thead>
<tr>
<th>TEST PARAMETERS</th>
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<th>3</th>
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<th>3</th>
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<tbody>
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</tbody>
</table>
| Cross modulation analog (mV pk-pk) | Vf = Transmitter supply voltage | Vp = Receiver supply voltage

For more information on the status of the technology of fiber optics and fiber-optic components today, see the special report in Electronics, Aug. 5, pp. 81-104.
Tunable notch filter suppresses hum

by Peter Lefferson
Milton Roy Co., St. Petersburg, Fla.

Close-tolerance components are not necessary in a hum filter if its rejection frequency can be adjusted to the frequency of the line-current hum. Such a filter is cheap and easy to build.

Notch filters are often designed into audio and instrumentation systems to eliminate unwanted signals or pickup such as 60-hertz line-frequency hum. For a given rejection frequency, close-tolerance components are usually required to guarantee repeatable design. An inexpensive, reproducible, narrow-stop-band circuit that can be built with wide-tolerance parts and can be tuned from 50 Hz to 60 Hz with 30-decibel minimum notch depth satisfies most hum-rejection requirements.

The illustrated circuit employs a bridge-differentiator RC network with active feedback. The notch frequency in hertz is given by:

\[ f_o = \frac{1}{2\pi C(3R_1R_2)^{0.5}} \]

where C is the farad value of the capacitors in the circuit; \( R_1 \) is the sum of the 4,700-ohm fixed resistor and the left-hand portion of the potentiometer, expressed in ohms, and \( R_2 \) is the sum of the right-hand portion of the pot and the fixed 75,000-ohm resistor. Although the operational amplifier can be of almost any sort, the 741 shown is typical. The notch bandwidth is set by the feedback gain of the noninverting amplifier, so replacing the 68-ohm resistor with a lower value narrows the rejection band.

With the given component values, this circuit can be tuned to reject the U.S. 60-Hz or the European 50-Hz power-line frequency. With 10%-tolerance capacitors, the minimum notch depth is 30 dB and the total 3-dB bandwidth is 14 Hz for 50 Hz and 18 Hz for 60-Hz center frequency. The insertion loss outside of the stopband is a negligible fraction of a decibel.

PROM decoder replaces chip-enabling logic

by Roy Blacksher
Signetics, Sunnyvale, Calif.

A microprocessor-based system with up to 6 kilobytes of memory and two input/output ports can be easily configured by using a single 32-word-by-8-bit programable read-only memory as the decoding element. In this application, the PROM generates all the chip-enable signals for the memory and also provides the clock pulses for the I/O ports so that it replaces a lot of random logic. And because the 6 kilobytes of memory are ample for most microprocessor applications, this arrangement is practical as well as simple.

The circuit diagram shows the implementation of the system, the heart of which is a Signetics 2650 microprocessor. The memory, which is segmented into 1-kilobit banks, can be all ROM, all random-access memory, or any combination of both. The diagram shows 3 kilobytes...
of ROM and 3 kilobytes of RAM. Each RAM bank consists of eight 2108 1-k-by-1-bit static RAMs, while a ROM bank consists of a single 2608 1-kilobyte ROM. Each of the I/O ports is an 8T31 8-bit bidirectional I/O interface element.

Ten of the address lines, A0 through A9, run from the microprocessor to all the six memory banks. The PROM enables just one of these ROMs or RAMs to read or write at a memory location indicated by the 10-line memory bus. The bus can have 210 or 1,024 different address descriptions, and the enable signals from the PROM can apply these to any one of the six memory banks, so the total number of unique memory locations for data from the 8-bit data bus is 6 kilobytes.

The 2650 microprocessor multiplexes address and I/O information on two of its lines—i.e., lines A13-E/NE and A14-D/C. In memory operation, these serve as the two highest-order address lines and thus determine which 8-kilobyte page of memory is addressed. In I/O operations, if line A13-E/NE is low, then either port D or port C is enabled, depending on whether line A14-D/C is high or low. The M/IO line of the microprocessor indicates whether the A13-E/NE and A14-D/C lines are in memory or I/O operation; the M/IO line is high for memory operation and is low for I/O.

As the schematic shows, input terminal A4 of the PROM is driven by the M/IO line from the processor. Therefore A4 must be high in any PROM input that enables one of the six memory banks, and it must be low to enable, or clock, either I/O port.

The WRP (for write-pulse) line from the processor is connected to input terminal A1 of the PROM. This line must be high to enable any RAM for either reading or writing. The state of the WRP line does not matter for ROM or I/O operation.

PROM input terminal A2 is driven by microprocessor address line A10. This line must be high to enable a ROM and low to enable a RAM.

Input terminals A1 and A0 of the PROM are driven by the multiplexed lines already discussed; they determine page number in memory, or choose between ports in I/O operation.

The one other input to the PROM is the operation-request (OPREQ) line from the processor, which enables the PROM. This line must be high to enable any RAM, ROM, or port.

The ROMs and RAMs are enabled by low signals; hence the notation (RAM A) indicates that RAM A is enabled, (ROM B) means that ROM B is enabled, etc. However, the I/O ports are clocked, or enabled, by high signals, so (PORT C) means that port C is enabled.

The PROM transfers the microprocessor's control and address lines into appropriate control signals to enable the memory and I/O according to the relationships shown in Table 1. In program form, the coding of the PROM is as shown in Table 2. Notice that input words 0 through
TABLE 1.
ENABLING CONDITIONS FOR ROMs, RAMs, OR I/O PORTS

<table>
<thead>
<tr>
<th>Component</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAM A</td>
<td>(OPREQ) (M/10) (WRP) (A13·E/NE) (A14·D/C) (A10)</td>
</tr>
<tr>
<td>ROM B</td>
<td>(OPREQ) (M/10) (A13·E/NE) (A14·D/C) (A10)</td>
</tr>
<tr>
<td>RAM C</td>
<td>(OPREQ) (M/10) (WRP) (A13·E/NE) (A14·D/C) (A10)</td>
</tr>
<tr>
<td>ROM D</td>
<td>(OPREQ) (M/10) (A13·E/NE) (A14·D/C) (A10)</td>
</tr>
<tr>
<td>RAM E</td>
<td>(OPREQ) (M/10) (WRP) (A13·E/NE) (A14·D/C) (A10)</td>
</tr>
<tr>
<td>ROM F</td>
<td>(OPREQ) (M/10) (A13·E/NE) (A14·D/C) (A10)</td>
</tr>
<tr>
<td>PORT C</td>
<td>(OPREQ) (M/10) (A13·E/NE) (A14·D/C)</td>
</tr>
<tr>
<td>PORT D</td>
<td>(OPREQ) (M/10) (A13·E/NE) (A14·D/C)</td>
</tr>
</tbody>
</table>

Table settings. Six output lines from the microprocessor go to the PROM, as shown in the circuit diagram. Table 1 indicates the states these lines must have to enable any one of the memory banks or I/O ports. (A read/write signal, R/W, from the microprocessor directly to the RAMs determines whether a byte is read into or out of a RAM; if the PROM enables one of the I/O ports instead of a memory bank, the R/W signal determines whether the port reads data on to the data bus or off it.) Table 2 contains redundancy because many of the input lines are “don’t care” lines for memory banks or for I/O ports.

TABLE 2. CODING OF 82S123 PROM

<table>
<thead>
<tr>
<th>WORD</th>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>COMPONENT ENABLED</td>
</tr>
<tr>
<td>A0</td>
<td>A1</td>
<td>A2</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>2</td>
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<td>27</td>
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<tr>
<td>29</td>
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<td>1</td>
</tr>
<tr>
<td>30</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

15 all have A4 low, producing I/O operation, and words 16 through 31 have A4 high for memory operation.

The arrangement described here decodes only the first 10 address lines (A0 - A9) of the microprocessor, along with the two page-address lines A13-E/NE and A14-D/C. Lines A11 and A12 are not decoded and are therefore “don’t care” lines, so the same 1 kilobyte of information can appear four places on one page. Only the first three pages are used in this system, although the ROM and RAM position on each page can be reversed by simply recoding the PROM. Recoding also allows the use of page 3.

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.

Electronics/September 2, 1976
Check list for 4,096-bit RAMs flags potential problems in memory design

Startup, noise, and other aspects of random-access-memory operation still vary enough, even in 4-k devices, to need careful checking out

by R.C. Foss and R. Harland, Mosaid Inc., Ottawa, Canada, and J.A. Roberts, Computing Devices Co., Ottawa, Canada

After all their timing and applications problems with 1103-type 1,024-bit random-access-memory chips, memory-system designers have been looking forward to presumably easier-to-use 4,096-bit devices. However, a 4-k-device user must still grapple with many subtleties of operation before he can confidently pass a design on to production. One of the best ways he can review his design is with a detailed check list.

Such a check list, first of all, offers a structured method for evaluating designs. If it is really good, it will show a deeper insight into design than simply asking such mundane questions as “Have all tolerances been examined?” or “Have the manufacturer’s design rules been adhered to?” But also note that a well-constructed check list can allow an objective, dispassionate critique of a design and thus avoid conflicts arising from simple personal preferences. The check list should command the same respect as a company’s design standard.

The check list on page 106 is not comprehensive, but it does represent a good starting point. It covers such trouble areas in memory-system design as startup, refresh modes, temperature effects, noise, latches on address and data buses, and clock circuitry.

1. Cold startup

The first point to check is what happens when power is applied. A memory chip usually is not required to successfully write valid data in its first active cycle after the supply voltage, \( V_{DD} \), is turned on. Most memory chips, in fact, require one or more active cycles before attempting a valid operation. However, this point could easily be overlooked in planning an incoming inspection test sequence, where each part is to be briefly checked before actual usage. The precharge clock generator shown in Fig. 1, for example, is used by several makers. On initial switch-on, a poor logic-1 level occurs at the output, and the circuit nodes, which are driven by the precharge clock or inverse of the chip-enable signal, \( CE \), will not be correctly set. At least one active cycle is needed to charge the bootstrap capacitor fully so that an output level can be set solidly at the supply voltage, \( V_{DD} \). Here, Intel often uses either a resistance load or a bootstrapped load, paralleled by a resistor to overcome low levels in cold starts. Some other manufacturers, however, have memory chips requiring clocks bootstrap-driven above \( V_{DD} \). When this is the case,

![Bootstrap Circuit Diagram](image)

1. Startup. This precharge clock generator requires at least one cycle to charge the bootstrap capacitor (the MOS transistor with drain and source shorted) before the output reaches \( V_{DD} \). The resistor shown dashed is sometimes used to help raise the output.

2. Refreshing. With burst refresh, in which all 64 cycles are grouped together, precharge levels can deteriorate more than when the 64 cycles are distributed over this 1-ms refresh time. Distributed refresh also smooths the load on the power supply.
How to gain clout with a RAM supplier

The most satisfied users of 4-k RAMs appear to be at two extremes—large-computer manufacturers who maintain their own extensive qualification and incoming inspection department, and small-volume users who can get by with data sheets and manufacturer's application notes. Medium-scale users, such as many of the smaller mini-computer manufacturers, face the biggest problems because they cannot afford large evaluation centers and yet must come up with optimum designs for their memory systems.

Most large-volume users have become more aggressive in gathering technical information and now take a number of steps at their own expense. They:
- Directly monitor the component through the design and vendor-qualification stages.
- Evaluate early engineering samples (probably after signing a nondisclosure agreement) and feed back data to the vendor.
- Purchase a significant quantity of early production samples for detailed in-house parametric and sensitivity testing.
- Demand access to and even control over the vendor's internal test specifications, which are based on the user's purchase specifications.

Often, in the early life of a component, the large user knows more about its deficiencies than the vendor. The user's extensive testing will show the component's weaknesses, and in fact many of the design changes made to new RAMs are directly attributable to the feedback from large-volume users.

The small-volume user of RAMs, on the other hand, also has certain protection mechanisms available to him. He can:
- State on each purchase order that the product must conform to a particular, dated, vendor data sheet and must be from a particular mask revision. (The mask-revision number can sometimes be determined from a microscopic examination of the chip; usually it is also possible to gain this information by calling the vendor product engineer.)

The small-volume user of RAMs, on the other hand, also has certain protection mechanisms available to him. He can:
- Design the memory cards as closely as possible to the published application notes.
- Use vendors who have adequate applications service—preferably those who also employ field-applications engineers.

The medium-sized user of RAMs is in an extremely vulnerable position. Whereas the small user usually is not pushing the state of the art and can design in larger safety margins, the medium user typically deals with larger memories and wants to get as much as possible from the components. Without the weight to monitor the design phase, to engage in qualification or early product testing and to influence the design changes, he is open to serious application problems. But there are several alternate possibilities for regaining control and for the generation of component design knowledge.

Above all, since vendor staff engineers are not anxious to reveal information that could be considered derogatory to their own components, it is vital to display a disarming degree of knowledge about their components early in any communications. This is where the help of third-party design authorities, who are engaged in evaluating RAM designs, can prove invaluable. They will not only supply insight into possible application problems but will help the RAM user gain the vendor's respect. All pretense will collapse at such a juncture, and it is in everyone's long-term interest that it should do so.

In addition, the user of a moderate volume of RAMs should:
- Use a purchase specification to define simple parametric and sensitivity testing and not simply to read back the vendor data sheet.
- Also, quote the mask-set revision number and require the marking of the component with the user specification number. Since manufacturers make frequent mask changes to eliminate bugs, improve performance, or enhance yield, it cannot be assumed that the work to prove in and accept a part necessarily remains valid, particularly in the case of unwritten parts of specifications. The supplier may not appreciate that such second-order characteristics are important in a system or even that the characteristics have changed as a consequence of a "fix" put in for other reasons.

- Monitor the design position, the design status, and the vendor-personnel responsibilities with a questionnaire such as is shown here.

The above procedure makes it possible to reject components which have undergone unnotified design changes, to communicate usefully with the appropriate vendor staff members, to develop simple incoming-test procedures, and to generate adequate design criteria for system engineers.

A related problem is with refresh-time specifications. Once the time limit for refresh is exceeded, not only can data be lost in active memory cells, but voltages in peripheral parts of the chip, such as the decoder and bit-line and address drivers, can droop away to an illegal condition and a preconditioning cycle will be needed.

In some RAMs, the need to restore parts of the peripheral circuitry, as well as the cells themselves, makes for a difference between "burst-mode" refresh (in which all 64 refresh cycles are grouped together, say, 0.5 microsecond apart) and "distributed-mode" refresh (in which the 64 cycles are spread over the entire 1-ms refresh time, say, 15 μs apart—see Fig. 2).

Distributed refresh can give a valuable bonus if, for example, any major line in the memory floats while the RAM is quiescent. It will restandardize the level of that line more often. Distributed refresh also smooths the load on the power supply and is, therefore, generally preferred. In systems using battery backup, however, burst mode may have to be used, to make the most economical use of power by allowing shutdown of associated logic elements between refresh cycles.

V₀₀ noise susceptibility

Most designs that use balanced sensing also generate an on-chip reference potential, V₀₀, which is a level intermediate between a stored 1 and a stored 0. The exceptions use geometric scaling between a dummy cell and the storage cell. In debugging a new design, varying
3. Reference generator. The chip reference voltage is commonly developed with a divider circuit and a source follower. While negative transients on the supply line are masked by the charge on the load capacitance, positive transients are stretched into variations in $V_R$.

4. Latches. Data-input lines may be latched in one of two ways—as 1's latch (a) or as 0's latch (b). After a write transition, the $D_{in}$ line can change positively in the 1's latch, negatively in the 0's latch. Internal signal $R/W'$ is the inverse of external input $R/W$.

$V_R$ can be a valuable technique for exploring the safety margins of the part. However, in actual operation, such variations, if excessive, can give read errors. Variation of $V_R$ as a function of the stored data pattern is particularly undesirable, while variation of $V_R$ with $V_{DD}$ makes the part sensitive to noise on the power bus.

A typical reference-generator circuit used by several major manufacturers is simply a potential divider and source follower (Fig. 3). Since there is no dc current drawn from $V_R$, there is less sensitivity to negative-going transients—such as those that occur when a heavy load is suddenly placed on the $V_{DD}$ bus. That’s because the circuit acts as a peak rectifier. If $V_{DD}$ suddenly dips, the level of $V_R$ is maintained for a while by the charge on its load capacitance even though the source follower is cut off. However, if a positive transient—a noise spike—occurs on the $V_{DD}$ line, $V_R$ will rise a proportionate amount of this transient and hold the new higher level until the extra charge can leak away.

A positive transient may also occur after heavy spike loads on $V_{DD}$. When enabled, a chip may go from near zero current to over 100 milliamperes. While $V_R$ will not fall in sympathy with the fall in $V_{DD}$, inadequate local decoupling may cause overshoot as the current spike combines with the printed-circuit track inductance.

A second source of $V_{DD}$ noise injection is in the storage cell itself. Most one-transistor-cell memories actually have two transistor structures per bit—one as the access device, and the other with the gate element connected to $V_{DD}$ as a storage capacitor. Any variation in $V_{DD}$ between


<table>
<thead>
<tr>
<th>ITEM</th>
<th>REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SWITCH ON</td>
</tr>
<tr>
<td>2</td>
<td>COLD START</td>
</tr>
</tbody>
</table>
| 3    | REFRESH    | (a) If a chip is left for more than the specified refresh time-limit (usually 2 ms), does the system expect to lose only the stored data without recognizing the need for a “cold start” resetting cycle?  
(b) Does the system use burst-mode refresh or refresh cycles distributed through the refresh period? (The latter is preferable with most chip designs and highly desirable where, in a memory array, the internal design allows major lines to float while the memory is quiescent.)  
(c) Does the system allow the Y address to change while it’s refreshing? (Although only the six X addresses must be cycled through to refresh all 4,096 bits, a few chip designs are NOT “don’t care” on their Y address inputs during that time and should be tested for refresh operation with differing Y-address patterns.) |
| 4    | TEMPERATURE| Is the thermal design of the system adequate? (Refresh time is highly dependent on chip temperature, and access time can increase by 15% to 20% at the maximum operating temperature. The usual “ambient” specification is extremely vague. Board type, orientation, use of sockets, etc., can all drastically affect case-ambient thermal resistance. Case temperature is usually a better defined condition and is used in device testing.) |
| 5    | NOISE      | Is the board noise environment compatible with the device used? |
| 6    | ADDRESS BUSES | (a) Do the drivers guarantee the pseudo-TTL levels generally required? (A safety margin on these levels is generally highly desirable for safe operation of the parts driven.)  
(b) Have spike loading currents been considered? (Some memory chips draw a relatively heavy load current at the instant the address bus is sampled.)  
(c) Has the behavior of the memory been checked for the condition where address state changes during the address “don’t care” time of an active cycle (e.g. reset high to save driver power)?  
(d) Can the driver handle charge feedback into it? |
| 7    | D\textsubscript{IN} LATCH | Has the different behavior of nominally equivalent parts with respect to D\textsubscript{IN} latching been considered? Is the system compatible in this regard with all the vendors it is planned to use? |
| 8    | D\textsubscript{0} LOADING | Does \( D_0 \) loading correspond to data-sheet specification conditions? (These are not always the same as the maximum load driving capability.) |
| 9    | D\textsubscript{0} LATCH | In 16-pin parts with a \( D_0 \) latch, have all the conditions for latch deselection been considered? In particular, if RAS only refresh is planned, what provision is made to deselect this latch? |
| 10   | CLOCK DRIVERS | Do the clock drivers provide the required clock levels at all part location on the memory boards? (With high-level drivers, soft failures can occur if the CE level falls too far below \( V_{DD} \) even on a noise spike. Compatibility of drivers and memories is particularly difficult if a common \( V_{DD} \) feeds both.) |

writing and reading is thus impressed on the stored level. The use of dummy-cell structures, as in TI’s 4-k RAMS, will compensate partially for this effect. Parts that do not use the reference level stored on a dummy cell are inherently more noise-sensitive. Thus, the permissible data-sheet variation in \( V_{DD} \) should not be interpreted as a change allowable while the part is in operation.

There is no really good design of address buffers to be found in any of the presently available parts. None meets all of the ideal criteria and, in fact, many fall far short. Ideal address buffers would:

- Operate with true TTL levels of 0.8 v and 2.0 v (none achieves this).
- Latch the address and have a true “don’t care” state after address hold time. Not only should the output level not change if the inputs are subsequently changed, but there should be no other second-order changes resulting in, for example, input current drawn, power-supply
current drawn, or drive conditions to decoders.
- Present only a moderate capacitance loading and neither draw spike current at the critical instant when address state is being read off the address bus nor pump charge back into the address driver.
- Fail in a "digital" way as input levels degrade. If output levels or internal time delays change significantly with input levels, then marginal parts will show pattern sensitivity as decoders are fed poor signals.
- Operate independently of other address buffers on the chip to eliminate any potential interaction.

**Differences in data-in latches**

Inputs are latched in 4-k RAM addressing as the chip-enable signal (CE) rises—or in 16-pin RAMs as row-address-select signals (RAS) fall. Much less well-defined, however, is the behavior of the data-in line (DIN). For the most part, specifications imply DIN should be stable as R/W goes to the write condition. In 16-pin designs, and in some 18- and 22-pin parts as well, DIN is latched at that time.

