JUNE 8, 1978

PROCESSOR CONVERTS DVM INTO AMPLITUDE-MEASURING SYSTEM/133

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Electronics

The International Magazine of Electronics Technology

Vol. 51, No. 12 • June 8, 1978

Highlights

Cover: Data-link control goes LSI, 104

The newest large-scale integrated circuit for data communications brings order to establishing the necessary protocols. The data-link control chips promise huge reductions in parts counts and hardware and software requirements.

Cover by Robert Strimban.

Where are the field testers? 83

Computer makers must swap good boards for bad in field service, because on-site repair is not possible. More sophisticated portable test equipment would be one answer to this expensive problem.

One-chipper has prototyping version, 126

The 6500/1 is a one-chip microcomputer with a difference. As well as the 40-pin production model, it comes in a 64-pin emulator version that makes the job of prototyping a system much easier.

Building a versatile DVM, 133

A microprocessor for fast, automated control and data manipulation in a software-intensive design produces a highly accurate digital voltmeter that makes many types of measurements easily and converts them into useful engineering units.

And in the next issue . . .

Designing with power V-MOS . . . applying CCDs to memory design . . . looking at a 12-bit hybrid data-acquisition system.

Electronics

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Publisher's letter

There's a real need for engineers to learn about data communications—the field has its own buzz words, and the standards are just plain confusing to most, says Alan Weissberger, senior staff engineer for Signetics Corp., whose cover article attempts to close that gap (see p. 104).

Weissberger points out that the protocols in data communications introduced some five years ago have still not caught on among designers because they are not well understood. In addition, the communications field, like all areas associated with electronic technologies, has been changing so fast that engineers working on computers and terminals have found it difficult to keep track.

The main reason the Signetics senior staff engineer gives for writing this article on data-link controls is a wish to aid engineers in adjusting—as they will have to—to the demands of multiple protocols despite the constant changes and the complexity of the standards.

"Designers are up against a complex problem in which even understanding the terms is difficult," Weissberger observes. "The importance of finding out what LSI data-link control chips can do to solve these complex problems lies in the ability of these new devices to perform multiprotocol support." He notes that the data-link control chips discussed in the article and others like them are more complicated even than microprocessors.

The engineers involved in designing and developing the nonverbal communicators used by the severely handicapped to form messages are highly motivated and unique. That's one of the conclusions Pam Hamilton of the Boston bureau draws after meeting and interviewing a number of the people connected with these unusual endeavors.

For one, Pam points out, the engineers have to work with occupational therapists to design equipment that can be used simply but efficiently by the disabled. This requirement poses some interesting problems. For example, a keyboard operated by one hand has to be different from standard keyboards.

"Crossover efficiency is the reason," Pam explains. "A person's ability to punch keys with one hand is best in the center of the board and very poor at the edges, especially in crossing over. So the keyboard built for these situations has to have all the most-used keys clustered in the center."

Another unusual aspect of communicator designers' work is that most have to study linguistics in order to understand what they are attempting to do. Surprisingly, that is more important than learning anatomy or medicine. At the same time, the engineers also become part of the education link with the handicapped. They have to appreciate the extreme importance the communicators have in the lives of their users.

In one case, a small handicapped boy using one of the communicators was able to compose messages for the first time in his life. "After trying out the machine, he spent the rest of the afternoon writing to his friends and relatives," Pam reports.

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Readers' comments

receive the appropriate emphasis.

Ervin J. Nalos
Boeing Co.
Seattle, Wash.

On the other hand . . .

To the Editor: R. W. Johnson [Readers' Comments, April 13, p. 6] may indeed be labeled a heretic for attacking solar-power satellites, but he does have a blind spot: "safe" nuclear power. Many prominent Government and industry officials have been advocating nuclear energy with waste-disposal systems that have earned a great deal of as-yet ignored criticism. Only one more of the many criticisms of such proposals is the life-span of a nuclear power plant before it must be decommissioned and left to rot as a piece of radioactive waste, essentially forever. Mr. Johnson would be wiser to suggest earth-based solar power.

Alan Falk
Califon, N. J.

Memory at any cost

To the Editor: Your article about charge-coupled devices and bubble memories ["New arrivals in the bulk storage inventory," April 13, p. 106] mentions the possibility of CCDs' being used as main memory in digital computers. That would of course require the use of high-speed cache memories to front-end it—which brings to mind an interesting idea: whenever the central processing unit requested a word from memory, the memory unit would have to decide whether it's "cache" or "charge."

Robert F. Gaebler
Rolla, Mo.

Correction

Credit for many of the programs appearing in "Say it in a high-level language with 64-K read-only memories" [April 13, p. 119] was inadvertently dropped from the the text. The LLL Basic software is the work of Michael D. Maples and Eugene R. Fisher of Lawrence Livermore Laboratory in Livermore, Calif. Their articles on the subject have appeared in the IEEE Computer and in IEEE conference proceedings.

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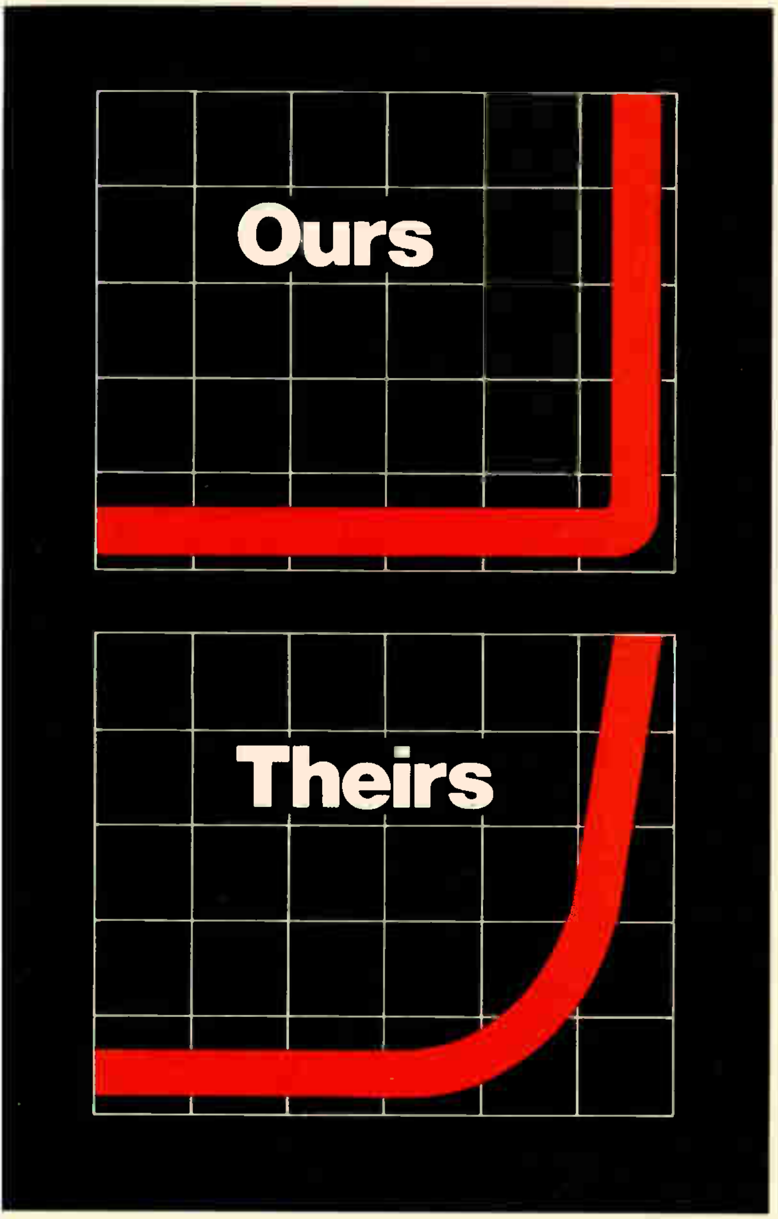

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Circle 9 on reader service card

News update

■ Researchers at Bell Telephone Laboratories in Murray Hill, N. J., cite improvements in the light-conversion efficiency of two types of photovoltaic cells designed with materials other than silicon. The experimental cells, although not as efficient, seemingly are easier to produce and less expensive than conventional silicon solar cells [*Electronics*, Aug. 4, 1977, p. 38].

One of the new cells has an efficiency of 14.4% and is made of a layer of amorphous indium-tin-oxide on a single crystal of indium phosphide. In 1975 Bell Labs first reported on an indium-phosphide–cadmium-sulphide solar cell having an efficiency of 12.5%.

The indium-tin oxide layer can be polycrystalline or amorphous, notes a Bell spokesman. This means the atoms in the cell's two layers do not have to be precisely aligned, he continues, "permitting simpler, more rapid preparation and opening up the possibility of using a wide variety of less expensive materials."

The second solar cell now has an efficiency of 12% and is produced by immersing single-crystal gallium arsenide (pretreated with a ruthenium solution) in a solution of selenium compounds. An untreated GaAs semiconductor–liquid-junction cell, with an efficiency of 8.8%, was reported by Bell Labs a year ago.

■ The U.S. Marine Corps has established a new beachhead in its efforts to obtain a new battlefield telephone exchange system. That is the significance of the award to Harris Corp.'s Semiconductor Programs division in Melbourne, Fla., of a contract for an undisclosed amount to develop a family of large-scale integrated circuits for use on the unit-level circuit switch program [*Electronics*, Nov. 25, 1976, p. 35].

Awarded by International Telephone and Telegraph Corp.'s Defense Communications Systems division in Nutley, N. J., prime contractor for the digital tactical telephone-switching system, the contract calls for Harris to develop five C-MOS circuit types. **Bruce LeBoss**

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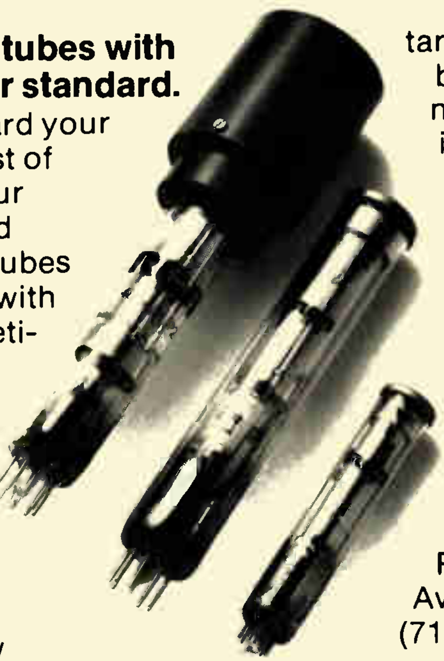

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People

Philips' Bok targets total industrial systems

New approach. Philips aims to concentrate on entire process-control systems, says Bok.

One thing is certain about Philips, Europe's giant electronics manufacturer: when the company does something, it does it in a big way. Therefore, when the recently appointed manager of the Scientific and Industrial Equipment division's Systems Group in Eindhoven, the Netherlands, says his operations are going to change course, the international industrial electronics sector has good reason to take note.

New emphasis. Alfred B. Bok, 38-year-old head of Philips' industrial control and automation programs, intends to swing from reliance on selling individual hardware to emphasis on marketing total processing systems. "We can do this by integrating all our resources into one package," Bok explains. "In this respect, we feel we are stronger than most of the competition because our expertise is so diverse."

What this strategy means is that the Philips group will de-emphasize the black box approach it has used so far. "Our studies have shown that users are not so much interested in a black box, say a monitor, data logger, or display unit to handle just part of a control job, but in a total-systems approach," Bok says.

What is called for these days, he adds, is analyzing a customer's overall requirements and satisfying them with a complete system, be it a laboratory automation setup or a region-wide air-pollution monitoring network. Besides appealing to the usual process-control industries such as steel and cement producers worldwide, Bok expects to attract food- and beverage-processing customers.

Of course, the Dutch firm has sold complete systems. "What was lacking in the past, however, was an organized approach," he says. "We took on jobs on the basis of opportunities as they came along."

Plus, minus. "Our strength is our many resources; our weakness is that we don't always make maximum use of them," Bok concludes. Today he has a staff of some 500, mainly in sales and engineering, stationed in several European countries, and it appears the number will increase.

"We are now bent on becoming a full-fledged profit center setting its own policies and promoting Philips' role as a major supplier of control and automation systems with a wide range of applications," he says.

IR's Pelly links U. S. and European technologies

"Applications activities in Europe and the United States have tended to be isolated in the past. Europe has not always been fully aware of what was going on in the U. S. and vice versa," observes Brian Pelly, recently appointed director of applications engineering worldwide for International Rectifier Corp.

But that situation is changing, particularly as it involves IR's bread-and-butter power semiconductors—and adjusting to the changes by stimulating a cross fertilization of knowledge is what Pelly's newly created job is all about. The El Segundo, Calif., firm manufactures components both in the U. S. and at facilities in England and Italy.

Generally, the products where the two continents can help each other most include transistors for switching power supplies, now further advanced in the U. S., and high-power solid-state drives, where the Europeans have a lot of experience. "European applications engineers

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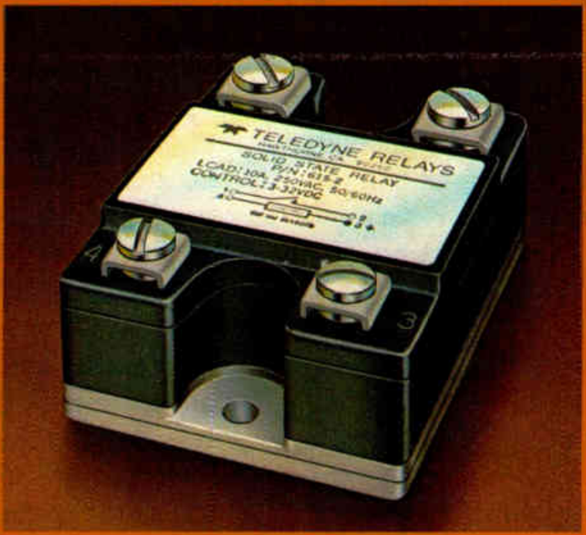

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Editorial

A savings program that needs saving

When the Productivity, Reliability, Availability and Maintainability program, called PRAM, was set up by the Air Force some two years ago, it had a budget of $30 million, a program office to keep track of projects, and a staff of dedicated people. As defense programs go, PRAM was pretty small, but it is paying off to the tune of almost $80 million projected over a five-year period. Its mission has been to identify items in older, established weapons systems that can be upgraded by new technology to improve total reliability or maintainability at a savings to the Air Force. About half the projects PRAM has in the works involve some electronics, mainly the avionics portions of aircraft (see p. 86).

Now PRAM is in difficulty with the military-budget planners in Congress. The fiscal 1978 budget was slashed to $2 million, and it's unlikely that funds will be restored in the fiscal 1979 budget. At present the Air Force is hoping to get PRAM funds increased to $8 million for fiscal 1980 through 1984, though the program would need $15 million to be on a sound footing and $20 million to perform at full efficiency, according to an Air Force official.

Considering the fact that PRAM has both performed its mission and won supporters in the Defense Department, it is natural to wonder about the cutback. PRAM appears to have been a victim of a misunderstanding of its objectives by House Appropriations Committee staffers. Indeed, the program has come under the suspicion of being a boondoggle designed to bail out faltering programs.

Since horror stories concerning Government waste abound, the House Appropriations Committee staff members have good reason to be skeptical. But in this case the results are known—the budgetary investment has been returned in measurable savings. Therefore, PRAM should not take the brunt of reductions prompted by the abuses in other programs.

Instead of curtailment, this program should be extended. Instead of the flap in Congress, it should be adopted by the other services (an idea that the Defense Department has considered already).

For PRAM to maintain its lease on life, the Defense Department will have to come up with a satisfactory argument on two issues. First, the House planners want to keep it in the research and development section of the budget while the Air Force wants the bulk of it returned to operations and maintenance because PRAM projects concentrate on updating portions of aircraft and weapons systems already in the Air Force hangars. The two commands sharing responsibility for PRAM—the Systems Command and the Logistics Command—are concerned with reliability and maintainability. There appears to be no reason to put this program solely into R&D budgets, particularly as the Air Force could use all the research allotments it can get for programs that are truly R&D.

Second, the congressional overseers are concerned about accountability in the PRAM program. They want projects budgeted as line items, that is, defined ahead of time. But the Air Force maintains that this requirement would hamper flexibility. Line items, the military argues, not only require congressional approval to proceed but need additional approval to change or even be dropped—a time-consuming process for individual activities that may only involve $25,000. A compromise will have to be reached on this accountability question, most likely by linking the budget to projects or entire weapons systems—a procedure the Air Force can live with.

PRAM has been tangled up unnecessarily in a budgetary conflict between Congress and DOD that goes well beyond this particular program. It would be a waste to see it slip through a crack during the maneuvering that accompanies the huge military budgets.

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INTERNATIONAL edition JUNE, 1978

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IN THIS ISSUE

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Make Your Instruments Smart at a Price you Can Afford—HP's 97S, 9815A, 9875A

The new 97S is the inexpensive solution to automating data acquisition operations for low-cost, low-speed instrumentation. It combines the HP-97A fully programmable, printing calculator with a powerful BCD interface.

For applications dedicated solely to data logging, HP offers an economical solution with the new 9875A Tape Cartridge Unit. In addition to acting as a peripheral mass storage device for data exchange between the HP Series 9800 desktop computers, the 9875A is a stand-alone data logger. With a built-in microprocessor, it can log data on a DC-100 tape cartridge without a controller.

Where enhanced small system performance, varied interfacing capability, and a moderate price are needed, HP's 9815A computing controller can serve as a data logger or controller for a small instrumentation system. The 9815A's Auto-Start feature cuts operator instruction by automatically loading and executing a program when the power is switched on. The controller also features a 16-character, alphanumeric thermal printer, two optional I/O channels, and a tape cartridge for quick storage and retrieval of 12,000 12-digit numbers. HP's four optional interface cards enable the 9815A to interface to a variety of HP peripherals.

For Greater Speed and Power—HP's 9825A, System 45

Consider the powerful and versatile HP 9825A controller with vectored priority interrupt for control of multi-device systems. You can increase data throughput by programming software buffers between the program and your instrument. For real-time communication with high-speed instruments, the 9825A has direct memory access (up to 400k transfers per second) and a built-in 250K byte tape cartridge. A memory load/record feature allows you to suspend processing anytime, store the complete contents of memory on tape, and continue later. A live keyboard also permits you to do calculations, call subroutines, list programs, etc., while the program is running.

If you have high-performance computational needs, HP's System 45 could be the answer. Similar to the 9825A in its da acquisition and control features, Syste 45 also offers 15 levels of priority interru and a CRT. Its dual processors allow I and computation operations to be handl simultaneously. On the CRT, you can pl your data, create drawings, histogram pie charts, and contour plots and circ diagrams. To make programming faste and easier, System 45 has a typewrite keyboard and enhanced BASIC languag

Five Interface Cards and User Guid

To get your system up and running fas plug in one of HP's standard interface cards and attach the cable to your instru ment. Choose from five cards:
• HP-IB-implements IEEE standard 488-1975 • Bit-Parallel-general purpose interface • Bit-Serial-RS-232-C communications interface • BCD-instrument/measurement interface and • Real Time Clock

To help you put things like interrup and direct memory access into perspective, HP recently published an **I/** **Guide**, a conceptual explanation of interfacing and **HP-IB Programmin Hints for Selected Instruments (9825A).**

Obtain full details by checking D on the HP Reply Card.

Troubleshoot data elephone lines quickly ınd accurately with new ınalyzer

New from Hewlett-Packard comes the 771A/B Data Line Analyzer for making ·oubleshooting measurements on tele-hone lines used for carrying high speed ata. Two versions are available—the 771A is compatible with CCITT stan-ards, the 3771B with Bell Publication 1009. Both measure two basic types of arameters affecting data lines—steady ·ate and transient. The steady state arameters measured are: level, phase jit-·r, weighted noise, noise-with-tone, and equency shift. The transients measured re: 3-level impulse noise, phase hits, ain hits, and dropouts.

Because of the nature of the transients, ıey are normally measured over 15-inute intervals and by measuring all of ıem simultaneously, the 3771A/B saves ›nsiderable operator time. Also, any ›mparison of results is statistically valid.

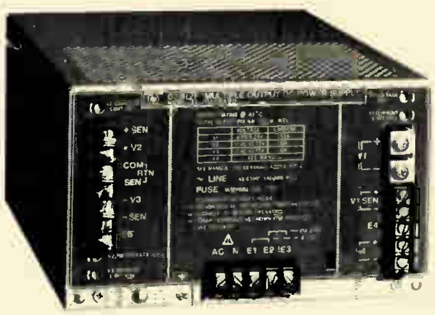
Though usable as a stand alone test strument, the 3771A/B also functions as ırt of an automatic test system. The 771B can be used with the HP 4943A/4A ·ansmission Impairment Measuring Set r complete data line characterization ıd testing. In addition, an option, avail-ıle starting next August, will allow the 71A/B to be controlled externally via e HP-IB.

›tain more information on other optional ıtures and multi-language instructions checking E on the HP Reply Card.

HP-IB

wlett-Packard's new 3771A performs troub-hooting measurements to CCITT standards high speed data transmission lines. When ɘd with the existing HP 3770B Telephone e Analyzer, shown in background, they pro-e a complete, portable data line test system.

New OEM switching power supply for computers and peripherals



If you're an OEM manufacturer of computers and peripherals, consider this 550 watt switching regulated power supply for your products.

Designed for use in electronic data processing equipment, HP's new 63312F multiple-output, switching regulated DC power supply provides three adjustable output voltages of +4.75 to 5.25V, −12 to −15V, and +12 to +15V. An optional fourth output can be specified by the customer to drive a CRT terminal, a motor, or control circuitry.

Featuring brownout protection, the 550W modular supply allows full output power with input voltages ranging from 87 to 127V AC for a 120V input, or 174 to 250V AC for a 240V input.

The unit's three main outputs are regulated to 0.1% for full line and load variations with ripple and noise of 0.05V p-p at the main 5V output and 0.075V p-p at the ±12 to ±15V outputs. To delay loss of DC output voltage following AC input interruptions, the supply maintains the terminal voltage for minimum carryover of 20ms under full load.

Available with barrier block or edge connector interface, the supply has over-voltage crowbar circuits for each of the three main outputs to help protect sensitive loads. Other protective features include output current limiting and overtemperature shutdown. Easy access to components also allows the 63312F to be readily serviced.

For full details about this product, check F on the HP Reply Card.

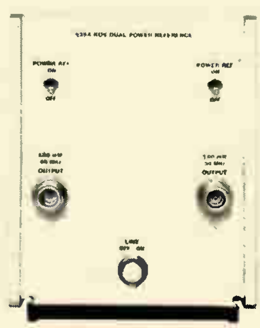
Two mobile reference standards calibrate remote measurement stations

A new measurement assurance concept is emerging in metrology to supplement the usual hierarchy of NBS, to company primary lab, to secondary lab. Critical to such a Measurement Assurance Program (MAP), is a stable portable reference which can carry a reference parameter right out to a production line, a flight line, or a communication tower.

HP now offers two such packages for verifying microwave power meters and frequency counters. The 435A-K05 Dual Power Reference features two totally redundant high-stability oscillators, each of which supplies 1 mW, 50 MHz reference power from a 50 Ω source to calibrate thermistor, thermocouple, and crystal detector power sensors. Each output is factory-set to 1 mW, ±0.7%, traceable to the NBS.

The 435A-K06 Frequency Power Reference verifies frequency counters and power meters with a 10 MHz, 0.5 V standard frequency source and a separate 1 mW, 50 MHz power reference (identical to source of 435A-K05). The frequency reference oscillator exhibits an aging rate of $<5 \times 10^{-10}$/day.

Complete specifications can be obtained by checking item G on the HP Reply Card.



435A - K05

435A - K06

Extremely fast, convenient time and frequency measurements for a broad range of applications

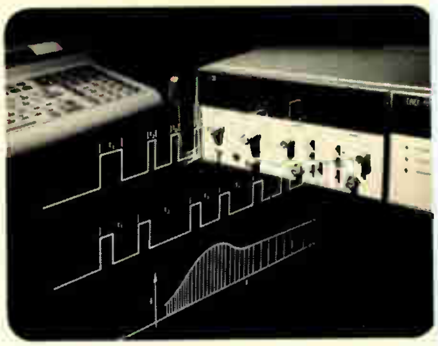
The new 5391A Data Acquisition System makes over 50,000 frequency and time measurements per second. Its 8K byte memory stores up to 2,000 four-digit measurements, all under convenient control of a computing controller. The 5391A also measures successive pulse widths or periods with 2 ns resolution, characterizes signals with rapidly varying frequencies up to 500 MHz, compares the varying frequency of two input signals, or totalizes a group of serially occurring pulses. Its many applications include:

Electronics - VCO testing, radar ranging, data communications, measuring pulse jitter and frequency stability, studying effects of high energy radiation upon electronic devices.

Mechanical Engineering - studies of: rotating machinery, turbine blade flexure, timing in fuel injection systems, high-speed mechanisms.

Physics Research - studies of: time of flight (including velocity and acceleration), nuclear fuel burning rates, and shock waves.

Check H on the HP Reply Card.



HP's 5391A Data Acquisition System is capable of over 50,000 measurements per second in frequency, period, time interval, ratio, or totalize mode.

Signature analysis starts paying off in digital field service

Signature analysis users report increased efficiency troubleshooting microprocessor-based products—in the field and on the line.

Signature analysis is the new digital troubleshooting technique for microprocessor based products. You troubleshoot quickly and confidently—right down to the component level in production or the field. Over 200 companies have designed signature analysis into their products so they can use the low-cost, portable HP 5004A Signature Analyzer for efficient field service. For example:

On-site service. A designer of controls for long-range pipe systems foresaw the difficulties of a board exchange program in remote locations. They designed their product for signature analysis and are forecasting lower downtime and reduced spares.

Field office repair. A cash register manufacturer with a new microprocessor-based product avoided retraining of a large, mechanically-oriented field service force by redesigning their product for signature analysis. Now existing dealer personnel service the product locally.

Service center savings. The board turnaround point for a minicomputer company's board-exchange program had a high rate of "no trouble found" for bad returned boards. By retrofitting some boards for signature analysis, they can troubleshoot most of those boards.

Production line troubleshooting. A maker of computerized games used the HP 5004A Signature Analyzer to cut troubleshooting time on the production line for a very cost-sensitive product.

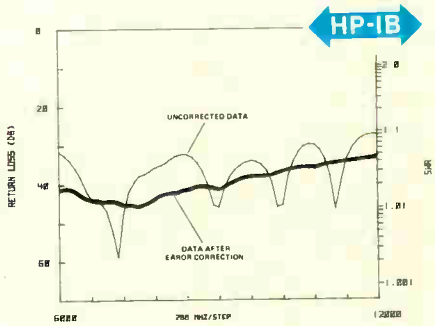
Check out the benefits of signature analysis and HP's 5004A for your products and send for a copy of A Designer's Guide to Signature Analysis. Item I on the HP Reply Card.

Economical, high-accuracy automatic network analyzer for RF/microwave measurements

You can make error-corrected vector measurements of RF/microwave networks rapidly and with results formatted in the form you want with the HP 8409A semi-automatic network analyzer. This system consists of programmable signal sources covering 110 MHz to 18 GHz, network analyzer with test sets, computing controller and digital plotter, plus the applications software to operate the system and perform the error-corrected measurements. The Hewlett-Packard Interface Bus is used to connect and control the system elements.

The system's ease of operation and the straightforward nature of the software make the 8409A an outstanding system for production applications requiring high-accuracy measurements.

Check J on the HP Reply Card for more information.



The dramatic effects of error correction are shown in this plot generated by HP's semi-automatic network analyzer system. It offers major advantages in speed, accuracy and convenience, yet costs only 50% more than a manual network analyzer.

HEWLETT-PACKARD COMPONENT NEWS

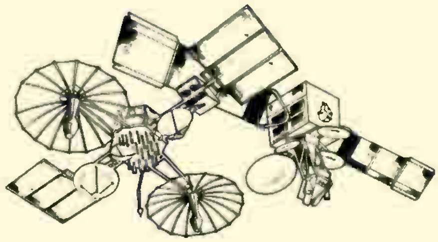
\ew, high-rel GaAs FET available off-the-shelf

Hewlett-Packard has developed a ;ost-effective standard test program for iigh-reliability Gallium Arsenide FETs hat enables us to provide these devices)ff-the-shelf. This means that component ınd reliability engineers can now easily ınd more economically obtain stabilized ¡aAs FETs which meet rigid specifica- :ions for applications requiring high relia- oility performance.

Products available under this program ıre based on the recently introduced standard HFET-1101 and HFET-1102 GaAs FET transistors.

A unique pricing policy distributes the cost of lot acceptance testing over the devices purchased by the various customers obtaining parts from each lot.

If you would like more information on the preconditioning and screening programs, designated TXVBF-1101/2, check K on the HP Reply Card.



Standard hi-rel programs will now give confidence to engineers considering the use of GaAs FETs in applications with demanding performance requirements.

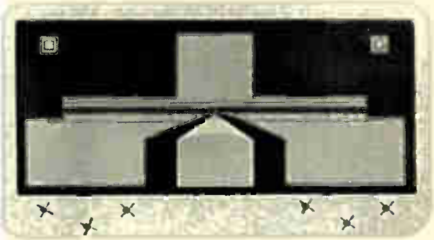
_owest guaranteed noise figure in new FET

The new HFET-1102 is a packaged nicrowave GaAs FET with superior gain :haracteristics and the lowest *guaranteed* ıoise figure at 4 GHz in the industry—1.7 lB maximum.

This low noise performance and a use- ul range from 1 to 12 GHz, makes the HFET-1102 excellent for use in critical irst stage microwave receiver/amplifier ıpplications in land and satellite com- nunications, radar, avionics, and ECM.

In addition, the HFET-1102 has a high ninimum small-signal associated gain of 11.0 dB at 4 GHz and should minimize listortion even at the moderate power evels at which the device can be oper- ıted. The HFET-1102 is packaged in the hermetically sealed HPAC-100A (100 mils square).

Check L on the HP Reply Card for more information.



This new rugged GaAs FET, with a 1.7 dB *guaranteed* noise figure, is intended for first stages of amplifier design.

New optoelectronic catalog now available from HP

The 1978 Optoelectronic Designer's Catalog is here. Included in this 228-page volume are complete, up-to-date, detailed specifications on HP's entire optoelectronic product line.

This catalog is divided into five major product sections: solid state lamps, solid state displays, optocouplers, emitters, and PIN photodiodes. Included is also a new section on fiber optic technology. Each section contains a selection guide, product photographs, package dimensions, complete specifications, and performance graphs.

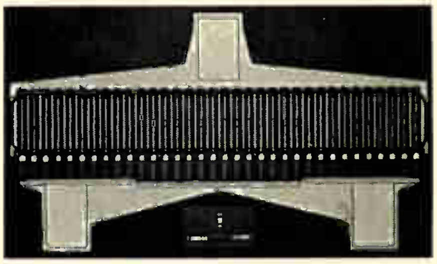
Order your free copy of the catalog by checking M on the HP Reply Card.

New bipolar transistor offers superior linearity

The linearity of HP's new HXTR-5102 microwave transistor at 4 GHz is unmatched by any other one-half watt bipolar transistor on the market and assures the user of minimal distortion.

The new transistor has typical power output figures at 1 dB gain compression of 29 dBm at 2 GHz and 27.5 dBm at 4 GHz. Typical associated gain is 11.5 dB at 2 GHz and 7 dB at 4 GHz. Class A power-added efficiency is 37% at 2 GHz and 23% at 4 GHz. Featuring superior power, gain and efficiency up to 5 GHz, this NPN device is a very reliable, cost-effective microwave transistor for applications requiring power and linearity.

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



Internal matching at input enables broad bandwidth designs with this 34-finger ballasted transistor.

HP introduces a new line of calculators that, logically, have no equal

With HP's new line of scientific, engineering, and business calculators—the Series E—excellence becomes available at a more affordable price. Like their predecessors, the Series E calculators have the "feel" and reliability, born of quality design and construction. And like their predecessors, the Series E calculators have no "equal". That is, they have HP's user-heralded RPN logic for fast, efficient problem solving that has no equal, literally and figuratively. When you add to those traditional HP qualities a number of new convenience features and a lower price, it all adds up to value.

The new conveniences include larger LED displays for improved readability, commas inserted between thousands, a new level of accuracy, and a built-in diagnostic system that tells you 1) when you've performed an incorrect operation; 2) w
it was incorrect; and 3) if the calcula
isn't working.

In addition, each calculator is acco
panied by a complete, modular docum
tation system.

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HP-32E. Advanced Scientific with Statistics. More math and metric capabilities than HP-31E, plus 15 user memories, hyperbolics, comprehensive statistics. Engineering, scientific, and fixed display modes. Decimal degree conversions.

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

HP-37E. Business Management. Features for intuitive problem solving. Simultaneous PV, PMT, and FV. Amortization schedules, statistics with trend-line forecasting, plus 5 financial and 7 user memories.

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HEWLETT PACKARD

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May/June 1978

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- ○ ☐ D. computing controller line
- ○ ☐ E. 3771A/B data line analyzer
- ○ ☐ F. 63312F switching power supply
- ○ ☐ G. 435A-K05/6 power references
- ○ ☐ H. 5391A data acquisition system
- ○ ☐ I. 5004A signature analyzer
- ○ ☐ J. 8409A semi-automatic network analyzer
- ○ ☐ K. TXVF-1101/1102 hi-rel GaAs FETs
- ○ ☐ L. HFET-1102 GaAs FETs
- ○ M. *1978 Optoelectronics Catalog*
- ○ ☐ N. HXTR-5102 bipolar transistor

41A

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Due to individual government and import regulations, the prices of the products featured in this edition may vary from one country to another.

For pricing information, please contact the Hewlett-Packard sales and service office nearest you, or write to any of the regional offices listed on the preceding page.

We look forward to serving you.

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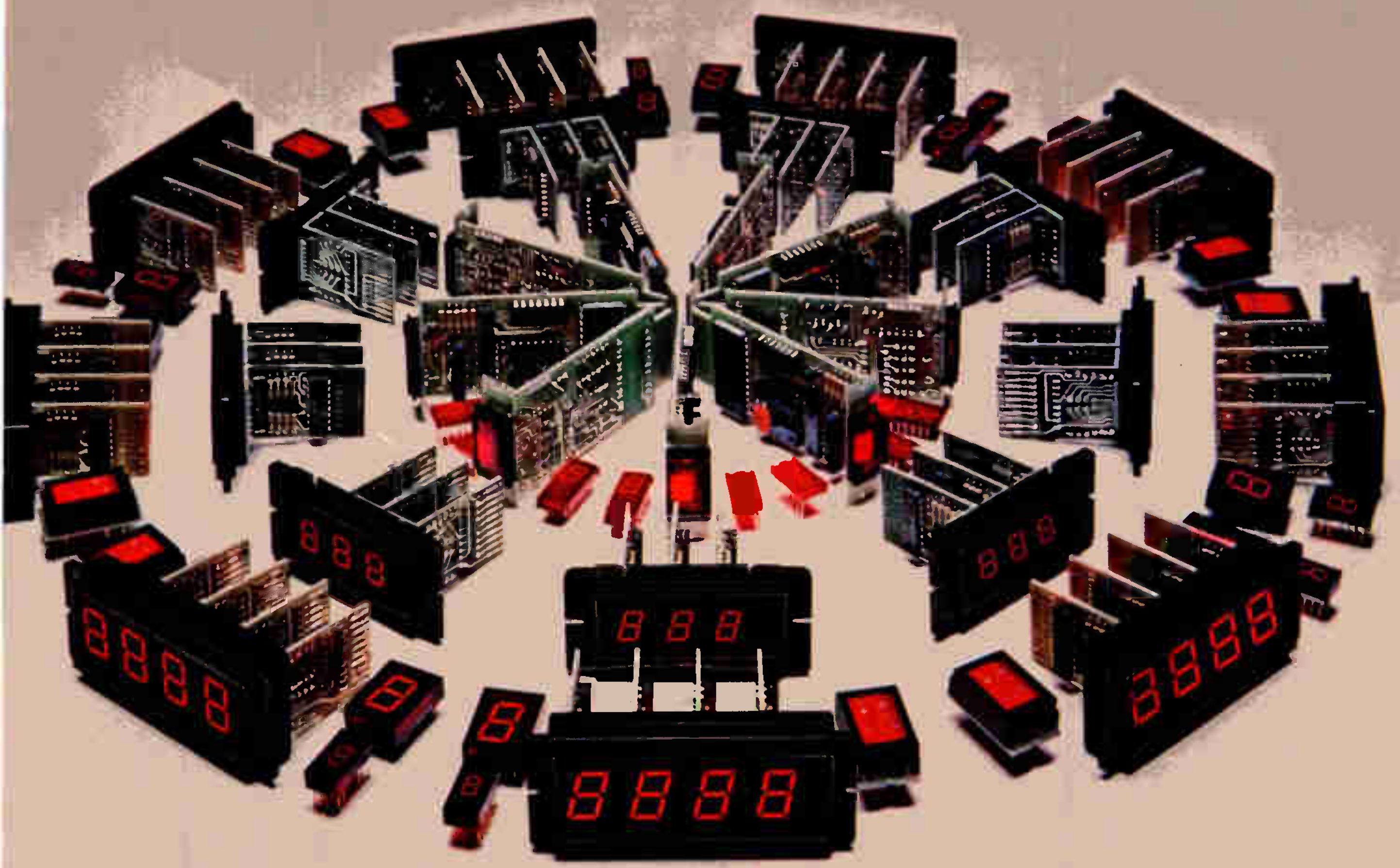
When you need LED readout displays or more than LED readout displays...



Come to Dialight. For built-in circuitry for example. If that's the type of convenience you're considering, then Dialight's the first place to look . . . because Dialight's the first in value-added LED readout displays.

For many years now we've been offering not only the latest technology, but also the latest in time and labor-saving pre-engineered displays. These can be ordered any way you wish: with or without on-board decoder/driver, with or without code generator, in any number of digits in an assembly, complete with bezel for instant panel mounting.

We also offer high brightness, low cost design flexibility with a choice of discrete and assembly displays with character heights of .270", .300" and .600".

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You save all down the line with AMP CPCs —from lower initial costs in materials to lower applied costs as a result of standardized Multimate contacts. Even the housing design saves costs—by reducing hardware and speeding coupling with fast threads.

There are also the substantial savings resulting from machine application of contacts and volume production. Machines can range from simple manual types up to the high speed AMPOMATOR lead making machine. The end result is lowest applied cost and greater uniformity and reliability.

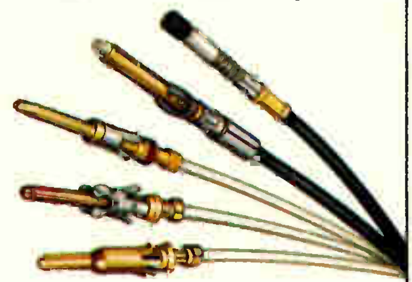
These lightweights are reliable in many other ways. Housings are U.L. recognized high grade thermoplastic that can withstand virtually any commercial and industrial environment. They meet military standards for resistance to thermal and physical shock, humidity and corrosion. They're CSA certified, FAA accepted and recognized for 250-volt service under the U.L. component program.

AMP CPCs are also part of our long-established program of full technical support. It comes with every AMP product. Because we believe professional engineers are entitled to our help and backing. Both before and after the sale.

They can be used practically anywhere. Applications include everything from automotive equipment and office machines to general aviation and data processing equipment.

A lot of people depend on AMP Circular Plastic Connectors for their equipment and we invite you to do the same.
For more information on CPCs, circle the reader service number or call AMP Customer Service at (717) 564-0100. Or write AMP Incorporated, Harrisburg, PA 17105.

AMP has a better way ...The Multimate system



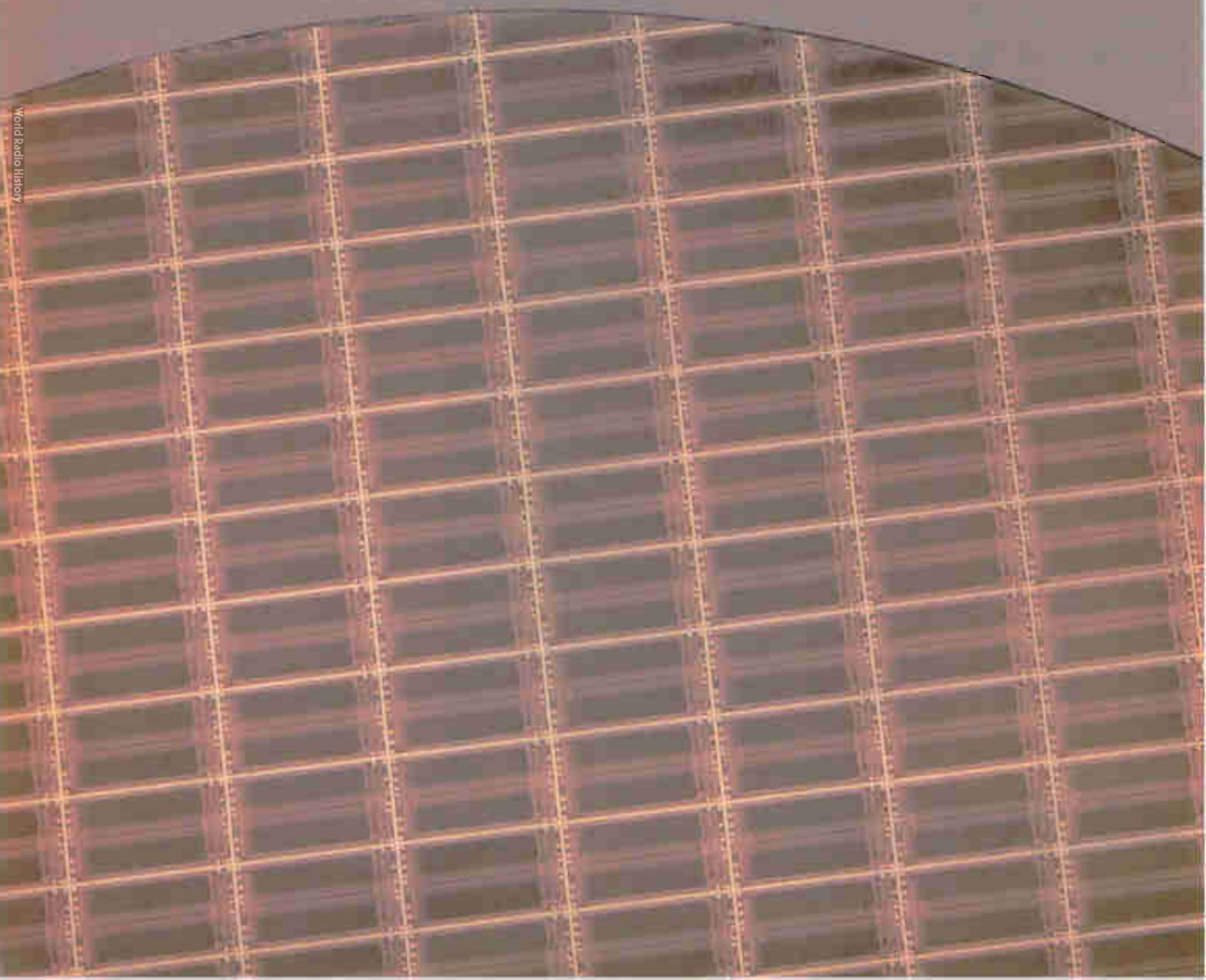
It means that the wide range of Multimate Connector families can accommodate a variety of common contacts to handle signal, power, coax, and even fiber optics. And you save on both inventory and tooling. In addition to CPCs, some of the other connector families that are part of Multimate are: **Metrimate connectors . . . Low Cost Sealed connectors . . . "M" Series connectors** . . . and several more.

For additional information on these Multimate products, just call Customer Service at (717) 564-0100 or write AMP Incorporated, Harrisburg, PA 17105.

AMP INCORPORATED

What the learning curve has done for Mostek's 16K RAM.

I. Availability



Production volumes are proving the learning curve again. Mostek has been manufacturing the MK 4116 16K RAM longer than any other supplier. During the first quarter of 1978 we delivered more 16K RAMs than we shipped in all of 1977. Our goal for 1978 is to deliver more than 5 million. With this increasing production momentum, Mostek is quickly solving the industry shortage of 16K RAMs.

2. Performance

Mostek's 4116 has always been the industry standard 16K RAM. Eleven companies have announced intentions to second-source our design, but no one has yet matched Mostek's performance or features.

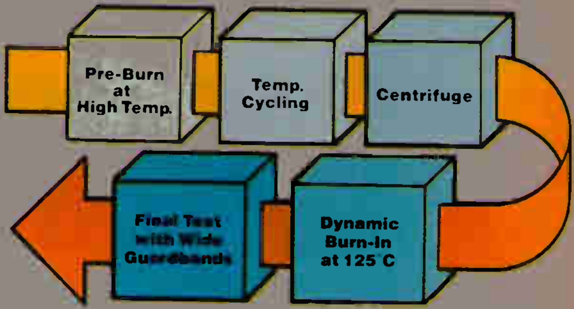
Mostek 16K RAM	Access Time	Cycle Time	Active Power (MAX)	Standby Power (MAX)
MK4116-2	150ns	320ns		
MK4116-3	200ns	375ns	462mW	20mW
MK4116-4	250ns	410ns		

There are several new features in Mostek 16K RAMs. For flexibility in system design, V_{BB} power supply now operates over the range of −4.5 volts to −5.7 volts allowing −5V operation with TTL, or −5.2V operation with ECL systems. In addition, cycle time has been reduced to 320ns for the 4116-2, improving system operating performance.

3. Reliability

Both the learning curve and our Poly-II™ process are key factors in Mostek's 16K RAM reliability record. Over 12 million circuits have been built using the Poly-I™ and Poly-II processes. During this time, quality and reliability standards have continued to lead the industry.

Comprehensive performance and environmental testing further ensure reliability in your system. Every 16K RAM we ship is thoroughly tested to rigorous screens and stresses.



Take advantage of Mostek's industry standard performance and reliability now. Call or write: Mostek, 1215 West Crosby Road, Carrollton, Texas 75006; Telephone 214/242-0444. In Europe, contact Mostek GmbH, West Germany; Telephone (49) (0711) 701045.

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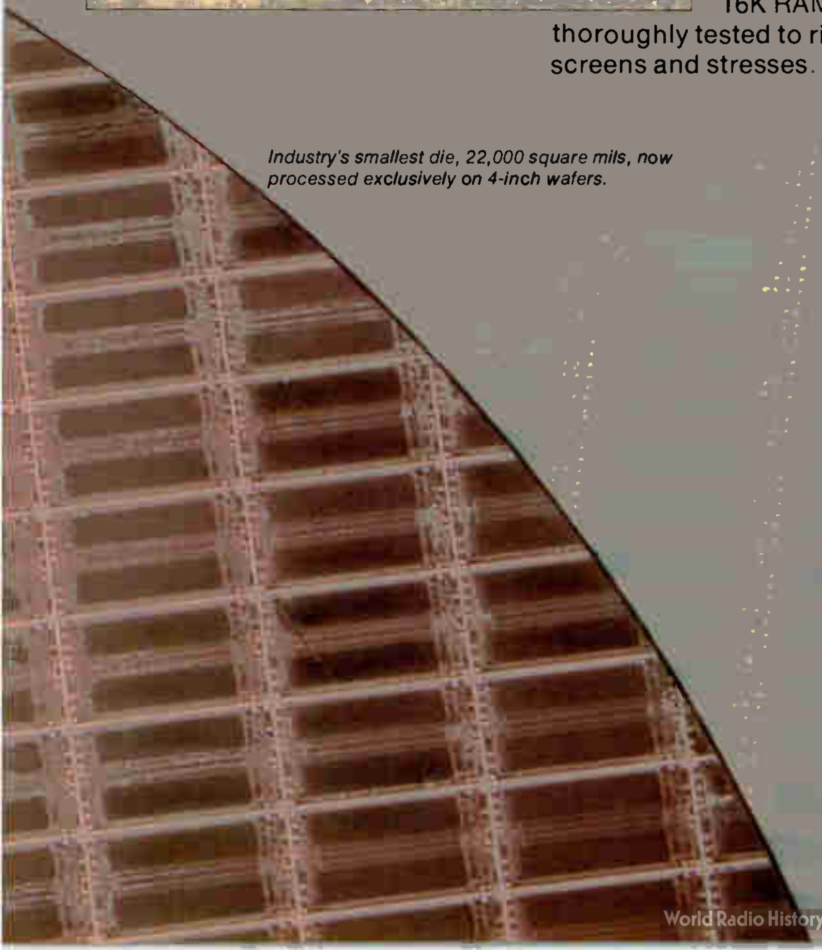

Industry's smallest die, 22,000 square mils, now processed exclusively on 4-inch wafers.

Meetings

International Colloquium on Reliability and Maintainability, GIEL (Groupement des Industries Electroniques, Paris) *et al.*, Tour Olivier de Serres, Paris, June 19–23.

International Symposium on Electromagnetic Compatibility, IEEE, Sheraton-Biltmore, Atlanta, June 20–22.

32nd Annual Convention of the Armed Forces Communications and Electronics Association (Falls Church, Va.), Sheraton-Park Hotel, Washington, D. C., June 20–22.

Eighth Fault Tolerant Computing Symposium, IEEE, Congress Hall, Toulouse, France, June 21–23.

Device Research Conference, IEEE, University of California, Santa Barbara, June 26–28.

Conference on Precision Electromagnetic Measurements, IEEE, Conference Center, Ottawa, June 26–29.

Applied Magnetics Workshop on Magnetic Recording, IEEE, Hilton, Hotel, San Francisco, June 27-28.

International Microwave Symposium, IEEE, Chateau Laurier Hotel, Ottawa, June 27–29.

Fiber Optic Con West, Fiber Optic Communication and Information Society (Boston), San Jose Convention Center, Calif., July 19–20.

Intersociety Energy Conversion Engineering Conference, IEEE, Town and Country Hotel, San Diego, Calif., Aug. 20–25.

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

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

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

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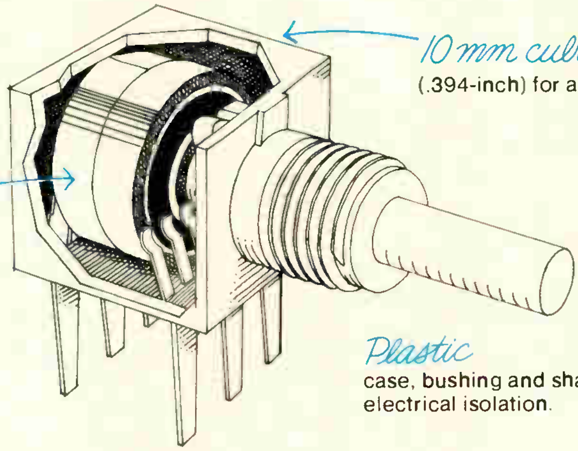

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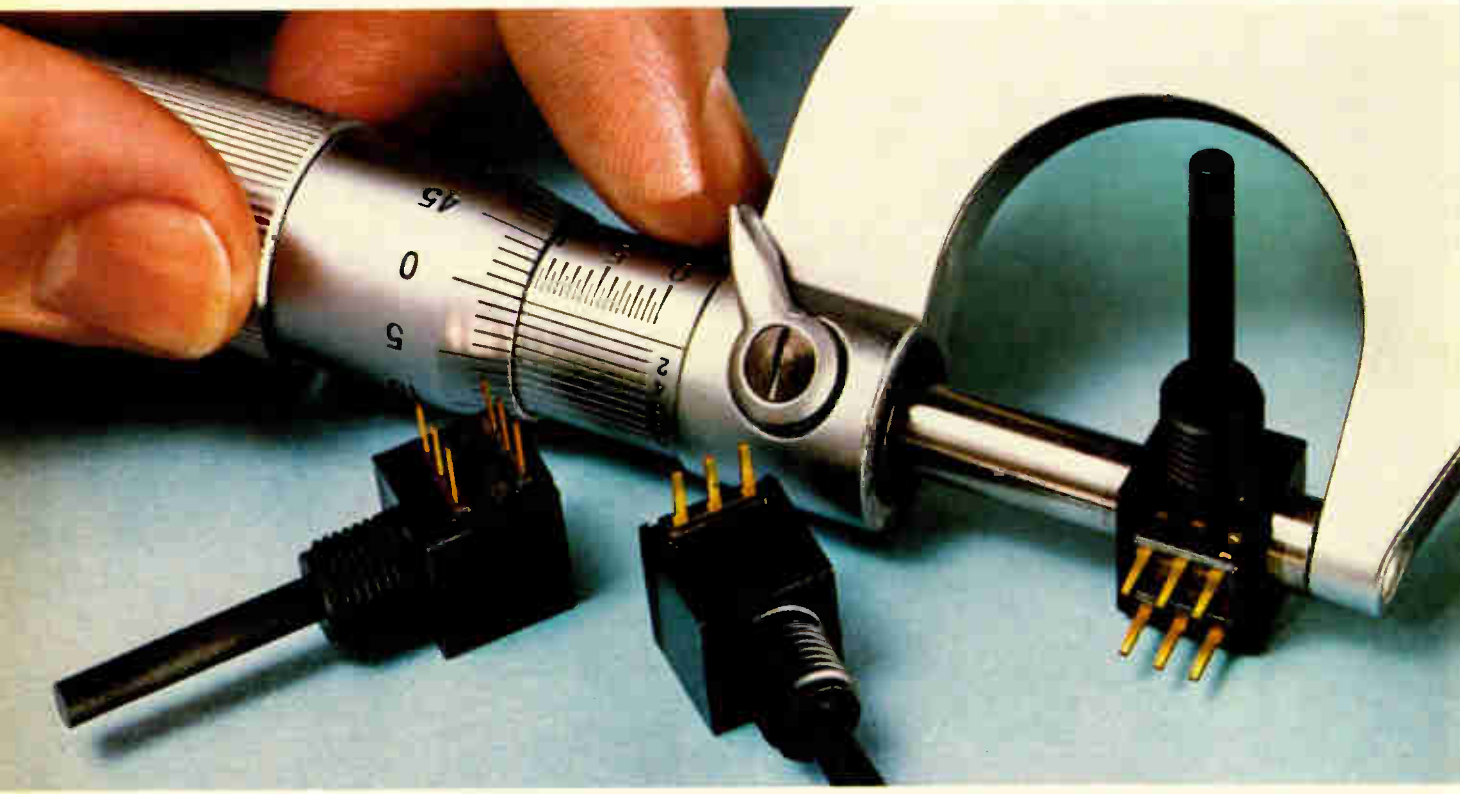

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EC131

Electronics newsletter

TI to launch raft of I²L military products

Texas Instruments Inc. is planning a major assault on the military marketplace with a barrage of microcomputer boards, modules, and devices. All are based on TI's integrated-injection-logic technology and **all are compatible with their commercial counterparts so that end users can take advantage of the existing commercial software and products base.** Due by the end of the third quarter is the TM 990/110, a militarized equivalent of the TM 990/100M microcomputer board.