But the user cannot assume that this is always the case. The DIN circuitry of TI's memory chip, for example, is a "1's latch" (Fig. 4a). This allows DIN to change after the transition to write—but only in a positive-going sense. Then a latch action is created by the discharge of a node that has been precharged during CE time. The ease of use of the TI 18-pin 4050, with its common I/O pin, depends on this feature.

Conversely, the Intel 2107B is a "0's latch" (Fig. 4b), which latches only as input data goes from 1 to 0 again by the discharge of a precharged node. As yet another variant, the AMD 9060 does not latch data at all. This is simpler in some respects, because DIN timing can vary relative to R/W and still allow correct data to be written in. This increases susceptibility to noise at a time when other memories are in a "don't care" state.

**Freeing the output latch**

In 16-pin RAMs, an output latch holds data into the next cycle. The combinations of conditions necessary to free that latch and restore a high-impedance output state are complex and differ from part to part.

Most specifications cover the case where the latch will be maintained. For example, it may be stated that the occurrence of a CAS rising edge no later than 50 nanoseconds after the RAS rising edge will not deselect the latch. But they do not explain and specify all the ways in which deselection is achieved.

The term "output latch" is itself liable to mislead the user. In practice, the latch storage function will most likely be dynamic and may even consist only of the charge left on the output transistor gates. This arrangement (Fig. 5) requires that the user understand several MOS circuit subtleties.

First, it is very undesirable to apply any load disturbances to the output pin. Any variation in output voltage couples back into the gate and can help bootstrap it off. More important, an unusual refresh problem occurs at high temperatures as the refresh time limit of the memory is approached. The stored charge may have leaked enough to bring output-current drive parameters outside specification limits.

A further consequence of the dynamic nature of an output latch is indeterminate operation if RAS-only refresh cycles are attempted. Since only the X-address bits are needed for refresh, there is no need to supply the column address strobe at all (or there shouldn't be). Depending on both the chip and the system design the CAS clock may have to be used, if only to clear down this output latch.

To help explain several of these points, sketches of various circuits have been used, but their suppliers are not always identified. The omission is deliberate because it is by no means sure that the circuit given represents the latest parts. A circuit configuration a year or so old, which is known to have caused problems, can reasonably be expected to have been changed by the manufacturer.

Finally, one bit of advice on "unwritten" portions of specifications. These are areas in which the relatively chaotic second-source situation on 4-k memories hurts most. Not only can the guaranteed limits and specified timing conditions vary in supposedly interchangeable parts, but when a follow-on producer aims his skills at a device specification, the result is often a part whose second-order characteristics differ drastically. Thus, it is not advisable to mix parts from different suppliers on one board.
A programmable hand-held calculator can identify spurious frequencies generated in the mixing of two signals. For instance, an HP-25 calculator can be used in place of a spur chart or a digital computer to calculate these values both accurately and quickly. The same HP-25 program is used for both up-conversion and down-conversion, and in contrast to many graphical methods, the maximum order of spur product need not be limited.

If frequencies \( f_1 \) and \( f_2 \) are mixed, some of the resulting frequencies are:

\[ f_s = \pm Mf_1 \mp Nf_2 \]

The arrangement of signs eliminates the trivial situations in which both terms are positive, and the meaningless cases where both are negative. \( M \) and \( N \), which are positive integers, are called the coefficients of a spur, and the order of the spur is the sum \( (M + N) \). The HP-25 program analyzes the situation sketched in Fig. 1. The lower input frequency, \( f_1 \), lies in the range from \( f_{11} \) to \( f_{12} \); the higher input frequency, \( f_2 \), lies in the range from \( f_{21} \) to \( f_{22} \), and the calculator finds all values of \( M \) and \( N \) that yield frequencies \( f_s \) in the test range of interest between \( f_{B1} \) and \( f_{B2} \).

The calculator begins the analysis with the order equal to 1. When both first-order spurs have been tested, the calculator tests all second-order spurs. The process continues until a spur falling in the test range is found or until the calculator is stopped; to conserve time, the program tests two products simultaneously. The calculator displays the coefficients in the form \( M + N/100 \) for the sake of brevity so that a \( -2 \times 5 \) spur is shown as 2.05, as is a \( 2 \times -5 \) spur. The user decides, if he wishes, which coefficient is negative.

The calculator selects one set of positive values for \( M \) and \( N \). Each set defines two mixer products, either or both of which may be spurs—i.e., in the output pass-band. The potential spurious product \( P_1 \) results when the term \( Mf_1 \) is positive and the term \( Nf_2 \) is negative. \( P_2 \) is the mirror image of \( P_1 \), in which the term \( Mf_1 \) is negative and \( Nf_2 \) is positive. Either or both products may be spurs, and if the calculator finds that \( P_1 \) does not fall in the output test range, it tests \( P_2 \). If \( P_1 \) does fall in the test range, the calculator displays the values of \( M \) and \( N \). If \( P_1 \) and \( P_2 \) are not in the test band, the calculator proceeds to the next set of values. The program is shown in the table.

The program is run by following these steps:
Log-ratio module measures high resistances

by Bucky Crowley


It doesn't take a voltmeter with a range switch to provide full-range measurement of low-level currents or high resistances. All it takes is a log-ratio module coupled with a voltmeter.

The module compares an unknown current to a reference current, producing an output voltage proportional to the ratio of the logarithm of the two currents. This proportionality allows accurate measurements over large ranges of input current. The inexpensive log-ratio module is a standard product from such firms as Analog Devices, Teledyne Philbrick, Intronics, and others.

The current-input terminals of the module are internally connected to inverting terminals of operational amplifiers, so they are at virtual ground. Therefore the driving voltage is applied to just one end of the device under test, as shown in the circuit diagram.

Reference currents of either 10^-9 ampere or 10^-14 A are provided. The output voltage is equal to \( k \times \log(I_{1000}/I_{REF}) \), but here the module has been connected so that \( k \) is 1 volt per decade. The bias current into the op amps is less than 10^-11 A, so resistance measurements can be accurate within 1% to 10^-10 ohms (10 V and 1 nanoampere) and have resolution of 10^-12 ohms (10 V and 10 picoamperes).

The table shows how this measurement technique is used for the production testing of different components. For example, to test the leakage in diodes, the reference input is set to a current that represents an acceptable level; screening for leakage current greater than 10 nA.
More Super-Fast Silicon Rectifiers

Featuring 30 nanoseconds Reverse Recovery Time

A breakthrough in junction technology makes Super-Fast silicon rectifiers possible. These new high speed silicon rectifiers feature low forward voltage drop at higher operating currents and reverse recovery time better than 30 nanoseconds. In addition, these devices have extremely low reverse leakage and high surge ratings. Super-Fast rectifiers use Semtech’s proven Metoxilite non-cavity monolithic high temperature construction. Designed for high frequency applications, such as high speed switching regulators and converter circuits. Semtech’s Super-Fast silicon rectifiers are stocked for immediate delivery.

LO-VF Metoxilite

Available as JAN, JAN TX & JAN TXV to MIL-S-19500/503 EL

Types: 1N6073, 74 & 75 (Tr 30ns)
PIV: 50, 100 & 150V
Reverse Current (Max.): 1µA @ 25°C
Instantaneous Forward Voltage @ 3.0A: 1.0V @ 100°C
Capacitance @ 12V DC (Max.): 20 pF
Single Cycle Surge Current: 50A
Dimensions (Max.): Body .070” D x .165” L
Leads .03” D x 1.25” L

Types: 1N6076, 77 & 78 (Tr 30ns)
PIV: 50, 100 & 150V
Reverse Current (Max.): 5µA @ 25°C
Instantaneous Forward Voltage @ 3.0A: 1.0V @ 100°C
Capacitance @ 12V DC (Max.): 50 pF
Single Cycle Surge Current: 75A
Dimensions (Max.): Body .110” D x .165” L
Leads .040” D x 1.10” L

LO-VF DO-5L Stud

Types: STFF05, 10 & 15 (Tr 40ns)
Add “R” to type number for reverse polarity
PIV: 50, 100 & 150V
IR (Max.) @ PIV: 25°C
Capacitance @ 12V DC: 10 pF
Single Cycle Surge Current: 75A
Dimensions (Max.): Body .070” D x .165” L
Leads .031” D x 1.25” L

Types: 3FF30, 3FF40 & 3FF50 (Tr 30ns)
PIV: 300, 400 & 500V
Reverse Current (Max.): 5µA @ 25°C
Instantaneous Forward Voltage @ 1.5A: 1.5V @ 25°C
Capacitance @ 12V DC: 20 pF
Single Cycle Surge Current: 25A
Dimensions (Max.): Body .154” D x .165” L
Leads .040” D x 1.10” L

LO-VF DO-4 Stud

Types: SFF05, 10 & 15 and *SFSS05, 10 & 15 (Tr 30ns)
PIV: 50, 100 & 150V
Reverse Current (Max.): IR
10 µA @ 25°C
*10 µA @ 25°C
Instantaneous Forward Voltage @ 10A:
1.2V @ 25°C
Single Cycle Surge Current: 250A
Dimensions (Max.): Body .64” D x .50” H
Leads ¼ 28 UNF X .43” L

DO-4 Doublers & Center Taps

Types: SDFF05, 10 & 15;
SPPF05, 10 & 15
*SPSS05, 10 & 15 (Tr 30ns)
PIV: 50, 100 & 150V
Reverse Current (Max.): IR @ PIV:
10 µA @ 25°C
Instantaneous Forward Voltage @ 10A:
1.1V @ 25°C
Single Cycle Surge Current: 125A
Dimensions (Max.): Body .424” D x .405” H

NEW

LO-VF DO-5DL

Isolated Stud

Types: STFF05DL, 100L & 15 DL
(Tr 30ns)
PIV: 50, 100 & 150V
Reverse Current (Max.): IR 20µA @ 25°C
Instantaneous Forward Voltage @ 10A:
1.2V @ 25°C
Single Cycle Surge Current: 250A
Dimensions (Max.): Body .64” D x .50” H
Leads ¼ 28 UNF X .43” L
**Covering many ranges.** A log-ratio module produces an output voltage proportional to the logarithm of the ratio of currents at inputs, so currents or resistance values can be measured without need for a range switch. Connections shown here give 1 V per decade of current ratio, and a reference current of $10^{-6}$ A. Hence, signal currents of $10^{-3}$ to $10^{-6}$ A (or test resistors of $10^4$ Ω to $10^9$ Ω) yield outputs of 0 to +5 V.

**TYPICAL LOW-CURRENT MEASUREMENTS**

<table>
<thead>
<tr>
<th>INPUT TO DEVICE UNDER TEST</th>
<th>DEVICE UNDER TEST (CONNECT TO SIGNAL INPUT)</th>
<th>MEASUREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1 V</td>
<td></td>
<td>Incoming sorting of resistors without range switching, over 6 decades (1 kΩ to $1 \times 10^9$ Ω).</td>
</tr>
<tr>
<td>-10 V</td>
<td></td>
<td>Switch leakage.</td>
</tr>
<tr>
<td>-10 V</td>
<td></td>
<td>Connector leakage.</td>
</tr>
<tr>
<td>-10 V</td>
<td></td>
<td>Printed-circuit board process leakage.</td>
</tr>
<tr>
<td>Voltage per specification</td>
<td></td>
<td>Diode leakage.</td>
</tr>
<tr>
<td>Voltage per specification</td>
<td>$R_{\text{LARGE}}$</td>
<td>Capacitor leakage.</td>
</tr>
<tr>
<td>-10 V</td>
<td></td>
<td>Potting materials, insulating oils, etc.</td>
</tr>
</tbody>
</table>

requires a reference current of 10 nA (0.1 V and 10 megohms). Acceptable diodes will produce negative output voltages, and rejects will yield positive numbers, the exact values on the voltmeter being expressed in logarithms. For instance, if the meter reads +2.00 V, the device fails (because the sign is positive), and the leakage current is 100 times worse than specification because the antilog of 2 is $10^2$ or 100.

In measuring the leakage current of a capacitor, a few extra components are used, as shown in the test arrangement in the table. The capacitor is charged to the desired voltage through the 10-kilohm resistor, and the switch is opened to take the reading of leakage. The other resistor, $R_{\text{LARGE}}$, prevents noise from being coupled from the supply into the input. This resistor should be as large as possible, but not large enough to cause a significant dc drop at the expected leakage current.

Engineer's notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.
Another odd job
for solar cells

If you need a simple noise generator for test purposes and you have a selenium solar cell handy, try biasing it with a voltage source and then applying the cell’s output to an audio- or radio-frequency amplifier, suggests Calvin R. Graf of San Antonio, Texas. (In an Oct. 30, 1975 newsletter item, Graf—a heavy hitter on this page—showed us how to make a solar cell into a moisture detector.) Whether it is forward- or reverse-biased, the solar cell will produce hiss-like white noise with an amplitude that increases directly with the bias voltage applied over the range of a few volts to about 15 v. And although it can work in the light, it’s better kept in darkness, says Graf, because an artificial light source, like an incandescent or fluorescent lamp, causes 60-hertz power-line hum that overrides the cell’s white-noise output, especially when the cell is forward-biased. Fluorescent lamps, he notes darkly, are worse than incandescent.

PROMs make it easy to change frequencies

Designers of phase-locked-loop frequency-control circuits can take a cue from some manufacturers of citizens’ band radios, who have discovered how to change a circuit’s operating frequency without redesigning it. They use a programable read-only memory to control the programable counter that locks the phase-locked loop to a particular frequency. A simple code change in the field then results in a new frequency.

A see-through pc board

Looking for a fancy circuit board? Try Rogers Corp., supplier of die-stamped printed-circuit boards. Its Electro Components division in Rogers, Conn., (203) 774-9605, will accept special orders for fiber-glass boards with conductive patterns of copper, stainless steel, brass—you name it. The division’s latest is a see-through board made of Lexan, a popular material for storm doors and windows. The plastic was chosen, say Rogers engineers, because it lends itself to die stamping. In fact, die stamping is the key to making pc boards out of offbeat materials that take poorly to the normal board laminating and etching processes.

How to cash in on scrap disk heads

Before throwing away any crashed heads—worn-out magnetic-disk heads to those of you in other businesses—check with Trans-Data Corp., 170 Glenn Way, Belmont, Calif. 94002. The company repairs and refurbishes disk equipment for third-party maintenance companies, OEM manufacturers, and disk users, and it is looking for disk heads that are compatible with the IBM 2314 or 3330 models. Call Trans-Data’s Don Collier at (415) 593-8545.

It’s simple, we’re told, to make sample-and-hold more precise than of old

You can, of course, build a sample-and-hold circuit by using an analog-to-digital converter to drive a digital-to-analog converter that controls a programable power supply [Electronics, July 22, p. 120]—but there’s an easier way, says Henry E. Schaffer, professor of genetics at North Carolina State University in Raleigh. Just replace the two converters with a single tracking a-d converter.

Better still, it’s a more accurate method. Included in a tracking a-d converter is an up/down counter that drives a d-a converter, and when disabled stops the converter’s output at its most recent value. Since this internal d-a converter operates inside a feedback loop, its accuracy is improved to the limits of its resolution, says Schaffer. Like all precision sample-and-hold methods, this one’s slow—but that’s not a drawback in many applications.

—Laurence Altman
SERIES 40's Frequency Marker ends frequency-chasing and control-twiddling.

1. **Sweep the Unit Under Test.** Here, for example, is the output of a filter being swept from 600 Hz to 60 KHz on channel 1 of the scope.

2. **Select Sweep Marker.** On Interstate's new F47 function generator, you select "Marker" and set its TTL output on the scope's channel 2.

3. **Adjust the vernier.** Then you fine-tune the marker vernier to pinpoint the TTL step at the exact position on the waveform for which you want to know the frequency. On the scope shown, the marker is positioned at the 70% roll-off point...the −3 db level.

4. **Select Calibrate Mode.** Next, you switch from the Continuous Sweep Mode to the Calibrate Mode.

5. **Get the exact frequency.** A counter at the F47's output will then display the precise frequency at which the filter's −3 db point occurs.

SERIES 40 Function Generators – New from INTERSTATE

SERIES 40 is the only function generator line with marker, 10-step frequency calibrator, state-of-the-art high output voltage to 40 v p-p open circuit, and Interstate's exclusive direct-reading sweep width control. The best function generators money can buy from $475 to $695. Write for the new SERIES 40 catalog for complete specifications and prices.

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Electronics/September 2, 1976

Circle 113 on reader service card 113
Microprocessors dominate scene at sold-out Wescon

For its silver anniversary, the Western Electronic Show and Convention, which is being held in Los Angeles September 14 through 17, may be celebrating one of its most successful shows. Unquestionably the stimulus comes from the booming electronics industries, a welcome condition that Wescon organizers are hoping will renew buyers' interest in big trade gatherings.

In terms of numbers of exhibitors and projected attendance, the 1976 show should not only be the largest since 1970, but could approach the halcyon days of the 1960s, when Wescon, together with the East Coast spring convention of the Institute of Electrical and Electronics Engineers, dominated the electronic industries new-product introductions.

Sold out since early summer, Wescon/76 has attracted nearly 400 companies, who will occupy more than 740 exhibition units in 170,000 square feet of the Los Angeles Convention Center. (Last year's show in San Francisco's Brooks Hall had 530 booths.) Moreover, Wescon officials are expecting from 30,000 to 35,000 visitors at some three dozen technical sessions.

Prospects for big trade shows began picking up at last year's gathering, when more than 31,000 visitors turned out, marking an upswing from several lackluster earlier shows. Next came this spring's Electro/76, the IEEE's successful Boston event. It drew 22,000 attendees at the technical sessions and saw some brisk exhibitor action on the convention floor. Thus, two good U.S. trade shows in succession have set the stage for big things at Wescon/76.

Microprocessors aplenty

While good business provides the backdrop, the colorful icing on Wescon's 25th birthday cake is the glamour aura of microprocessors that promises to permeate the show. Along with more than one third of the technical sessions devoted to some aspect of the devices, a complete array of processor product lines will be there. Two suppliers, Intel and Mostek, will show their own devices, which also will appear with other lines at the booths of major electronics distributors.

The excitement of having the most advanced semiconductor products at a show is considered an important event, lacking since the big semi houses pulled out in the mid-1960s. Cramer Electronics, occupying 15 booths, and Hamilton-Avnet Electronics, with 14 booths, as well as Semiconductor Specialists and Wyle Distribution Group, are four major distribution firms showing complete microprocessor lines and related design and simulation systems. In addition, Avnet will display microprocessor software from Ryan-McFarland Co., which it calls a first for distributors.

An interesting question that will be raised by the attention distributors will undoubtedly get with their processor hoopla is: "What happens at future shows?" One view holds that the big manufacturers will remain content to let distributors carry their selling load, supporting them with money and technical personnel. Others familiar with the highly competitive nature of semiconductor marketing speculate that swelling Wescon crowds at distributor booths might well cause the makers to jump right back into the shows.

Avnet president Tony Hamilton agrees with the latter view. "My feeling is this trend will retrigger the interest of chip manufacturers to come back in, in a big way, and with their full lines," he says.

While resolution of this question will play a big role in determining the shape of future Wescons, the product composite of the show is already changing. Past Wescons maintained a rough balance between the components/packaging and instrument categories, with each having about 40% of the exhibits. This year finds the former category up to about 55 – 60% of the exhibits. Instruments, with the same number of companies as in the past, is down to about 35% of a larger show.

Moreover, new product activity at Wescon appears to be somewhat stronger than in 1975 (see p. 131). But it is below Electro/76, where companies rushed new model introductions to take early advantage of the upturn in the national economy.
Wescon can trace its origins to 1944, when a group of West Coast electronics pioneers decided that a trade show would be a good way to sell products in the post-world-war period. Spearheaded by the late Les Hoffman, a prominent manufacturer of electronic equipment, the show made its debut at the Los Angeles Elks Club. It featured mostly radio equipment laid out on card tables. A few hundred local engineers attended.

So it remained through the late '40s—a small regional event sponsored by the West Coast Electronics Manufacturers' Association (now called WEMA), which put on the trade exhibits, and the Institute of Radio Engineers (the IEEE now), which organized the technical program. But, in 1949, the institute pulled out and held its technical sessions separately (goaded by purists who saw the trade portion of the convention as a distraction). The trade show almost died.

In 1952, the manufacturers convinced local institute officials to come back. Wescon as it's presently conceived got started—this time in the Long Beach Municipal Auditorium where 25 companies displayed their wares. A few years later, the show began alternating between Los Angeles and San Francisco. Since then, participation has built steadily, with the peak years coming in the aerospace boom of the mid-1960s, when nearly 50,000 were attracted to the shows at the Los Angeles Sports Arena.
Anyone doubting that microprocessors are already out of their adolescence need only look at the Wescon/76 program. Of the host of papers devoted to microprocessors, none introduces a new device. Rather, they are devoted to design problems associated with presently available devices and to their impact on computer systems, as well as to formulating guidelines for the standardization of microprocessors for military programs.

Particular attention is being given to bipolar bit-slice microprocessors in Session 26, which comprises four papers, one from each of the major makers of bit-slice devices—Fairchild, Advanced Micro Devices, Intel, and Monolithic Memories. First, Peter Alfke, of Fairchild Microsystems, San Jose, Calif., distinguishes between presently available families of devices: Intel's 3000 series; Monolithic Memories' 5700/6700 family; Advanced Micro Devices' 2900 family; Fairchild's Macrologic, and Motorola's M10800 family.