TI's family of militarized boards will be expanded in the first quarter of next year with the TM 990/304, a MIL STD 1553A multiplexed data-bus interface module, and the TM 990/1481, a high-speed-microcomputer that uses the firm's 74S481 4-bit slices and has sine, multiplication, division, and floating-point functions. A SEM 990 module, functionally equivalent to the 990/110 but packaged in the Navy's standard electronic module format, is expected to be available early next year.

HP discontinues its 2000 system

One of the first minicomputer-based timesharing systems, the HP 2000 from Hewlett-Packard Co., will no longer be sold by the Cupertino, Calif., manufacturer. **The reason: HP is beefing up the surrounding systems—the HP 1000 and 3000.** The 1000 line was only recently refurbished [*Electronics,* May 25, p. 193] and the 3000 is in its second generation; what's more, HP's DS 3000 distributed network, which hooks together the 1000s and 3000s, has all but squeezed out the 10-year-old 2000 system.

Intel's 64-K CCD on hold

Although its eagerly awaited 64-K charge-coupled-device memory, the 2464, was discussed by Intel Corp. in a paper last month at Electro/78 in Boston, samples of the part are still a few months away. Apparently beset with some reliability problems, the 2464 is in transit with Intel's other memory components to a new facility outside Portland, Ore. The short-loop device, organized as 256 loops of 256 bits each, promises to eliminate many of the high-capacitance and power-consumption drawbacks associated with earlier CCD designs.

National Semiconductor Corp. will begin second-source production of the device in two to three months, as soon as the masks arrive from Intel. The part is a two-chip hybrid: the CCD array accompanied by a small timing and interface chip that makes the 2464 compatible with transistor-transistor logic.

Burroughs signs for amorphous semiconductor EAROMs

Energy Conversion Devices Inc., the tiny Troy, Mich., company set up by Stanford R. Ovshinsky to develop amorphous semiconductors, has won a vote of confidence from giant Burroughs Corp. **The two firms have agreed to couple ECD's amorphous-memory technology with Burroughs' improvements.** Burroughs wants the resulting electrically alterable read-only memories for its own computers, and the two firms are seeking to jointly license the package to semiconductor makers to ensure a commercial source for the unusual devices.

Under an earlier license, Burroughs mated the nonvolatile memory cells—built on amorphous films sputtered onto single-crystal silicon substrates—with on-chip current-mode-logic steering circuits to produce bit-alterable parts with access times as fast as 15 ns. It has also pushed up the technology's process, operating, and storage temperatures and cut its write voltage to 12 V. The firm is now reportedly churning out 1,024-bit devices and has started masks for an 8-K version.

The agreement comes on the heels of a $7 million purchase order from 3M Co. for ECD's MicrOvonic file, a desktop imaging unit using thin amorphous films on Mylar. Unlike conventional photographic microfiche, the film can handle add-ons and deletions.

Frequency reuse by cable net starts in fall

The frequency-reuse concept will get its first workout by cable TV in September when UA-Columbia Cablevision starts using the RCA Americom satellite, Satcom I, with its vertical polarization. **Frequency reuse allows both horizontal and vertical polarization on a given channel, thus effectively doubling capacity.** Earth stations that are equipped just for single-polarization reception will need relatively simple modifications to pick up the additional programming, according to Harold W. Rice, Americom's vice president for video and audio services.

National 8331 joins list of memories for IBM 303X

The ranks of manufacturers of IBM-compatible add-on memory manufacturers that offer units for the 303X computers are almost complete with the introduction this week by National Semiconductor Corp. of its 8331 memory. Offering from 1 to 8 megabytes of memory in a single cabinet, **the unit will be priced in the $70,000-per-megabyte range** and will be marketed by National's recently formed end-user sales force. National Follows Intel Corp.'s introduction last October, Cambridge Memories Inc.'s April announcement, and the recent unveiling by Electronic Memories & Magnetics Corp. of a unit priced at 80% of IBM's $110,000 per megabyte. Still to be heard from is Intersil Inc.

Three terminals based on LSI-11 shown by DEC

Three intelligent terminals incorporating the company's LSI-11 microcomputer were shown for the first time this week at the National Computer Conference by Digital Equipment Corp.'s Components Group, Marlboro, Mass. **The PDT 11 family is the first designed to be fully compatible with DEC's PDP-11 minicomputers** and can run programs developed for the minis or their own stored programs. The PDT 11/110 uses the family's new VT100 cathode-ray-tube terminal and LSI-11 without magnetic storage. The PDT 11/130 has those same features plus two magnetic-tape storage units, while the PDT 11/150 offers single or dual floppy-disk storage and CRT or hard-copy printout.

All three can drive up to three additional "unintelligent" terminals, have a minimum of 16,383 bytes of local storage expandable to 60,000, and their prices include a run-time version of DEC's RT-11 operating system. Prices range from $3,900 ($2,890 in hundreds) for the 11/110 to $6,325 ($4,322 in hundreds) for the 11/150.

RCA unveils small-plane weather radar

The Avionics Systems unit of RCA Corp.'s Government Systems division in Camden, N. J., is taking the wraps off **what is believed to be the first weather radar developed specifically for use in single-engine general-aviation aircraft.** Called the WeatherScout I, the system is designed to mount inside a wing and will be priced at about $5,500. Slightly more expensive at around $6,200 is the WeatherScout II weather radar developed for light twin-engine general-aviation aircraft but usable on single-engine aircraft as well, if used with a wing-mounted pod.

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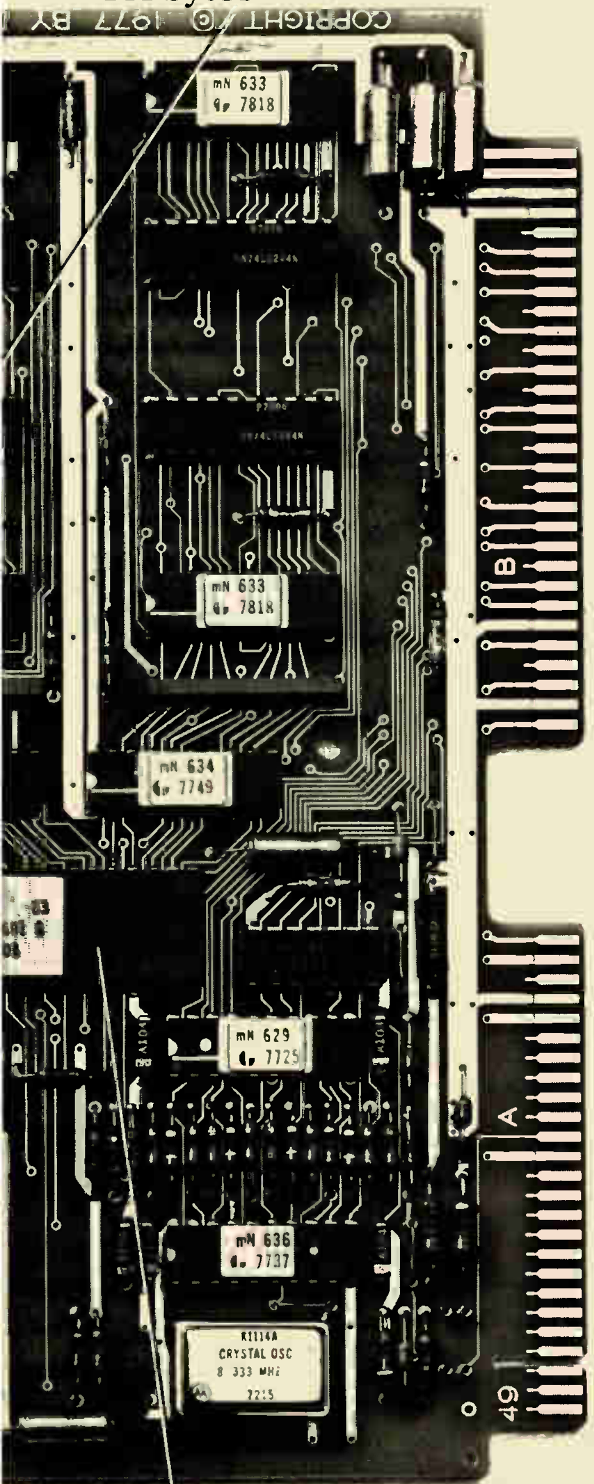

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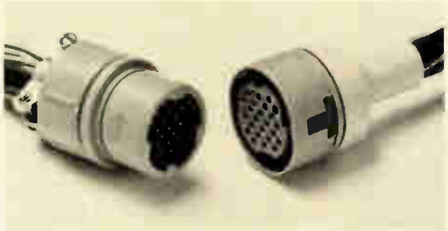

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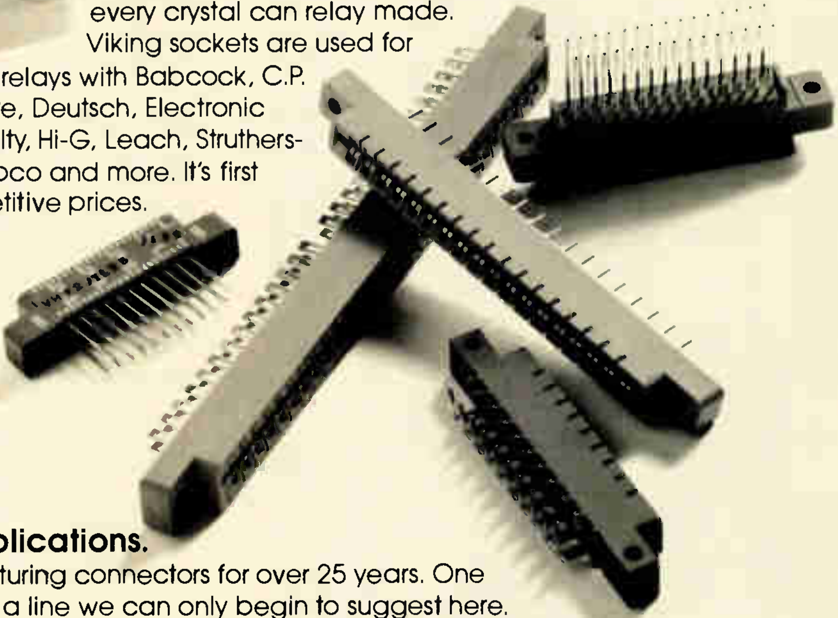

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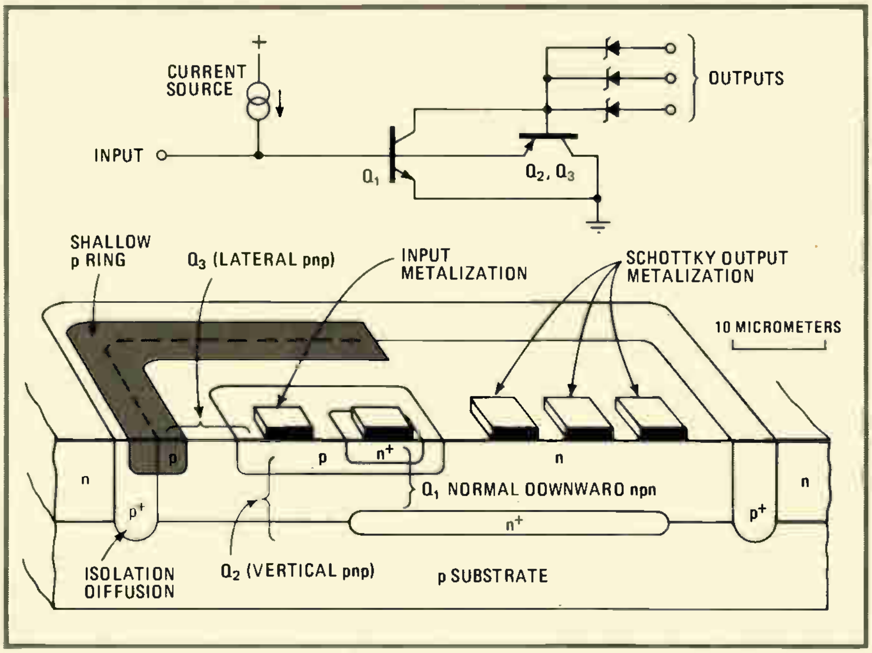
Two popular bipolar technologies combine in Philips' device

Low-power Schottky TTL for high speed and I^2L for packing density are mated to double benefits



New logic. In ISL, the normal downward npn transistor inherently adds a vertical pnp device. A p ring parallels the vertical transistor with a lateral pnp one.

Consider a pair of bipolar technologies: low-power Schottky transistor-transistor logic aiming at high speed for medium-scale parts like the 7400 family, and integrated injection logic, which merges transistors specifically for the high packing density needed in large-scale integration. What if the attributes of both could be found in a high-speed, low-power logic suitable for LSI? Apparently they can—in ISL, a newly developed technology that stands for integrated Schottky logic [*Electronics*, May 25, p. 42].

Developed by Jan Lohstroh and colleagues at the Digital Circuitry and Memory Group of Philips Gloeilampenfabrieken in Eindhoven, the Netherlands, ISL has already performed admirably in "kit" parts—flip-flops, oscillators, and the like. Such devices have exhibited gate propagation delays of about 3.5 nanoseconds (half that of low-power Schottky and a quarter that of I^2L), with each gate drawing only about 400 microamperes. An ISL D-type flip-flop toggles comfortably at 60 megahertz, as compared with a limit of about 33 MHz for a similar low-power Schottky device.

Filling the gap. "What led to the invention of ISL," Lohstroh explains, "was the compulsion to fill the gap between I^2L and low-power Schottky." Though I^2L exhibits high packing density and low power consumption, it cannot attain the speeds desirable for many applications. Low-power Schottky, on the other hand, features good speed but consumes too much power and chip area for LSI.

Work on the new process started about a year and a half ago, Lohstroh says. "We went through a thorough comparison of all the types of logic circuits that can be made in standard Schottky processes." After extensive computer simulations, he adds, "we concluded that ISL would be a very good solution."

The configuration of an ISL gate is shown in the figure. Like I^2L, ISL has one input and multiple outputs. The concept for it had been proposed by C. L. Schuenemann and S. K. Wiedmann of IBM Corp.'s Boeblingen, West Germany, research facility back in 1973, in a process called Schottky Di-istor Logic that looked like ISL without the pnp transistor (Q_2–Q_3). The problem with di-istor logic, however, was that the npn transistor went heavily into saturation when it turned on, and because of the saturation delay, the logic was slow. ISL adds a merged pnp transistor to limit the saturation in the npn device, thus greatly increasing speed.

Built in. The neat thing about ISL is that the pnp transistor was virtually built in already. As shown in the cross section, the npn transistor is in a normal downward configuration (I^2L has an inverted npn device). This places a parasitic vertical pnp transistor just where the saturation-limiting pnp device is needed. All that was required was to enhance this element.

But for ISL to be a viable LSI technology, the parasitic pnp transistor had to be enhanced without enlarging the npn device. This is done two ways. First, a shorter buried layer than usual for the npn device is applied, giving the vertical pnp more area. Second, a shallow p ring overlapping the isolation diffusion is added around the base of the npn transistor to create a lateral pnp that actually parallels the vertical one, Lohstroh explains.

Though the normal downward-mode npn device solves some of the problems, it creates another. In that mode, the current-injection source, which would normally be a pnp transistor, cannot be merged with the npn device; since ISL, like I^2L, requires a current source, this pnp transistor (or just a series resistor in some cases) must occupy its own island. That is why ISL occupies an area some 40% larger than I^2L.

Among the products Lohstroh envisions being made with ISL are fast microprocessors, frequency-divider circuits, and gate arrays. ISL can also be used in analog applications, he says, where it offers three to five times better speed than I^2L.

Signetics Corp., owned by Philips, has hurried into fabrication of ISL devices. The first part from the Sunnyvale, Calif. company is expected to be a 1,200-gate array, though larger ones will become possible as the process is refined. Right now, Philips is working with conservative 5-micrometer geometries in ISL. "Smaller dimensions and washed emitters will improve speed, density, and power consumption," Lohstroh says. □

Solid state

Dynamic memories racked by radiation

Having grappled with nonrecurring, random errors due to system noise or voltage marginality, the producers of charge-coupled-device and dynamic random-access memories are now facing an enemy from within—alpha particles that cause nondestructive soft errors in these memories and are emitted by the minuscule amount of radioactive material found in chip packages.

Engineers have been aware for some time of alpha particle activity inside packaging materials. But it has become a problem only in recent years with the advent of shrunken geometries and increased bit storage capacity of recently introduced dynamic memories.

The upshot, as suggested by Timothy C. May and Murray H. Woods of Intel Corp., Santa Clara, Calif., may well be that the trend toward shrinking the storage cell for future dynamic memories has hit a snag. The basic design parameters—the circuit densities, storage-cell sizes, and critical charge—increase the likelihood that soft errors will occur in association with alpha-caused ionization, the engineers points out.

A soft error is one in which a misread or miswritten bit can be corrected by repeating the operation. Soft errors, therefore, are both detectable and correctable, unlike hard errors, which are detectable but not correctable except by hardware replacement since hardware failures are what causes them.

"It is coincidental that alpha particles have ranges of penetration in silicon that are comparable with new device storage-cell widths and diffusion lengths," states Woods, Intel's reliability engineering group leader. "That is the reason this effect has only recently become evident in reliability analysis projects."

The dynamic-memory vendors are working hard to find solutions to the problem, but in doing so they face the increased costs incumbent upon using larger die sizes with attendant lower wafer yield, more complex testing devices to accumulate soft error statistics, and the like. They are attacking the problem from several different directions—for instance, by devising new packaging material processes or applying protective coatings to the upper surface of the chip, says Gene Miles, director of memory components marketing at National Semiconductor Corp., Sunnyvale, Calif. Solving the problem will no doubt affect the prices of large-capacity dynamic memories because of the increased costs of production and testing, as well as of developing more complex packaging materials.

Problem source. CCD memories, as reliability engineers know, have a soft error mechanism, but the source of the problem had eluded them. Investigation pointed to radiation as a possible cause, but at first the culprit was thought to be cosmic radiation. Finally, researchers identified the naturally occurring radiation from materials within the package as possibly to blame. It seemed likely that alpha radiation could cause problems in dynamic RAMS, as well, and subsequent user feedback

The radiation is common

The alpha particles that produce soft errors in dynamic memories are emitted by radioactive uranium and thorium, present at parts-per-million levels in packaging materials. They are helium nucleii with a mass of approximately 4 atomic mass units (1 amu = the mass of a proton) and a charge of 3.2×10^{-19} coulomb.

The energy of an alpha particle, lost as it collides with the molecules of the substance through which it is traveling, is measured in electronvolts. One electronvolt is the energy of an electron that has been accelerated by a potential of 1 volt. Thus, the kinetic energy of a 5-megaelectronvolt alpha particle is equivalent to that of an electron accelerated by a potential of 5 million volts. In silicon, as an alpha particle is slowed to a stop, its energy is absorbed and produces electron-hole pairs at a rate of 1 pair for each 3.6 eV. A 5-MeV particle therefore produces up to 1.4 million such pairs concentrated within a 25-micrometer length.

about soft error headaches with sensitive 4,096-bit dynamic RAMs began to appear.

The problem has been magnified with the 16-K dynamic devices that are now being applied. According to Miles, there is increasing statistical data tying the occurrence of soft errors to die size and critical charge. What's more, all the current 16-K dynamic RAMs have observable soft errors to varying extents. The implications for 64-K dynamic RAMs are ominous unless the memory manufacturers learn to cope with the alpha particles.

Ionization caused by a 5-megaelectronvolt alpha particle coursing through a silicon die and coming to rest after its energy is absorbed produces approximately 1.4 million electron-hole pairs (see "The radiation is common"). Key to the problem is that the newly liberated pairs are concentrated within a 25-micrometer length (the typical penetration depth of a 5-MeV alpha particle in silicon). In contrast, a beta particle would easily penetrate to 10 mils in silicon and leave a much smaller concentration of electron-hole pairs in its wake.

Critical charge. Whether these concentrated electrons will cause a soft error or not depends in part on the proximity of the alpha particle's path to a storage well, the angle at which it travels relative to the chip surface (90° being the worst case), and, very significant, the number of electrons that differentiate a logic 1 from logic 0. Called the critical charge, this number is complexly related to the integrated-circuit layout, charge-collection efficiency, and storage-cell size. The higher the critical charge, the less likely are alpha-caused soft errors.

Other contributing factors are electrons generated thermally within the die and less-than-complete transfer of charge to sense amplifier lines, according to Intel's Woods and May. Methods exist by which designers can lessen the effects of these factors and increase the critical charge, but producers are still cautious about them. In any case, "no one factor can diminish the soft-error probability to more than a few orders of magnitude," Miles points out. The approach appears to be one of collective action on packaging material processes, better design layout, absorbant surface coatings, and other techniques now under investigation.

The system designer is not really in too much of a bind. He has the option of using the dynamic memories and designing in hardware error-correction circuitry or using static devices, which do not store charge and are therefore immune to these soft-error effects. It does, increase the system cost. And in very small systems, the soft errors may not be very significant, so the designer may choose to ignore them. □

Radar

Radar gets really long-range test

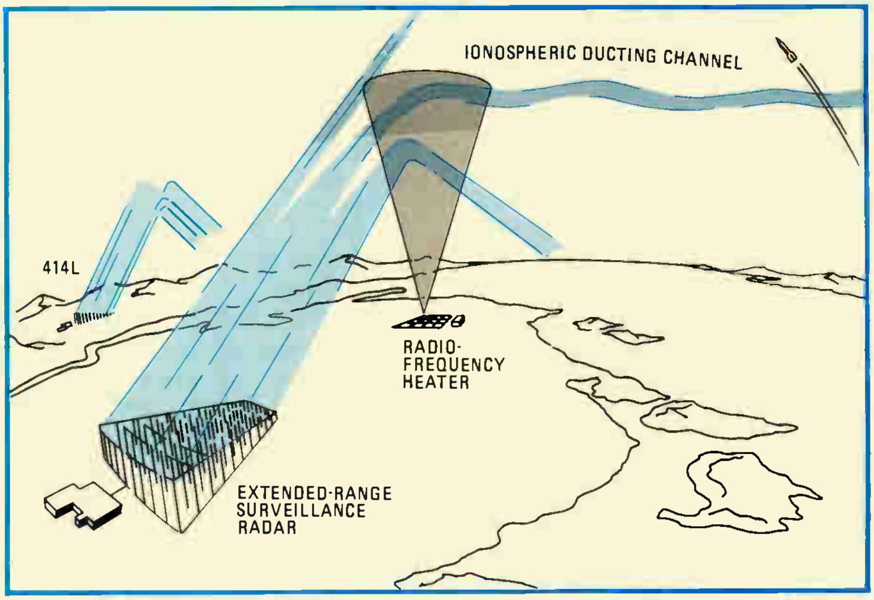
There is a tunneling, or ducting, effect in the ionosphere that has been known for many years. But now the Air Force thinks it could lead to a system for detecting ballistic missile launchings at very long ranges—even over intercontinental distances.

Accordingly, the service is beginning a series of experiments this week to measure how efficiently very-high-frequency signals can be carried through these ducts and scattered earthward through portions of the ionosphere that have been heated and altered with rf energy.

If these and later efforts are successful, they could lead to the installation at radar sites of special rf "heaters" for injecting signals into an ionospheric duct. Then signals, after traveling to a target and back through the duct, would be ejected from the heated region to the radar receiver. The reach of such a system would far exceed that of today's over-the-horizon radars, some of which bounce signals off the ionosphere and back to earth at ranges of 3,000 kilometers.

Mirror. "We can get very long-range vhf using an artifically altered ionosphere as a big mirror in the sky," says Terence Elkins, deputy chief of the propagation branch in the Electromagnetic Sciences division of Rome Air Development Center. The experiments will last until October at four U.S. sites using mostly existing installations, and they should go a long way toward determining just how good that mirror is at injecting signals into the ducts.

Elkin's branch, located at Hans-



Long-distance radar. The tunneling or ducting effect in the ionosphere could provide a means of using long-range radar signals injected into the duct via rf "heaters."

Radar ducting known in World War II

Radar ducting is not a new discovery. During World War II, operators noticed that occasionally their aircraft tracking radars would operate out to much greater ranges than usual. No explanation of the phenomenon was possible if the radar energy was assumed to be propagating in a straight line through a uniform atmosphere.