The session then turns to three aspects of bit-slice devices: microprogramming, present and future applications, and the impact on computer systems.

Monolithic Memories' John Birkner, in "The Bipolar Microprocessor Revolution of 1976," makes the point that the rapid pace of development of bipolar large-scale integration is beginning to outrun the ability to use it. The next generation of bipolar microprocessors, he says, "will face the challenge of making everything—programmable ROMS, RAMS, field-programmable logic arrays, and interface circuits—play together with maximum speed in minimum real estate."

One way is through distributed processing, in which each block performs a few specialized functions with maximum efficiency. A task processor, for example, could direct the system by interpreting the stored program, responding to interrupts, and controlling other processors, while a multiply-divide processor could perform those specialized tasks, and a special-function processor could perform such operations as floating point, square roots, or transcendental functions.

Also included in session 26 is a good tutorial review on microprogramming techniques. John Mick, Advanced Micro Devices Inc., Sunnyvale, Calif., suggests that an engineer beginning his first microprogramming job temporarily ignore the width of the microprogram words and concentrate on the machine architecture. Later, he can study the format of the words to see if any bits may be saved in the width of the microprogram memory. (This is one of the few papers that must be read carefully to get its full import, since Mick is teaching a technique.)

Finally, Rob Walker of Intel Corp., Santa Clara, Calif., will present survey results on applications of bit-slice microprocessors. Walker asked engineers working on 30 different projects for their comments on data word length, emulation of instruction sets, speed program preparation, sizes of microprogram stores, and so on.

One of his major conclusions is that most users have been attracted to the bipolar bit-slice devices because of their higher speed compared with MOS devices, rather than the flexibility inherent in microprogramming. This leads him to believe that many of the present applications will eventually fall prey to higher-speed MOS devices with fixed instruction sets.

The Navy standardizes

Session 11 contains the papers on military standardization of microprocessors and microcomputers with Ralph Martinez, Naval Electronics Laboratory Center, San Diego, Calif., covering the Navy's program. He says the program is aimed at selecting a commercially available 8-bit central processing unit, since "the 8-bit technology has matured sufficiently to be well-sourced and price-competitive." Moreover, the development time (estimated at two to four years) and cost (estimated between $2 and $10 million) "is simply not favorable for a custom 8-bit CPU development," he adds.

On higher-performing devices, Martinez reports that the technology is not adequately developed to specify a standard for 16-bit or slice CPUs. But the Navy's work will move forward in this area during the next year.

In session 28, John Stidd, Four Phase Systems, Cupertino, Calif., shows the effect of LSI circuit technology on traditional computer design. Its impact has been restricted primarily to the central processing unit itself.
While the CPU never accounted for more than 10% of the total system cost, one built with large-scale integrated circuits offers more capability at a lower price. For $2,500, Stidd says, LSI techniques may soon provide a 32-bit CPU with 32,000 words of memory and many features that cost $25,000 to $30,000 today.

Also in this session is Robert F. Wickham's overview of the next generation of LSI computer systems. Wickham, president of Vantage Research Services, Los Altos, Calif., notes that "we are already into the stage where the chip design must also take into account the system architecture and system software." He goes on to make the point that the cost of software and system overhead required for the extensive operating systems will move more of the software into hardware and result in the increased use of high-level language for applications programs. Thus, the present high start-up costs for high-level language programs will be offset by reduced memory costs and processors compiling and translating the language directly into machine language.

Charles Bass, Zilog Inc., Los Altos, Calif., takes off on this point in "Microprocessor Architecture versus High-level Language Execution." Although microprocessors will undoubtedly be built to execute high-level language programs directly, he concludes this approach will be secondary to processor designs that simplify the translation and execute the code more efficiently.

Viewing development

Development systems are the meat of session 16. Bruce Gladstone, Microkit Inc., Santa Monica, Calif., points out that there are two basic approaches in development systems—using one or two microprocessors. The two-processor approach allows one to act as a host to run the system, while the target, or user's microprocessor, executes the program under development. Only a minimum of new software is needed for each new target processor added. But the technique does require extra processor or hardware and could create problems in matching new processors to the timing of the memory bus. On the other hand, the single-processor approach requires new software each time a new device is added; yet it's cheaper, needing less hardware.

In-circuit emulation is the subject of a paper by Roger Doering, Digital Electronics Corp., Berkeley, Calif. He introduces a new control scheme, called bus intercept. It involves a two-processor system in which the master processor intervenes during emulation and takes control of the user system by substituting a set of instructions stored in a stack. For example, the master would take over upon sensing a certain breakpoint address on the address bus. The scheme, however, is not in use on any commercial system.


Each author, rather than being strictly mini-oriented, has one foot in the minicomputer camp, since each company offers a computer on a board—DEC's LSI-11 and Data General's microNova. Each points out the minicomputer's main strength—software compatibility with larger computers—but Dickhut notes that it's not easy to quantify such aspects as flexibility, ease of use, and price/performance. He recommends that a potential user study the available operating system for a comparison of the usefulness of such basic design tools as an editor, an assembler, and a debugger.

George Adams, Intel, will present the semiconductor maker's viewpoint on microcomputers, using his company's SBC 80/10 as an example [Electronics, Feb. 5, p. 79.] Such devices, he says, allow a manufacturer to add computer control to a product without incurring the costs and long development time of designing a controller from scratch.

□ While automatic test equipment gets plenty of attention in the instrumentation sessions, the chief emphasis is an analysis of microprocessor design. "The wave of new microprocessor applications has brought with it a wave of new measurement problems not easily solvable by traditional time-domain analysis," say Thomas A. Saponas and Jeffrey H. Smith of Hewlett-Packard's Colorado Springs division.

Their paper on logic-state analysis describes the features and applications of HP's new model 1611A microprocessor analyzer. It is one of four in session 17 devoted to testing in the data domain.

Saponas and Smith point out that time-domain measurements aren't very important in most microprocessor systems, since there is no specific test to be performed on the 24 signal lines that make up the primary signal path. "The important measurement is the flow of information on those 24 lines," say the authors.

Looking at analyzers

Along with HP's model 1161A, other new circuit analyzers aimed at the needs of the microprocessor user are Motorola's MPA-1, Scanoptik's Logicorder 32, and Systron-Donner's model 50. In session 16, Zoltan Tarczy-Hornock, director of research for Systron-Donner Corp., Concord, Calif., shows how the analysis of the complex random logic of microprocessor designs can be simplified by allowing direct connection to the processor sockets instead of the myriad of separate leads needed in older analyzers. Moreover, these newer instruments may offer octal, hexadecimal, or (as in the case of HP's instrument) alphanumerical mnemonics. All of them are compatible with a microprocessor's operating codes.

Differentiating between the classes of analyzers is the subject of a session 17 paper from Edward S. Jacklin of Biomation Corp., Cupertino, Calif. He explains that timing analyzers display a timing diagram for the digital circuit under test so that the user can examine timing relationships among several digital signals. On the other...
hand, state analyzers display signals in 1s and 0s so that the user can examine the information on the display from the software point of view. Timing analysis is especially useful in catching hardware problems, while state analysis is best for uncovering software bugs.

A hybrid class of logic analyzers, capable of both timing and state analysis, has recently become available. Carver Hill of E-H Research, Oakland, Calif., describes his firm's entry into this class, the model 1330 Digiscope. His paper shows how the instrument can display the data during each bit-time as a column of three octal digits below the timing-diagram curves. Thus the user can obtain logic-state information directly from the screen without translating it from waveforms.

**Plugging in**

Tektronix Inc.'s digital-analyzer approach is embodied in the 7D01 logic analyzer plug-in unit [Electronics, April 29, p.121] and a new DFI companion digital formatter. These instruments are the subject of a paper by Murlan Kaufman, project manager for the series for the Beaverton, Ore., firm. The beauty of the Tektronix units is that, taken together, they permit selection with a front-panel switch of timing diagrams, state diagrams, or map-like displays of digital data. The state table can then be coded in binary, octal, or hexadecimal notation—again, a feature intended to appeal to designers of microprocessor-based circuits.

Two sessions deal with automatic test equipment. Both functional and in-circuit testing will be explored, with a description of the costs of hardware and software associated with each method. The emphasis on ATE hardware/software tradeoffs was built into the session, says GenRad Inc.'s Robert Szpila, organizer and chairman of session 8, "because even after an appropriate automatic tester has been chosen, you can spend a fair amount in software and additional hardware just to get going. And there's a different formula for functional or in-circuit methods.

Another hidden cost in ATE systems is preparing test programs, and that's the subject of a paper by Pat Harding and Wade Williams from GenRad, Concord, Mass. "As board complexity increases", they say, "cost for test-program preparation can become the dominant cost item, while the cost for the test system and its operator becomes less significant."

**Monitoring test sequences**

GenRad's approach to cutting ATE programming costs, called interactive test-generation, involves an interactive simulation system to monitor the effects of test sequences as they are added to the test program. Thus, test programs can be developed in stages, sequence by sequence, and the results obtained quickly.

A different scheme aimed at similar ends applies pseudorandom patterns to the unit under test. The technique, explains Noel Lyons, Fluke Trendar Corp., Mountain View, Calif., boils down to the fact that if enough patterns are used and analysed in any one measurement, any fault present will be uncovered. He says this vastly reduces the time take in selecting a set of test programming, since all patterns are used.

□ This year's communications sessions concentrate on three areas: satellite transmission (three sessions) and fiber-optic and surface-acoustic-wave technologies for secure communications and commercial television systems (one session each). Perhaps most interesting of the satellite papers is the entry in session 20 from NASA's Goddard Space Flight Center, Greenbelt, Md., on improvements in search and rescue programs using satellites. It deals with a relatively cheap, low-altitude satellite method for finding downed aircraft equipped with emergency locator transmitters.

"The old way of searching with volunteer aircraft is inadequate because all areas of the U.S. can't be covered," says coauthor D. L. Brandel. "In contrast, our satellite system not only detects the radio signals from low-power beacons aboard downed aircraft, but, using doppler-frequency measurement from a single satellite pass, the downed aircraft can be positioned to within 10 kilometers." Moreover, he expects a tenfold improvement in resolution. With multiple satellites, North America and the bordering Maritime regions could be covered in considerably less than 12 hours.

Satellite-borne radar systems get a good airing in session 4. Chairman Frederick C. Williams, Hughes Aircraft Co., Culver City, Calif., set up the session to concentrate on applications demanding high resolution.

**Mapping Venus**

Best of the lot is Williams' own paper, coauthored with two other Hughes workers, in which a synthetic-aperture radar technique for mapping Venus is described. The technique, which will be used on the upcoming Pioneer Venus spacecraft, is a good example of high-resolution systems that could also be used to map weather patterns, storms, and even predict crop yields.

"Synthetic-aperture radar increases resolution," Williams says, "because it lets you synthesize a very long antenna—kilometers long—on a very small satellite, making it possible to distinguish 5 feet at 20 miles. With conventional methods, that resolution would require an antenna several kilometers long."

To get around the complex processing required with synthetic-aperture systems, Hughes is using fast Fourier transforms in the data reduction. The FFT analysis can cut 1,000 calculations to 10—"it's what makes high-quality synthetic-aperture radar possible," he says.

The paper also describes the radar package earmarked for the Pioneer spacecraft. Operating about 200 km above Venus, the on-board system will map the surface with resolutions of less than 30 km and an altitude accuracy of 600 meters. The biggest problem was power—"we were allowed only 25 watts," Williams says, "and, rather than just using most of it to boost transmitter power, we put the major portion into signal processing except for 1 w for the transmitter and 2 w for the receiver."
In the optical-communication and surface-wave technology sessions, the emphasis is on the effect of these technologies, emerging from research-and-development laboratories, on military and commercial communications. Good general reviews on fiber technology are offered in session 14 by Don N. Williams, program manager for fiber optics at the San Diego Naval Electronics Research Laboratory, and Larry U. Dworkin and Louis Coryell of the Army Electronics Command, Ft. Monmouth, N. J. They give an overview of fiber-optic transmission applications, backing it up with data from actual systems running at their laboratories.

The session has three papers from industry. Jim E. Goell and Tom A. Eppe, ITT Electro-optical Products division, Roanoke, Va., and Gerald Aaronson and John Fulenwider of GTE Sylvania give separate updates on analog and digital fiber systems. Eric N. Randle, Valtec Corp., a W. Boylston, Mass., manufacturer of fiber cables, surveys the commercially available fiber types, giving data on bandwidth capability, attenuation, etc.

Most interesting of the surface-wave papers in session 24 is one showing how this technology is getting into commercial applications, such as TV sets, to replace costly, hard-to-tune LC filters. Surface-acoustic-wave bandpass filters, for example, are already displacing lumped-constant LC devices in intermediate-frequency filters—the subject of a paper by A. J. DeVries and R. L. Miller of Zenith Radio Corp., Oak Grove, Ill., the first U.S. TV maker to install these devices.

The weight of the evidence in session 25, which deals with wiring high-speed logic, suggests that the popular multilayer pc-board wiring methods are being superseded by Multiwire, stitch welding, Solder-Wrap, and Wire Wrap. These alternatives can lead to lower production costs, while maintaining low-loss transmission essential for fast logic. Indeed, this session should of great interest to designers of emitter-coupled-logic systems, since all the papers deal with that logic form.

R. J. Clark of General Electric Co., Syracuse, N. Y., discloses his firm's successful applications of Multiwire in a series of ECL prototype boards. He shows that Multiwire boards designed with computer aid provide a controlled impedance environment for mass production.

Comparing stitch welding

A paper by Don Moore, Moore Systems, Chatsworth, Calif., briefly reviews the advantages of the stitch-weld process and compares test results obtained for an ECL ring oscillator with a three-layer stitch-welded board and a specially balanced laboratory fixture used as a standard. The stitch-welded oscillator operated at frequencies up to 540 megahertz compared to 544 MHz for the standard, while maintaining practically constant performance over the operating range. According to Moore, this is proof enough of the worth of the process.

Robert Whitehead of the United Wiring and Manufacturing Co., Garland, Texas, describes Solder-Wrap, a new wiring process that is beginning to emerge on automatic assembly lines. It is based on machinery that can lay down, test, and solder as many as 1,800 insulated wires per hour (a faster rate than a fully automatic wire wrapper). The wire used for Solder-Wrap is a special type whose plastic insulation melts from the heat of soldering, eliminating the need for wire stripping. For high-speed logic, this system puts down twisted pairs between circuit nodes to reduce transmission losses. For transistor-transistor-logic digital integrated circuits, single wires are adequate.

Working with Wire Wrap

Len Doucet of Augat Inc., Attleboro, Mass., describes the construction details of a wire-wrapappable, multilayered IC socket panel usable with ECL packaged in dual in-line packages. In addition to providing higher speed and lower power losses, this technique allows the ECL terminating resistor lines to accept single in-line packages—which makes system layout easier and less expensive. This method eliminates the expense of wiring in many discrete resistors.

Session 3 is the latest in a continuing series of Wescon microelectronic clinics. Led by Stanley M. Stuhlburg of Hughes Aircraft Co., Fullerton, Calif., and Ralph Redemski of Teledyne Microelectronics, Los Angeles, this clinic serves as a technology-exchange program between panelists and the audience. The session will examine such topics as the application to hybrid substrates of chips on tape carriers, automatic wirebonding, and beam-leadred or flip chips.

Component reliability has long been a staple at Wescon meetings, and this year is no exception. The chairman, James E. Bridgers, a reliability specialist for Hoffman Electronics Corp., El Monte, Calif., says session 10 "will compare the manufacturing processes of military and commercial devices, with the aim of identifying those components in the lower-price commercial sector that satisfy military specifications."

The reason for this is simple. Standard military parts come in several levels of reliability, all easily identified by a military numbering system, Bridgers explains. Although popular commercial parts can also be purchased in several levels of reliability, there is no industry-standard numbering system for identifying them. "Many designers simply don't know where to get their hands on the information," he says, adding that the session should go a long way toward doing the job of providing the information.

The three papers in this session examine the manufacturing processes that determine the various reliability levels of standard commercial and military parts. Each speaker will also give some cost-effective procurement
tips for specifying commercial devices as substitutes.

Steve Stephens, a reliability engineering manager at Motorola Semiconductor Products Group, Phoenix, Ariz., will concentrate on transistors. Jerry Myers, manager of material-process engineering at Siemens Corp. in Scottsdale, Ariz., will cover diodes. And Robert Marlow, product marketing manager for tantalum capacitors at Sprague Electric Co., North Adams, Mass., will discuss solid-tantalum capacitors.

Panel follows

Bridgers will wind up the session with a panel discussion, in which the audience is encouraged to participate. Joining the three speakers will be two industry representatives for commercial-equipment manufacturers: Lincoln White, a project engineer for automotive braking systems at Rockwell International Corp. in Anaheim, Calif., and Robert Hunn, director of quality assurance at King Radio Corp., Olathe, Kan.

Reliability of power supplies in minicomputers, as well as other characteristics essential for successful design with them, will be taken up in session 2, "Minicomputer Power Supplies." It includes useful but hard-to-locate information on power-line characteristics, safety hazards, certification standards, environments, and so on.

Perhaps most useful is the paper of Rudolf Severn, a designer for The Magnavox Co., Torrance, Calif., "User Performance Characteristics for Minicomputer Power Supplies." He tabulates the wide variations of line-voltage requirements, frequency ranges, transient standards, and so on, that power-supply manufacturers must satisfy for various computer manufacturers.

This paper is followed by one from Robert Harris, an applications engineer from Underwriters Laboratories, Santa Clara, Calif. He discloses the thinking behind UL standards on shock and fire hazards for minicomputer supplies. Finally, Kenneth Check of Hewlett-Packard's Data Systems division, Cupertino, Calif., puts it all together in "Power Supply Design for Today's Minicomputer Needs," which summarizes all the power requirements for minicomputer system design—safety, radio-frequency interference, EMI standards, and so on.

Also at this year's Wescon is a pocket-calculator update. Building on the lively response to his calculator session at Boston's Electro/76, Rudolph Panholzer of the Naval Postgraduate School, Monterey, Calif., is throwing the proceedings at session 7 open to the floor, after four experts warm up the gathering.

Here's a preview of what some of the experts will say. The founder of the HP-52 users' club, Richard J. Nelson of Statek Corp., Orange, Calif., promises to show how capabilities of existing programmable calculators far outpace the software available for them.

Users find capabilities

"Sure the user has a powerful tool, but he lacks vendor information necessary to fully apply it," he says. Nelson has many examples of how users discover capabilities not disclosed by the makers, such as extra memory and programs to call in a card with another program.

Edward Lybrand of Texas Instruments Inc., Dallas, Texas, will tell what to look for in choosing a hand-held programmable unit, giving the pros and cons of algebraic and reverse-Polish notation, etc. George McCarty of the University of California, Irvine, and Robert B. Johnson, National Semiconductor Corp., Santa Clara, Calif., will offer pointers on calculator calculus and calculator decision-making in business, technology, and government.

Fireworks expected at career sessions

As was the case at the Electro/76 technical sessions, career-related topics will get serious attention at this year's Wescon. Indeed, the two sessions slated promise to be hot ones.

Harold S. Goldberg, president of Data Precision Co., Wakefield, Mass., will hold a West Coast repeat of a panel on the engineer past 40, which proved to be a good draw at Electro/76 in Boston in May. Expected to be provocative, session 5 will feature almost the same panel members debating topics such as: continuing education is useless; the engineer after 40 is on borrowed time, and others. As before, about a third of the time will be devoted to statements by panelists, a third to interchange among the panelists, and a third to fielding questions from the audience.

"The big fact is that it's the engineer's career, and the engineer shouldn't be deluded by others into believing that he has no control over his own career," Goldberg says. "We intend to present the facts as we see them; for facts, not demigods to hang onto, are what engineers need."

Even more likely to produce fireworks is session 30 on forming professional unions. Headed by a lawyer, Thomas A. Skornia of Skornia and Rosenblum, San Francisco, the panel will have a union representative, a successful union stopper from industry, and a lawyer who advises both companies and individual engineers on contract negotiations.

Knowing that Southern California is a hotbed of pro-union thinking among engineers, Skornia expects that engineers in the audience will put management representatives on the spot. "The main question, it seems to me, is that, even with employment agreements in which engineers can get good salaries, fringe benefits, and even stock options, how is the engineer to be protected or avoid layoffs?" he says. "The unions have an answer: organize, join a union, and be protected. But it will be interesting to hear management's answer."

Skornia intends to devote about an hour to questions from attendees to the three panelists: Jerald E. Rosenblum, also of Skornia and Rosenblum; Jerry Whipple, United Auto Workers, Bell, Calif., and Carl Peacock, ITT-Rayonier, New York.

If similar discussions held elsewhere are any indication, the audience will no doubt have a number of union organizers on hand to try to sway the engineers. And, although sessions 5 and 30 are separated by two days, they are closely related. Many engineers feel that, to help solve the plight of engineers past 40, they must organize a strong union to bargain on job security.
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A buyers’ mood will prevail at Wescon/76

A buying atmosphere is anticipated when the 25th anniversary Wescon show convenes Sept. 14–17 in Los Angeles. Sponsors and exhibitors say their optimism springs from the gradual economic upswing plus the emergence of exciting products to be introduced.

Data-acquisition system takes 5,000 readings a second

Where high-speed testing and on-line computational capabilities are required, computer control is usually necessary. These tasks include parametric testing of electronic parts, process-monitoring and control, stimulus-and-response testing, and signal-analysis systems. To reduce costs of performing similar functions, Hewlett-Packard’s 3052A automatic data-acquisition system is controlled by a calculator instead of a computer. What’s more, it uses the standard instrumentation-interface bus (IEEE-488) to allow simple and low-cost restructuring of the system when the user needs change.

A basic 3052A system, priced at $16,500, consists of a model 3455A high-resolution digital voltmeter, a model 3437A high-speed digital voltmeter, a model 3495A calculator with 6,844 bytes of memory, and accessories. The system can make measurements at rates up to 18 channels per second with 1-microvolt resolution on a 100-millivolt full-scale range, so that, for example, thermocouple measurements with resolutions of less than 0.5°C can be obtained.

True-rms measurements can be made up to 1 megahertz with the standard true-rms converter, and a programable fast-ac mode provides an ac measurement rate of up to 10 channels per second for inputs above 300 Hz.

Repetitive waveforms up to 1 MHz or transients below 1 kHz can be digitized by the 3437A sampling DVM. Combined with the 9825A calculator, up to 5,000 readings a second on a single high-speed channel may be stored for analysis.

By multiplexing the 3437A’s input with a scanner, up to 100 channels a second can be measured with a resolution of 100 µV and 3½ digits. In addition, the 3455A DVM can make two- or four-wire resistance measurements.

The 9825A calculator can be programed to perform such calculations as transducer linearization and statistical analysis. Multidimensional arrays allow logical data organi-
New products

zation and storage for complex testing, and a high-speed bidirectional data cartridge provides bulk data storage.

From 10 to 40 fully guarded channels are available in each 3495A scanner, and the 3052A system is expandable to 480 channels by means of the standard interface bus. A total of 14 bus-compatible instruments can be connected to the system, and more channels can be obtained by the addition of one or two bus-interface cards in the calculator's input/output slots. Each such card can interface up to 14 other bus-compatible instruments.

Supplied with the 3052A is a complete system library, consisting of three volumes of documentation to aid the user in system startup, operation, programing, and problem diagnosis. One volume contains pre-recorded program cartridges with verification checks, system-programming routines, and example programs ready to be loaded and used.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Road., Palo Alto, California 94304 [341]

Logic-analyzer formatter offers five display modes

As the electronics world becomes more and more digitally oriented, the demand increases for troubleshooting instruments that provide quick, direct readout—in such configurations as hexadecimal, octal, or timing diagrams; as well as binary. Few instruments have that versatility, despite a market projected to reach $50 million by 1980. Dave McCullough, marketing program supervisor for logic analyzers at Tektronix, says, "If you look at the 6800-type and 8080-type microprocessors, they all relate to the hex numbering system.”

At the Wescon/76 show, Tektronix will introduce its DFl display formatter, a microprocessor-controlled plug-in option to its 7000 series oscilloscopes. The formatter allows designers of microprocessors and mainframes, as well as engineers working with digital circuitry, to get the desired display state and timing mode by pushing a button. The DFI module, shown at lower left in the photo, is designed for use with Tektronix' 7D01 logic analyzer only. It is aimed, says McCullough, at anyone involved with digital-system design work, including microprocessor transmission systems for telephone companies, computers, video games, and digitally controlled brake systems and similar automotive accessories—"anything that has output in terms of a high and a low that will swing from -12 to +12 volts,” he adds. The $1,195 DFI displays test results in the state mode, offering binary, hexadecimal, octal, exclusive OR, and mapping. The 7D01 logic analyzer provides the timing mode.

In a typical microprocessor application, for instance, use of the hexadecimal mode will be most prevalent, McCullough says, while octal will be more useful for large-mainframe designers. To get a “quick thumbprint” of a situation in which, for example, the operator wants to check data in a random-access memory, he would turn to the map mode. Then, if he saw a particular dot that was out of place in the map display, he could switch to hexadecimal to pin down its location even further.

The DFI is controlled by a 6800 microprocessor in the 7D01. That 4,096-bit formattable memory plus the hex display allow the user to "page through and glance at the 4-k bits stored in the 7D01 in the form that it is in the spec sheet or whatever you happen to be checking against," McCullough says. Previously, digital troubleshooters could get that information in binary form only and had to convert it.

The DFI, says McCullough, automatically converts those configurations and, as a result, "is a tremendous time-saver to many of the software designers.”

The DFI is priced at $1,195, but users with a 7603 scope would save $400 since they would not need the cathode-ray-tube readout capability of the 7000 series mainframe. Delivery time is 12 weeks.

Tektronix Inc., P.O. Box 500, Beaverton, Oregon 97077 [342]

8-bit d-a converter in DIP includes storage register

The growth of microprocessor applications has stiffened industry requirements for smaller, more complex digital-to-analog converters at low cost. Micro Networks Corp. has met this requirement with a multi-range 8-bit d-a converter that includes a storage register. Priced at $39 each in small quantities, the
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model MN3020 is the only d-a unit with a register in a dual in-line package. It measures .925 by .52 by .15 inch, approximately 1/16 the size of comparable d-a converters in modular form.

Housed in an 18-pin hermetic DIP designed to withstand hostile environments, the MN3020 also includes an internal reference and an output amplifier. The Worcester, Mass. company has laser-trimmed the thin-film resistor networks so that no external components or adjustments are required by the user to reach initial specifications. The trimmed unit guarantees linearity within ±1/2 LSB, zero offset and range.

The MN3020 provides user-selectable output ranges of 0 to +10, +5 to −5, +10 to −10, and 0 to −10 V. The input circuitry is TTL-compatible, and the output voltage is linear within ±1/2 LSB. A Mil Spec version, the MN3020H, guarantees linearity within ±1/2 LSB from −55°C to +125°C. Worst-case settling time is 3 microseconds.

Micro Networks notes that with the converter clock input high, digital words are converted to analog voltages and will follow all changes in the inputs; with the clock low, the information present at the inputs is retained and the analog output will not change with input changes.

In quantities of 1 to 24, the MN3020 is priced at $30 each; the military-type MN3020H is priced at $69 each. Both are available from stock.

Micro Networks Corp., 324 Clark Street, Worcester, Massachusetts 01606. Phone (617) 852-5400.

Simulator cuts cost of writing logic-test programs

Since becoming commercially available in the early 1970s, automatic logic testers have been indispensable to manufacturers designing equipment that uses an ever-growing number of complex circuit boards. With a succession of improved testers and lower prices, the test field has grown into one of the most competitive. In particular, logic simulation of equipment, needed to generate the software required by the automatic tester, has been a focus of differing design and marketing approaches.

One of the latest developments, being introduced by Computer Automation's Industrial Products division, is an add-on logic simulation system configured as a package that may be attached to most of the firm's 4000-series testers. Priced at $21,900, the model 4850 add-on simulator is intended to offer substantial savings, both against the company's two stand-alone units, selling at $78,900 and $57,900, and against competitive models combining the testing and software-simulation functions.

"The 4850 really should be regarded as a memory expansion of our testers to supply simulation software," says David Smith, director of product development and manufacturing. "It is a simple aid to help users solve production testing problems."

Key to the new add-on unit lies in its sharing and moving-head flexible-disk system and alphanumeric cathode-ray-tube peripherals that are part of the top tester models in the Computer Automation line, he says. This is possible because of the modular nature of the entire line and accounts for the short time—less than three months—that was required to take the 4850 off the drawing board and into finished hardware.

"In effect, what the 4850 package does is just add the extra core memory required to run the simulation software," he explains. In operation the 65,536-word-by-16-bit memory of the add-on simulator is divided as needed between the central processing unit in the tester and by the simulator. Dimensions of the simulator are 21 by 26 inches; it has its own dc power supply or operates from commercial current.

Smith says that development of the simulator is an important aid in helping the customer cut the costs of writing logic-testing programs: "After we had the tester perfected, it was apparent that the software was still a problem, with engineers needing weeks to work out the programs."

With the new add-on simulator, programs for even the most complex logic boards may be written in two or three days, he says, and the testers then run these programs in minutes.

A customer now can have a complete Computer Automation testing and simulation package, using the 4850 add-on, for less than $70,000, says a marketing official at the firm's plant in Irvine, Calif. Smith says he believes that add-on simulators will attract many smaller manufacturers who previously could...
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California firm.
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applications where temperature
measurements must be displayed or
recorded by a printer. At $350 these
multipoint data units have scanning
rates of from 30 channels per second
to 1 channel every 10 seconds. Ten
channel boards, at $115 each, may
be added to the basic unit for a
maximum of 100 channels.
Key specification for the 850
series, Halsey says, is a thermal emf
of 0.1 microvolt per degree celsius
maximum. The units can multiplex
low-level thermocouples, resistance
temperature detectors, and isolated
floating input signals to a single
digital panel meter. An adjustable
time delay allows system transients
to settle.
The 850 is designed for flexibility,
the Newport sales official says. In
the manual mode with a printer, for
example, the system prints the
selected channel continuously or
once only, through front panel
switching. It can be manually
advanced to any channel. In the
automatic mode, the model 850 can
be programmed to scan continuously
or for just one complete cycle. An
external input initiates the single
cycle scan mode, he says, while an
clock input permits a user to
decrease the system scanning rate.
The design philosophy underlying
the 850 and other Newport instru­
ments is to obtain reliability by
keeping down the parts count, which
in turn minimizes the internal tem­
perature rise. This is accomplished
through extensive use of low-power
LSI C-MOS circuitry.
One result is seen in the new
model 213 2,000-count and model
216 6,000-count edgewise voltmeters,
which have calculated MTBFs
exceeding 40,000 hours. Features of
the two models include a differential
input circuit with less than
1 nanoampere bias current, which

MODEL 1776 DIGITAL CURRENT METER

Current Ranges
10, 100, 1,000
amperes, FS.

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A.C. (Sinusoidal) ±2.0%, FS.
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Circle 137 on reader service card 137
At least it seems like everybody wants a sample. It's easy to understand why. These miniature low cost, quick disconnect, high-contact-density Thorkom connectors will go just about anywhere.

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COMPANY: ____________________

CITY: ________________________  STATE: ___________  ZIP: ___________

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And we can add the cable.

What kind of cable? Any kind. Our cable assembly service is custom tailored to your exact specifications.

Expensive?
No, just the opposite. The fact that we’re in the connector business usually makes it possible for us to bring connectors, cable and labor together on a project—cut out a higher quality assembly than you can (each pre-tested for hi-pot, IR and continuity) and cut your cost and time in the process.

When the time comes, make sure you ask us about it.

New products

allows accurate measurement of high-impedance signals up to 1 volt from digital ground. Supply voltage is 4.75 to 5.25 V dc. A dual-slope measurement technique is used for good rejection of line-frequency normal-mode noise. Priced from $65 in 100 and up quantities, the voltmeters have 30-day deliveries.

A product that employs Newport’s patented Polylog linearization technique to achieve better than 0.25% accuracy is the model 268 digital pyrometer. Measuring thermocouples and platinum RTDs, it offers celsius, fahrenheit, and Kelvin temperature scales, plus automatic zero and polarity. Options include a one- or two-setpoint controller, linearized analog output and 5 V dc input power capability. The model 268 sells for $165 in 1-4 quantities, with delivery taking four to six weeks.

Two Newport instruments that primarily feature versatility of programming are the model 204 digital process monitor and the model 6130 universal panel counter. The 6130, with an input sensitivity of 20 millivolts over the range of dc to 20 kHz and 40 mV to 100 kHz, may be programmed for each mode of operation from the rear connector, Hasley says. The model 204 counter may be scaled to virtually any engineering unit, he claims, with a number of available options, including a 350-V optoisolator and a true-rms converter. The model 6130 is priced at $250, and the model 204 sells for $150.

Newport Laboratories Inc., 630 East Young St., Santa Ana, Calif., 92705. Phone (714) 540-4914

10-MHz counter sells for $295

Low cost and high performance don’t often go together in counters. Add low frequency, say the product development engineers at Systron-Donner, and they think they have achieved the combination.

At Wescon, the company’s Instrument division will introduce the model 6202B, a 10-megahertz frequency counter for $295. According to Gail Dishong, product sales manager, it combines features that make it usable in industrial plants, on production lines, in school laboratories, telephone service units, field use and in systems.

Unlike most low-cost counters, says Dishong, the input of the 6202B was designed to accommodate the type of signals most frequently encountered in low-frequency applications and will accept nonsinusoidal as well as sinusoidal waveforms. In addition, an input attenuator control provides the operator with a choice of three attenuation factors: 1, 10, or
New products

100. This insures that the applied input signal does not overdrive the input amplifier, says Dishong, and thus cause false counting.

Furthermore, the 6202B counter has a control that provides a plus or minus offset of about 0.8 volt times the attenuator setting. What this means is that the operator can vary the input trigger point and set it to the best amplitude level where triggering occurs. For input signals not requiring adjustments in offset, the 6202B can be operated in a fixed trigger-control position.

Since input signals may vary greatly in waveshape, it is important, Dishong points out, to have a counter with adjustable input controls that accommodate all types of inputs. "The 6202B is this type of counter," he adds. "Its measurement capability is not limited to sinusoidal waveforms."

Measurements on the 6202B are displayed by a parallax-free 7-digit light-emitting-diode display that includes an automatically positioned decimal point. Not all measurements require the same resolution, so the 6202B provides four different gate times to allow the operator to measure the input frequency to the most convenient resolution. These gate times are 10 seconds, 1 s, 100 milliseconds and 10 ms, with corresponding resolutions of 0.1, 1, 10 and 100 hertz.

The 6202B also has a rear-panel dc power connector that can be used to operate the counter where ac power is not available. And in applications that require a temperature-controlled crystal oscillator in place of the standard oscillator, this can be satisfied with the option 08 high-stability oscillator, which adds $100 to the price.

Also being introduced at Wescon is a new series of communications counters in the range from 20 Hz to 1.25 gigahertz. The $595 model 6241A measures frequencies from 20 megahertz to 100 MHz; the $795 model 6242A from 20 Hz to 512 MHz, and the $995 model 6243A (shown in photo on page 139) from 20 Hz to 1.25 GHz. Features common to all three units include 10-millivolt sensitivity, ability to withstand exceptionally high input-signal levels, an overload-fuse-protected rf input, full 8-digit LED display, selectable resolution in decade steps from 10 KHz to 0.1 Hz and a high-stability time-base oscillator offering ±2 parts in 1 million per year.

Systron-Donner Corp., Concord Instrument Division, 10 Systron Dr., Concord, Calif. 94518 [346]

Unit resolves single events to 100 ps

Single-event measurements should become a practical reality in automatic testing with the introduction by Eldorado Instruments Co. of a 100-picosecond time-interval meter—the model 797—at Wescon. Un-
The failure. A 16 W overload causes this 1/2 W carbon film resistor to burst into flame. The initial failure mode is a short circuit, causing even more current to be drawn as shown on the meter.

The successful failure. The TRW 1 W rated BW-20F (1/2 W size) stays cool and fuses quickly and safely under identical power surge conditions. The failure mode, as shown, is an open circuit.

A failure your circuit can live with.

Failsafe, Fusible, Wirewounds Offer Built-In Circuit Protection.

Cool wirewounds like our BW failsafe series have a dual personality. They provide stable resistance to normal operating current. But at specific overloads, they open the circuit like a good fuse. So, as shown above, they'll protect your circuit from excess heat and fire in places where severe fault conditions are encountered.

The BW failsafe series, UL listed per Document 492.2, can save cost by eliminating the need for both resistor and fuse. Save space, too, because they're about half the size of standard 1 and 2 W devices.

Depending on your specific circuit parameters, other TRW film and wirewound resistors can be engineered to meet your requirements.

When you specify AMP high current connectors you get the problem-solving support a professional engineer deserves. On the production line, in quality control, in sampling for prototyping and by working with you on future improvements.

Product solutions too—like the Power Lock Connectors which feature hermaphroditic contacts rated at 30A or 75A, and snap together housing designs that reduce inventory and provide unlimited variations. Our economical rectangular High Current Commercial Connectors incorporate a positive locking feature. With silo construction housings, they are suitable for both free hanging and panel mounted applications. And are recognized under the U.L. component program for 35A, 125 V circuit breaking.

Widely accepted in many industries, the Circular Plastic Connector series features two designs rated up to 35A, and includes the recently introduced, sealed 7-way version for highway equipment.

Need a solution for a p.c. board power problem? The Hi-current Edge Connector is an economical one, available in 2 through 12 positions and rated to 30A.

Write today for information on AMP High Current Connectors. Learn why we have an international reputation for innovation. AMP Incorporated, Harrisburg, PA 17105. (717) 564-0100.

AMP is a trademark of AMP Incorporated.
New products

test and measuring systems.

Using an enhanced version of the vernier digital interpolation technique pioneered by Eldorado in its 1-ns model 796, the model 797 provides single-event absolute resolution of 100 ps with no ±1 count ambiguity (equivalent to ±50-ps resolution) as well as an accuracy of ±100 ps.

"The instrument is specifically designed for single-event measurement," Beech says, "and all of the internal circuits are optimized for this purpose." The single event may be the time interval between two separate pulses, the width of a single pulse, or one period of a repetitive signal. The start and stop points may be independently selected for positive or negative slope and for positive or negative polarity on any input waveform.

For either single-event or continuous signals, a period mode is available, which measures the time interval between two successive start-channel input transitions at the same trigger point and slope, Beech says. In the period mode, the stop measurement occurs at exactly the same point on the input waveform as the start to assure accurate determination of the time of one input cycle.

A width mode is available in which the time interval between two successive start-channel input transitions is measured at the same trigger amplitude level but with opposite slope.

With the start and stop channels externally connected to a single input, the start threshold may be set at 10% of the maximum input level and the stop threshold at 90%, in this way providing a single-event rise-time measurement with 100-ps resolution. When used in a programmable system, the model 797 may be readily sequenced to measure rise time, pulse width, fall time, and period.

Aging rate on the oscillator is ±1 ppm per year after 30 days, but higher-stability options are available. The 3.5-by-17-by-18-inch model 797 has a 10-decade seven-segment planar display and is priced at $4,850. The model 797 may be ordered with options that include binary-coded-data output for $250 (option PL), or a general-purpose interface bus for $490 (option P4). Remote programming of all functions is available for $450 (option J).

Eldorado Instruments Co., 2495 Estand Way, Pleasant Hill, California 94523 [547]

Thermal printer gives DPM readouts

Designed to provide numeric printouts from groups of digital panel meters, a thermal printer from Gulton Industries can be rack-mounted in hospital intensive-care units, laboratories, and other noise-sensitive areas.

Virtually silent, the model NP-7 produces seven columns of digits, or six digits with a sign, as fast as four lines a second. The packaged unit is supplied with interface electronics for most digital panel meters. It accepts binary-coded-decimal data and is compatible with diode-transistor and transistor-transistor logic.

The company points out that the model NP-7 is designed and built to standard rack width. Thus, it can be
incorporated into a rack containing a wide variety of measuring instruments in order to provide hard copy of their outputs. The printout is on thermally sensitive paper, and the only moving part in the paper-advance mechanism is a permanent-magnet motor. A front-panel switch provides for selection of manual or continuous operation.

Paper can be loaded in 5 to 10 seconds by swinging out the front panel, sliding the roll onto a spindle, and inserting the paper through the drive rollers. Unit price of the NP-7 is $459. Delivery time is 30 days.

Gulton Industries Inc., Measurement and Control Systems Division, East Greenwich, Rhode Island 02818. Phone (401) 884-6800

Traceable to the National Bureau of Standards

Standard calibrates ac and dc meters

Most users who buy panel meters and multimeters must make both ac and dc measurements. To accommodate them, RFL Industries has developed a precision voltage and current standard to be used for the incoming inspection and calibration of analog and digital meters. Designated the model 82, the new instrument is accurate within 0.01% for dc measurements and 0.05% for ac over its range of 100 millivolts to 10 volts (ac and dc) and 100 microamperes to 100 milliamperes (ac and dc). The standard, which has a percent deviation dial and fractional scale division, also has a frequency range to 1 kilohertz internal and 25 kHz external.

Robert Schmehl, sales manager for RFL's Instrumentation division, says other precision voltage and current standards on the market may have comparable accuracies for either ac or dc measurements. But, he claims, most other standards of this type, if not all of them, don't have the versatility of the model 82 in that they measure either ac or dc only.

The model 82 does not yet cover as broad a voltage and current range as RFL's earlier 829 series of standards, but it uses solid-state zener references, resistors matched within 0.005% and an internal calibration point to improve the earlier series' accuracy, which was within 0.05% dc and 0.08% ac. Ken Jacobson, product manager, notes the 829 series had an optional internal calibration point, and used 0.03 – 0.04% wire-wound resistors and electro-chemical cells "which really weren't in the heart of the system, but were used more or less as a self-check reference."