It was soon discovered, however, that the radar energy was being guided through waveguide-like ducts in the atmosphere. As radar waves decrease in speed when they pass through high-humidity air, a varying height-humidity profile is enough to create the ducts. Low moisture content in the air at the earth's surface, when overlaid by high moisture at higher altitudes and low humidity again at still higher altitudes, creates a high-velocity region above and below a low-velocity region. Such a structure continuously focuses energy back toward the center of the channel instead of letting it drift out of the channel. "Over the horizon" transmission occurs, and the earth's curvature has little effect.

com Air Force Base, Bedford, Mass., has awarded contracts totaling $620,000 for the experiments to two companies over two fiscal years. He points out that it has been demonstrated only recently that a region of the ionosphere could be artificially altered by rf heating and produce irregularities that could be used to inject signals into the ducts.

Cause. Elkins says the irregularities are caused by heat generated when the heater frequency equals the resonance frequency of the plasma in the ionosphere. This causes instabilities in the plasma and strong absorption of radio energy in a very narrow height range. Not only could this phenomenon be used to inject the vhf radar signals into any duct lying near the heated region, it could also eject signals from the duct as they return from a target.

The heated region will be located in the skies above Platteville, Colo., created by an rf heater source on the ground there by the Department of Commerce's Institute for Telecommunication Sciences in Boulder, Colo. Vhf transmissions will be beamed toward the heated region from transmitters at Ava, N. Y., and Lost Hills, Calif. The signals will be scattered some 500 km to the south, where a scatter receiving site has been set up at Los Alamos, N. M., by ITS. Along with ITS, the other major contractor for the first-phase experiments is SRI International of Palo Alto, Calif., which owns transmitters and receiving arrays already in place at Lost Hills.

The heated region will be 20 km high and about 100 km in diameter and will be suspended in the ionosphere between 150 and 250 km above the earth. The heater consists of nine 200-kilowatt transmitters that feed a large array of nine dipole antennas on the ground, sending a narrow beam to the ionosphere.

The Lost Hills transmitter, about 1,400 km westward, and the transmitter at Ava, owned by the Air Force and some 2,500 km to the east, are sending swept-frequency, frequency-modulated continuous-wave signals in a range of 6 to 30 megahertz. The transmitter in New York can put out 10 kilowatts continuously. The Lost Hills site also has a 10-kw transmitter for the 6-to-9-MHz range and a 20-kw transmitter for the 9-to-26-MHz range.

Receivers. There are two receive systems at Los Alamos. One is linked to a Beverage antenna array of eight 300-foot-long elements and is aimed at the heated region. This receiver system will produce plots, or ionograms, of the ionospheric properties during heating and transmission from the transmitters. The other receiver system makes use of an end-fire loop array aimed east or west to pick up any signals arriving not through the ducts but directly from the transmitters.

In addition, the transmissions from New York and California will be directed in exactly the opposite direction from the heated region above Platteville. The energy could be carried in the ducts around the globe and ejected to earth through the heated region. □

Fiber optics

Standards work is heating up

As with all new technologies, the need for industrywide standards in fiber optics is rapidly becoming apparent. And it appears they are on the way for both the international and national markets.

The first step toward international standardization of commercial fiber-optic products will be taken in Florence, Italy, on June 26 with the presentation of nine proposed standards to the newly organized International Electrotechnical Commission fiber-optics subcommittee, SC46E.

"Numerous technical editorials are emphasizing the need for early standardization of fiber optics," says Gustave Shapiro, the Electronic Industries Association international standards administrator and international secretary of the new subcommittee. "However, standards adopted before the technology matures can be premature. On the other hand, if standards are delayed until the technology matures, industry becomes committed to so many diverse approaches that no agreement is possible."

In between. SC46E can be expected to take a middle-of-the-road approach. The initial emphasis will probably be on definitions and test methods, says Shapiro. The more difficult problems of standardizing hardware will follow.

"Many nations will probably adopt the IEC fiber-optic standards as their national standards, since there is an increasing tendency for both the industrial and emerging nations to take such action," he says. The proposals are based on U. S. standards under development by organizations like the Society of

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Automotive Engineers fiber-optics task group and the EIA's P6 committee on fiber optics.

Already available from the EIA is a connector-terminology standard, RS-440. The American National Standards Institute has approved it as a national standard.

Other proposals that either have been or are being circulated to industry include standards for a cable-test procedure, fiber diameters, and material classes. In addition, projects are under way for standards on connector splices, light sources and detectors.

Work on the EIA fiber-optic standards began two years ago with connectors, and industry user interest is producing expanded activities. Groups formed over the past few months now include:

- P6 committee on fiber optics (chairman, Joe Neigh, AMP Inc.).
- P6.2 *ad hoc* group on terminology, definitions and symbology (chairman, Tore Anderson, Solitron Corp.).
- P6.3 working group on interconnecting devices (chairman, John Makuch, Amphenol Inc.).
- P6.4 working group on test methods and instrumentation (chairman, Jim Wittmann, Hughes Aircraft Co.).
- P6.5 working group on optical transducers (chairman, Franc Noel, IBM Corp.).
- P6.6 working group on fibers and materials (chairman, Roy Love, Corning Glass Works).
- P6.7 working group on cable (chairman, Ramesh Sheth, Belden Wire and Cable Inc.).

However, there is still time to get on board in the standards-setting effort. "Participation in these groups by manufacturers and users of fiber-optic components is welcome," says EIA staff engineer Charles W. Flint. The next group meeting is in Phoenix, Ariz., Oct. 3–5, he notes. □

Packaging

Chip carrier thrives on ceramic substrates, lifts off epoxy-glass boards, GE says

Most packaging engineers agree that the ceramic chip carrier is going to be the large-scale integrated-circuit package of the 1980s because of its small size. But how should the carriers be attached to printed-circuit boards?

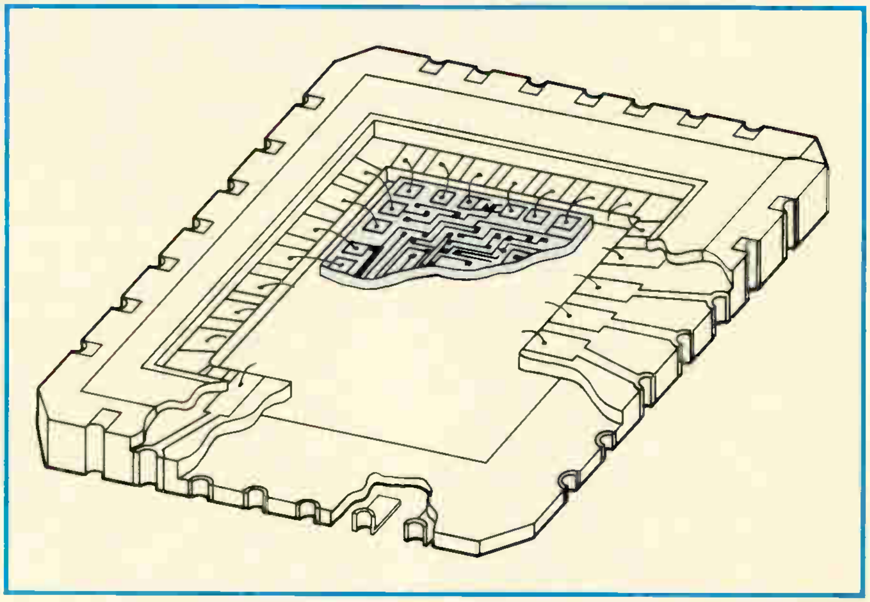
That is not such an easy question to answer, apparently, as major chip-carrier users keep coming up with experimental test results that disagree. The latest to take a position is General Electric Co.'s Aerospace Electronic Systems department in Utica, N.Y., which says that at present chip carriers cannot be soldered directly to pc boards; instead, they need protective ceramic motherboards with lead frames. This opinion goes contrary to what Martin Marietta Aerospace Co., Orlando, Fla., says it recently found and is now implementing—namely, that the ceramic chip carriers do very well attached directly to the circuit boards [*Electronics*, April 27, p. 42].

At GE's recent component engineering seminar held in Utica, Tom Schoonmaker of the department's advanced reliability test group reported the results of his company's tests on thermal cycling of chip carriers soldered both to ceramic and to epoxy boards.

Test results. One test concerned the integrity of the solder joint between ceramic chip carriers and ceramic substrates. Two substrates carrying 24 chip carriers apiece were fabricated, and each sample was repeatedly cycled through a range of −65°C to +125°C. One sample had carriers lifting off the substrate after 60 cycles, but the cause was traced to a defect in the substrate's thick-film conductors rather than to failure of the carrier-to-substrate joint. The other sample has survived 875 cycles and is still going strong.

A second test was run with a group of eight similarly loaded substrates, each of which was placed in a modular assembly. The complete assemblies were put through a temperature range of −55°C to +100°C, with power applied to resistors in the chip carriers for half the cycle. The result: no failures in any of the assemblies after a total of 514 cycles.

Lastly, GE's test engineers had the carriers reflow-soldered to epoxy-glass test boards. These units were



Future package? GE says ceramic chip carrier, seen in exploded view, works with ceramic substrates.

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MCR64	-5	300	550	10/15 (typ)	5.68	6.06	6.69
Stud	-6	400			6.21	6.85	7.21
	-7	500			6.92	7.30	7.93
MCR65	-8	600			7.91	8.53	9.16
Isolated	-9	700			9.25	9.87	10.50
Stud	-10	800			10.83	11.21	11.83

†(One cycle, 60 Hz)

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put through a −65°C-to-+125°C range. After only 30 to 40 cycles, a significant amount of solder-joint cracking developed. But Schoonmaker points out that since there is a 3:1 mismatch between the temperature coefficients of expansion of alumina and epoxy-glass, these results are not surprising.

Pro-ceramic. At the present time, the department's component and reliability engineers see the chip carrier compatible with ceramic substrates but not with pc boards. They do not, however, see the problem of attaching the carriers to circuit boards as insoluble.

Despite its present incompatibility with pc boards, the engineers still believe the chip carrier will be the LSI package of the future. In fact, at the same seminar Dale Cole, advanced component group leader at GE/AESD, predicted that by 1985 the chip carrier will be on a par with the dual in-line package and that by 1990 it will be the standard. □

Fiber optics

Univac steers light with garnet film

Sperry Univac thinks it can take advantage of the magnetic characteristics of certain garnet crystals to build a low-cost, solid-state device that can steer beams of light.

Engineers at the firm's Defense Systems division are now preparing to demonstrate their approach, admittedly still in the laboratory stage, says Thomas R. Johansen, senior electrical engineer in the Physical Sciences Laboratory at Sperry Univac's Eagan, Minn., facility. The team hopes to take the demo to a missile test range this summer to show off the precise position and velocity data that can be gathered by a laser harnessed to the magneto-optic steering device.

Recent boost. The company came across the steering possibilities of garnet material in 1969 when it was developing thin films for memory cells. But it only recently beefed up its internal funding to develop the higher-quality crystals that will be needed to demonstrate a laser steering device. It received some early money from the Office of Naval Research, interested in developing a laser scanning system to access optical memory cells. Now it is under contract to the Air Force Avionics Laboratory, which sees the magneto-optic approach as the only one that can access points randomly and quickly within a wide field of view. Gimbaled mirrors at present used to steer laser beams are relatively bulky and slow.

Garnet setting. Multiple exposure shows laser beam diffraction through a garnet crystal in the laboratory test setup.

"The approach is reasonable if Univac can whip the [garnet] quality problem, but its feasibility hasn't been demonstrated," cautions Kenneth R. Hutchinson, technical manager of the Air Force's Avionics Lab's electro-optic techniques and applications group.

Sperry Univac's hopes are pinned to a technology that rests on a 2-millimeter-square gallium-gadolinium-garnet substrate. On that, it grows an epitaxial film of a bismuth-substituted rare-earth iron garnet that forms parallel magnetic strips, each 0.5 to 2 micrometers wide. The component of magnetization pointing parallel to the light beam alternates from stripe to stripe, essentially forming a phase grating that diffracts light, Johansen explains.

When the crystal is coupled to two pairs of drive coils that change the magnetic field, the width of the stripes can be altered to change the diffraction angle and the entire grating pattern can be rotated, thus also rotating the diffracted laser beam. Sperry Univac introduces bismuth and adds more iron to the garnet so it differs from the thin-film garnet used for bubble memories. The extra materials serve to increase both the diffraction angle and efficiency, the firm says.

No moving parts. Unlike beam-steering mirrors, the approach is free from moving parts—an obvious advantage. And because there is no mechanical inertia to overcome, laser beams can be steered very fast: Sperry Univac has measured speeds up to $10^{6°}$ per second. "That agile beam capability translates into multitarget capability," Johansen points out. "We think we can track up to 60 targets simultaneously."

Further, because the magnetic grating will diffract light as much as 45°—as opposed to the 5° or so of acousto-optic deflectors now being developed for solid-state beam steering—its field of view is very wide, improving the technique's resolution. Sperry Univac says it has a device that will resolve 10^4 points, and it thinks it can get 10^8. "We're now limited by defects in the [garnet] crystal," Johansen says, "so we're upgrading our crystal growth facility to clean-room status." Eliminating crystal flaws will also improve the grating's diffraction efficiency—the amount of light diffracted—to 50%, up from the 10% that the company has shown to date. □

Distributors

Hamilton/Avnet takes on LSI-11

Data General Corp. was the first major minicomputer maker to offer its microcomputer products through distributors when it announced last

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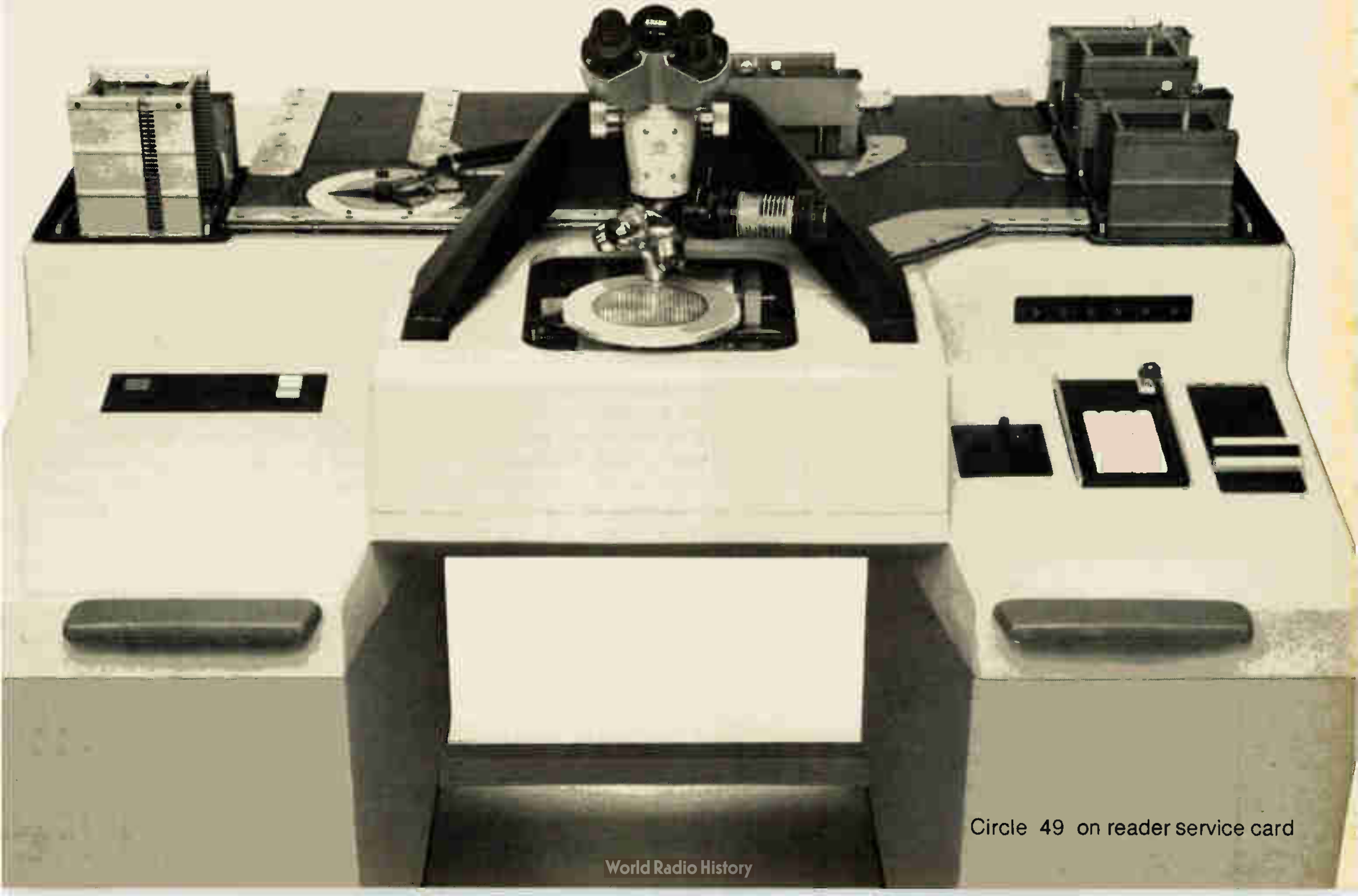

Circle 49 on reader service card

News briefs

DEC reorganizes to consolidate responsibilities

In a move to achieve better coordination during its growth toward multibillion-dollar sales, Digital Equipment Corp., the Maynard, Mass., minicomputer giant, has reorganized itself into three major product groups. Three senior managers have consequently been given new corporate responsibilities as well. Winston R. Hindle, formerly vice president and group manager with six business areas reporting to him in the old multiple-product-line structure, becomes vice president for operations on July 1. At the same time, Andrew C. Knowles becomes vice president for marketing and William H. Long will be vice president for corporate planning. They were managers of the components group and the OEM group, respectively. Also, all former product lines are being consolidated under the three major groups: computer, commercial products, and technical products. Total sales for the company in 1977 were just over $1 billion, making DEC the first minicomputer manufacturer to reach that dollar mark.

Rockwell unveils educational microcomputer

The Electronic Devices division of Rockwell International Corp. has introduced a powerful educational-type single-board microcomputer. Built around the Anaheim, Calif., company's 6502 microprocessor, the AIM 65 (for advanced interface module) boasts a full typewriter keyboard, a 20-character display, and a 20-column printer, all on board. Unlike others that have only a keypad for programming in hexadecimal code, AIM 65 deals in full alphanumerics, in both printer and display. Yet at $395, it is comparably priced and even offers an optional interpreter, resident in read-only memory, for programming in Basic.

Cutler-Hammer acquires Singer Instrumentation

The Singer Co.'s Instrumentation operation in Los Angeles has been acquired by Cutler-Hammer Inc. of Milwaukee for an undisclosed amount of cash. The acquired company, a manufacturer of radio-frequency-interference–measuring equipment and mobile-communications test instruments, had sales last year of approximately $9.5 million. It will continue to be operated from its present location and with its present staff as part of the Ailtech division of Cutler-Hammer's Instruments and Systems group.

New head named at Perkin-Elmer Data Systems

William W. Chorske has been appointed a senior vice president of Perkin-Elmer Corp. and general manager of the firm's Data Systems group in Tinton Falls, N. J. Formerly vice president and deputy general manager of P-E's Instrument group, Chorske succeeds Daniel Sinnott, who has resigned. Sinnott was a founder of Interdata Corp., the minicomputer manufacturer acquired by Perkin-Elmer in 1974.

AMI agrees to buy Millennium Systems

Semiconductor manufacturer American Microsystems Inc. of Santa Clara, Calif., has agreed in principle to acquire Millennium Systems Inc. in nearby Cupertino, a producer of microprocessor development systems. The privately held firm, which had sales last year in excess of $5 million, will become a wholly owned AMI subsidiary if its proposed purchase for approximately 500,000 shares of AMI common stock, valued at nearly $10 million, goes through. Subject to the approval of both boards of directors and Millennium's shareholders, the transaction is expected to be completed by mid-July, according to an AMI spokesman.

fall that Schweber Electronics Corp. was stocking its microNova line. But it appears Digital Equipment Corp. may have pulled off an even bigger distributor coup when it announced last month with Hamilton/Avnet Electronics that the Culver City, Calif.–based distributor will have DEC's LSI-11 microcomputer line stocked at all 36 of its locations

Electronics review

starting within the month on July 3.

The nonexclusive agreement links the largest electronics distributor in the U.S. and Canada with the world's largest minicomputer manufacturer. It also marks the first time DEC has resorted to distributor channels for any product in the company's history. Andrew Knowles, who was named DEC's corporate vice president for marketing recently (see related story, p. 50), estimates that 30% to 50% of the Maynard, Mass., company's LSI-11 sales could be through Hamilton/Avnet in the next few years. He adds that DEC is not looking to sign up any other distributors in the United States or Canada in the foreseeable future.

DEC is putting the microcomputer line, principally the second-generation LSI-11/2 [*Electronics*, Nov. 24, 1977, p. 50], in the hands of Hamilton/Avnet's sales force of 600. Tony Hamilton, president of Hamilton/Avnet, believes the strong sales to date of the original LSI-11—more than 16,000 since it was introduced in 1975—will help his organization sell even more of the newer, smaller four- and five-board systems.

Hamilton adds that his company, which will easily top last year's sales of $286 million in its fiscal year ending June 30, sought the LSI-11 line because "it's the tops in microcomputer technical capacity." For his part, Knowles says DEC listened carefully to Hamilton/Avnet's proposal some 15 months ago, "because they're the largest and best-managed operation we could go with from a marketing standpoint."

Lots of customers. He points out that DEC's Components group has only 35 to 40 persons concentrating on selling the LSI-11 boards, "along with some other corporate people, so this arrangement will allow us to reach a lot of customers we can't reach now." Hamilton says his organization has more than 90,000 customers. The development system version of the machine, the PDP-11/V03, will be available as a software development tool to the original-equipment manufacturers who are the distributor's main customers, Hamilton adds.

Data General followed the Schweber signing [*Electronics*, Sept. 29, 1977, p. 50] by adding the Wyle Distribution Group for the microNova last December. Schweber has 16 U.S. locations, and two of Wyle's six locations now stock the microNova. The Westboro, Mass., company's microcomputer system on a single board, the MCB/1 [*Electronics*, May 25, 1978, p. 187], will also be offered through these distributors soon. □

Production

Molecular beam makes epitaxy bid

As a means of growing epitaxial layers on wafers, both vapor and liquid-phase methods may soon be outclassed by a molecular-beam approach. Under development at Mitsubishi Electric Corp. in Japan, the process has already yielded a low-noise, gallium-arsenide, metal-semiconductor field-effect transistor that operates at 8 gigahertz. Different sizes of this MES FET are replacing silicon devices and Impatt and Gunn diodes in applications in small-signal amplification, frequency generation, and power amplification.

So far, these wafers have achieved a gain of 8.4 decibels at optimum bias and a noise figure of 2.5 dB, or only 0.3 dB poorer than the figure for devices made from vapor-phase epitaxy wafers. But Mitsubishi engineers are confident that molecular-beam epitaxial growth will soon come up with higher-performance chips, promising as it does devices with high carrier mobility, sharp epitaxial layer-to-substrate interfaces, and layers grown to the desired thinness.

Molecular-beam epitaxy is a technique very similar to vacuum deposition of metals. Like deposition, it is carried out in a high vacuum. Sources of gallium, arsenic, and dopant are heated to send vapor beams to the substrate. The substrate is also heated to an appropriate temperature to enhance the

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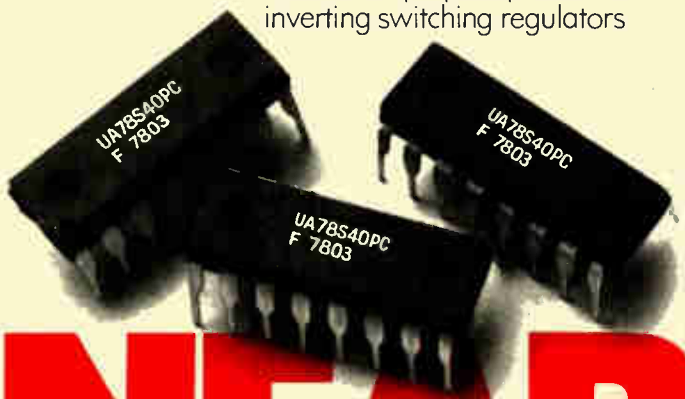

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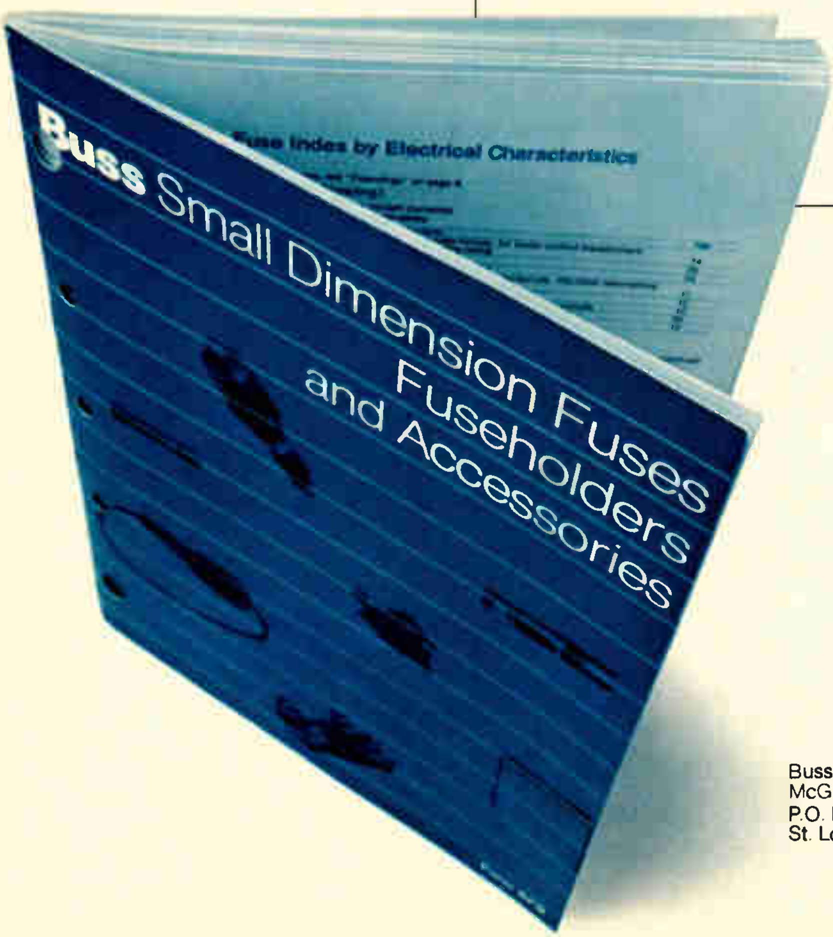

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NATO to jump EW, ASW outlays in 5-year plan

The North Atlantic Treaty Organization will sharply increase outlays for electronic warfare—particularly tactical-communications jamming and air defense systems—and antisubmarine warfare during the next five years, said NATO officials at the organization's summit meeting just concluded in Washington. **"That seems to be our only effective response to countering [Soviet] force numbers we cannot begin to match,"** one explains, citing U. S. Defense Department figures. The new, unreleased status-of-forces estimate lists respective strengths at 67 NATO divisions vs 86 for the Warsaw Pact, not including 91 Soviet divisions in western Russia and another 50 on the Chinese, Afghanistan, and Iranian borders. Warsaw Pact forces in Europe also have a 4-to-1 advantage over NATO's 11,000 tanks and 3,000 combat aircraft. NATO submarines number 238, including 122 nuclear-powered boats and 45 carrying 720 ballistic missiles.

10 electronics experiments picked for space processing

The high promise of perfecting materials processing for semiconductors, battery electrolytes, and electro-optics in the weightless environment of the space shuttle and Spacelab has led the National Aeronautics and Space Administration **to select electronics applications for 10 of its first 17 experiments to be flown aboard the two spacecraft.** NASA's Marshall Space Flight Center has named 17 scientists as principal investigators under its initial $12 million, five-year program. Three electronics materials experiments will be among the first five flown next year aboard an early orbital test of the space shuttle to get preliminary data and see if refinements in the experiments are needed before being flown again.

Photovoltaics gets 65% budget boost from House unit

The House subcommittee on advanced energy technology has approved a $125 million Department of Energy spending program for photovoltaics in fiscal 1979 despite the department's refusal to support the 65% increase in the White House budget request [*Electronics*, Feb. 2, p. 76]. Although a precise breakdown of proposed outlays must still be written into the pending appropriations bill, both committee and energy sources say **approximately $80 million will go for research and development with another $45 million to be used for equipment** in demonstration, test, and applications programs. Like most committee budget recommendations, the bill is expected to be approved by the full House, although a separate long-term plan by subcommittee chairman Mike McCormack (D., Wash.) to establish a $1.5 billion photovoltaic development program over the next decade [*Electronics*, April 27, p. 59] faces stronger opposition on the floor.

MCI hits AT&T tariff filing for Execunet

MCI Telecommunications Corp. is charging American Telephone & Telegraph Co. with "filing lies," "double billing," and "a serious violation of antitrust laws" in AT&T's proposed tariff filed with the Federal Communications Commission to cover **local switching rates for MCI's extension of its intercity Execunet service in 16 cities.** The filing came after a Supreme Court refusal last month of an AT&T petition for review of a ruling ordering it to provide MCI with local loops. Execunet permits users to dial a local number, give a billing code, and then be connected by microwave to another city and dial a local exchange number there.

The price of making NATO pay

When Congress gets the military budget for fiscal 1980 that President Carter will submit in January, defense officials expect its emphasis on the North Atlantic Treaty Organization will be new and different from the one in the fiscal 1979 spending program now close to being wrapped up on Capitol Hill. "Other NATO members are going to have to pick up a larger share of systems costs if the alliance is going to continue its buildup," says one defense budget specialist. "There is no other way that I can see now because we won't have the money," he explains, citing new White House budget guidelines now being distributed to Federal agencies by the Office of Management and Budget. The guidelines call for limiting Government outlays as a means of curbing inflation as well as reducing the Federal deficit—two Carter promises no closer to fulfillment now than when they were first made two years ago.

For U. S. defense electronics suppliers, there is allegedly more good news than bad in the prediction that NATO allies will demand an increasing share of the contractual pie if they are expected to cough up more for their own defense. "Europe can't match American military electronics, so the business its contractors get will be concentrated in relatively static technologies like transportation systems. State-of-the-art electronics will be either made by or licensed from U. S. companies," the official says. "If there is any lost business at all—and I doubt it—it probably will come in discrete passive components used for replacement parts."

Retrofits a plus?

More than that, budget analysts believe electronics contractors will benefit further from NATO's efforts to achieve systems commonality and standardization of parts. "A lot of the [weapons] platforms will vary, like planes and tanks, and may never achieve uniformity," the official notes. "But standard communications and tactical things like missiles mounted on these platforms are really the only things that matter. They will come much more quickly through retrofits on old platforms." That, too, should benefit electronics suppliers, particularly in the area of countermeasures and telecommunications, he argues.

As work on the fiscal 1980 budget proceeds, these and other nostrums are being put forth by Pentagon planners to salve industry concerns about the prospects of reducing military outlays in fiscal 1980 and spending more of the available monies in Europe. However, congressional staffers and contractor representatives in Washington are waiting for more specifics to emerge as budget planning gains momentum during the Capital's hot and humid summer after Congress has adjourned.

Lowering the ceiling

The new OMB guidelines placing a $122 billion ceiling on fiscal 1980 outlays are what trouble military planners most, including the proposed limit of $36.5 billion on procurement. The figure is well under the $126 billion spending level with its $38 billion procurement account forecast for fiscal 1980 by Defense Secretary Harold Brown before Congress just four months ago [*Electronics*, Feb. 2, p. 73].

Congress may raise that spending program when the time comes, as it has just done in the House by authorizing another $2.5 billion for the fiscal 1979 procurement account that Carter had not sought, raising the total to $38 billion. "But we can't count on Congress to give us more money," notes DOD's planner, "We work for the White House and take our orders from there."

Military-budget watchers in industry believe at this point that Carter's proposed ceiling and its option to put more contract money into Europe faces trouble in Congress and with military leaders as well. "We can talk about cooperative efforts," says one, "but when it comes down to a buy, Congressmen don't like to see jobs that might be in their district going abroad. The Joint Chiefs don't like foreign production either because it jeopardizes sources of supply and technological security as well. And, if the F-16 fighter is any example, it raises program costs, too." The General Dynamics plane is the first NATO coproduction venture.

There is still eight months until the fiscal 1980 budget is locked up, of course, and international political considerations not now foreseeable could force a change in Carter's spending plans. Failure of the upcoming strategic arms limitation talks with Russia or an escalation of the infighting in Africa are two possibilities.

Nevertheless, an increasing number of defense electronics contractors are not counting on the unpredictable. Nor are they ready to swallow the DOD nostrum that more contracting with companies in NATO countries is unlikely to hurt their military sales. Instead, they are counting on congressional support to keep the military market at home while covering themselves by exploring new corporate alliances of their own in Europe for licensing and coproduction of subsystems.

Ray Connolly

Electronics International

June 8, 1978

C-MOS op amp fits onto chip beside digital circuits: page 69

The pace is quickening and the recording time lengthening in video cassette recorders for the European market: page 70

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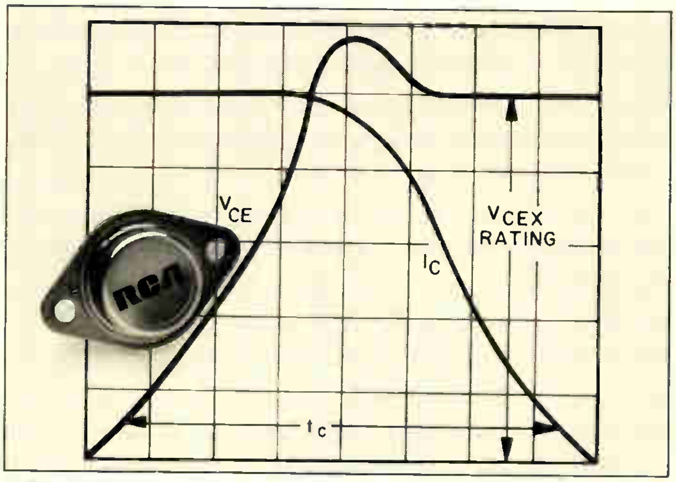

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Circle 64 on reader service card

Britain to back memory maker with $40 million

Aiming for a success like that of an Intel or Mostek, the United Kingdom's three-year-old National Enterprise Board is to fund a startup semiconductor memory company **and hopes for partnership with British engineers who are now key figures in the U. S. semiconductor industry.** The company, UK Memories Ltd., which aims to leapfrog Britain into the 64-K–random-access-memory race, is to be backed to the tune of $40 million to $60 million. It will be in the north of England and is expected to employ some 4,000 as production builds.

Under a parallel $200 million, five-year program [*Electronics*, May 11, p. 88], the Department of Industry aims to provide a custom capability in large-scale integrated circuits for British equipment manufacturers centered around Plessey, General Electric Co., and Ferranti, while at the same time building a standards capability with aid to multinationals. Although the NEB-backed company plan is to meet Japanese and U. S. semiconductor makers head on and the DOI's low-risk scheme precludes such strategy, the semiconductor company is expected to play a role in the DOI's overall program.

EIA-J seeks four changes to aid consumer industry

Consumer electronics manufacturers in Japan have proposed four new broadcast services that would generate $3.2 billion in additional sales as a means of lifting their industry out of its doldrums. With a sluggish economy at home and new export restrictions to contend with, the Electronic Industries Association of Japan has petitioned the ministry of posts and telecommunications to expand broadcasting regulations to include **multiplexed sound for television, an increased number of commercial fm stations, use of multiplexed data displays, and the transmission of still pictures** over TV channels.

Multiplexed sound for television, which could be used for either stereo or dual-language broadcasts, was singled out by the association as the most attractive of the new proposed services. Estimates place increased revenue from this new venture alone at about $1.3 billion.

Viewdata export sales near as trials get under way

As the British post office's Viewdata service, linking a central computer bank by phone to home TVs, hiccups into its marketing trials, additional overseas customers could soon be signing. West Germany has already purchased a system, the Netherlands and Hong Kong are believed to be in the final stages of negotiation, and a big marketing push is now under way in the U. S. But all is not roses for British set makers. The first of the 1,500 sets to be delivered for the trials **will require additional current limiters to meet post office safety standards,** a teething trouble that will delay the buildup of sets for the service—now trade-named Prestel—which is to go public in the first quarter of 1979.

Ferranti teams with Honeywell on military lasers

Capitalizing on its expertise in laser-ranging and target-marking systems, Ferranti Ltd. is joining with Honeywell Inc. to develop and market neodymium yttrium-aluminum-garnet laser systems for the U. S. military. Such systems are already in volume production at Ferranti's Edinburgh factory, which recently took its **first production order for laser target marker equipment to be supplied to the British army.** Honeywell has complementary skills in the development and production of detection and imaging equipment for military and civilian applications.

PCM codec with $10 price tag due from Siemens

Siemens AG is coming out with samples of a fully integrated pulse-code-modulation dual-channel coder-decoder system priced low enough to make it a formidable contender in the emerging and hotly contested codec market [*Electronics*, April 13, p. 77]. In lots of 50,000 or more, the system will sell for less than $10 apiece, which works out to less than $5 per channel. Volume deliveries will get under way by August, the West German company says.

Convinced that a highly complex codec on a single, one-technology chip is an uneconomical solution, the Siemens designers settled on two large-scale integrated circuits, each using a different but well-established process. **That and proper partitioning of system functions are the prime reasons for the low cost,** declares Werner Flagge, a product manager in the Components division.

One LSI chip, the SM61A, uses n-MOS technology and encompasses the logic controller, the successive-approximation register, the code converter, the input and output sampling switches, and other digital circuitry. The other LSI chip, the S291, is a bipolar device that integrates a voltage-reference source, the comparator, and three amplifiers. In addition, the two-chip set needs a few resistors and capacitors in its periphery.

Thomson to produce memory systems for Amdahl

Thomson-CSF of France may soon start providing memory systems for Amdahl Corp.'s V-series mainframe computers, says chairman and founder Gene Amdahl. He says **talks between the two firms are "very promising" and expects an announcement soon.** The Thomson operation may include production of the memory chips currently supplied by Motor-Ola Semiconductor. The French firm may find it cheaper to go on buying them, but "at least the deal will be an opportunity for them to consider chip production, if not at this time, then in the future," says Amdahl. The memories are presently based on 4-K chips but soon will move up to 16-K versions.

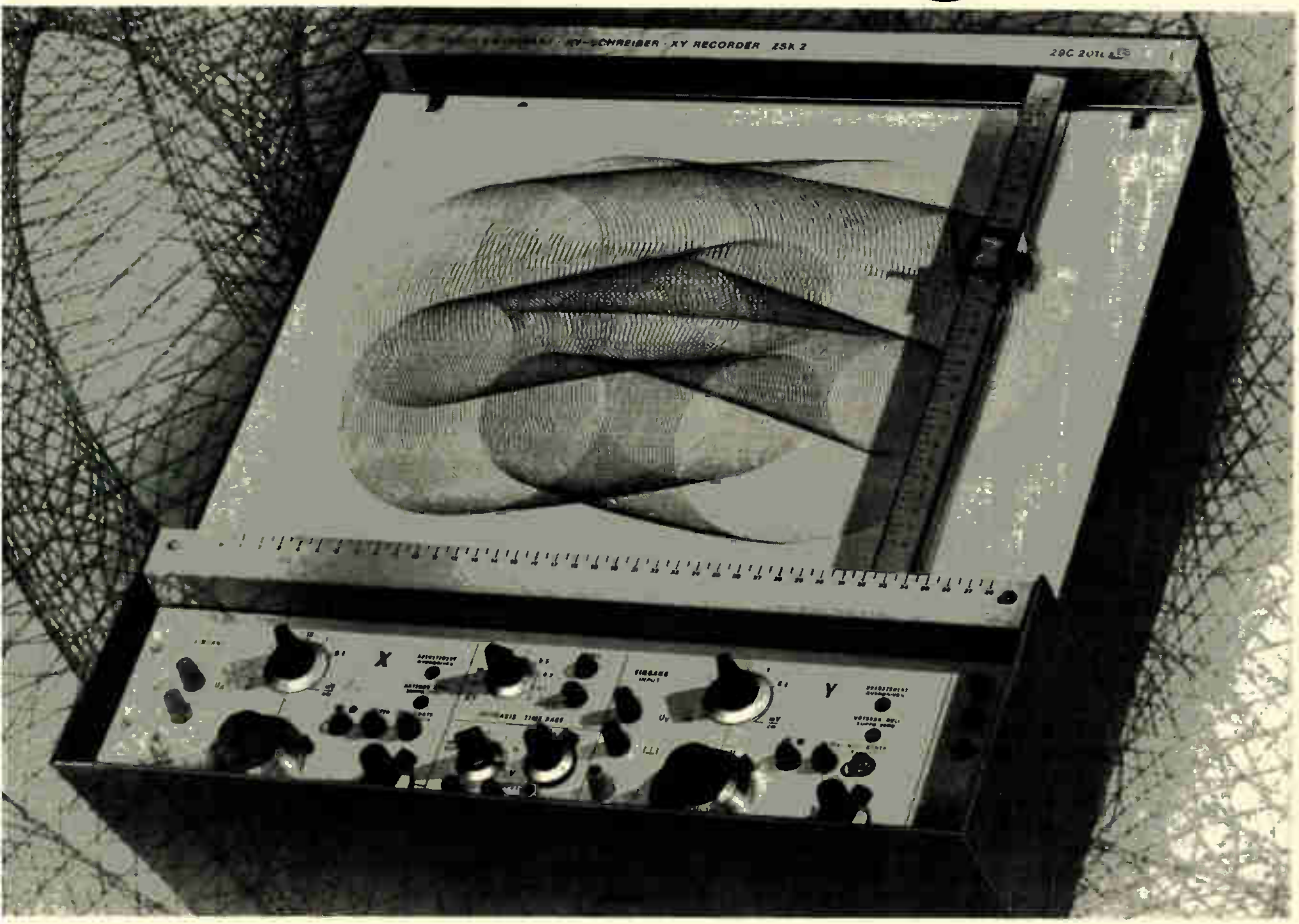
Japanese firm slims down analog watch

With the market in analog watches still very strong in Japan, companies are vying with each other to produce slimmer ones. The latest entry in the race comes from Citizen Watch Co. Its new timepiece is only 4.1 mm thick, which company spokesmen say is a world's record. To make its debut in Japan in July, **the new watch has a movement only 2.25 mm thick, including battery.** Seiko, a major competitor, is currently marketing an analog watch with a movement that is 2.9 mm thick.

Addenda

Some 60 electronics companies now have plants in the Republic of Ireland, **with the latest addition to the list being Computer Automation Inc. of Irvine, Calif.** The minicomputer maker will produce its Naked Mini and Cipher systems in a plant in Dublin. At the same time, authorities predict that exports from Ireland will jump to $910 million annually by 1980 from the 1977 total of $520 million. . . . Sperry World Trade Inc. and Czechoslovakia's ministry for technical development and investment have signed a deal to explore possible areas of industrial, scientific, and technical cooperation. **One area to be investigated is commercial computer systems.** The accord is reported to be the first between an American firm and a Czech government agency.

New recorder family: precision priced right



For XY and YT plots there's now the recorder ZSK 2 in five different models so you can choose exactly the right one for your application, and at the right price.

ZSK 2 works on the principle of a self-balancing potentiometer. This gives minimal non-linearity (0.1%) and guarantees good reproducibility (0.05%). The high writing speed of >110 cm/s on both axes combined with fast acceleration produces superior dynamic characteristics. Deflection factors calibrated between 10 μV/cm and 11 V/cm, electronic limiting of the writing area for DIN A3 and A4 plus governable zero offset make operation easier, whilst inputs for remote control and ratio recording mean greater variety of use.

The models differ in their inputs:

Universal model 02
Sensitivity 10 μV/cm; floating input amplifiers with guard; timebase generator.

Standard model 04
Sensitivity 5 mV/cm; differential amplifiers for both inputs.

Lab model with timebase 06
Sensitivity 100 μV/cm; floating input amplifiers; timebase generator; offset-voltage source.

Lab model 08
Sensitivity 100 μV/cm; floating input amplifiers.

System model 10
Sensitivity 100 mV/cm; direct inputs Z_{in} 20 kΩ.

For more information quote
ZSK 2 recorder family

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ROHDE & SCHWARZ

Circle 110 on reader service card

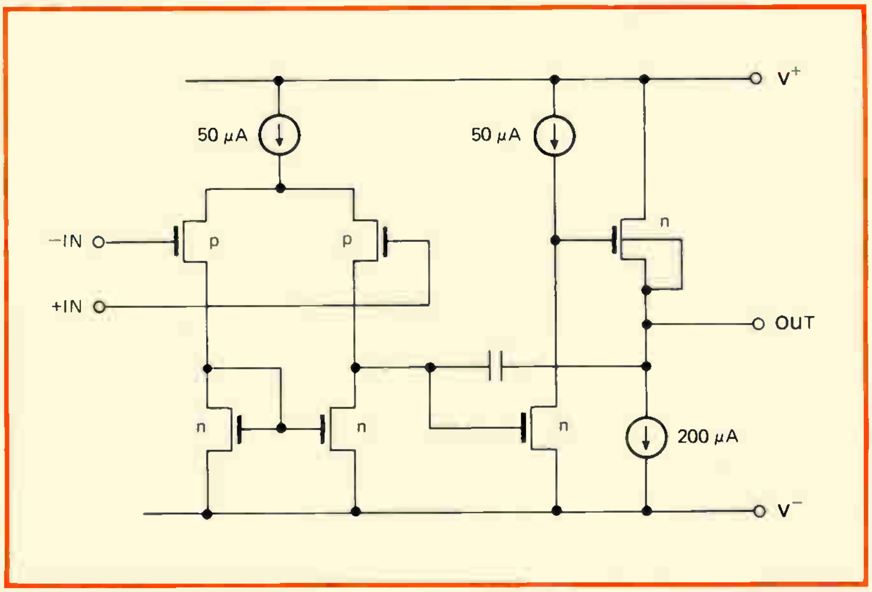
Silicon process shrinks op amp to fit onto digital chip

Making the operational amplifier with a C-MOS process permits fabrication by digital techniques that lay down the rest of the chip

The ubiquitous operational amplifier is entering the LSI world in a Japanese adaptation of a digital silicon-gate process. At this stage in its development, the resulting circuit need occupy no more than a quarter of a square millimeter on a chip that includes digital devices. So designers will be able to squeeze a good number of op amps onto such a chip.

As large-scale integration incorporates more and more circuitry onto a single chip, such devices as the op amp are likely to become leading candidates for inclusion. In fact, the Nippon Electric Co. engineers who are developing the complementary-metal-oxide-semiconductor op amps say that chips incorporating similar devices will be marketed soon. An op amp will be needed for low-cost one-chip analog-to-digital and d-a converters that will come into use for interfacing microcomputers with the outside world in the expanding control applications.

Configuration. Working at the NEC integrated-circuit plant in the Tokyo suburb of Kawasaki, the engineers fabricated the differential input stage with C-MOS technology, because it allows an active load with a higher impedance, resulting in a higher gain. They chose p-channel transistors for the differential input pair and n-channel transistors for the load, because this configuration permits operation over a 0-to-+6.5-volt input range when the op amp operates from a single +8-v supply.



On a chip. In experimental LSI operational amplifier built with complementary-MOS technology, dc gain is 90 dB, slew rate is 2.5 V/µs, and common-mode rejection is 65 dB.

In the resulting LSI circuit (see figure), the differential stage is followed by a single-ended n-channel driver and then by an n-channel source-follower output stage. The three constant-current power supplies are each p-channel enhancement transistors. The 20-picofarad phase-compensating capacitor is also fabricated with C-MOS technology.

Input offset voltage of the silicon-gate devices is about 5 millivolts, compared with the 10 to 20 mv common with aluminum-gate devices. Moreover, input drift with temperature is on the order of 50 microvolts/°C. The low-frequency noise referenced to the input is about 20 microvolts.

The NEC engineers note that their device's characteristics are less than spectacular when compared with independent op amps. But they are confident they will set the pace for LSI op amps that can be built with digital techniques. □

France

Protocol-linkup plan would stymie IBM

Taking dead aim at IBM Corp., a newly released French government report proposes a linkup with other European countries and perhaps even with the American Telephone and Telegraph Co. to set international protocols for telecommunications. Such an agreement would keep control over interfaces out of the hands of the computer giant, thus

Proposals are wide-ranging

The charge laid upon Simon Nora by the French government was to assess the increasing impact of telecommunications, computers, and broadcasting upon the world and to make proposals for the government's policies in light of this. Because his group looked at computers, it also gave a passing glance to semiconductors.

A key recommendation is the call for a ministry of communications to coordinate efforts between the equipment-making, broadcasting, and satellite-technology industries. Also, the telecommunications side of the PTT should be split off to make an independent commercially oriented company—and it should begin hiring some high-level salesmen, the report urges.

Components and computers take a back seat in Nora's proposals, though he stresses as strongly as anyone the impact they will have on society and economic growth. Given the current hard bargaining between the French and various American firms over joint ventures for integrated-circuit production, the discussion of components is understandably brief. But Nora observes that a state without the ability to make high-technology ICs will be in a position like that of a nonnuclear state.

Surprisingly, the report backs recent industry suggestions that CII-Honeywell Bull could have a crippling effect on France's relatively prosperous smaller computer firms, those making terminals, minicomputers, and peripherals, as well as on France's computer-service industry, second only to the U. S. Too big a market share for CII-HB in either area could spell disaster for the smaller firms—an important part of France's data-processing plans.

slowing its inroads into the communications business.

The report's principal author, Simon Nora, insists that he is not anti-IBM. Yet, implicit in the final version is the belief that a main imperative for France and for the rest of the world is keeping IBM out of the key telecommunications network. "Control of the network market conditions control of telecommunications and the behavior of the computer market," says Nora, a senior adviser in the finance ministry. "If IBM became master of the network market, it would have a share—willingly or unwillingly—of the world power structure."

Cooperation. He proposes that France work towards setting up a telecommunications body involving other European countries and possibly AT&T. The report envisions that such a group would have the clout to set international interface standards and the power to make them stick over possible IBM objections.

If such standards are designed to exclude compatibility with IBM protocols, then the firm could well be hobbled in carrying out any plans for a major role in telecommunications. At the very least, it would have to junk a substantial investment in switching to the new protocols. On the other hand, failure to agree upon an international standard might let IBM's protocols become the *de facto* standard.

Prepared on the orders of French president Valery Giscard d'Estaing, the report, L'Informatisation de la Société, also calls for a national telecommunications company to take that responsibility from the PTT, the national common-carrier and postal agency (see "Proposals are wide-ranging"). The aim of the move would be to boost France's commercial effectiveness in the world telecommunications market.

Nora also thinks that an international agreement on protocols will benefit the French telecommunications industry, among others. "It would be better to have no standards than to have a mixture of national standards," he observes. "This would only isolate the French from export markets."

Reaction. At this point, there has been no approach to AT&T on the proposed linkup. One Paris-based international specialist in computers, information, and telecommunications does see it as a logical move. "AT&T could be interested in teaming up with the Europeans to protect its monopoly at home from IBM and to break into export markets," he says. "And control of interfaces is the important thing. It is just what IBM is hoping to escape by going into satellites."

In basic agreement with that assessment, Georges Péberau, administrator-director general of CIT-Alcatel, adds that the American company "has similar problems to those of the European PTTs. But any big deal with AT&T would have to involve more than just the French. You have to have somebody pretty big to dialog with AT&T"—such as an all-European body. □

West Germany

4-hour-and-more video cassette recorders aim at retaining quality of sound and video

European manufacturers of consumer equipment are readying stiff resistance to the expected Japanese onslaught on the lucrative market in video cassette recorders. The latest effort to make the market a tough one for outsiders to break into comes from Grundig AG, West Germany's leading manufacturers of entertainment electronics.

Thus the Fürth-based company is beginning to market a unit that can record 4 hours of programs on a single cassette. Its engineers have coupled the longer playing time with design improvements intended to maintain the picture and sound quality at the level found in VCRs with shorter attention spans.