Traceable to the National Bureau of Standards.
Now 1% time measurements are this easy...

Faster Timing Measurement
Differential time measurements are made faster when the new OM 44 with Delta Delayed Sweep* and direct numerical readout is included on a TEKTRONIX Portable Oscilloscope. At the same time, measurement repeatability is improved, the chance for computational errors is eliminated, and 1% accuracy is consistently achieved. Frequency measurement (on periodic waveforms) with 2% accuracy is obtained by simply pushing the 1/Time button.

Built-in DMM as a Bonus
There's no need to carry a separate multimeter. OM 44-equipped TEKTRONIX Portables also measure dc voltage with 0.1% accuracy and temperature from -55°C to +150°C simultaneously with oscilloscope display of related waveforms. And you get ohms measurement with 0.25% accuracy as well.

Your Choice of Oscilloscope Performance
The DM 44 is available on five high-performance portable oscilloscopes to best match your performance and price needs. Choose bandwidth of 100, 200, or 250 MHz. Or select from two fast storage models. One actually stores single-shot signals at its full 100 MHz bandwidth.

Due to highly cost-effective design, the outstanding DM 44 option adds only $410 to the price of the basic portable oscilloscope chosen. All DM 44-equipped TEKTRONIX Portable Oscilloscopes, and seven more models as well, perform analysis on up to 16 channels in the digital domain by simply adding the LA 501W Logic Analyzer. Capabilities of the DM 44 are also available in the TEKTRONIX 7000 Series of plug-in oscilloscopes.

Let Us Show You
To see how the DM 44 makes faster, more accurate measurements in your application, contact your Tektronix Field Engineer. Or write to Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077 for complete information. In Europe, write to Tektronix, Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

*Two independently adjustable delayed sweeps.

U.S. Sales Price FOB Beaverton, Oregon
New products

The proliferation of microprocessor applications has led suppliers of hardware/software development systems to upgrade performance, particularly in the operating speed of the programs.

Initial development systems used teletypewriters as data inputs, followed by plug-in cassette tapes, and then resident semiconductor memories. Now a floppy-disk operating system is being offered by Microkit as an external, augmented memory. It edits and assembles large programs up to 16 times faster than a combination of resident random-access memory and cassette tape, the company says.

This system, called Microdisk, has dual Pertec disk drives and a controller and provides a half-million bytes of on-line storage. In assembling a 4,000-line program, the Microdisk requires about 2.5 minutes, compared to 42 minutes using tape, or 7 hours with a teletypewriter input, according to the company. A 200-line program takes 10 seconds, compared with 2 min and 20 min.

Microkit is marketing the Microdisk primarily as an addition to its stand-alone A model 8/16 development system that accommodates either the Intel 8080 or Motorola 6800 microprocessor. The Microkit 8/16, including 20,000-character-per-second cathode-ray-tube display, keyboard peripherals and software, is priced at $3,850. The microdisk, with interface and software, sells for $3,650. As a development package, the two systems are said to be cheaper than comparable equipment without floppy-disk capability and limited to only one type of chip.

Microkit Inc., 2180 Colorado Ave., Santa Monica, Calif. 90404. Phone (213) 828-8539 [350]
From those wonderful folks who brought you the best high-priced testers.

The best low-priced tester.

Introducing the GR 1795 logic circuit tester. The first tester to give you the full diagnostic capability of our GR 1792 series of testers. For about one-third the cost.

This means that for the price of a pretty ordinary tester, you can now get one that will run our powerful CAPS Computer-Aided Programming Software.

So you get all the trouble-shooting speed and accuracy of our big systems.

You get our latest look-ahead probe with pulse-catching capability and automatic programming for different logic families.

And you get a diagnostic clip, fast floppy disc storage, and the same device adapter we use on our big machines.

So what don’t you get with the 1795?

Simple. You don’t get CAPS simulation and programming capability.

For set-up, you have to program on either an existing 1792 or a separate GR 1797 Programming Station, or use our Programming Service.

Or, you can buy our alternate model GR 1795-LTM.

Instead of CAPS, the LTM uses our new Learner/Tester Mode for set-up and trouble-shooting. It’s far more accurate than other schematic/operator-guided probing techniques since it stores full data per node instead of making transition counts. And, it allows you to move up to full CAPS diagnostics at any time.

Now that this kind of performance is available in a low-cost system, big-time testing capability can come to a lot of places it’s never been before. Like service depots, to reduce board float. Or small companies on small budgets. Or large companies with multi-station applications.

The new GR 1795 and GR 1795-LTM.

The first low-cost testers that are as good as a GR tester.

GenRad, Inc. (formerly General Radio), Test Systems Division, 300 Baker Avenue, Concord, Mass. 01742, 617-369-8770.

GenRad
The difference in software is the difference in testers.

Circle 147 on reader service card
Hewlett-Packard announces two powerful breakthroughs in fully programmable portable calculators.

Two important breakthroughs distinguish Hewlett-Packard’s newest personal-sized calculators.

**Breakthrough Number One: Power.**

The HP-67 and HP-97 are the most powerful personal calculators Hewlett-Packard’s ever built. Both can handle programs up to 224 steps. But there’s a lot more to program capacity than just the number of steps available.

Example: All prefix functions and operations are merged—conserving steps—allowing you to store two or three keystrokes as a single program instruction.

Also, for the first time ever in a battery-powered calculator, you can directly record the contents of all 26 data storage registers on a separate magnetic card for easy reloading later. The result: Another substantial saving in program steps since constants and other numerical data don’t have to be incorporated in your program.

And while we’re still on the subject of power, here are a few more of the programming features built into the remarkable HP-67 and HP-97:

- **3 Levels of Subroutines**
- **10 User Definable Functions**
- **10 Conditional/Decision Functions**
- **4 Flags**
- **3 Types of Addressing**
  - Label Addressing
  - Relative Addressing
  - Indirect Addressing

But there’s more to the HP-67 and HP-97 than raw power. There’s ease of use.

**Breakthrough Number Two: Ease of Use.**

With the HP-67 and HP-97, a “smart” card reader automatically records the display mode, angular mode setting and flag status separately from your program so you never have to waste program steps for these “housekeeping” chores. What’s more, it also prompts you—via a “Crd” display— when there’s additional information on the card that must be loaded into the machine. Moreover, it’s virtually impossible to improperly load programs or data from the cards.

In addition, the “smart” card reader enables you to automatically expand the capacity of either calculator beyond 224 steps. Here’s how: At the appropriate point in your program—and under program control—the card reader can automatically turn on and read another card. This new card can be used to load either selected portions of program memory or selected data registers.

For ease of editing, the line number and all keycodes of every instruction are displayed. You can insert, delete or change functions at any point in your program. And, you can check or execute your programs step-by-step in order to locate programming errors.

Still another reason the HP-67 and HP-97 are so easy to use: RPN logic and four-register automatic-memory-stack. This means you can forget about parenthesis keys and tackle complicated programs with confidence.

**Your Choice of Models. Pick the One That Suits You Best.**

The HP-67 and HP-97 are identical in both versatility and capability. All programs written and recorded on the HP-67 can be loaded and run on the HP-97 (and vice-versa).

The HP-67 gives you shirt-pocket portability. The battery-powered HP-97 gives you attaché-case compactness plus a quiet, built-in thermal printer.

Programming, debugging and editing are so much faster and easier with a printer, you’ll wonder how you ever got along without one. The printer provides hard copy not only of routine calculations but also of programs, listed by stepnumber, key mnemonic and key-code. Or you can TRACE a running program and have the stepnumber, function, and result printed for each step as it is executed. And you can also list the contents of the automatic memory stack or the contents of the data storage registers. With a clear record of your programs or data, you don’t have to remember what you’ve done and what remains to be done.

**An Unparalleled Program of Product/Owner Support.**

With either the $450 HP-67 or the $750 HP-97 you get all of the following: A detailed Owner’s Handbook and Programming Guide, Standard Application Pac (with 15 programs of broad appeal), and a free one-year subscription to a Newsletter that provides programming assistance and keeps you informed about new Application Pacs.

Optional Application Pacs of up to 24 prerecorded programs are available in a variety of disciplines such as statistics, mathematics, finance, electrical engineering, surveying, mechanical engineering, and medicine. In addition, Hewlett-Packard maintains a User’s Library of programs contributed by owners.

If you would like additional information about the HP-67 or HP-97—including the name of a nearby dealer, simply call 800-538-7922 (in Calif.) 800-662-9862 toll-free, or send in the coupon.

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**Electronics / September 2, 1976**
WANTED:
GOOD PROGRAM PROPOSALS
FOR ELECTRO/77 IN NEW YORK

If you've got a good idea for a solid, half-day professional session, we'd like to hear from you!

This is a Call for Sessions for Electro77, the international electronics convention in New York, April 19-21, 1977.

The Professional Program Committee will present a program of about 35 half-day sessions at the Hotel Americana, concurrent with the Electro77 product exposition at the New York Coliseum. They will be selected competitively from submitted proposals and sessions originated by the committee.

This is a Call for Sessions, not for individual papers. Proposals should be for sessions of no more than four individual speakers, each covering a part of the main subject.

The committee is interested in sessions that are timely and relevant, and of direct near-term benefit to electronics engineers.

The program will also be weighted in favor of disciplines and interests prominent in the eastern United States. The majority of Electro77 program participants will come from that area.

How to Propose a Session
The Electro77 program selections will be made in a two-step process.

The first step is for the proposer to submit a letter of intent to propose. This is a simple statement, in letter format, that includes the following:

1. The subject and topic of the proposed session.
2. The scope and range of the material to be presented. How general or specialized will the session be? Will it be an "update" on the subject; applications-oriented; or describing a trend?

3. What is the significance of the subject? Why is it important and to whom is it important?

4. The names and affiliations of up to four speakers or panelists. (No more than two from one organization.)

The deadline for letters of intent is October 5, 1976.

Address your letter to:
John J. Golembeski, Chairman
Electro77 Professional Program Committee
c/o IEEE
345 East 47th Street, New York, N.Y. 10017

Some Guidelines to Proposing

The Electro77 Professional Program Committee will pursue its programming task according to a plan that assumes the following:

1. That the "session unit" approach (rather than solicitation of individual papers) results in sessions in which individual papers are related and will be complementary to each other.

2. That Electro audiences are primarily regional, with a small percentage of participants from distant geographical areas. The committee will emphasize those technologies, kinds of manufacture, and electronics applications that are most prominent in the eastern United States.

3. That the committee will plan a program which is timely and relevant to the electronics engineering, manufacturing, and marketing of today. It will include major trends in technology; applications of hardware and software to important new tasks; needs for new devices and systems; trends in management and marketing; and new tools and techniques for design engineers.

4. All sessions will be presented in carpeted and air-conditioned rooms of the Americana, with professional audio and visual services, rehearsal facilities, and full-time program supervision.

5. In making your proposal and selecting speakers, please keep in mind that Electro77 plans to pre-publish manuscripts in full, and will tape all sessions, to be available at the convention. Manuscript deadline is February 1, 1977.

If your letter is accepted:
You will be asked to prepare a second, more detailed proposal. (Session title, speakers' names and topics, and short abstracts or summaries.)

The deadline for the second proposal is December 1, 1976.

For further information, write to Electro77 Professional Program Committee, attention Joseph Antonaccio, Convention Manager, c/o IEEE, 345 East 47th Street, New York, N.Y. 10017.

Electro77
April 19-21, New York Coliseum and Hotel Americana

Sponsors: METSAC Sections and New England Council, Region 1, IEEE; New York and New England Chapters, ERA. Produced by Electrical and Electronics Exhibitions Inc.
**New products**

**Character generator fits on one chip**

Bipolar LSI device provides 64 alphanumerics for CRT displays and matrix printers

by Bernard Cole, San Francisco bureau manager

Now that microprocessors have reduced the number of packages in computing systems, designers are turning to peripherals with the same idea in mind.

A good example is National Semiconductor Corp.'s introduction of the industry's first one-chip character generator for cathode-ray-tube displays and matrix printers. The move could be the beginning of the end for the use of standard medium-scale-integrated circuitry in these applications.

The bipolar large-scale-integrated device, the DM8678, is a 64-character unit housed in a 16-pin standard dual in-line package. It performs the system functions of parallel-to-serial shifting, character-address latching, character spacing, and character-line spacing without the addition of other packages.

To do the same job in present systems, a character-generating ROM usually requires two to four additional chips. And, compared to a systems component cost of about $15 to $30 using present devices, the DM8678, says Larry Jordan, bipolar memory product manager, does the same job for a 100-piece price of $14.95 each. In larger volumes, he says, the price is below $10 each.

National chose to go the bipolar route on the DM8678, says Jordan, because the requirements of the marketplace—in CRTs, 80 characters per line and 24 lines per screen—meant the device needed a serial output clock rate of 20 megahertz. "And nothing but bipolar would give us that," he says. "While MOS should have given us greater density, we would have had to add external circuits to make a similar MOS device operate in a system going at 20 megahertz."

The 124-by-161-mil chip consists basically of a 6-bit series of fall-through latches for the character address; a 4,032-bit ROM; a 4-bit line counter; a 7-bit parallel-in, serial-out shift register; a data-output buffer with a tri-state control; a multiplexer, and in addition an edge-trigger generator.

The DM8678 is particularly unusual, says Jordan, in that the onboard ROM, depending on the customer's choice of mask program, can have either of the two standard printer/CRT fonts, 7-by-9 or 5-by-7. In addition, it can be programed to scan horizontally across the page in CRT fashion, or vertically, down the page, in matrix-printer fashion.

The line counter consists of a 4-bit ripple counter with an asynchronous clear input, plus an input clock that is shaped by the edge-triggered clock generator. The output can sink 16 milliamperes at 0.45 volt for a low signal out and will source 2 mA at 2.4 V for a high signal out.

Total power required for the MM8678 is 725 milliwatts, about 30% less than conventional character-generation systems incorporating MOS ROMs and 50% less than those with bipolar ROMs. The combination of low cost, low power, and low components count, says Jordan, makes the bipolar device applicable in several high-volume markets such as home video games and standard television sets.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051
New products

Instruments

**True-rms-meter prices drop**

3½-digit DMM at $235 and 4½-digit unit at $425 are suitable for field service.

Accurate measurement of a waveform more complex than a pure sine wave can only be achieved with an instrument that responds to the signal's root-mean-square value. But most rms-responding meters are expensive. While within the reach of the laboratory budget, they have been too costly for large-scale use in field service, or on the production line, for example.

Two new digital multimeters from Fluke offer true-rms response in low-cost instruments whose small size and light weight are designed for field service as well as bench use. The 3½-digit (1,999-count) model 8030A is priced at $235, and the 4½-digit (19,999-count) autoranging model 8040A (shown in photo) is priced at $425.

Each of the two instruments has 26 ranges and five major functions (ac and dc voltage, ac and dc current, and resistance). In addition to five ranges for each function, the 8040A has an additional resistance range and the 8030A has a diode-test position.

The diode-test function allows measurement of diode and transistor forward-voltage drops. A 1-milliamper bias current is forced through the junction, and the resultant voltage drop, in millivolts, is measured and displayed.

In the ac-measurement modes, ac coupling rejects dc bias during voltage measurements, and dc coupling in the current ranges provides the ac + dc capability necessary for measuring power supply and SCR regulating circuitry.

In either instrument, a standard set of four alkaline C cells typically provides 10 hours of operation.

Optional nickel-cadmium battery packs provide eight hours of operation from full charge, and typical recharge time is 14 hours.

In dc voltage ranges, the 8030A is typically accurate within ±(0.1% of reading + 1 digit) and the 8040A is typically accurate within ±(0.05% of reading + 2 digits). In ac voltage ranges, the 8030A is accurate within ±(0.5% of reading + 2 digits) from 45 hertz to 1 kilohertz, and the 8040A is accurate within ±(0.5% of reading + 10 digits) from 45 Hz to 10 kHz.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, Wash. 98043. Telephone (206)774-2211 [351]

**A-m/fm signal generator covers 125 kHz to 175 MHz**

A phase-locked signal generator that covers the frequency range from 125 kilohertz to 175 megahertz in 11 bands can be amplitude-modulated over its entire range and frequency-modulated on its top five bands (8 MHz and above). A built-in six-digit frequency counter can be used to read the generator's frequency or the frequency of any externally applied signal. In addition to acting as a standard signal generator, the model 103B can be used as a sweeper. Five sweep modes are standard: a swept range of 60 kHz centered at 262 kHz, a range of 60 kHz centered at 455 kHz, a range of 200 kHz centered at 1.2 MHz, 2 MHz centered at 10.7 MHz, and 40 MHz centered at 100 MHz. Other sweep ranges may be...
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Best of all, we've built them with freedom-from-maintenance in mind. For example, we offer convection cooling, that practically reduces special preventive maintenance to zero! No noisy fans that can fail on you. No filters that can clog…require cleaning.

Right now, we're ready to produce—as many as 1000 terminals a month—so you'll have no problems with fast delivery. Here's what we have—and more is on the way:

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- **Model 92452 Conversational Display.** A neat console device for a computer. Scroll or page mode. Cursor Position. Optional Hardcopy and Numeric Pad Keyboard.

Both models offer asynchronous communications at 110 to 9600 Baud and detachable keyboards. And both are backed by 15 years of CDC experience in the terminals business.

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Control Data Corporation, 2401 N. Fairview Ave., Roseville, MN 55113
Please tell me more about your new OEM Terminals Line.

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Ask the CDC OEM people
NEC Matrix Plasma Display Panel — compact, complete with driver circuits. TTL compatible.

Type PXD0503A displays 256 characters (32 x 8 lines) in 5 x 7 dot matrix form. The 0.26-inch high characters are high contrast neon orange. No glare, distortion, flicker or fuzziness. NEC's unique transparent electrodes enhance inherent high readability. TTL level interface. Measures 5.5 x 12.6 x 2.1 inches including connectors. Ideal for terminal display applications.

AC-coupled Plasma Display Panels
- Inch-high or up to 4 inches.
- Static/dynamic drive.
- Usable up side down.
- Noble display appearance.

Type PO2504T-02
Type PH2524T-02

Inexpensive unit locates pc-board short circuits

Short-Trak is an instrument designed to pinpoint the exact location of an etch or solder short on a fully loaded printed-circuit board without damaging land areas or components. Unlike other short-circuit locators, Short-Trak does not sense the magnetic field associated with a current; hence, it cannot be confused by very dense wiring patterns.

The instrument consists of a box that injects current pulses into the board under test and a two-tip probe that detects the current by sensing its induced voltage drop. Two col-

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Want to see it again?

Just call Plessey and ask about the 16-bit MIPROC 16, the first microcomputer fast enough for your real-time systems.

It has faster hardware (350 ns full cycle time).

Faster software (most instructions take only a single cycle at a throughput rate of 2.8 megahertz).

And it’s months faster to get on line (no microprogramming, no hardware design and development).

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For starters, the Plessey MIPROC 16 has 82 powerful 16-bit instructions, a versatile prototype development kit and a FORTRAN IV cross-assembler/simulator for use on the Tymshare and GE Mark III networks.

Options include 75 more instructions, a DEC and Data General cross-assembler, a 1.4 µs hardware multiplier, serial and parallel I/O ports, priority interrupts, an extended temperature range (−55° to +125°C), and a ruggedized version for military applications.

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probe is on the right track. When it
changes to red, the probe is at the
short location.

Short-Trak sells for $287.50. A
version for operation from 220 v ac
is priced $10 higher. Delivery is
from stock to three weeks.

Digital Facilities Inc., P.O. Box 34834, Dallas,
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3½-digit multimeter
also has analog display

By adding option 20 to the model
3028A digital multimeter, one ob-
tains both the meter’s 3½-digit
display and an analog indication of
the same quantity. The edge-type
analog panel meter option, which
adds $65 to the price of the $279
DMM, should prove very useful in
those applications where a trend
indication is required. Examples are
the adjustment of a bridge circuit for
a null indication and the tuning of
various resonant circuits for maxi-
mum (or minimum) output. The
panel meter is marked with 10 linear
divisions—0 to 2—and is accurate to
within 5% of full scale. A decibel
scale that extends from -20 to +6
dB is also provided. 0 dB corresponds
to 1 mw into 1 kilohm. The 3028A,
which will be shown at Wescon,
measures ac and dc voltage and
current and resistance. It is an rms-
responding instrument with a band-
width that extends from 15 hertz to
When spray or dip coatings fail...

Parylene works.

You are looking at magnified cross-sectional views of copper conductors on a circuit board...and why parylene protection brings the highest reliability to electronic circuitry.

The spray-applied urethane coating (top photo) bridges the channel between conductors, and offers scant protection at the edges. Urethane, silicone, epoxy...liquid coatings are uneven, and can produce potential failure points.

Parylene forms a thin and even coating, whatever the configuration, however complicated or delicate or densely populated. Without bridging. Without pinholes, voids, bubbles. We call it a conformal coating. From conformality comes reliability.

Parylene conformal coatings can be applied in precisely controlled thicknesses from 0.002 to 3 mils. In one step.

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Parylene has qualified under the stringent requirements of MIL-I-46058C; it does so with a 0.6 mil coating—parylene excels in the micro-electronic virtue of thinness.