The introduction follows closely an announcement from Dutch electronics giant Philips Gloeilampenfabrieken of 3-hour cassettes for its VCR-standard recorder. The move is

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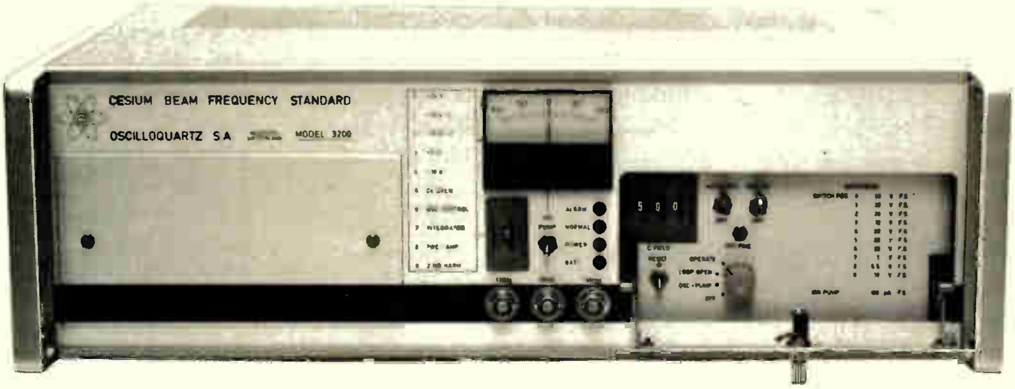
Circle 112 on reader service card

The smaller lighter self-contained Cesium frequency standard



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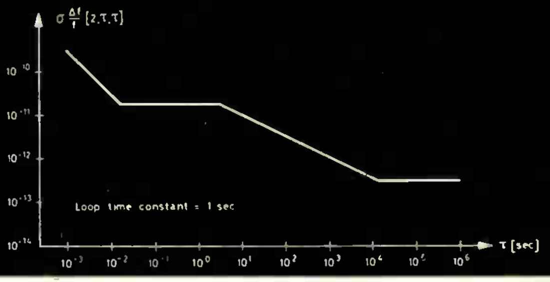
Accuracy:	$\pm 1 \times 10^{-11}$ over temperature range (without calibration)
Reproducibility:	$\pm 5 \times 10^{-12}$
Settability:	$\pm 2 \times 10^{-13}$ total range $\pm 4 \times 10^{-11}$
Output:	10, 5, 1 MHz/1 Vrms/50 Ω
Power supply:	220/110 VAC and 20 to 30 VDC
Dimensions:	height 131 mm, width 483 mm, depth 456 mm

Stability



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slab is laser-trimmed until the 70-μm gap length is obtained.

Available for the SVR4004 recorder are four cassettes, for 1, 2, 3, and 4 hours of playing time. While the 1-, 2-, and 3-hour cassettes use a 20-μm-thick tape, the 4-hour version has a tape only 16 μm thick. It contains a 570-m-long tape and sells for about $33 on the German market. The 5-hour cassette will have a 13-μm tape.

To enhance the SVR4004's usefulness, Grundig includes a digital electronic clock that permits programming of turn-on and -off times as long as 10 days in advance of the show to be recorded. The built-in receiver section can automatically search for stations and has a nonvolatile station memory.

What's more, the user can remotely control the unit with infrared signals from a hand transmitter. The signals go to an appropriately equipped TV set, and the recorder's optional remote-control adapter interconnects it and the TV receiver.

The 4-hour model consumes only 75 watts of power, weighs 14.5 kilograms, and measures 590 by 320 by 151 millimeters. The firm also makes a 4-hour professional version, the SVR4004AV, which has inputs and outputs for signals from camera equipment and the like. □

Great Britain

It's green all the way for vehicles using flat antennas to control signals

Fire engines in the English town of Northampton will soon encounter only green lights as they speed on their way. A compact roof-mounted planar antenna array will transmit a pencil-thin microwave signal ahead of each vehicle to switch traffic lights equipped with companion receiver units.

The application calls for a low-power transmission by emergency vehicles. Such a system needs to be highly directional, so the planar array forms the front face of the transmit and receive units. The receiver thus has a narrow receiving angle with low side lobes, and the transmitter beam width is 10° in the system, which is under evaluation.

Narrow. In operation, the transmitter can approach to within a few meters of the receiver, from behind or from the side, without triggering. Yet the straight-ahead range of the experimental 10-milliwatt Gunn generator is over 500 m.

The developer, the Philips research laboratories in Redhill, Surrey, is supplying 25 systems to the Department of Transport for the Northampton trials. Other applications for the array include manpack radio transceivers, burglar alarms, road and sea traffic-control and location systems, hand-held and vehicle radars, and speed-measuring systems including collision-avoidance systems.

The transmitter operates in the continuous mode. Operating frequency is in the 10-to-20-gigahertz band; a lower frequency would require larger aerials to meet the low-beam-width requirement, while a higher frequency would increase manufacturing costs because it would use components that are less readily available.

The antenna itself is made from a square dielectric substrate, copper-clad on both sides. The top face is etched to produce a matrix of radiating elements interconnected by diagonal copper tracks. These elements are arranged so that the high-impedance microstrip lines connecting each to its neighbor are a wavelength apart, for a parallel forward beam.

A miniature coaxial connector feeds the center of the array through the dielectric substrate. The configuration thus comprises four parallel, balanced arms, which together match the 50-ohm source impedance. The resulting power distribution has maximum power at the center, tapering to a minimum at the edges of the beam. This tapering insures excellent side-lobe performance; typically the gains are between 19 and 27 decibels down on the main beam for a 25-dB gain aerial.

The number of radiating elements controls the beam width—the greater the number, the narrower the beam. Arrays from 2 by 2 to 24 by 24 elements have been formed with beam widths from 50° to 7°. Further beam-width control can be achieved by warping, or squashing the antenna like a concertina. The size of a 100-GHz array is typically 23 centimeters square. □

Weighing performance and economy

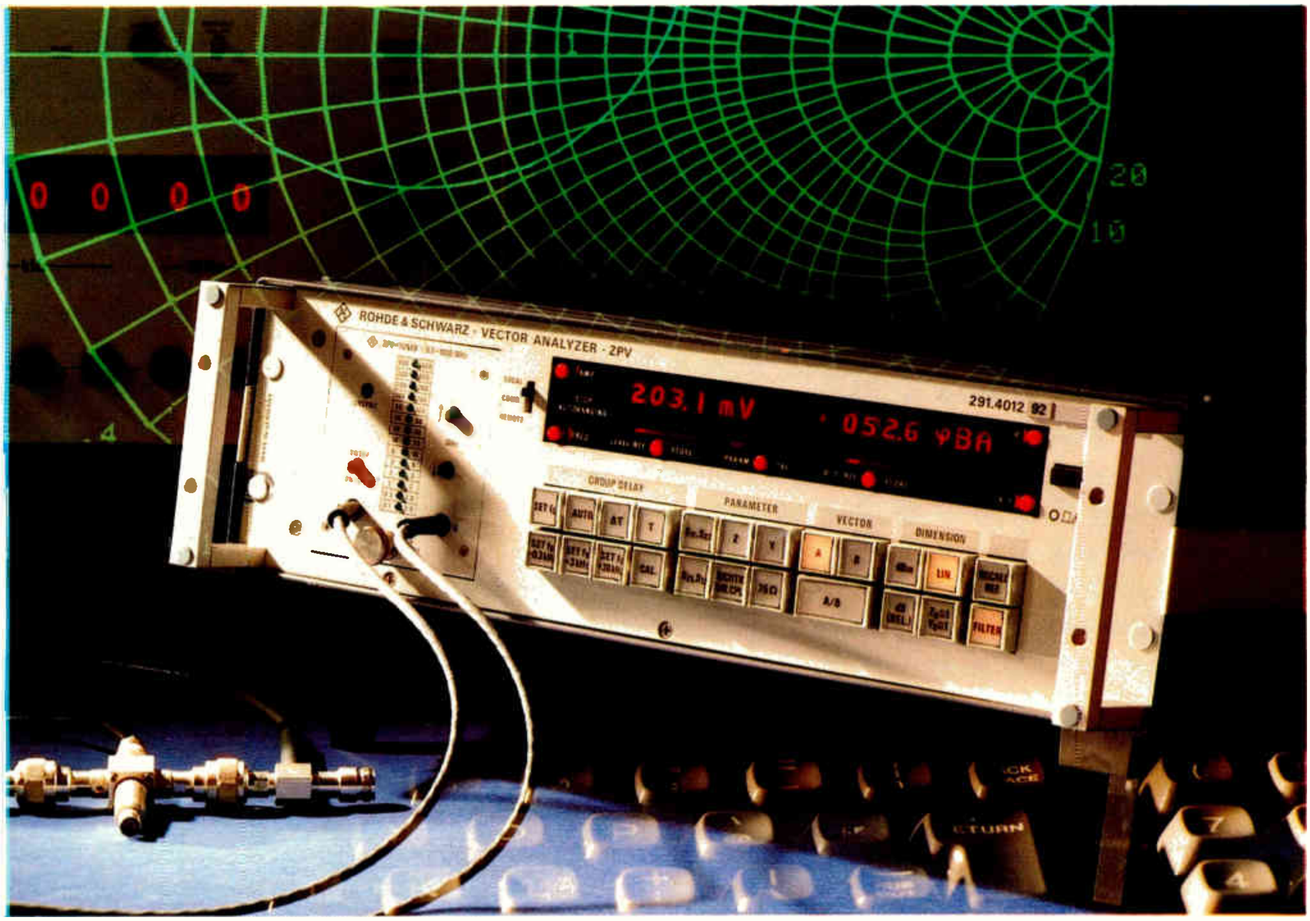
Since the antenna arrays are planar and are reproduced accurately in quantity by a photolithographic process, they are smaller, cheaper, and lighter than their three-dimensional equivalents made by machining. Add to this their compatibility with coaxial and microstrip components, their good control of beam width and side-lobe level, and their typical radiation efficiency of 80%, and it is easy to see why the Philips researchers chose the technology for Evade (emergency vehicle automatic detection equipment).

Polyethylene is one of the best materials for the dielectric, because it has a low permittivity and a very low dissipation factor. But, at about $400 per square meter, it is prohibitively expensive for such applications.

So Philips turned to a cheaper material with higher dielectric losses. This glass-fiber-mat reinforcement, used in TV tuners, costs about $20/m² and drops the typical overall gain on a large multielement array by 3 decibels, as opposed to 1 dB for a polyethylene-substrate aerial.

Already the Philips lab has supplied one customer with planar aerials designed in its new configuration. It should be well placed for business, should the Department of Transport give the green light to the priority-light scheme after the Northampton trials come to a close this fall.

Going new ways: vector analyzer ZPV



Completely new of its kind, ZPV combines three measuring instruments in one:

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+ RF impedance meter (option)
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Σ = vector analyzer ZPV (100 kHz through 1000 MHz)

ZPV for measurement and direct digital readout of:

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ZPV for highest operating ease through built-in intelligence: choose type of measurement, store reference value by pushing button, read off result – everything else (selection of measuring and frequency ranges, calculation of values measured and performance monitoring) is handled by the microprocessor.

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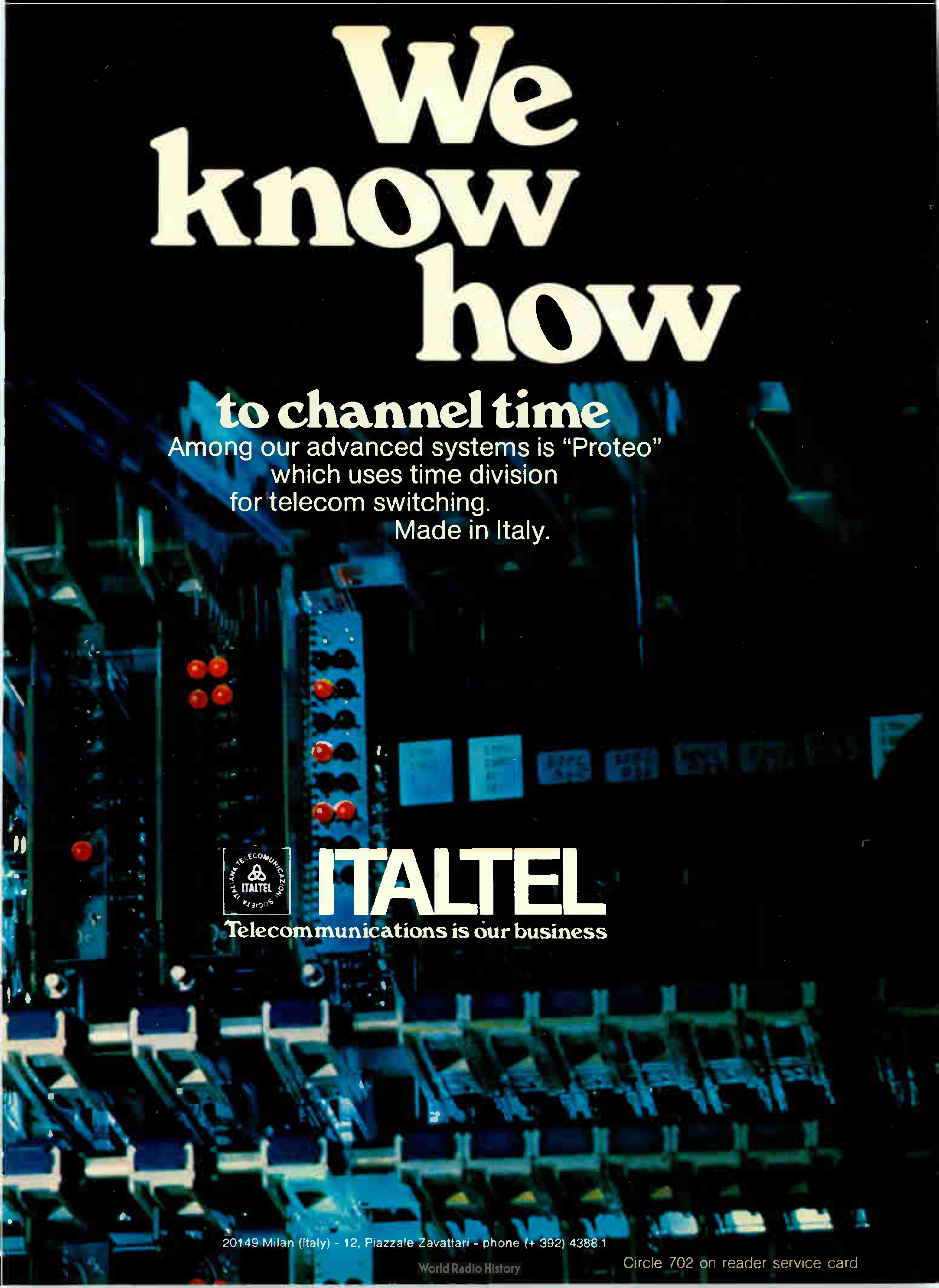
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Circle 702 on reader service card

Microcomputer cards tailored to industrial controls start at $300

by Arthur Erikson, Paris bureau manager

With basic Eurocard, Belgian firm puts variety of memory and interface chips into low-cost systems

Standard microcomputer boards designed to cover a wide range of applications often provide a superfluity of capability when applied to industrial-control systems. On the other hand, it usually does not pay to go for a special-purpose board unless there are enough systems involved—the threshold may be between 100 and 1,000 units—to write off the development cost. The cost threshold has often been too high for designers of low-cost systems.

This threshold, however, will soon shift significantly, says Claude Simpson, managing director of Data Applications International, a small Brussels-based microcomputer maker. At the late-June International Microcomputers Minicomputers Microprocessors 78 exhibition in Geneva, it will introduce its RCS family of microcomputer control modules that Simpson maintains will "get functional cards into the lowest end of the market."

The RCS module, which the company calls its kernel system, will sell for some $300; fully fitted cards will run up to almost $1,000. A development system for the modules will sell for just under $1,000, too.

"What we have done is put a little bit of everything on a single Eurocard," explains Nimal Jinadasa, DAI's marketing director. All the modules in the RCS family—there will be four initially, in addition to the kernel system and the development module—are built around an Intel 8085A microprocessor and a companion 8156 multipurpose chip.

Along with these two devices are a bipolar fused-link programmable read-only memory, up to 8 kilobytes of erasable programmable ROM, 1 kilobyte of random-access memory, and an optional floating-point mathematics chip, the Advanced Micro Devices 9511. The 100-by-160-mm card also carries programmable square-wave and pulse-width generators.

The bipolar PROM is special, Simpson points out. It receives the high-order address bits of the microcomputer's central processor and translates them into chip selects for memory mapping. That way the module can have a pair of 16-kilobit (2716) chips for 4 kilobytes of memory for starters and later be upgraded to 8 kilobytes by using 32-kilobit (2532) chips in the same sockets. "I don't know of any other microcomputer system that has this feature of programmable memory mapping," Simpson says.

The power supply is on the card as well, which means the module can run off the unregulated 24-V dc supply commonly found in industrial-control systems, and adapters are available for 24 V ac and 220 V ac. These, as well as an interface adapter and RS-232 input/output interface, have the screw terminals that designers of industrial equipment generally prefer for their hardware design.

The input/output features represent the main differences among the modules in this family. The general control module (RCS-GCM) has four 0-to-10-V analog input channels, two analog output channels, four opto-isolated digital inputs, and four reed-relay outputs. The automation control module (RCS-ACM) has two 3-A current drives, six 300-mA drivers (at 24 V), and 14 opto-isolated inputs.

Then there is the position and temperature controller (RCS-PTC), with four analog input channels, two opto-isolated digital inputs, four 10-mA constant-current output channels, and four medium-current drivers. Finally, an instrument-control module (RCS-ISC) comes with 22 programmable digital I/O lines and an IEEE-488 bus interface.

As for the basic module (RCS-K), it is essentially the microcomputer with opto-isolated serial I/O on a slightly smaller card. This card can be mated with a breadboard for prototyping. It has free area of 100 by 110 mm with a predrilled 0.1-inch grid for mounting integrated circuits that users need to tailor the module to fit their requirements.

The bus on each of the cards is accessible through a flat-cable connector, so that hooking up the development module (RCS-DEV) is merely a matter of plugging in a flat cable. This automatically redefines the host module's address map and provides automatic bootstrapping to a high-memory–resident utility program on the development module. PROM and RAM on the host and development modules can be freely shared and interchanged by software command, allowing the latter to start at address zero—a particularly handy feature for the low-cost systems targeted by the firm.

To check out the on-line workings


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of the host control modules, the development module offers the usual resident assembler, text editor, and PROM space for resident development software with programmable memory mapper, so that either 2716 or 2532 erasable PROMS can be used with equal facility.

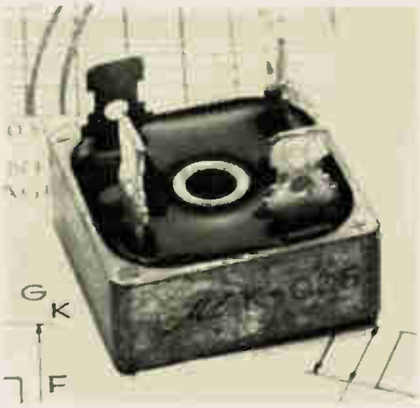
For debug, there are 4 kilobytes of RAM into which the system program in the erasable PROMS of the control module is transferred. When the contents of the RAM are all right, they can be put into erasable PROMS by the development module's programmer.

Data Applications International SA, 6 drève des Renards, 1180 Brussels, Belgium [441]

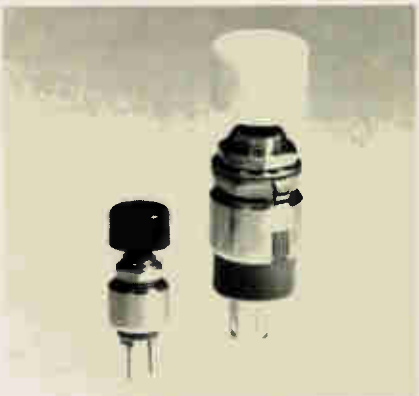
Intended for production, laboratory, and test applications, the 477 spectrum analyzer will operate in the range of 0 to 50 MHz. Values can be selected between 100 kHz and 10 MHz. Sharetree Ltd., 70 Westward Rd., Stroud, Gloucestershire GL 5 4JA, England [448]

Digital capacitance meter NS434 is especially designed to test capacitors in quantity and to gather inspection data. It has a range of 0.1 pF to 1.999 nF. Digital limit comparators can be added. Anglo Japan Electronics Corp., Maruzen Bldg. 2-3-10 Nihonbashi, Chuo-ku, Tokyo 103, Japan [446]

For laboratory and production control applications, multipoint recorder PM 8236 will record up to 12 channels of information; used with one of three different input modules it performs as a universal, single-range, or six-range unit. Pye Unican Ltd., York St., Cambridge, England [449]

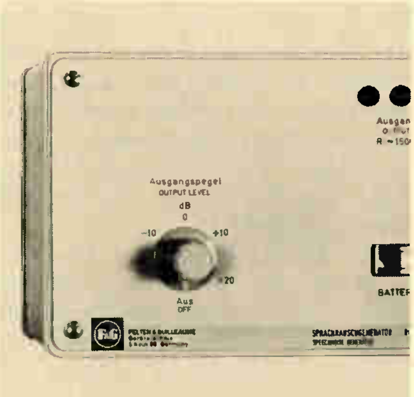


Single-phase full-wave bridge rectifiers, designated the J and K series, are meant for use in high-current applications—up to 10 A and 25 A maximum average dc output current, respectively. Micro Electronics Ltd., York House, Empire Way, Wembley, Middlesex, England [447]



The 9100 momentary push button is 6.5 mm in diameter and 17.5 mm in overall length. Its contact resistance is less than 30 mΩ and its insulation resistance is greater than 1,000 MΩ measured at 500 V. It has a life of 300,000 operations. APEM, B. P. 1, 82300 Caussade, France [450]

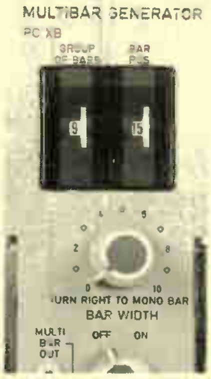
Designed for consumer and industrial applications, power relay 172 operates with ac or dc. It handles about 3,500 VA at a maximum continuous current of 16 A. Two working contacts are spaced 3 mm apart. Rausch & Pausch, 8672 Selb, P. O. Box 1540, West Germany [451]



Speech-noise generator model RGS-1, for speech simulation on telephone channels, produces a quasi-random noise signal using MOS shift registers. An active RC filter performs a spectral evaluation. Felten & Guilleaume, 5 Cologne 80, P. O. Box 805001, West Germany [452]

The Thermotron TM/14/2 is a vacuum-measuring instrument for pressure ranges from 10^{-3} to 10 millibars, which are commonly used in electronic laboratories. The unit measures 100 by 70 mm (front area). Leybold-Heraeus GmbH, 5 Cologne 51, P. O. Box 510760, West Germany [453]

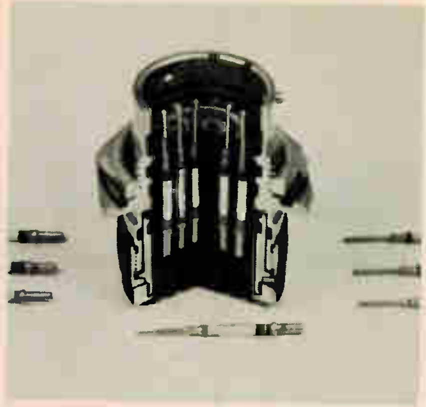
A universal counter, UZ46, has a quartz-controlled time base and operates at up to 15 MHz. Six different modes enable the instrument to count events, frequencies, time units, rpm values, pulse widths, or pulse duration. Grundig AG, 8510 Fürth, West Germany [454]



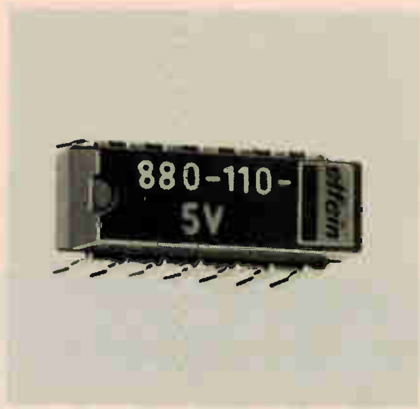
PCXB, a programmable color-bar generator, can store 256 test colors for reference and comparison with processed signals on the screen. Every color is defined with an 8-bit binary word. Each signal's amplitude is stored in a PROM. Bosch-Fernsehenlagen, 61 Darmstadt, West Germany [455]

The type 300 digital ohmmeter can measure from 10$\mu\Omega$ to 20 MΩ in 13 decades. Use of a four-wire technique reduces the maximum error to 0.1%. All leads are shielded to reduce risk of false measurements. Dietechnik, 8041 Weng, Am Kirchfeld 2, West Germany [456]

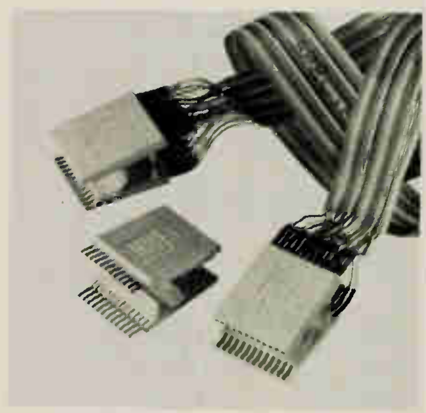
New products international



Voluminous filter sets are replaced by these pin contacts with integrated filters. The contacts handle up to 5 A and are available with π, C, LRC, and CLR characteristics. Connectors house from 3 to 64 contacts. Amphenol-Tuchel GmbH, 8024 Oberhaching, West Germany [457]



Featuring bounce-free mercury contacts, dual in-line reed relay Q43 handles 300 mA and 28 V at a 10-W switching power. Transfer resistance is 100 mΩ; maximum deviation, 10 mΩ. Life is between 5×10^6 and 5×10^7 operations. Elfein GmbH, 6 Frankfurt, Wienerstr. 120, West Germany [458]



The series PC14 to PC40 test clip adapters connect to integrated circuits with from 14 to 40 pins for applying power to them and performing functional tests. The chance of short circuits is eliminated. Atlantik Elektronik GmbH, 8 Munich 70, Hofmannstr. 20, West Germany [459]

New products international

Semiautomatic attenuation tester DT-1 feeds a 1-kHz sine-wave noise signal into the line and then measures noise level with its built-in level meter. Automatic range selection of results simplifies operation. Felten & Guilleaume, 5 Cologne 80, P. O. Box 805001, West Germany [460]

The RI-200 series of compact chokes is designed to suppress radio-frequency interference for thyristors and triacs. They are vacuum-molded in polyurethane for protection against moisture and are suitable for printed-circuit-board mounting. Schaffner, CH-4708 Luterbach, Switzerland [461]

Metalized polypropylene capacitor PHD 470 can be used for many ac applications, particularly in motor circuits and for coupling. Its range is from 1.5 to 3.0 µF, and its tolerance is ±10%. It operates at 260 V ac at 50 Hz. RIFA, Fack, S-161 11 Bromma, Sweden [462]

There's more to 7045....

....than first meets the eye

Under the elegant cover of this new $4\frac{1}{2}$ digit DMM is the very latest technology from Solartron – which places the 7045 in a very special position in the marketplace. Pulse width conversion, used in the best-selling Maestro DVM, has been compressed on a single chip designed by Solartron and manufactured by Plessey. The result – a *laboratory standard* multimeter in a low-cost portable package. Both mains and battery operated, look at some of the features:

✳ measures temperature from −20 to 200°C
✳ six functions: range hold: display hold
✳ voltage: dc 1 μV – 1000V
ac 10 μV – 750V
✳ current: dc 1nA – 2A
ac 10nA – 2A
✳ resistance: 10mΩ – 20MΩ

Contact any of the companies listed for full details about 7045 – or fill in the magazine's reader reply card.

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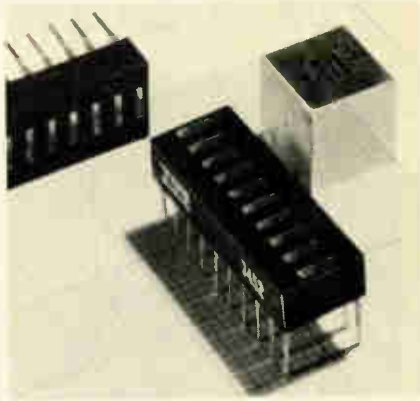
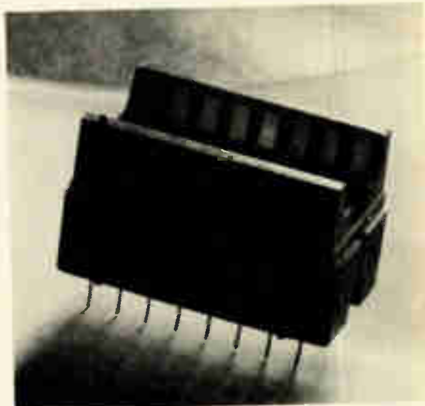
Solartron Schlumberger

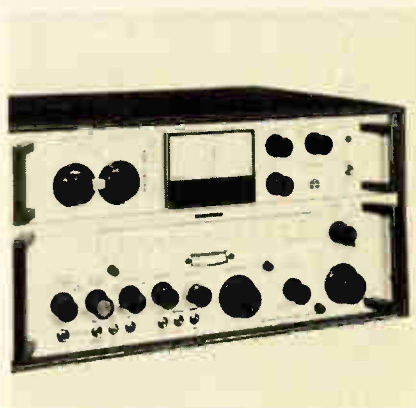
New products international



A 10-bar light-emitting-diode line array permits assembly of linear displays of any desired 10-multiple length. It is intended for applications where it is desirable to have a display output in linear analog form. ITT Components Group Europe, Edinburgh Way, Harlow, Essex, England [463]



The TSN integrated-circuit socket will permit high-density mounting on pc boards for increased burn-in oven production. It measures 12.53 mm wide, accommodating a 16-pin unit. Astralux Dynamics Ltd., Brightlingsea, Colchester, Essex, CO7 0SW, England [464]



Two noise measurement systems, designated models 1561 and 1562, are specifically designed to meet international CISPR standards. Ranges are 150 kHz–30 MHz and 25 MHz–300 MHz, respectively. GEC-Marconi Electronics, Marconi House, Chelmsford, CM1 1PL, England [465]

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Voltage range	0–40 V	0–20 V	0–40 V	0–75 V	0–20 V	0–40 V	0–75 V	0–7 V	2x0–20 V
Current range	0–0,5 A	0–2 A	0–1 A	0–0,5 A	0–6 A	0–3 A	0–1,6 A	0–3 A	0–1 A
Stability*	≦ 0,5% or 4 mV	≦ 0,01% or 1 mV	≦ 0,01% or 2 mV	≦ 0,01% or 4 mV	≦ 0,01% or 1 mV	≦ 0,01% or 2 mV	≦ 0,01% or 4 mV	≦ 0,05% or 1 mV	≦ 0,05% or 2 mV
Ripple* Voltage (RMS)	≦ 1,5 mV	≦ 1 mV	≦ 1 mV	≦ 1 mV	≦ 1 mV	≦ 1 mV	≦ 1 mV	≦ 0,5 mV	≦ 1 mV

*Ripple and stability figures in constant voltage mode. Stability given for ± 10% line variations.

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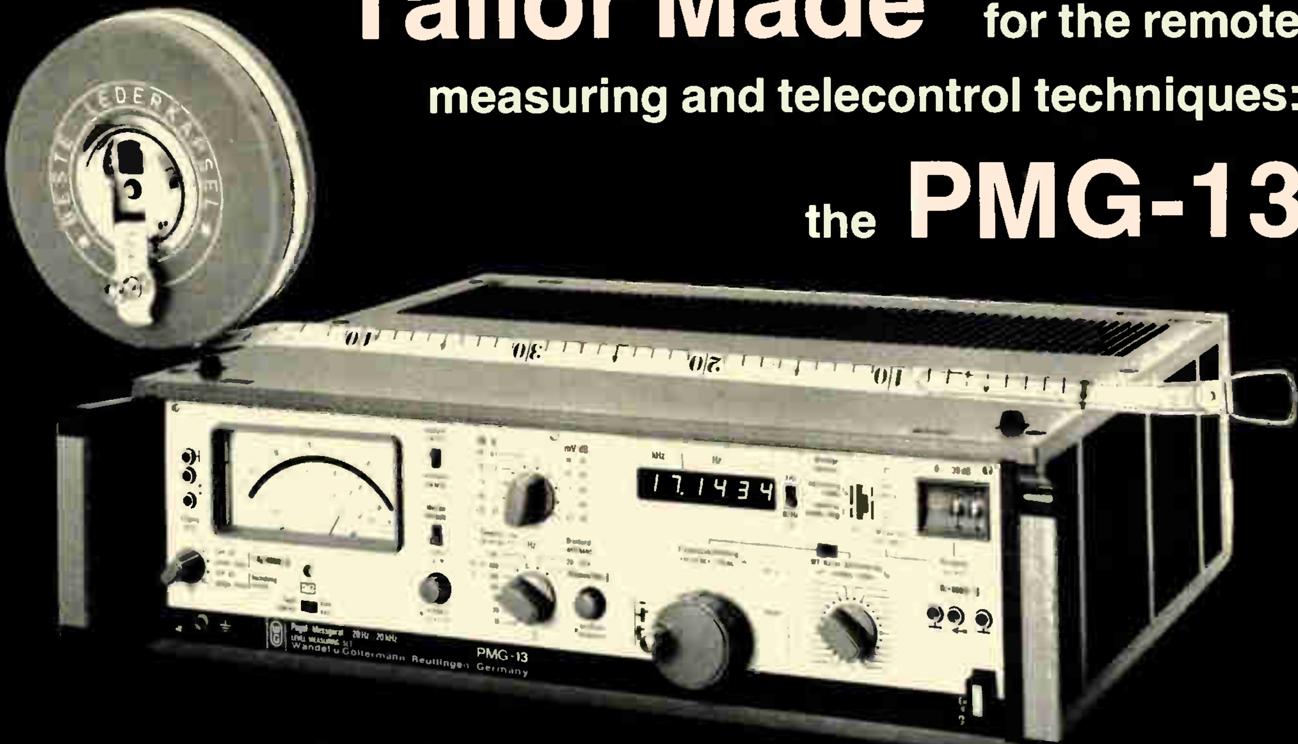

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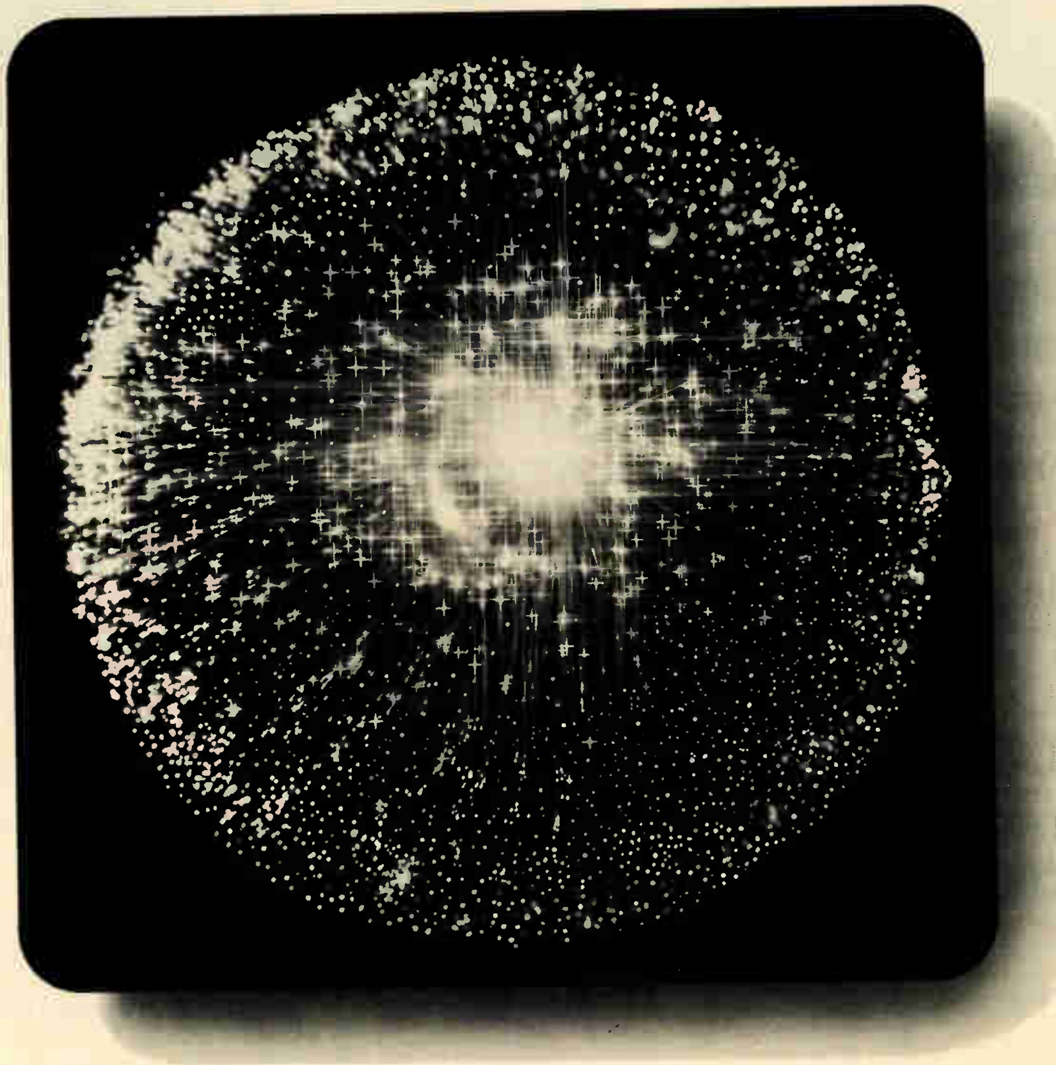
Light Fantastic

Technological progress is a process of evolution. The familiar light-spray lamp, for example, uses minute-diameter flexible glass fibres to transmit light along a curved path. This same principle has evolved into a science that will have a significant impact on 20th century communications technology.

Philips optoelectronics engineers have developed this 'light fantastic' sufficiently to install the fibre optics transmission system.

Using 0.1 mm diameter fibres – each with a capacity of 1920 telephone channels – the system is also suitable for transmitting data, telegraph, videc telephone and television signals. Once the problem of short-haul transmission have been resolved, it stands to reason that much greater distances will be covered. For, quite apart from its enormous economic and technical advantages over traditiona copper-cable transmission systems, fibre optics is a



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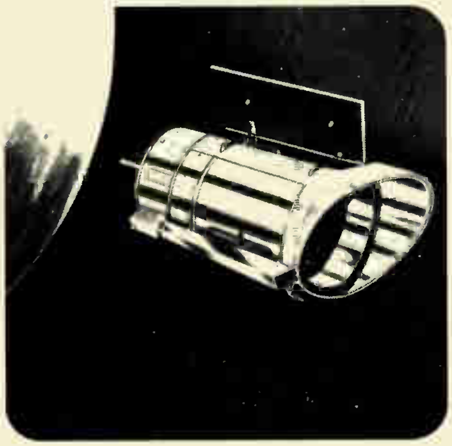
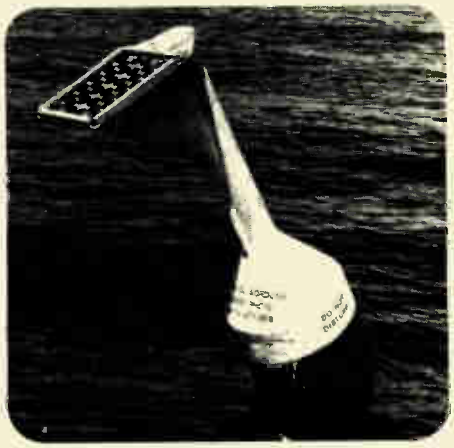


IRAS - Infra-Red Astronomical Satellite - due to be launched into a 900 kilometre polar orbit in 1981, is the first scientific satellite designed to make a detailed inventory of infra-red sources in space. The on-board computer, which will process about 500 million bits of measured data per day, will be supplied by us along with other electronic systems.



Solar energy is used to re-charge the storage battery aboard each of the forty survey buoys currently performing a marine study in the Indian Ocean. Continuously monitored data is automatically transmitted from each buoy every hundred minutes via the Nimbus-Six satellite. The study is being carried out by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Philips supplied the solar collector panels.

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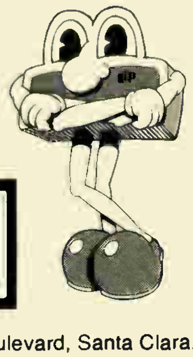

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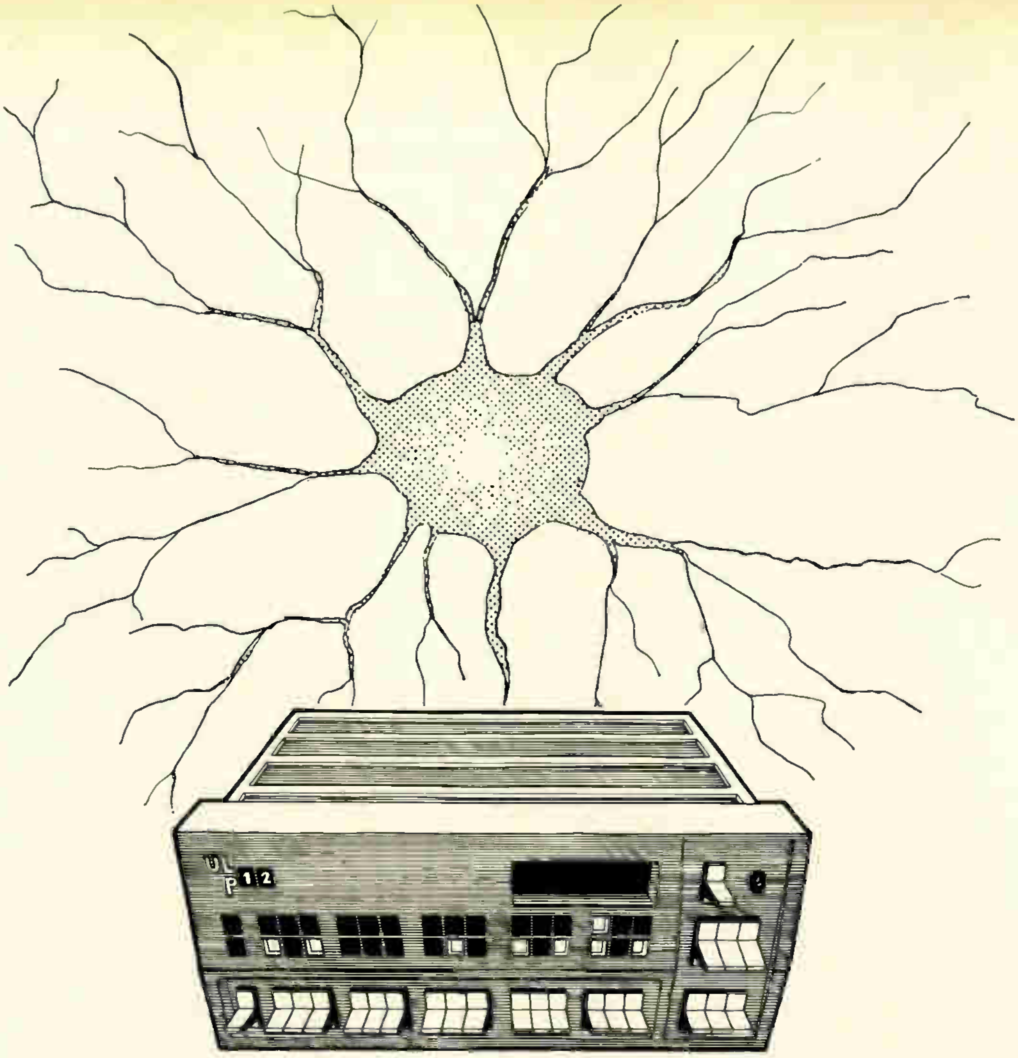

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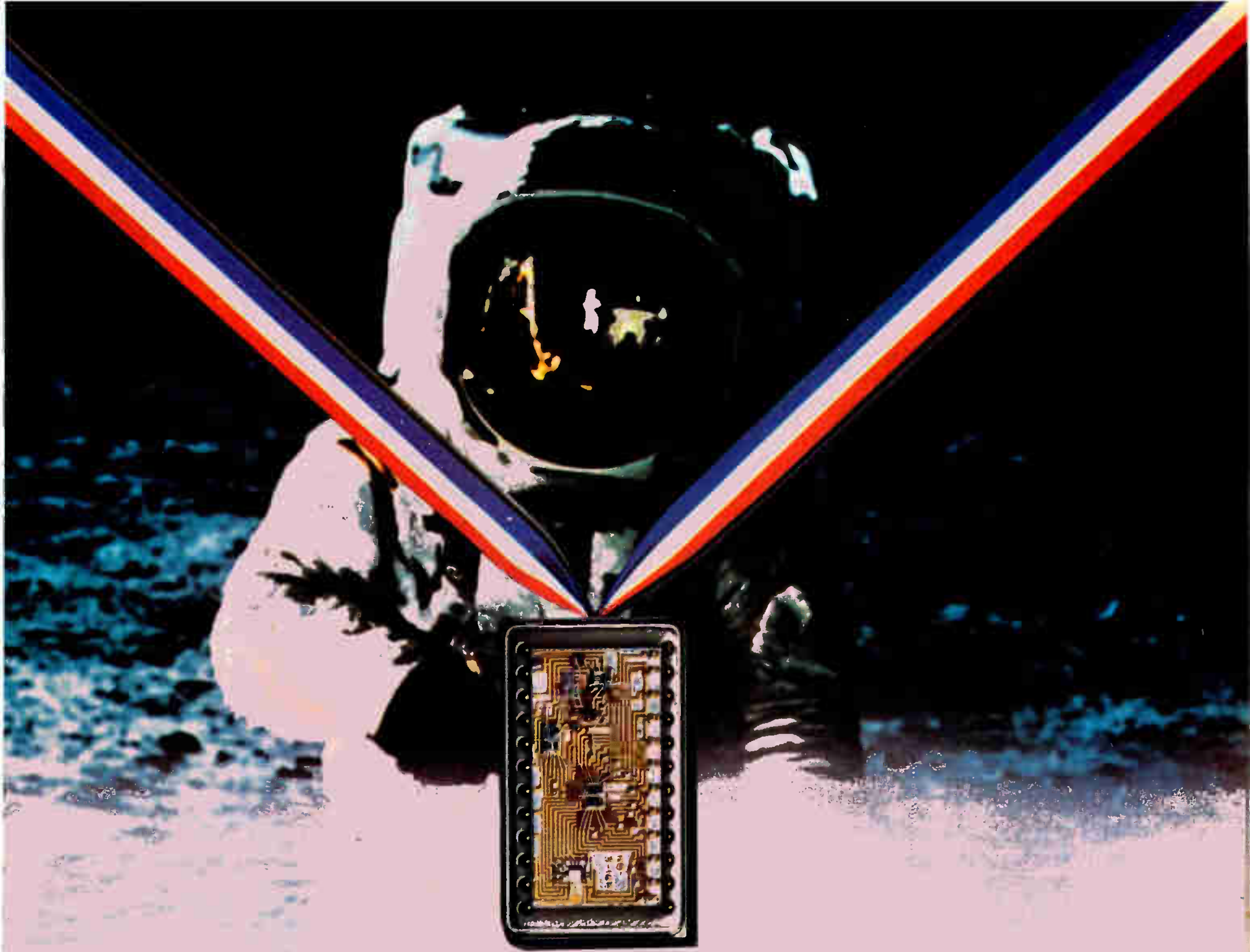

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2141-3	150	70	20
2141-4	200	55	12
2141-5	250	55	12
2141L-3	150	40	5
2141L-4	200	40	5
2141L-5	250	40	5
2147	70	160	20
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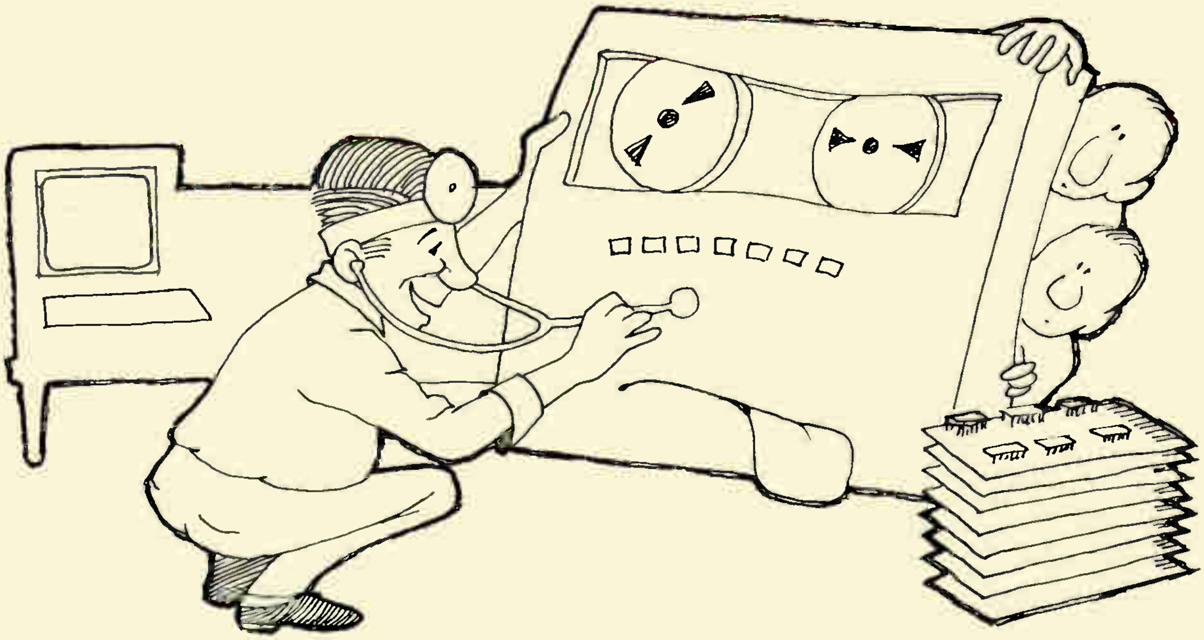


Board inventories mount

Computer makers seek the ideal field tester as way to get off the expensive merry-go-round of replace, repair, and ship

"Once it was common for us to send out a field engineer with an oscilloscope and a pocketful of chips, but that's not practical anymore. It has become necessary to go out with replacement modules, swap good boards for those we think are defective, and send the suspect boards back to the factory for repair."

That statement, made by John Fiorelli, national logistics manager for customer service at Interdata Inc., a unit of Perkin-Elmer Corp.'s Data Systems Group in Oceanport, N. J., neatly encapsulates the widespread problems of field service and replacement-board inventory that confront computer manufacturers large and small. One reliable estimate puts the costs—for reworking and board inventory—at close to $100 million for each of the major computer makers. Another estimate is that worldwide $6 billion in circuit boards is languishing at repair depots or on their way to and from those depots. But regardless of the estimate, everyone agrees that computer companies account for a large chunk of the total.

At NCR Corp. in Dayton, Ohio, Donald Phelps sees board swapping and inventory as a multimillion-dollar expense. Phelps, manager of corporate maintainability and reliability in the Research and Development division, says NCR is trying to reduce those costs by moving its testing and repair capability closer to the field. That is why it funded the development by Omnicomp Inc. of the portable service processor [*Electronics*, Feb. 16, p. 41].

Looking. Also seeking a solution is Control Data Corp. The mainframe maker now uses Mirco Systems Inc. programmable testers in nine locations and also employs chip-level testers from Testline Instruments Inc. at some facilities. "But we're looking very seriously at the Omnicomp tester and expect to make a decision within three months," says H. Ben Meeks, manager of repair and refurbishment operations. The Omnicomp approach is attractive to CDC because the tester is speedy and can handle large-scale integrated circuits, memories, and some analog circuits.

One way to control costs is to design with an eye to field testing. Burroughs Corp. of Detroit follows that route. Beginning with the Weir meter developed in England, Burroughs has spurred development of Data Test Corp.'s 1000 and Tektronix Inc.'s 851 field-service instruments. George R. Johnson, vice president and head of Burroughs' field engineering and technical support organization, says, "New system development is approached, in part, with a view toward the capabilities of those field-test instruments."

Differences. Burroughs' attitude toward replacement points up a difference in philosophies among the computer makers regarding approach and, therefore, the ideal test instrument. Burroughs has more than 1,100 field-service locations around the world employing 12,000 field engineers. The emphasis, says Johnson, is on having the field person restore the system in one visit and go on to the next user. "If he has to come back to base to replenish a board supply, that impedes the overall efficiency. That's why we are aiming at component-level repair in the field," he says.