Parylene conformal coatings have shown excellent cost effectiveness in many applications. On delicate, sophisticated and complex circuitry, in hybrid circuits and components, they may be the most cost effective answer for long term reliability.

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You can get complete information on parylene by writing for our 16-page brochure: Union Carbide Corp., 270 Park Ave., Dept. RB36, New York, N.Y. 10017. Further investigation will no doubt indicate a trial run, which we can perform at reasonable cost. If you would like to discuss that or any other related matters, please call Bill Loeb at (212) 551-6071.

In Europe: Mr. Peter Crook, Bakelite Xylonite Limited, Redfern Road, Tyseley, Birmingham, England.

In Japan: Mr. N. Fusada, Tomoe Engineering Co. Ltd., Shin Shin Kai Bldg., 14-1 Nihonbashı 3-Chome, Chuo-Ku, Tokyo.
Up to 86% efficiency in Tecnetics DC to DC regulated converters.

When your design calls for a highly efficient regulated converter in a compact package, Tecnetic's 3000 series fits the bill. Efficiencies range from 66% to 86% with packing densities up to 2.78 watts per cubic inch. Our broad product line gives you a choice of models with 25, 50, 100 and 150 watts of power and outputs from 5 to 48 volts.

Standard features of the 3000 series include input-output isolation, overload and short circuit protection, input filters to reduce conducted EMI, and remote error sensing to insure that the proper voltage is maintained at the point of load. All units are fully encapsulated and designed to meet the vibration, shock, humidity and altitude specs of MIL-E-5400.

So, when you are looking for state-of-the-art power converters, look to Tecnetics, the company with proven expertise. For more information and prices on the 3000 series, or three-hundred other power supplies, write for our 26 page catalog.

3000 SERIES HIGH EFFICIENCY REGULATED CONVERTERS

<table>
<thead>
<tr>
<th>Output Power</th>
<th>150, 100, 50, &amp; 25 watt models</th>
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<tr>
<td>Output Voltages</td>
<td>13 standard outputs from 5 to 48 V</td>
</tr>
<tr>
<td>Input Voltages</td>
<td>28VDC or 48VDC (48 VDC only on 150 w units)</td>
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<tr>
<td>Price range</td>
<td>$395-$525.</td>
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Dimensions (excluding terminals):

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<tr>
<th>25 &amp; 50 watt</th>
<th>4x4x2 inches</th>
<th>36 oz. Fully encapsulated</th>
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<tbody>
<tr>
<td>100 &amp; 150 watt</td>
<td>4x4x2 1/2 inches</td>
<td>60 oz. Fully encapsulated</td>
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</tbody>
</table>

Regulation:

- Line (LL to HL): 0.3%
- Load (1/10 FL): 0.1%
- Load (NL to FL): 0.4%
- Temp: 0.01%/°C

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Electronics / September 2, 1976

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New products

200-watt power limitation. The unit is regulated to within 0.01% with ripple and noise of 1 millivolt rms, 10 mv peak to peak. Without the interface-bus capability, the 6002A sells for $800. Programability adds $350 to the base price.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [357]

Data-acquisition controller has analog and digital I/Os

A microcomputer-based data collection and control system called the Tychon Data Acquisition Controller has both analog and digital inputs and outputs. Consisting of a variety of standard hardware and software modules integrated to fit a specific need, the Controller is easily adapted to fit a user's changing demands. Typical applications are in auto-
HOW THE LEADER IN DIGITAL VOLTMETERS PLANS TO STAY THERE.

A while back, we got a head start on everybody else in DVM's. People bought more of our instruments than they did the competition's.

Nothing has changed.

We still have the lead because we discovered a few things about the test and measurement field. We learned some things about developing new DVM's for the changing electronics industry.

Above all, we learned, don't offer a DVM unless it truly has value for the guy on the bench.

That means value across the board.

<table>
<thead>
<tr>
<th>Feature</th>
<th>Only Fluke</th>
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<tbody>
<tr>
<td>Five-range AC/DC volts to 1200V</td>
<td></td>
</tr>
<tr>
<td>Six-month calibration cycle</td>
<td></td>
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<tr>
<td>10,000-Hour demonstrated MTBF</td>
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<tr>
<td>Environmental capability specified and defined</td>
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<tr>
<td>Full line of accessories offering</td>
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</tr>
<tr>
<td>Hi volts to 40 KV, RF to 500 MHz, current to 600A</td>
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</tr>
</tbody>
</table>

*There's not much competition.*

Not just one feature that's unique or one lock-out spec, but an entire package that makes complete sense and offers you total value all the way around. Take specs, for example. We publish very conservative specifications. No one else does, but we think it's important that the instrument gives all the specs we've guaranteed. And then a little more. We feel that you ought to get better performance than you expected when you buy a Fluke instrument.

So what should you expect in a DVM? First, an initial low cost. But also a low cost of ownership.

The Fluke 8600A sells for $549.*

But, even more important, the 8600A has a demonstrated 10,000 hours MTBF. We've fully defined and specified environmental capabilities. And the calibration cycle is 6 months.

That's going to save you a bundle in cost of operation.

Without any sacrifice in specs. Guaranteed six-month accuracy specs at 15°C to 35°C with an extremely low

overload specified for all ranges/functions with overload indication.

Features for flexible operation.

Environmental capability specified and defined. Automatic zeroing. Low 7-watt power consumption for reliability. And a full line of accessories including 40 KV high voltage probe, 500 MHz RF probe and 600 A ac current probe. A self-contained rechargeable battery option.

And remember, those are conservative specs for the 8600A. At $549.

A genuine value from Fluke.

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Fluke (Nederland) B.V., P.O. Box 5053, Zevenheuvelenweg 53, Tilburg, Netherlands.

Phone: (013) 673-973 Telex: 52237

*Domestic price only.

THE INDUSTRY STANDARD. 8600A DVM.
AN INVITATION TO LEARN WHY THE FLUKE 8500A IS CALLED THE WORLD'S FINEST DVM.

We'd like to introduce you to a new concept in digital voltmeters. The Fluke 8500A.

It's a measurement system—not a dedicated instrument, but a bus-oriented, microprocessor-controlled measurement device. Modules which convert parameters, such as ac voltage, resistance or current, are simply plugged into any available slot in the bus structure. The microprocessor then talks to the module and displays the new value in the desired parameter.

That's the heart of the 8500A—unlimited measurement architecture. At any time, different measurement, control or servicing modules can be plugged in the bus.

And the 8500A is a different measuring device.

All for a basic system price of $2,695*

Most other DVM's offer only 20%-60% overranging.

The 8500A is a high-speed 5½-digit DVM capable of 500 readings per second at full resolution and accuracy. Fluke's patented Recirculating Remainerder (R²) A/D Conversion technique is used for high, long-term accuracy and linearity. There's a calibration memory that allows for automatic correction of calibration error. And it's the only systems DVM that measures ac and dc current.

DC voltage measurement and dc ratio are standard features. DC voltages are measured over five ranges, with resolution between 1 µV and 10 mV and a basic accuracy of ±0.001% (10 ppm) for 24 hours, 20°C ±1°C. Starting with the lowest range, a maximum display of 312.5 mV is possible with a resolution of 1 µV. Displays on the lower ranges are in volts, followed by an exponent display of -3.

Two types of ac measurement options are available for the 8500A. While only one can be installed in the instrument at a time, removing one option and installing the other requires a minimum of time and/or operator training. At power up or after reset, the front panel displays whether the averaging converter, true rms converter or neither is installed in the instrument.

The Averaging Converter (Option -01) measures up to 1000V ac on four ranges with a bandwidth from 30 Hz to 100 kHz and accuracies up to ±0.05% + 5 digits. The True RMS Converter (Option -09) measures up to 1000V ac on four ranges with a bandwidth from 10 Hz to 300 kHz and accuracies up to ±0.1% + 15 digits.

Resistance measurements can be made on eight ranges from 10Ω full scale to 100 MΩ full scale with the Ohms Converter (Option -02). Basic accuracy from 100Ω to 1 MΩ is ±0.003% + 1 digit, with resolutions up to 100 µΩ obtainable.

Both ac and dc current can be measured with the Current Module (Option -03) provided one of the ac options is installed in addition to the basic dc. Current measurements to 1A can be made with sensitivity to 1 nA. Accuracies to ±0.03% + 10 digits, for dc readings and to ±0.06% + 8 digits for ac readings. Bandwidth of the 100 µA through Amp ranges is 30 Hz to 10 kHz. For the 1A range only, the bandwidth is 30 Hz to 3 kHz.

Guaranteed accuracies for the 8500A measurement options are based on 90 days, 18°C to 23°C.

Three Remote Interface options are available with the system. Only one of the three may be installed at a time; however, one can be easily exchanged for another when the top cover is removed. This allows the instrument to be used with more than one interface system, requiring only that additional modules for the desired interfaces be obtained.

The IEEE Standard 488-1975 Bus Module (Option -05) provides an eight-bit (one byte) parallel interface. The Bit Serial Asynchronous Interface Module (Option -06) interfaces the 8500A to systems using either RS232B, RS232C, or Current Loop interface. Selection of type and Baud rate is made with bit switches accessible through an entry
Automatic correction for zero, offset, calibration and drift with microprocessor controlled memory storage.

Extra digit of resolution.
As an extra bonus, the range digit can be converted to a 6th measurement digit—for 6½ digits of resolution.

IEEE-488 interface bus Fluke
ASC11 interface Fluke
Parallel interface (16 bit) Fluke

Only one system DVM offers all the interfaces you need.

18 different sample rates Fluke
5 different filter modes Fluke
Programmable scaling factor Fluke
Store and test for limits Fluke
Local and remote lockout Fluke
Front panel display on/off Fluke
Line and non-line synchronized readings Fluke
Store and display of highest and lowest values found Fluke
Recall and display status Fluke
6½ digits of resolution Fluke

And with any interface there are expanded remote features.

Why the 8500A is called the world's finest DVM. Microprocessor control, modular design, complete measurement and systems interface capability and ease of service are all combined in one instrument. And the best thing about it is that it's made by Fluke. So you know you can count on quality and service throughout the world.

The 8500A. One more reason why Fluke is the leader in digital voltmeters.

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Data handling

**Mini offers 600-ns cycle**

Wang machine uses 4,096-bit RAM for microinstruction storage and user memory

Since the 1970 introduction of its 2200A minicomputer, Wang Laboratories has incrementally improved the central processor in at least four evolutionary steps. Now the company has thoroughly redesigned the CPU as part of the 2200VP, which will be introduced at Wescon/76. The minicomputer allows instruction executions six to eight times faster than its immediate predecessor, the 2200T. However, both software and peripherals are compatible with earlier 2200 models.

A redesigned microprocessor, to accommodate the operating system and systems interpretive language, and a new random-access memory combine to deliver a cycle time of 600 nanoseconds compared with 1.6 microseconds for the earlier 2200T. A 4,096-bit RAM is used for both microinstruction storage and user memory, which also contributes to system speed; in earlier 2200-series minicomputers, system microcode was stored in slower read-only memory.

Everett Sheppard, Wang’s product manager for large systems, points out that the increased speed means that an instruction such as **FIND A NEW FILE** requires 0.28 second per record in the 2200VP. The same instruction in the 2200T took 1.72 seconds per record, which translates into more than a 6:1 improvement for the VP. Sheppard says further that if the 2200T software were recorded to optimize it for the VP, the throughput increase could average as much as 10:1. But he emphasizes the importance of maintaining software compatibility with the earlier systems to protect the customer’s investment.

Sheppard says that the increased performance of the VP, plus the capability to address up to 64,000 bytes of memory vs 32,000 for earlier 2200 models, will enable Wang to compete more favorably against certain minicomputers offered by Digital Equipment Corp., Data General Corp., and IBM Corp. “We’re starting to compete more and more with those companies,” Sheppard says. “We’ve always been able to compete with them in price, but the 2200VP will make us competitive in both price and performance.”

The system is intended for both engineering and commercial applications. It can be used as a stand-alone unit by a small business, in a department of a larger company, or in a multiterminal distributed-processing system. It can communicate with larger mainframes because it accommodates most asynchronous and synchronous telecommunications protocols. The 2200VP will be priced between $12,000 and $15,000. Deliveries will begin in late October.

Wang Laboratories Inc., 836 North St., Tewksbury, Mass. 01876. Phone (617) 851-4111 [361]

Thermal-printer option annotates analog charts

An internally mounted alphanumeric thermal printer that requires no user adjustment is now available as an option on Astro-Med analog chart recorders. The printer, which

Gulf Power Company
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Electronics/September 2, 1976
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730 SERIES A new 0.600" LED character in super bright red, seven-segmented readout... low power... draws 10mA/segment or less... operates with standard IC power supply levels. Very high contrast ratio... visible from 40'. Available with or without on-board decoder/driver, plus or minus bar, and with bezel mounting. In 1000-lot quantities each LED 730-6007 ...... $6.05. 730-6001 ...... $2.55.

745 SERIES A new 0.300" LED character in a very bright red, seven-segmented readout... low power requirements. Standard 14-pin DIP... available with left and right decimal with ± 1, and with and without on-board decoder/driver. Compatible with most TTL and DTL circuits. In 1000-lot quantities each 745-0014 ...... $2.10.

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See Dialight.

New products
automatically responds to programmed commands, can be useful in the interpretation of analog data from medical and seismic monitors, for example. Typically, the printer would be used to record such data as station number or location, date, and time along the margin of the chart paper.

The printer contains a character generator, a clock, and a 5-by-7-dot matrix of integrated resistive elements that do the actual thermal printing. It is fast enough to print at least 10 characters per second on chart paper moving at speeds up to 50 millimeters per second. All of the characters, which are 0.1-inch high, belong to the standard 64-symbol ASCII code. Priced at $150, the printer is available from stock. Astro-Med, Attan-Tol Industrial Park, West Warwick, R.I. 02893. Phone (401) 828-4000 [363]

Data General introduces new Nova and a printer family
Data General Corp. will show at Wescon its top-of-the-line Nova 3/D computer—a system-level machine with memory mapping and protection, and a main memory capacity of 131,072 words. In addition, the company will introduce four terminal printers, the 6040 series, which are the first to be designed and manufactured by Data General. The 16-bit, 12-slot Nova 3/D uses 32,768-word MOS-memory modules

Electronics / September 2, 1976
How to tell the good guys from the bad guys.

First, the real villains aren't the ICs that come to you dead-on-arrival.
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New products

with a cycle time of 700 nanoseconds. Built with the same architecture as the family of Nova-3 computers introduced 10 months ago, the new machine is compatible with Nova-line software and peripherals.

For its printer-terminal debut, the company is offering units capable of printing at 30 characters per second and at 60 c/s. For each speed, there is a receive-only model and a keyboard version that can be used offline as a typewriter. All models print full 132-column lines on paper widths from 4 to 15 inches. They interface with all Eclipse and Nova computers and are compatible with standard ASCII input devices. Prices range from $2,200 for a 30-c/s receive-only terminal to $2,650 for a 60-c/s KSR unit.

Prices on the Nova 3/D start in the vicinity of $10,000 for a machine with 32,768 words of memory and reach about $100,000 for the largest system with such accessories as expanded memory, disk drives, tape drives, CRT displays, a real-time clock, and a printer. Both the printers and the computers have a delivery time of 90 days.

Data General Corp., Southboro, Mass. 01772. Phone (617) 485-9100 [364]

Rugged tape recorder has head sealed in tape module

For maximum protection against severe environments, the four-track head of a rugged quarter-inch tape recorder is not mounted on the tape transport itself, but is sealed into each of the unit's removable tape modules. Each sealed module, which contains 300 feet of quarter-inch tape, can either store 16.8 megabits with industry-standard block-recording or twice that amount with a high-density technique. The tape drive has a bidirectional read/write capability at a preset speed of up to 30 inches per second. Search and rewind speeds are four times the preset read/write speed.

Among the unit's high-performance specifications are an operating
Logic Probe 1 is a compact, enormously versatile design, test and troubleshooting tool for all types of digital applications. By simply connecting the clip leads to the circuit's power supply, setting a switch to the proper logic family and touching the probe tip to the node under test, you get an instant picture of circuit conditions.

LP-1’s unique circuitry—which combines the functions of level detector, pulse detector, pulse stretcher and memory—makes one-shot, low-rep-rate, narrow pulses—nearly impossible to see, even with a fast scope—easily detectable and visible. HI LED indicates logic “1”, LO LED, logic “0”, and all pulse transitions—positive and negative as narrow as 50 nanoseconds—are stretched to ½ second and displayed on the PULSE LED.

By setting the PULSE/MEMORY switch to MEMORY, single-shot events as well as low-rep-rate events can be stored indefinitely.

While high-frequency (5-10MHz) signals cause the “pulse” LED to blink at a 3Hz rate, there is an additional indication with unsymmetrical pulses: with duty cycles of less than 30%, the LO LED will light, while duty cycles over 70% will light the HI LED.

In all modes, high input impedance (100K) virtually eliminates loading problems, and impedance is constant for all states. LP-1 also features over-voltage and reverse-polarity protection. Housed in a rugged, high-impact plastic case with strain-relieved power cables, it’s built to provide reliable day-in, day-out service for years to come.

CSC’S MULTI-FAMILY LOGIC PROBE 1.
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HI/LO LED’s—Display level (HI-logic “1”, LO-logic “0”) of signal activity at node under test

PULSE LED—Lets you know what’s going on—and off. Indicates positive and negative pulse and level transitions. LP-1 stretches pulses as narrow as 50 nanoseconds to ½ sec. (3Hz pulse rate)

PULSE/MEMORY Switch—PULSE position detects and stretches pulses as narrow as 50 nanoseconds to ½ sec. Switch to MEMORY and it stores single shot and low-rep-rate events indefinitely; HI/LO LED’s remain active

Logic Family Switch—TTL/DTL or CMOS matches Logic “1” and “0” levels, for greater versatility. High Input Impedance—100K virtually eliminates circuit loading problems and is constant in both “0” and “1” states. CMOS position also compatible with HTL, HNIL and MOS logic

Non-corrosive nickel-plated probe tip and clip leads—for reliable contacts and maximum life

Protected—Features built-in reverse polarity and over-voltage protection; strain-relieved power cable

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New products

temperature range of -54°C to 95°C for MIL-E-5400 Class 2 applications. Operation consumes less than 30 watts, and the standby-power requirement is only 5 w.

The BDSU (for bulk data storage unit) transport sells for $5,000, and each tape module is priced at $595. Electronic Memories &Magnetics, Severe Environment Products Division, 20630 Plummer St., Chatsworth, Calif. 91311 [365]

Modules cut cost of fast Fourier transform processing

A series of fast Fourier transform modules is claimed to provide spectrum-analyzer systems with performance matching that of minicomputer-based FFT systems at much lower cost. The first two modules in the series are the SPM-01 at $5,000, and the SPM-02 at $6,000. The former has a transform characteristic of 1,024 complex points in 600 milliseconds, while the latter requires only 250 ms. Data input for

Electronics/September 2, 1976
132 columns. Over 300 lines per minute. Under $2000:*

In printers, it's not just a question of how much they cost, but one of how much you get for your money. And on a price/performance basis, nothing even comes close to the Teletype® model 40 OEM printer.

Besides getting a 132-column, heavy-duty impact printer that delivers over 300 lpm for less than $2000, you also get a printer with outstanding flexibility and reliability.

The big reason behind the model 40's price/performance advantage over the competition is our unique design. Even though it operates at speeds over 300 lpm, wear and tear is less than you'd find in a conventional printer operating at a much slower speed. Fewer moving parts and solid-state components add up to increased reliability and reduced maintenance.

We'd be ahead if we just stopped there, but the model 40 also offers you a number of other features. Like a choice of character sets, operator-adjustable form width and form length, parity error indication, and a built-in self-test feature, just to name a few.

For complete information, please contact our Sales Headquarters at: 5555 Touhy Ave., Skokie, Ill. 60076. Or call Terminal Central at: (312) 982-2000.

The Teletype model 40 OEM printer. Nothing even comes close.
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3. Matsuo provides better leakage control Our standard units are .01XCV. Selected capacitors are .001XCV. Ten times better when you need it.

4. Matsuo saves costly assembly time Matsuo lead spacing is fixed — always the same to fit assembly board quickly, easily. Positive leads are longer — touch tells assembler, eliminates examining. Leads are square — “bite” corners so Dip stands upright even during soldering. Each feature saves you costly assembly minutes.

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New products

the two modules may be in either analog or digital format at speeds up to 50 kilohertz.

Based on the high-speed Plessey Miproc-16 microcomputer, the modules perform both forward and inverse transforms and can present the output data either in analog or digital form in a variety of formats: real part, imaginary part, alternating real and imaginary parts, or as a computed power spectrum.

Plessey Microsystems, Microcomputer Products, 1674 McGaw Ave., Irvine, Calif. 92714. Phone Jay Jhu at (714) 540-9945

'Smart' CRT terminal operates up to 9,600 bauds

Built around an 8080 microprocessor, the model 8030 is a firmware-programed cathode-ray-tube terminal that communicates at speeds to 9,600 bauds. Unlike most firmware-programed terminals, the 8030 permits users to program communications functions from the terminal keyboard. A two-page refresh memory with a total of 3,840 characters allows the user to scroll through both pages of stored data and to edit it as necessary before transmitting it to the computer. Time-saving features are provided in the $2,750 unit for applications employing the protected-field mode.

The 8030 uses a 15-inch CRT, on which it displays 1,920 characters. Omron Corp. of America, Information Products Division, 432 Toyama Dr., Sunnyvale, Calif. 94086 [368]
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Nelson “Nervous Nellie” Nelson.
To avoid undue confusion, had the same first and last names.
Always wore a belt and suspenders at the same time.
Owned several shares of Amalgamated Safety Pin.
Hated to make decisions. Especially when choosing minicomputer memories. “Nervous” was sure he didn’t like the high prices of the mini manufacturers.
Yet he was afraid to buy from a lower-priced independent because he wasn’t sure what he would be getting.
One day, while shopping for a security blanket, “Nervous Nellie” spotted the following message monogrammed on the label:

“Plessey Microsystems is the largest independent supplier of minicomputer add-on memories there is, and they are part of an international billion dollar corporation. Plessey’s low prices are complemented by the high quality and reliability of their products and the comprehensiveness of their support services.

“Plessey Microsystems.
“P.S.: Do not remove this Plessey pitch under penalty of law.”

He was certain he sort of liked that.
With a newfound surge of self-confidence, he placed a person-to-Plessey call and reassured himself that Plessey Microsystems was everything the label said they were. And more.

From then on, Nelson Nelson bought all his mini peripherals from Plessey. And threw away his suspenders.
You, too, can find out how add-on core memories, single and dual disc drives and punched tape readers from Plessey Microsystems can expand your mini at low prices without your having to sweat about the results.
Just call and we’ll be glad to tell you more about our products.

The Pacifiers
Plessey disc drive systems store up to four times the data in one quarter of the space at a much lower cost than drives from the mini manufacturers.
They are software, hardware, and media compatible with DEC and Data General minicomputers and they are available in a variety of types and sizes for doing your job your way.
To expand your mini systems even further, just plug the compatible Plessey disc controller into your mini mainframe. It will control up to eight Plessey disc drives, or any mix of Plessey and mini manufacturer drives with total capacities of 10, 20 and even 327 megabytes (depending on your mini model).
It all adds up to a great deal more capacity, performance and reliability for a great deal less than equivalent competitive drives.
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Circle 175 on reader service card
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Our new series of male and female “D” connectors offer you a cost effective external mass termination cable and connector system second to none. Its uniqueness begins with a one-piece “D” connector package that meets industry standards for size, pin spacing, and contact reliability. With no loose parts to match up, positive cable-to-contact alignment is assured. Conductors are mass terminated in seconds with our standard BLUE MACS™ hand or bench tools. The results? Faster installation, higher reliability.

Contact pins are spaced on .054” centers - a perfect fit for any standard inter-cabinet “D” type connector application. Our new “D” connectors are designed to mate with standard 50 mil pitch flat cable as well as our new, improved jacketed cable - the only flexible flat cable engineered specifically for out-of-cabinet use.

a new meaning to cost effectiveness.

The Ansley BLUE MACS™ jacketed cable is U.L. listed for external interconnection of electronic equipment. Electrically, it outperforms standard jacketed twisted pairs in typical I/O applications. And there's no special zipper lock tubing required - reducing the need for an extra cable accessory. Installation is faster, easier. And like all Ansley connectors, you can daisy chain our “D” types anywhere in the cable - along with our DIP socket, card edge, or pc board connectors.

Cable alignment and high contact reliability is assured — because both cable and connector are grooved for absolute alignment. Our patented TULIP™ 4-point insulation-displacing contacts are permanently fixed and sealed-in to provide a reliable, gas-tight, corrosion-free mass termination.

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Semiconductors

Chip controls two motors

With an external transistor, IC provides speed regulation that is within ±0.1%.

To prevent sound distortion in cassette recorders or lack of synchronization in the motors that control the sound and film functions in a movie camera, accurate control of motor speeds is important. That's why engineers at Micro Components Corp. feel that their integrated circuit for dual motor-speed control is going to find its way into such consumer equipment.

The MCC 140, when used with an external output transistor, provides typical motor-speed regulation to within ±0.1%. Indeed, the company guarantees regulation to within 1% maximum over a supply range of 7 to 12 volts and over a temperature range from −20°C to +70°C. George Fowler, an MCC design engineer, says the tight accuracy is achieved in the device by using a closed-loop feedback system employing an optical or sinewave-tachometer technique—the more conventional back-electromotive-force technique typically has only 1% to 2% accuracies.

The 16-pin plastic dual in-line package contains two identical motor-speed-control units on a single monolithic chip. Each unit contains a high-gain input amplifier and comparator, one-shot multivibrator, a phase comparator, output amplifier, and short-circuit protection.

"The big advantage of this circuit is that we use a closed-loop technique to detect the frequency of the motor under control," Fowler says.

He adds that the accuracy is generated by the one-shot multivibrator. The tachometer's zero-cross-over voltage is compared to the pulse width of the one-shot multivibrator, "and from this we detect an error voltage and correct the speed of the motor," Fowler adds.

The optionally programable delay offers the capability to delay the start of a second motor for some predetermined time after the first motor starts.

The MCC 140 is available from stock, with a price of $2.60 each in quantities of 100, or $2.35 in thou-
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**New products**

sands. A $1 version for single-motor control is planned.

Micro Components Corp., 99 Bald Hill Rd., Cranston, R.I. 02920. Phone (401) 463-6000

[411]

Voltage-frequency-voltage units give 11-bit accuracy

In the year since bipolar monolithic voltage-to-frequency-to-voltage converters first made their appearance ([Electronics, May 15, 1975, p. 91]), use of them to replace modular and discrete configurations has been slight. Apparently, this is because one of the main areas of application for v-f-v converters is in data-acquisition systems where analog information is transmitted digitally from remote locations. Such systems typically require at least 8- to 11-bit accuracy and linearity to within 0.4 to 0.5% or better to avoid signal degradation. But present monolithic converters, while low-priced at $3 to $6, usually require the addition of several external active components to achieve greater than 7-bit accuracy.

Hoping to overcome these limitations, Intech/Function Modules Inc. of Santa Clara, Calif. is going into production with its A-8402, an $8.95 monolithic v-f-v converter capable of 11-bit accuracy and linearity within 0.05% at 10 kilohertz without the need for external active components.

Housed in a 15-pin dual in-line package, the A-8402 provides linear conversion of 0- to +10-volt analog signals to a digital pulse train whose repetition rate is proportional to the analog voltage. An improved form of the charge-balancing technique of conversion is used in the 8402 to convert analog input voltages to a stable linear output pulse rate of 0 to 100 kHz, selectable by external components.

When linked to an 8402 for f-v operation, an accurate two-wire data link may be formed with the v-f as the transmitter and the f-v as the receiver. The 8402 may also be linked to a binary counter that can
Once upon a time, in a place known as Testingland, there was a big company. Fairchild, as the company was called, was a veritable giant in the field of semiconductor testing. But a kind and benevolent giant. And so, when Fairchild stumbled upon an old and dusty tome hidden deep within the walls of a wise old engineer's office, it decided to share it with the world. And so our story begins...

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Electronics/September 2, 1976

Circle 179 on reader service card 179
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How did we do it?

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We didn't acquire the largest selection without selling a lot of power supplies along the way. Our way, for 35 years, has been giving the user what he wants; and in a watts/dollar ratio that gives him no choice but E/M.

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<th>Type</th>
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6.9-volt IC zener has 1-ohm dynamic impedance

A two-terminal integrated circuit consisting of a zener diode and circuitry to buffer it against current changes behaves like a zener diode with a dynamic impedance of less than 1 ohm. The 6.9-volt voltage-reference diode operates over the current range from 0.5 milliampere to 15 mA. At the center of the monolithic device is a new subsurface-breakdown zener that exhibits lower noise and more stable breakdown than conventional zeners. Noise is typically 7 microvolts rms from 10 hertz to 10 kilohertz, with a guaranteed maximum of 20 µv rms. Long-term stability, at constant temperature, is within 20 ppm.

The model LM 129 IC zener is offered with selected temperature coefficients from 0.001%/°C to 0.01%/°C and a temperature range of either 0°C to 70°C or -55°C to 125°C. In addition, it is available in either a TO-46 hermetic transistor package or a plastic TO-92 package. Depending upon packaging, specifications, and temperature range, the IC zener is priced from 75 cents to...
In short, our cased-radial NPO Ceramic Capacitors are unique.
They feature capacitance tolerances as low as ±0.25% — the tightest we've seen advertised — in all values from 10 pF to .051 μF.

Our other commercial and military ceramic capacitors are unique, too. They all bear the stamp of 'Vitramon' — a mark of high-quality capacitors and contemporary technology since we introduced the first 'VK' part (forerunner to all radial CK capacitors), at WESCON in 1959.

Looking for high-quality CK and CKR military capacitors . . . a variety of commercial cased-radial components . . . dipped-radial parts in NPO, BX, X7R and Z5U dielectrics . . . values from 1.0 pF to 4.7 μF?

We offer them all — as well as 29 styles of 'VY' Porcelain Capacitors that put the word monolithic into capacitor technology nearly three decades ago.

As important, we deliver what we offer. Call us at (203) 268-6261.

Vitramon North America
Division of Vitramon, Incorporated
Box 544, Bridgeport, Conn. 06601

Subsidiaries: Vitramon Limited (London) • Vitramon GmbH (Stuttgart) • Vitramon France S.A.R.L. (Paris) • Vitramon Pty. Limited (Sydney) • Vitramon Japan Limited (Tokyo)
A SLIDE WITH PRIDE.

C&K's new Model 1101 subminiature SPDT slide switch has a proven internal mechanism because it's the same one we've been using for years to build our famous toggle switches. We've retained all the toggle terminal and sealing options and added a spring-loaded teflon actuator. It's a powerful 6 amp (at 120 VAC) slide switch offering 40,000 actuations at full load. Because the actuator is only .200" high, the 1101 slide switch maintains a low profile but deep down it's a proud little son-of-a-toggle.

C&K Components, Inc.
103 Morse St.,
Watertown, Mass. 02172, U.S.A.
Tel: (617) 926-0800 Telex: 92-2546
TWX: 710-327-0460.
Free Engineering Sample on request.
Circle 182 on reader service card

New products

$15 each in lots of 100. Delivery is from stock.
National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051.
Phone Brent Welling at (408) 737-5884

Bipolar transistor has 2.5-dB noise figure at 4GHz

A microwave bipolar transistor with a gain of 9 decibels has a typical noise figure of 2.5 dB at 4 gigahertz. Guaranteed maximum noise figure is only 2.7 dB. The ion-implanted device, designated the model HXTR-6102, is housed in a rugged hermetic metal/ceramic package. For quantities of one to nine units, the transistor sells for $150. For 10 to 24, the price drops to $130.
Inquiries Manager, Hewlett-Packard Co.,
1501 Page Mill Rd., Palo Alto, Calif. 94304

Divide-by-eight count extender uses only 40 mW

A divide-by-eight count extender that operates at frequencies from dc to at least 120 megahertz dissipates only 40 milliwatts of power. The extender is used to increase the division ratio of modulus-2 counters while retaining their ratio differences. It converts a divide-by-10 or -11 counter into a divide-by-80 or -81 counter, or it can change a divide-by-5 or -6 counter into a divide-by-40 or -41 unit.

Electronics / September 2, 1976
Quality materials and advanced manufacturing techniques make a world of difference when it comes to today's reed switches. And Fujitsu FDR-series reed switches are tops in both. You get Rhodium-plated contacts for the highest cold-weld immunity. You get state-of-the-art infrared sealing techniques via fully automatic carousel assemblers for the finest contamination-free packaging. And, of course, you get Fujitsu's dedication to excellence that ensures the highest reliability and longest service life for trouble-free operation for millions of operations to come. Our FDR-series is comprehensive, too, offering models to meet almost every switching requirement. Whether it be for general-purpose, high electrical load, telecommunications, telephone exchange or latching applications, there's an FDR-series reed switch to cover the job. So, get smart. Choose the maker known the world over for the finest in reliability. Get Fujitsu! Availability is NOW. Write or call for more information. You'll be glad you did.

<table>
<thead>
<tr>
<th>Class</th>
<th>Model</th>
<th>Contact</th>
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<td>Latching</td>
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<td>Center</td>
<td>1.142&quot;</td>
<td></td>
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</table>

FUJITSU LIMITED
Communications and Electronics
Tokyo, Japan
Spectrum Analyzer Checklist

If you've checked at least one in the YES column, we are certain you'll be enthusiastic about PARC's new Model 4512 FFT Real Time Spectrum Analyzer. And it's priced at only $6,900.

For full details about this versatile new instrument, or a demonstration in your lab, contact Princeton Applied Research Corporation, P. O. Box 2565, Princeton, New Jersey 08540, (609) 452-2111.

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Tallahassee, Florida 32304
(904) 488-5507

New products

The model SP8794 offers considerable power savings for low-power synthesizers because it can bring the combined output frequency down to the range where C-MOS or low-power TTL can be used to control the divider. It is offered in three temperature ranges: 0°C to 70°C, -40°C to 85°C, and -55°C to 125°C. The first of these sells for $7.10 each in hundreds. Plesey Semiconductors, 1674 McGaw Ave., Irvine, Calif. 92714. Phone Dennis Chant at (714) 540-9979 [417]

Serial/parallel register completes processing trio

An 8-bit serial/parallel register, the model Am25LS22, is the third member of a triad of integrated circuits designed for digital-filtering and signal-processing applications to 30 megahertz. The other devices are a multiplier and an adder/subtractor. The low-power Schottky register is available in a variety of packaged and uncased forms, in both commercial and military temperature ranges, at prices that range from $4.25 each to $9.20 each in hundreds. The ic, which is available from distributors, will be second-sourced by other manufacturers as the 54/74LS322.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086. Phone (408) 732-2400 [415]

GaAs FET chip has 10-dB gain at 10 GHz

The model AFT2000 is a gallium-arsenide FET chip with a maximum available gain at 10 GHz of 10 to 12 decibels. Typical noise figure at 10 GHz is 3.5 dB. The device, which has a 1-micrometer gate, may be used in low-noise applications up to about 15 GHz. Similar in physical configuration and s-parameter characteristics to devices now in use, the AFT2000 can be employed in existing designs with little or no redesign. Available from stock, the transistor sells for...
All aerosols are not alike.

The constant progression of sophistication in electronics has demanded a parallel progression in standards of purity. Industrial cleaning is one very vital link in maintaining component and system purity and reliability.

Let's look at eight important criteria and compare Miller-Stephenson products to the general aerosol industrial cleaner industry.

**SOLVENTS:**
Miller-Stephenson — Most of our aerosols contain 80% Active Ingredient, 20% Propellant. Other Aerosol Cleaners — Active Ingredient averages 70-75%.
Miller-Stephenson — Uses only Certified Virgin Solvent. Other Aerosol Cleaners — Some utilize reclaimed solvents. Though lower in cost, reclaimed solvents usually contain foreign substances.

**PROPELLANTS:**
Miller-Stephenson — Uses only the highest purity, safest propellants. They are nonflammable - TWA 1000 ppm. Other Aerosol Cleaners — Many use cheap, sometimes flammable, sometimes higher order of toxicity propellants.

**FILTERING:**
Miller-Stephenson — We double filter “Freon” solvent and propellant — first with a 0.5 micron filter, then with a Millipore 0.2 absolute filter. Other Aerosol Cleaners — Some use no filters; others only a 0.5 micron filter.

**LOADING LINES:**
Miller-Stephenson — All loading lines are dedicated to the individual ingredients used. Other Aerosol Cleaners — Loading lines are often used for multiple products and if not thoroughly flushed, contamination will occur.

**LOADING ENVIRONMENT:**
Miller-Stephenson — Class 100 Clean Room conditions. Other Aerosol Cleaners — Normally uncontrolled — environmental contamination can occur.

**VOLUME PRODUCTION:**
Miller-Stephenson — Our principal raw materials come direct from Du Pont tankers into our 5500 gallon storage tanks through a closed system direct to container. Other Aerosol Cleaners — Low volume suppliers often load from open 55-gallon drums thereby introducing possibility of contamination.

**CONTAINER:**
Miller-Stephenson — Our new seamless cans further reduce the possibility of contamination. Other Aerosol Cleaners — Cans with soldered seams may introduce residual contaminants.

**SAFETY IN SHIPPING:**
Miller-Stephenson — Most of our “Freon” aerosol solvents are non-regulated items, exempt from all Federal Regulations “Restricted Articles”. May be Shipped Air Transport. Other Aerosol Cleaners — Do not meet Air Transport Regulations.

MS aerosol solvents have the lowest residual contamination in the industry — some approaching 5-7 ppm. The general range for the industry is 50-130 ppm.

"Freon" is Du Pont's registered trademark for its fluorocarbon compounds.
The time you save may be your own.

Used to be you'd get a circuit idea, lay out a pc board, print it, solder everything together, troubleshoot, change your layout, try a new board, and spend absolutely too much time breadboarding. Now A P ACE All Circuit Evaluators let you breadboard in a fraction of the time. Make your changes immediately. Keep full leads on your components. Avoid the heat damage possible with repeated soldering and desoldering. And have a pattern for your board—if you need a board—sitting in front of you. In about as long as it takes to sketch a schematic. Get cooking with ACE, ACE: The All Circuit Evaluator from A P Products.

<table>
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<tr>
<th>Part No.</th>
<th>ACE Model No.</th>
<th>Tie Points</th>
<th>DIP Capacity</th>
<th>No. Buses</th>
<th>No. Posts</th>
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<td>36</td>
<td>4</td>
<td>10-1/4x9-1/4</td>
<td>$79.95</td>
</tr>
</tbody>
</table>

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- (213) 788-3800
- (415) 326-5432
- (617) 879-0880
- (213) 875-2862
- (415) 965-9240
- (713) 350-6771
- (215) 698-4000
- (513) 236-9990
- (713) 777-1666
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- (516) 483-9220
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- (312) 298-8580
- (516) 883-0999
- (803) 779-5332
- (312) 525-1800
- (612) 488-0201
- (315) 664-0088

If no distributors in your area, call factory.

New products

$95 per chip in lots of 10 to 49 pieces.
Aertech Industries, 825 Stewart Dr., Sunnyvale, Calif. 94086. Phone Van Price at (408) 732-0880 Ext. 471 [416]

TOPICS

Semiconductors

Motorola Semiconductor Products Inc., Phoenix, Ariz., is second-sourcing the popular 3N201, -02, and -03 series of n-channel dual-gate MOSFETs. Designed for vhf television and communications applications, the 3N201 and -02 sell for $1 each in small quantities, while the 3N203 is priced at 85 cents. . . Electronic Devices Inc., Yonkers, N.Y., has modified its 12-ampere bridge rectifiers to handle 15 A and increased the surge rating from 150 A to 200 A. At the same time, the price has been dropped to $2.40 each in thousands. . . Texas Instruments Inc., Dallas, Texas, is second-sourcing the Fairchild 7800 and 7900 series of three-terminal voltage regulators. Price is $1.38 each in hundreds. . . SMC Microsystems Corp., Hauppauge, N.Y., is expanding its baud-rate generator series with the addition of the model COM 5026 single-baud rate generator. Priced at $11 for singles and $6 for hundreds, the COM 5026 is compatible with the COM 5016 dual-baud rate generator. . . Teledyne Semiconductor, Mountain View, Calif., has announced the availability of its 8-bit monolithic analog-to-digital converter in a 24-pin plastic dual in-line package. The price in hundreds is $9.95 each.
Big technology for Mini-computers.

The mini-computer market has grown to the point where it demands "3330" disk technology in a package that fits.

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Circle 187 on reader service card
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The microprocessor has permanently changed the methods of designing and building electronic equipment—from process and industrial control to computer-based designs in instruments communication and consumer/commercial equipment.

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"Large Scale Integration" is a compendium of recent articles published in Electronics. Although in some ways it is a companion piece to "Microprocessors" because it explains the new circuits that play in mp systems, it is much more. "Large Scale Integration" deals with the entire range of design applications: main memory systems, peripheral memories, memory controllers, on-line industrial controllers, data acquisition boards, communication systems, calculators, watches, etc.

3 BASICS OF DATA COMMUNICATIONS
Data communications is one of the fastest-growing electronic equipment markets in the U.S.—during the decade of the '70's, better than 15-20% per year, compounded!

Chances are you are going to be a part of the data communications market. There's no better place to start than getting a copy of "Basics of Data Communications"—a 316-page compilation of essential articles which have appeared in Data Communications magazine. From the basic, tutorial, still state-of-the-art information published in the 1972 and 1973 Deskbook issues (now out of print), on through information on the practice of present-day data communications, this book includes forty-seven articles covering more than eleven key areas.
Even in the solitude of the forest depths, from rooftops, arctic tundra, swamps to sweltering tropics, 'neath snow, sand or ice, the Hermes Loop antenna keeps an ear to the sky.

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Circle 189 on reader service card 189
New products

Subassemblies

Camera uses CCD array

System with 1,024 sensors is aimed at measurement, control, document work

Making use of its charge-coupled-device technology, Fairchild Camera and Instrument Corp. will soon begin production of a line-scan camera subsystem, the CCD1300. Frank Bower, marketing manager for CCDs, says the system, consisting of two basic units—a remotely positionable computer-compatible camera (the CCD1310) and a camera-control unit (the CCD1320)—is aimed at such applications as measurement, process control, document scanning and object recognition.

Heart of the subsystem is the CCD131, a monolithic self-scanned 1,024-element image sensor, which in addition to the row of sensing elements contains two charge-transfer gates, a pair of two-phase analog shift registers and two gated charge integrators that provide a 1-volt swing at the output. This 1,024-element array in the camera senses a line of optical information and produces an analog waveform proportional to the brightness of the image. When motion is being sensed, a complete picture or series of line scans can be generated.

When used with a microprocessor or a computer, says Dennis Stoscher, manager of CCD-systems applications, the CCD1300 is a powerful scanning and recognition tool. For example, he says, to bin or store rear-lighted documents being sensed by the line-scan camera, a digital representation of one or more desired objects to be binned is stored in the microprocessor read-only memory and is placed in synchronization with the unknown object located on a transport. When both the camera output and the microprocessor output indicate a match, the proper binning control is activated to receive the document.

The CCD1310 camera contains the sensor elements, a timing module, a signal-processing module, and one of five standard lenses. The camera measures 2.6 by 5.5 by 6 inches. Its spectral range covers the visible to infrared, and dynamic ranges go from 200:1 up to 500:1. Saturation exposure is 0.06 foot-candle-second.

The CCD1320 control unit, which measures 12 by 4 by 8 inches and contains the power supply, provides three basic control functions: video output controls for both analog and binary mode, with selectable automatic gain control; a video data rate that is variable from 100 kilohertz to 10 megahertz; and either synchronous or asynchronous exposure control. Available from stock, price of the subsystem is $3,250 with one lens.

Hybrid op amp delivers

±75 mA at ±140 volts

Housed in a standard eight-pin TO-3 package, the model 3583 operational amplifier provides output-voltage swings as wide as ±140 volts with currents as high as ±75 milliamperes. The op amp has a monolithic FET input stage which provides an input impedance of 10⁹
Turn on the heat, set up the program, and give 10,000 4K RAMs a chance to fail.

At Microtest we succeed when your parts fail—whether you make IC’s or buy them. We do testing, you see. And build life-test systems. Our biggest Murphy's Oven, System 10,000, will put 10,000 16-pin 4K RAMs through a complete dynamic life-test regimen. It will do lots of other devices, too. But RAMs are what people need to test most this year. And system 10,000 has programs and capabilities for all 4K RAMs:

- ANY VOLTAGE
- ANY TIMING
- ANY PINOUT

So if your job involves large quantities of 4K RAMs that must not fail in a system, please give them a fighting chance to fail in Murphy's Oven. And when you're ready for 16K RAMs, so are we. If you need to life-test smaller quantities of digital and linear devices, ask about Murphy's Oven System 1,000, which starts at $15K. Use the reader card or write/phone/TWX Microtest Systems, Inc., 743 N. Pastoria Ave., Sunnyvale, CA 94086. (408) 739-8001. TXW: 910-339-9325.

Electronics / September 2, 1976
New MCL power generators feature flexibility, high output, minimum distortion.

Main frames for 115 VAC and for 208/220/240 VAC operation. Six standard front panel plug-ins provide frequency range from 10 MHz to 2500 MHz with a minimum output of 65 watts. Two optional plug-in modules are available which produce 100 watts narrow-banded. Single knob tuning for each plug-in provides exact frequency selection. Front panel, direct frequency readout is accurate to ±1 percent.

Solid-state mainframe designed for minimum components, optimum reliability. Residual AM held to .1 percent, eliminating nearly all AM distortion in output waveform. Generates continuous or 1 KHz square wave pulsed output. External AM signal generator can be added with single plug-in connection. External pulse circuit is TTL compatible. Automatic VSWR protection.

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Vactec's latest development is a new Blue Enhanced Silicon (BES) photodiode with exceptionally low dark current for efficient response in the blue region (200 - 400 nm). Made in Missouri, U.S.A., it performs equally well in an expensive Japanese SLR camera or in an American-made colorimetric analyzer as well. And you'll like the price, which could be as big a breakthrough as blue sensitivity.

Vactec also introduces a new line of PIN photodiodes that operate at high voltages, low noise levels, and fast rise times, with about half the blue sensitivity of the BES photodiode. For larger areas, Vactec offers a complete range of Blue Enhanced Silicon photovoltaic cells up to 1 1/8" diameter.

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- CdS & CdSe photoconductors
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MADE IN U.S.A.

Unity-gain buffer amplifier
has 100-MHz bandwidth

The MSK model 350 is a closed-loop unity-gain buffer amplifier with a small-signal bandwidth of 100 megahertz. Optimized for linear applications as a noninverting device, the 350 has a full-power bandwidth of 20 MHz and a slew rate of 1,300 volts per microsecond. The amplifier has a settling time to within 1% of the final value of 15 ns, a minimum

For more information contact
Dick Hanschen, 4441 Sigma Road, Dallas, Texas 75240, (214) 233-6631.
Circle Reader Service No. 250

4441 Sigma Road, Dallas, Texas 75240

Electronics / September 2, 1976
Design with the complete flat cable/connector system.

Assembly-cost savings are built in when you design a package with "Scotchflex" flat cable and connectors. But more important, 3M Company offers you the full reliability of a one-source system: cable plus connectors plus the inexpensive assembly aids that crimp the connections quickly and securely (with no special operator training required).

The fast, simple "Scotchflex" assembly sequence makes as many as 50 simultaneous multiple connections in seconds, without stripping, soldering or trimming the cable after assembly.

Connector units provide positive alignment with precisely spaced conductors in 3M's flat, flexible PVC cable. The connector contacts strip through the insulation, capture the conductor, and provide a gas-tight pressure connection.

With cable, connectors and assembly tools from one design and manufacturing source, you have added assurance the connection will be made surely, with no shorts or "opens."

And "Scotchflex" now offers you more design freedom than ever. From stock you can choose shielded and non-shielded 24-30 AWG cable with 10 to 50 conductors, and an ever-increasing variety of more than 100 connectors to interface with standard DIP sockets, wrap posts on standard grid patterns, printed circuit boards, or headers for de-pluggable applications. 3M's DELTA "D" type pin and socket connectors are now also available. For full information, write Dept. EAH-1, 3M Center, St. Paul, MN 55101.

3M's "Scotchflex" line.

See our catalog in EEM—Page 1056.

Don't miss THE PUZZLE CHILDREN October 19 on PBS.

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Now Power/Mate brings you 33% more power in the same package size with the second generation of our Econo/Mate series.

The size is the same, the basic components are the same for easy interchangeability. But that's where the similarity ends.

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We wouldn't call it Econo/Mate if it weren't.

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Housed in a 1-by-1-by-2-inch module and weighing only 3 ounces, a dc-to-dc converter will deliver up to 5 watts at 5 volts from input voltages in the range of 42 to 56 v dc. Under full load and with an input voltage of 42 v dc, the converter will put out a minimum voltage of 5.0 v dc.

With no load and with an input voltage of 56 v dc, the unit will put out no more than 5.3 v dc. Its maximum temperature coefficient is 0.02%/C. Maximum peak-to-peak ripple is 50 millivolts, while typical ripple is half of that.

Powercube Corp., 214 Calvary St., Waltham, Mass. 02154. Phone John C. Prestidge at (617) 891-1830 [386]

1,500-volt optoisolator has output rating of 300 V

A compact optically coupled isolator, the model OPI 6000, has an input-to-output isolation rating of 1,500 volts dc with an output breakdown rating of 300 v dc. The unit, which is housed in a six-pin plastic dual in-line package, consists of a gallium-arsenide infrared emitter

Spares parts in stock

Radio Research Instrument Co., Inc.

3 Quincy St./Northvale, N.J. 07649
(203) 853-2600

Electronics/September 2, 1976
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Electronics / September 2, 1976
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Dana Laboratories, Inc., 2401 Campus Drive, Irvine, California 92664, 714/833-1234.

New products

and a high-voltage npn phototransistor. Guaranteed maximum output leakage current is 100 nanoamperes at a collector-emitter voltage of 200 V.

Saturation voltage for the output transistor is 0.4 V maximum with an input current of 10 milliamperes and an output of 0.5 mA. Current transfer from input to output is a minimum of 20% with a 10-mA input current and 5 V on the output transistor. In thousands, the OPI 6000 sells for $1.25 each.

Optron Inc., 1201 Tappan Circle, Carrollton, Texas 75006. Phone (214) 242-6571 [387]

Sample-and-hold unit has 200-ns acquisition time

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New products

digital converters, the SHM-5 has important applications in pulse-code-modulation systems and in fast data-acquisition systems.

The module has an input impedance of $10^6$ ohms, a tracking bandwidth of 5 megahertz, and a slew rate of 25 volts per microsecond. In the hold mode, maximum droop is 20 microvolts per microsecond and maximum feedthrough is 0.005% of input signal. Key to the performance of the module is a very fast hybrid amplifier manufactured at Datel Systems' thin-film hybrid facility. Preceding the amplifier and the hold capacitor is a fast FET sampling switch controlled by a TTL-compatible input. In small quantities, the SHM-5 sells for $189. Delivery time is four weeks.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone Eugene Zuch at (617) 828-8000.
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For more information contact Milt Folds, Commissioner, Georgia Bureau of Industry & Trade, P.O. Box 1776, Atlanta, Georgia 30301, Dept. EL-732.

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Electronics / September 2, 1976

Circle 201 on reader service card 201
The new IWATSU SS-4511 portable DC-50MHz oscilloscope provides a variety of functions and precision ±2% accuracy comparable to that of sophisticated bench type oscilloscopes, yet weighs only 7.8kg (17.2 lbs.). The new scope not only features a brighter, clearer CRT, but also provides excellent linearity. AC power: 100, 117, 217, 234 volts ±10%, 50 to 400Hz.

Main Features
• CRT designed for 100MHz scope under 20kV accelerating voltage
• ±2% accuracy at 5mV/div. and 0.1µs/div.
• 1mV/div., both channels
• Delayed and mixed sweep
• Composite trigger

For further details, please contact the following distributors.

USA: Dumont Oscilloscope Lab.
201-575-8666
W.Germany: NBN Elektronik 08151-13036
Sweden: Teleinstruments AB 08-380370
Finland: OY Honeywell 780311
Austria: Universal Elektronik 422358

IWATSU ELECTRIC CO., LTD.
1-3, Nihonbashishi 2-chome, Chuo-ku
Tokyo 103, Japan
Phone: Tokyo 272-0461
Telex: J24225 TELEIWA

New products/materials

High-conductivity ceramic potting compound Ceramacast 510 is a high-alumina formulation with a thermal conductivity of 25 BTU-inches per ft²-hr-°F. Neither acid nor alkaline, the material will not attack electrical windings. It has a compressive strength of 7,500 psi and a modulus of rupture of 1,500 psi. Dielectric strength is 50 volts per mil. Supplied as a powder to which water is added, Ceramacast 510 sets up chemically and then requires a bakeout at 200°F to complete the cure. It sells for $27.50 a quart, $50 a gallon, and as little as $15 per gallon in 50-gallon lots. Delivery is usually from stock.

Aremco Products Inc., P.O. Box 429, Ossining, N.Y. 10562 [476]

Platinum-silver conductor ESL 9501A is a glass-free formulation for use in hybrid microcircuits. Priced at 55 cents a gram, the conductor is said to have better solder-leach resistance than similar low-cost platinum-silver materials. ESL 9501A can be fired at peak temperatures from 850°C to 940°C with little variation in its electrical and mechanical properties. It is compatible with Electro-Science Laboratories' 2800 series thick-film resistors, and can be bonded by either ultrasonic or thermo-compression techniques. Sample quantities sell for $1.25 per gram.

Electro-Science Laboratories Inc., 1601 Sherman Ave., Pennsauken, N.J. 08110. Phone (609) 663-7777 [477]

Conductive coatings for the rf shielding of plastic enclosures are included in a $25 kit from Electro-Kinetic Gas Sensing Semiconductor FIGARO GAS SENSOR TGS quickly senses even small amount of gas.

New Models, some with highly sensitive CO sensor, now on the market. Please contact the address below directly for catalogs and price/delivery information.

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Circle 202 on reader service card
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Each 24dB/octave filter can be used as high pass or low pass with selectable gain of 1 or 10. Or connect them in series for bandpass. 48dB/octave high pass, or 48dB/octave low pass, with selectable gain of 1, 10, or 100. Select normal (Butterworth) and pulse (Bessel) by the push of a button. All of this is standard.

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It'll tell you all you need to know about our newest filter. And when you need a filter that does just what you expect, you'll know where to find it. The predictable filter™ $655. Ithaco. Box 818, Ithaca, New York 14850. Call (607) 272-7640.
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Circle 204 on reader service card

New products/materials

Systems Inc. Included in the kit are copper-loaded coatings X-Coat 330 and X-Coat 332 plus Conduct-X 5003 caulking compound, an application brush, and instructions. All of the materials in the kit have a surface resistivity of 1 ohm per square or less. Each is available from stock in production quantities.


Low-viscosity casting resin Stycast 3051 is a one-part potting and encapsulating material that can be cured at temperatures as low as 150°C. The material has a shelf life of three months at 25°C. This may be increased greatly by storing below 0°C. Viscosity at 25°C is less than 3,000 centipoises. This may be reduced by heating the Stycast 3051 just prior to using it. Elevating the temperature to 45°C, for example, reduces the viscosity to 1,200 centipoises. The resin sells for $1.75 a pound in 60-pound pails.

Emerson & Cuming Inc., Canton, Mass. 02021. Phone (617) 828-3300 [479]

Mica Insulation for use up to 1,200°F maintains high insulation resistance in the presence of high humidity. Called Vitra-Bond, the mica insulation has high flexural strength and can be readily punched.

Midwest Mica & Insulation Co., 4853 West 130 St., Cleveland, Ohio 44135 [480]
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New literature

Photomask life. A paper entitled “Photomask Degradation in Contact Printing of LSI Circuits Onto Silicon Wafers” describes the results of a joint experimental effort by researchers from Corning Glass Works and the Hewlett-Packard Co. During the experiments, comparisons were made between soda-lime, alumina-soda-lime, and alumina borosilicate glasses. Also studied were chrome films, dc-sputtered iron-oxide films, and rf-sputtered iron-oxide films. A major result of the study was that alumina borosilicate glass can double mask life. Perhaps more importantly, it can also increase yields in critical multilayer fabrication. Copies of the paper may be obtained from the Materials Dept., Corning Glass Works, Corning, N.Y. 14830. Circle reader service No. 421.

Triac and SCR guide. A 32-page cross-reference guide that covers more than 2,100 triacs and SCRs has been put out by the RCA Solid State division, Box 3200, Somerville, N.J. 08876. Designated CRG-421, the guide includes an easy-access short listing of the more popular thyristors, in addition to the comprehensive directory. [422]

Microscopes. A line of 13 microscopes and their accessories is described in a 10-page catalog entitled “From Slice to Circuit.” Among the covered inspection and measuring microscopes are units for checking the flatness and surface characteristics of wafers, units for measuring the thickness of junctions and thin films, and microscopes for detecting pinholes, stacking faults, voids, and other flaws. Copies of the catalog are available from Carl Zeiss Inc., 445 Fifth Ave., New York, N.Y. 10018. [424]

Semiconductors. A 52-page catalog from Semitronics Corp., 64 Commercial St., Freeport, N.Y. 11520, lists more than 5,000 semiconductor devices, including transistors, rectifiers, thyristors, and signal diodes. [426]
Flat-cable connectors. Catalog 73-177 from AMP Inc. covers nearly 100 latch connectors for the mass termination of flat cables. The cable conductors, which can be 28-gauge stranded or 30-gauge solid, should be on standard 0.050-inch centers. The connectors can be applied at the end of a cable or anywhere along its length. Also described in the catalog are new card-edge connectors in sizes that accommodate from 20 to 60 positions. Copies are available from AMP Inc., Harrisburg, Pa. 17105. [429]

Magnetic shielding. One of the features of the new Ad-Vance Magnetics magnetic-shielding catalog/manual is a 28-page engineering section that includes technical articles, graphs, and tables for aid in the solution of shielding problems. An important part of this section is an article entitled “Why You May Need More Than Figures to Design Magnetic Shields.” For a copy of 48-page manual No 76, write to Richard D. Vance, president, Ad-Vance Magnetics Inc., 226 East Seventh St., Rochester, Ind. 46975 [430]

Zener Diodes. A 146-page catalog put out by Siemens Corp., Components Group, 186 Wood Ave., South, Iselin, N.J. 08830, covers the company’s full line of zener diodes. Included are cross-reference lists, diode specifications, and application notes. [431]

4-k RAMs. A 16-page commentary on the reliability of 4,096-bit random-access memories manufactured by Texas Instruments covers the company’s popular series TMS 4030, 4050, and 4060. Reliability figures from five customer locations are reported. Copies of the report may be obtained from Texas Instruments Inc., Inquiry Answering Service, P.O. Box 5012, M/S 308 (Attn: Bulletin CR-112), Dallas, Texas 75222. [432]
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**Electronics**/September 2, 1976
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Actual Size

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Electronics / September 2, 1976
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Circle 266 on reader service card

Circle 167 on reader service card
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- Complete solid state construction.
- Operates over a wide temperature range.

Specifications:
- Transfer equation: \( E_o = \frac{XY}{10} \)
- Input impedance: Both inputs 20K ohm.
- Output impedance: 1\( \Omega \)
- Full scale output: ±100° or ±16V (for any condition)
- Zero point virtually unaffected by temperature
- Distortion: 3° maximum
- Linearity: 0.5% of full scale all over the specified temperature range
- Regulation control better than ten times superior to any other unit under the same load, frequency and temperature changes
- Cycle life: Unlimited
- Transformer isolation between all power inputs and the outputs
- Power requirements: ±15V DC ±15MA max.
- Transformer: 5K ohm
- Load: 0 to 500 MA, RMS
- AC input line voltage: 115V RMS ±20% @ 400 Hz ±20%
- Distortion: 2% maximum
- AC input current: 100 MA, max. at full load
- DC power: ±15 V DC ±5% @ ±1 MA, max.
- Phase angle: 0° max.
- Temp. Range: -40°C to +85°C
- Case Material: High permeability nickel alloy
- Terminals: Glass to metal hermetic seal pins

High Precision Analog Multipliers

PRODUCT ACCURACY (MCM 1519-1): 
- All units are hermetically sealed and are not affected by external fields
- High analog product accuracy and wave quality allows dual multiplier assemblies to be matched with 1% of point over the specified temperature range
- Full four quadrant operation
- Package size, power supply requirements and other specifications may be altered to your exact requirements at no extra cost.

Features:
- No external trims required
- Distortion free AC output over entire dynamic range
- Linearity, product accuracy and zero point virtually unaffected by temperature

Specifications:
- Transfer equation: \( E_o = \frac{XY}{10} \)
- X & Y input signal ranges: 0 to ±10V PK
- Maximum zero point error (X=0; Y=0 or X=±1; Y=0 or X=0; Y=±1): ±2MVRMS
- Input impedance: Both inputs 20K ohm.
- Full scale output: ±100° or ±16V (for any condition)
- Zero point virtually unaffected by temperature
- Distortion: 3° maximum
- Linearity: 0.5% of full scale all over the specified temperature range
- Regulation control better than ten times superior to any other unit under the same load, frequency and temperature changes
- Cycle life: Unlimited
- Transformer isolation between all power inputs and the outputs
- Power requirements: ±15V DC ±15MA max.
- Transformer: 5K ohm
- Load: 0 to 500 MA, RMS
- AC input line voltage: 115V RMS ±20% @ 400 Hz ±20%
- Distortion: 2% maximum
- AC input current: 100 MA, max. at full load
- DC power: ±15 V DC ±5% @ ±1 MA, max.
- Phase angle: 0° max.
- Temp. Range: -40°C to +85°C
- Case Material: High permeability nickel alloy
- Terminals: Glass to metal hermetic seal pins

Precision AC Line Regulator

Total Regulation 0.15% Max.
- Output set to ±1% accuracy - this includes initial set point plus line, load, frequency and temperature changes
- Foldback short circuit protection provided resulting in protection against overloads and short circuits of any duration
- Low profile package with straight pins makes the unit suitable for PC board mounting
- Transformer isolation between all power inputs and the outputs
- Other units available at different power levels. Information will be supplied upon request.

Specifications Model MLR 1476-2:
- AC input line voltage: 115V RMS ±20% @ 400 Hz ±20%
- Output: 26V RMS ±1% (for any condition)
- Load: 0 to 250 MA, RMS
- Total regulation: ±0.15% maximum (any combination of line, load or frequency)
- Distortion: 2% maximum
- AC input current: 100 MA, max. at full load
- DC power: ±15 V DC ±5% @ ±1 MA, max.
- Phase angle: 0° max.
- Temp. Range: -40°C to +85°C
- Case Material: High permeability nickel alloy
- Terminals: Glass to metal hermetic seal pins

GENERAL MAGNETICS • INC
135 Bloomfield Ave., Bloomfield, New Jersey 07003 - Tel. (201) 743-2700

Circle 320 on reader service card