On the other hand, Hewlett-Packard Co. believes in changing an assembly—board or box—to get the system up and running as quickly as possible. Thomas C. Lauhon, head of the 1½-year-old Computer Service division, Sunnyvale, Calif., is not in favor of establishing remote testing facilities using less costly small-scale testers much as NCR is doing with the Omnicomp instrument. "Those systems," he says, "cannot check the full scope of uses a board may be put to once it is put back in float; all they can establish is that it functions in the specific applications they are programmed to test for. We prefer to bear the expense of shipping the board back—across borders, if necessary—to a fully equipped test site where it can be tested more thoroughly." HP has two such sites outside the U. S.: one in France and the other in Japan. It also has about 200 field bases and 1,100 field engineers.

Chain. The scenario for Sperry Univac is a bit more complicated. After Sperry's field people snap out malfunctioning multiple-board assemblies, those three or four boards are sent up through a chain that starts at one of the field-service centers. The next stop is one of a half-dozen central service repair depots, and the final stop is the factory, vendor, or scrap pile. That procedure will be followed for the next year or two, says Thomas Chernetsky, manager of technical services at the division's headquarters in Blue Bell, Pa. However, system diagnostics will be beefed up so that, "as boards become more complex and more expensive, the system will be able to pinpoint a board, instead of a group of boards," he says.

Data General Corp., the Westboro, Mass., minicomputer maker, maintains 150 field locations around the world and 1,400 to 1,500 field engineers. There are a dozen main depots where, in the words of technical services director Thomas Cook, faulty boards are "renewed." Data General relies on internal diagnostics—which may be either software routines or microcode in firmware—and Tektronix or Philips oscilloscopes for on-the-spot identification of faulty boards.

Various needs. While instrument makers are working hard to advance the art of field testing, they have yet to develop the instrument that will meet the needs of all makers—a goal that could well be unattainable considering the variety of needs listed by the computer companies.

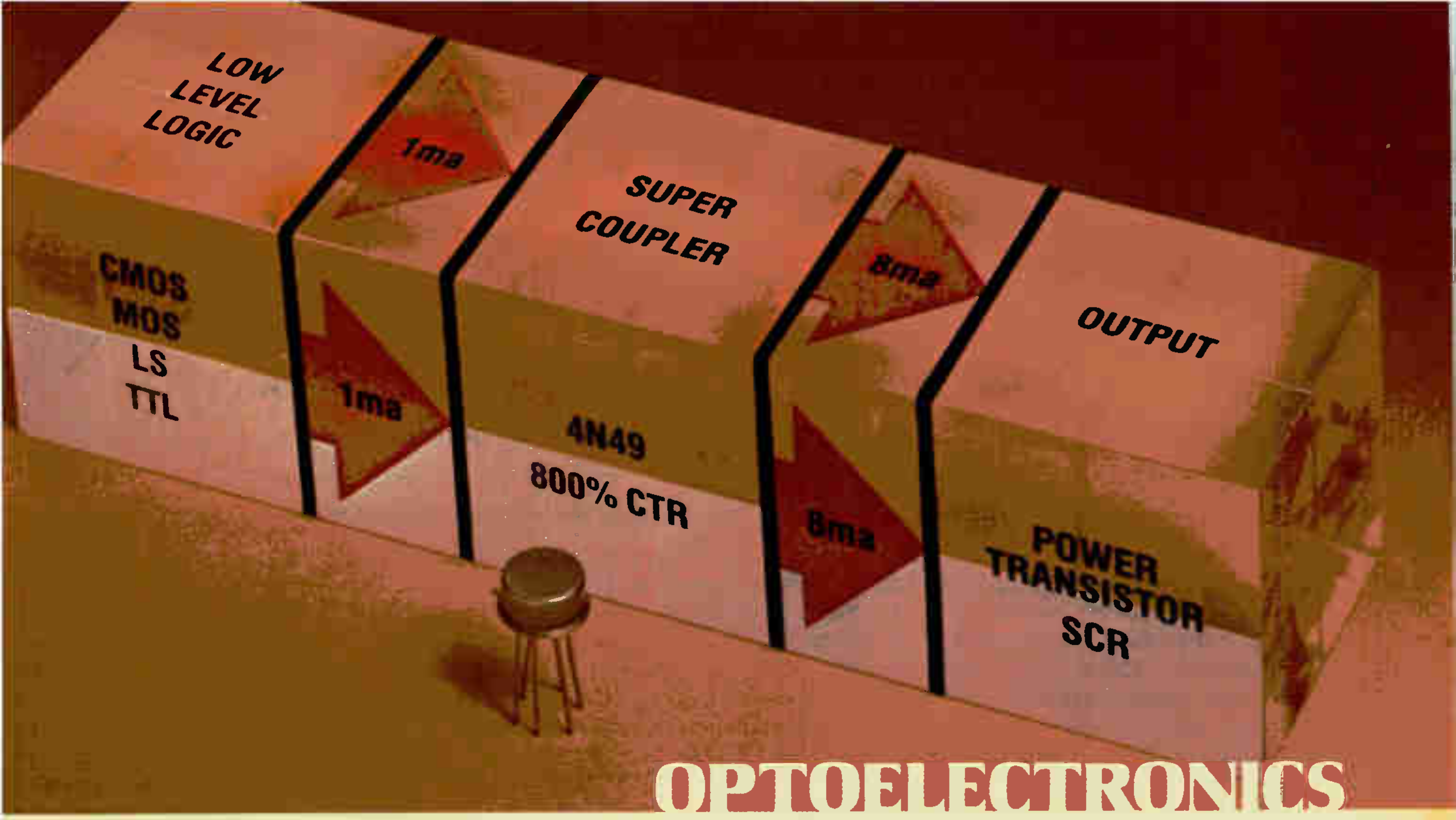
For example, while NCR backed the development of the Omnicomp tester, it still does not have the true field tester it seeks. And Control Data says it would like a more sophisticated tester to keep up with the more sophisticated boards, rather than to extend field service closer to the customer. "That's an evolution," says repair manager Meeks. "With our new generation of equipment we'll need a new generation of testers, and we've already started planning for that." So, to be sure, have the instrument makers.

Perhaps Univac's thinking about the problem sums it up. Technical services manager Chernetsky points out that his company is evaluating the Omnicomp tester, "but I don't think you can give each man one of these testers. No matter how sophisticated systems get, there are always going to be some assemblies that have to be sent to a repair center, and that's where the expensive testing and repair equipment will be." □

Makers of field testers keep pace

Instrument makers are setting out in different directions to develop and build testers designed to enable technicians to economically service computer mainframes and peripherals in the field. Although marked improvements over what was available before, none of them appears to hit the mark of being the ideal tester. Here is a partial rundown of what is available:

- Hewlett-Packard Co. of Palo Alto, Calif., offers the 5004 signature analyzer, a lightweight (5.5 pounds), $990 instrument that checks out a compatibly designed digital product by detecting bit streams at circuit nodes and displaying them as hexadecimal signatures [*Electronics*, March 3, 1977, p. 95].
- Tektronix Inc. of Beaverton, Ore., has developed the model 851 digital tester that combines a digital multimeter, a counter, and a logic-state indicator [*Electronics*, Sept. 1, 1977, p. 116]. The $1,995 instrument measures voltage, resistance, time, temperature, and logic states.
- Akin to the 851 is another multifunction instrument, the Datatester 1200 [*Electronics*, July 21, 1977, p. 31], developed by Data Test Corp. of Concord, Calif. Costing $1,200 in volume, this instrument does the job of a digital voltmeter, voltohmmeter, frequency meter, and timer, as well as of a duty cycle meter, logic probe, and integrated-circuit and logic tester. Like the others mentioned, it is a purely manual troubleshooting instrument that lacks any degree of automation.
- Perhaps the most sophisticated approach to field testing is the automated portable service processor developed by Omnicomp Inc. of Phoenix [*Electronics*, Feb. 16, 1978, p. 41]. Fully automated and using the software data base available on large production test systems, the PSP steps the technician through the troubleshooting process. However, its weight of 40 pounds and price tag of $20,000 in quantities of 10 or more will likely limit its use primarily to repair centers, rather than at customer sites.



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Military

Savings program runs into flak

A budgetary flap is slowing an Air Force project that cuts costs by infusing aging weapons systems with new technology

by Alfred Rosenblatt, Associate Editor, and Ray Connolly, W ington bureau manager

When one of its cost-savings programs turns out to be a success, the Air Force expects a pat on the back from Congress. But in the case of its Productivity, Reliability, Availability, and Maintainability program, which applies new, off-the-shelf technology to established weapons systems to reduce their running costs, the service is getting something more like a kick in the pants.

For an initial investment of $3.5 million, the two-year-old program has already chopped nearly $80 million from the Air Force's operations and support costs for a projected five-year period. Nevertheless, disapproving of PRAM's method of funding and organization, Congress slashed the program's fiscal 1978 budget to $2 million from $30 million and is unlikely to restore the cut for fiscal 1979. The service is giving up, though: it hopes to bo PRAM funding to $8 million in t. fiscal 1980 budget request that it will submit next January.

Misunderstanding. Both the Air Force managers who oversee PRAM and the Defense Department, which would like to have the concept extended to the Army and Navy, contend that Congress misunderstands the program. The military points to documented results chalked up by PRAM, which is run as a joint operation of the Systems Command's Aeronautical System division and the Air Logistics Command, both of which are at Wright-Patterson Air Force Base, Dayton, Ohio.

PRAM's team of just 33 specialists (reduced from 50) modified 93 systems for the anticipated $80 million savings. Of the 362 projects undertaken, about half involve electronics technology, with 71 avionics programs representing the largest electronics share.

Under the direction of the Wright-Patterson joint office, the projects are spread out to nine program offices at various Air Force installations. PRAM activities can range from replacing 15-year-old magnetically damped rate gyroscopes found on the F-4 fighter with more reliable fluid-damped gyros to introducing electroluminescent displays into aircraft cockpits (see "PRAM's savings account," p. 87).

"We have been shooting for a 5:1 return on investment after you take the PRAM cost and implementation cost into account," explains Col. Bill Moss Jr., program director for PRAM and 26-year Air Force veteran. George Britton, PRAM chief engineer, adds, "We find that 10% of the parts are causing 90% of the problems. Those are the parts we concentrate on."

House complaints. If the projects are paying off, why are staffers on the House Appropriations defense subcommittee down on the program? The criticisms at the heart of this budgetary flap—and the Air Force responses—are these:

- Congress suspects that PRAM money is being used to bail out incomplete development programs. But the Air Force points out that the targets of PRAM projects are older weapons systems already in their arsenal—items that need to be studied to infuse today's cost-effective technologies into their designs.
- The House has insisted that the

PRAM's savings account

A sampling of PRAM projects provides an idea of the program's range of activities. For example:

- One project replaced rate gyros in the F-4 that were magnetically damped, expensive, and prone to failure with less expensive and more reliable fluid-damped gyros from Timex Corp. [*Electronics*, April 13, p. 44]. PRAM cost for the project—$48,000; projected five-year savings—$2 million.
- Another project found an improved encapsulant for a traveling-wave tube that halved the tube's rejection-rate. PRAM cost—$200,000; projected five-year savings—$6.99 million.
- A system was instituted for erasing and recertifying 1- and 2-inch-wide video and instrumentation tapes used by intelligence-gathering agencies, instead of throwing them out. PRAM cost—$35,000; projected five-year savings—$1.14 million.
- Another study aims at replacing mechanical-movement clocks costing $225 to $250 and watches costing $118 with quartz-crystal liquid-crystal-display units costing $115 to $125 and $25 respectively. PRAM cost—$100,000; five-year savings—$1.3 million. Field tests are now going on.
- A project requiring engineering development involved equipping aircraft cockpits with electroluminescent displays that use a technique for microencapsulating individual phosphor particles to provide hermeticity. The PRAM office is making 10 sets of panels for testing in the A-10 attack aircraft.

Man from PRAM. Col. Bill Moss Jr., program director for the Air Force cost-savings, reliability, and maintainability program, says that PRAM projects work best when his office can pick opportune targets as they arise.

Air Force break out PRAM activities as line items in the budget in order to ensure funding accountability. However, Col. Moss says that, though possible, this kind of budgeting could hamper his efforts. Congress would have to approve projects before they begin as well as those that are ended.

"We look upon PRAM as an office of opportunity—one where we find the funding flexibility to look at what offers the best potential for saving dollars," he explains. "We'll attack systems with reliability and cost problems, but not everything may pay off. When we see that, we want to be able to drop it. We're after low-cost, high-payback fixes that we can do now rather than wait two years to get the money programmed for it."

■ Congressional budgeters are determined that PRAM should be funded solely from research and development funds, not with procurement, operations, and maintenance funds as well. But PRAM is not involved with R&D, retorts Defense Department Under Secretary William J. Perry. Until House appropriations cutbacks crippled the PRAM program, he says, "it went after the readiness and ownership cost problems of older systems—it did not address systems in production or early deployment."

Another DOD official bristles, "We are willing to see PRAM funded with different kinds of money. PRAM is too good a concept, with too high a return on investment, to let it slip through a crack while we decide which pocket the money should come from." Consequently, the Air Force's $8 million PRAM budget for fiscal 1980 is made up strictly from R&D funds, which it finds in short supply.

■ The House staff members' charge that really riles the Pentagon and the Air Force is that the split management of PRAM is causing internal conflicts. Top officers at two Air Force commands simply deny there is any problem at all and point out that the service itself set up the joint program in the first place. Briefly, Systems Command provides the engineering backup for the programs, while Logistics Command is closer to the operational aspects of the program and implements shortcomings and whatever fixes have to be made in the field.

Says Col. Norman Hoyt, assistant deputy chief of staff for financial management at Logistics Command, Wright-Patterson, "There is no problem between Log Command and Systems Command. PRAM has done an outstanding job."

Closing ranks. For now, the program may be limping along on a slashed budget, but it is still yielding cost savings. Chief engineer Britton has had to focus on the possibilities of repairing what have heretofore been throwaway parts, since these investigations cost little.

"What is being thrown away might be repairable," he says. "The price has gone up, but the poor guy in the field has no option because of the way the parts were coded years ago. We're looking at weapons systems to see how they are breaking and recoding them when they can be repaired at a field depot."

One example of what can be done: the Air Force is now repairing a $240 over-pressure sensor in an aircraft hydraulic system. After three or four years in the field, a plastic cap worth $1.65 had been breaking, causing the entire sensor to be thrown away. "We never expected the cap to be the problem. It involved a very simple fix," Britton observes. □

measuring synthetic textile fibers [*Electronics*, Nov. 11, 1976, p. 34]. Analog Devices owns 81% of Micro Sensors now with "limited business" to date, Stata says, adding, "There's still a question about how much we want to grow in that business." He emphasizes that "our greatest growth momentum and market potential is in data-acquisition components."

But strategy is at least as important as plant capacity in the IC business, and the word that keeps recurring in Stata's vocabulary—and the current five-year plan—is "focus." His company's focus is on industrial, scientific, and avionic instrumentation—all areas that require precision. Its product focus is on semiconductor data-acquisition components, and "our competitive focus is on becoming a very significant factor in a small slice of the business."

Familiar areas. That means concentrating the semiconductor capability in areas in which Analog is already established: precision measurement and control applications involving data acquisition, control, and computation. Converting the company's module products—high-performance operational amplifiers, data converters and computational devices——into precision ICs was the company's plan as early as 1969, and it's working.

By concentrating on the precision market Stata is convinced that Analog can avoid the withering competition from the likes of Texas Instruments Inc. or National Semiconductor Corp. if those semiconductor giants choose to enter the market for precision monolithic devices. But he thinks that the market is not large enough to attract them in a big way and that the customer base, well known by Analog, is too fragmented for them.

"There's growing evidence that strategic management is a critical factor in the semiconductor business," Stata asserts, citing Mostek Corp. in memories and Intel Corp. in microprocessors. "They've grown from small companies a few years ago to muscle out larger firms in those markets. Our objective is to be unto data-acquisition components what those companies have been to memories and microprocessors." □

Military

Updates add to P-3C capabilities

Navy continues to introduce new avionics into its $5 billion program with deliveries of latest version to start in 1980

by Ray Connolly, Washington bureau manager

With the Soviet submarine fleet already the world's largest and continuing to expand by a dozen or more boats a year, the U. S. Navy is pushing for greater tactical mobility in its antisubmarine warfare forces. A major beneficiary of this trend away from ASW systems fixed in place on ocean bottoms [*Electronics*, April 3, 1975, p. 61] is Lockheed Aircraft Co.'s P-3C Orion, the lumbering land-based, four-engine turboprop plane now being updated for the third time.

"ASW electronics contractors have done well with the P-3C," says one senior officer. "Those old Electra airframes haven't changed much in 10 years, but their black boxes certainly have." He estimates that about $5 billion has been spent on the program, including research and development, since the first Orion in 1969.

For that investment the service now has 24 squadrons of nine planes, each with a 3,000-mile range, operating from 17 bases to cover the world's oceans. It will buy another dozen P-3Cs in fiscal 1979, just as it is doing this year and did the year before, spending $333 million on the planes plus a lot more on Government-furnished electronics.

Deliveries of the P-3C Update III, which includes six additions and improvements to major electronics systems, will not begin before 1980. ASW personnel have no complaint about that, however. "We're just getting our arms around Update II," explains Lt. Cdr. C. T. "Skip" Moyer of the Tactical Support Center at the Jacksonville, Fla., Naval Air Station. Users are still taking delivery of Update II's 20 hardware changes in new aircraft while older models wait.

Missiles. One key Update II change is the Orion's capability to carry and fire six McDonnell Douglas Harpoon missiles against ships as far away as 100 kilometers, using their active radar terminals. These, the first missiles in the P-3C's weapons inventory, complement eight torpedos, six 2,000-pound mines, 10 depth charges—including two nuclear ones—plus a broad range of air-droppable sonobuoys.

The sonobuoy mix includes new command-activated types and passive systems using Difar (direction-

Sub chaser. The P-3C Update II Orion land-based subhunter incorporates a variety of new sensors, avionics, and weapons. Included are a passive infrared-detection system and the Harpoon antiship missile that enables the aircraft to attack surface targets 60 miles away.

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finding and -ranging) techniques and older, longer-range systems like Lofar (low-frequency analysis and recording) employing very high frequencies for detection at up to 80 miles. In addition, the plane carries a tail-mounted Texas Instruments Inc. ANSQ-81 magnetic-anomaly–detection set known as MAD, plus TI's APS-116 antisubmarine radar.

Increased traffic by surface ships and partially submerged subs has led to inclusion in Update II of the AAS-36 infrared-detecting set designed by Texas Instruments, one of the first to use forward-looking infrared modules. Basically, the IRDS senses heat in the 8-to-14-micrometer region from a target and converts it to an electrical signal that is processed and amplified for conversion to a video image on an 875-line vidicon. Since all targets emit IR energy, the 360° scanner in the nose radome can detect objects in spite of haze, smoke, camouflage, or darkness. However, moisture from clouds, rain, or fog will cut the range by scattering the IR energy.

New hardware that will enhance the Orion's submarine-detection ability and simplify the tasks of the plane's tactical coordinator, known as Tacco, is Cubic Corp.'s ARS-3 sonobuoy reference system. With its 10 antennas, Navy officials explain, it employs electronic phase measurements to simultaneously track up to 31 sonobuoys for processing by the Univac CP 901/ASQ-114 computer system that is also used with the IR detection set.

Problems. The computer system does pose problems for its users, some of whom note that its recording heads and tapes regularly get out of alignment and that interchangeability of tapes between systems is difficult because no two alignments are the same. The Update III will correct such problems with the installation of a new digital magnetic-tape system common to both the ASQ-114 and to a new advanced signal processor developed by IBM Corp. Called Proteus and first used in the SSN-688 attack submarine, the signal processor delights the Navy, particularly with its potential to increase by up to four times the processing ability of the AQA-7.

Another Update III addition, the Navy says, will include two more Precision Data Inc. AQH-4(V)2 wideband recorder-reproducers for both Difar and Lofar sonobuoy signals to double capacity. The new black box will have two 14-track recording heads and two more for reproduction, instead of the single-head model in Update I. □

The Canadian way with the P-3C

After the U. S., Canada is the next biggest user of the P-3C long-range antisubmarine warfare system. Australia, Norway, and other North Atlantic Treaty Organization members also employ the plane. Canadian expertise in submarine detection with what it calls the CP-140 Aurora is regarded as superior to that of the U. S. and somewhat less frustrating as well, U. S. officials say privately.

"Canada keeps its crews together for the duration of their service and on the same plane where possible," explains one, "and that is important not only to developing a team concept but also to knowing the idiosyncracies of the plane's hardware. Equipment performance varies widely from plane to plane. In the U. S., we are always transferring personnel around."

One dedicated P-3C specialist observes, "We have enough trouble getting spare parts that fit, but when a squadron undergoes a complete personnel change in one year, that is a bit much—especially if you finally get a man who learns how to operate and repair a million-dollar computer or radar in flight and then lose him to another unrelated assignment."

Although such gripes are widespread among P-3C personnel, a highly dedicated and competent group, the Navy indicates it has no plans to change its policy of giving seamen and officers as wide a range of experience as possible. It does admit to difficulty in recruiting such ratings as aviation ASW operator, of which it needs 2,400, and aviation ASW technician, of which it requires 1,000.

Medical

Communicators help the handicapped

Severely-disabled persons have new ways of forming messages, using programmable keyboard and display combinations

by Pamela Hamilton, Boston bureau

To 12-year-old Jennifer, a brain-damaged child, it opens the way to education, despite the fact that she cannot speak and has limited use of her hands. To 53-year-old Matthew, a stroke patient, it is a way of getting back in touch with the world cut off when he lost the ability to speak and move his right arm. And for 20-year-old Susan, paralyzed in an automobile accident, it is a start toward regaining a small bit of independence even though she cannot speak.

Those are not their real names, but these three, along with a growing number of other speech-disabled persons, owe their ability to form messages to the development of electronic communicators designed for those unable to do so on their own. Indeed, one of the fastest growing areas of research and development for the severely handicapped centers on this equipment.

Problems. Researchers close to the development of nonverbal communicators see valuable design advances in using microprocessors in programmable hardware that is easy for the handicapped to use. But they concede that the problems of getting this equipment to large numbers of users will not be solved easily.

First of all, no one is certain how many people would benefit from a nonverbal communicator—there is a pressing need for a demographic study to identify the "market." The best estimate is that there are between 400,000 and 1.5 million potential users. However, even if the population of potential users is identified, the cost of the equipment might be too high. Finally, rehabilitation experts, design engineers, and occupational therapists must work more closely in developing the hardware in order to provide the maximum benefit for the user.

The uncertainty that these problems create for potential hardware manufacturers is obvious. Lack of knowledge on market size and the sorts of educational or therapeutic programs with which the communicators will operate make entering the field risky.

"There has been a growth in manufacturing, but we don't know how many companies there are. A lack of funding has also been an impediment," observes Richard A.

Message center. To form a message with the Tufts Interactive Communicator a disabled person selects each letter by stopping a scanner in the correct box. Messages are printed out on a strip printer mounted on the back of the unit. Each system sells for $2,500.

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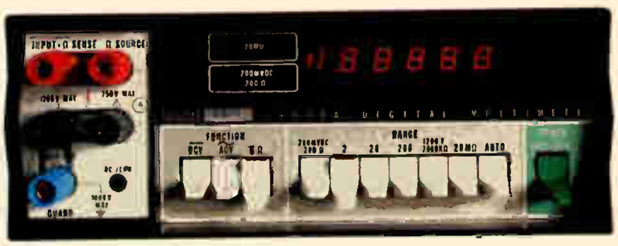

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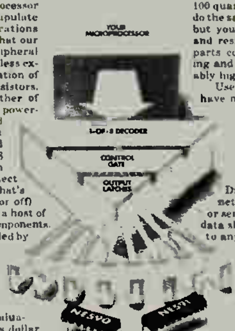

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SE538/530/5534

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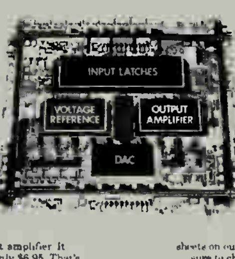

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SE5018

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(Use the individual reader service numbers to get more information.)

Model	Frequency (MHz) Direct	Prescaled	No. of Digits	Sensi-tivity	Period, T.I.A., Ratio & Totalize	Trigger Level Auto	Adjust	Fixed	Programma-bility	RF Shielding	Battery Option	L.F. Multiplier Option	Base Price (U.S. List)
9015	100		9	25mV	*	*	*		*			Standard	$2,995.00
9035	100	512	9	15mV	*	*	*		*			Standard	$3,495.00
9510	500	1250	9	25mV	*		*						$1,295.00
9514	500	1250	9	25mV	*	*	*		*				$1,995.00
9901	50		6	10mV	*			*					$ 675.00
9903	50		7	10mV	*		*				*		$ 850.00
9905	50	200	8	10mV	*			*					$ 795.00
9913		200	8	10mV				*		*		*	$ 395.00
9915	60	520	8	10mV				*		*	*	*	$ 650.00
9917	560		9	10mV				*		*		Standard	$ 895.00
9919		1100	8	10mV				*	*	*	*	*	$1,095.00
9921	560	3000	9	10mV				*	*	*		*	$1,995.00

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A guide to data-communications abbreviations

ADCCP	advanced data-communications control procedure
ANSI	American National Standards Institute
ASCII	American standard code for information interchange
Bisync	binary synchronous communications (IBM)
BOP	bit-oriented protocol
bps	bits per second (also b/s)
CCITT	International Consultative Committee for Telegraphy and Telephony
CCP	character-controlled protocol (also character-count protocol)
CRC	cyclic redundancy check
DCE	data-circuit-terminating equipment
DDCMP	digital data-communications message protocol (Digital Equipment Corp.)
DDD	Direct Distance Dialing (AT&T service)
DLC	data-link control
DLCC	data-link control chip
DMA	direct memory access
DTE	data-terminal equipment
EBCDIC	extended binary-coded-decimal interchange code
EIA	Electronic Industries Association
FCS	frame check sequence
FIFO	first-in, first-out (buffer)
HDLC	high-level data-link control
I-field	information field
ISO	International Standards Organization
LRC	longitudinal redundancy check
NCP	network control program (IBM)
NRZI	non-return to zero inverted
NSP	network services protocol (DEC)
Rx	receiver
SDLC	synchronous data-link control (IBM protocol)
SNA	systems network architecture (IBM)
Tx	transmitter
UART	universal asynchronous receiver/transmitter
Usart	universal synchronous/asynchronous receiver/transmitter
USRT	universal synchronous receiver/transmitter
VRC	vertical redundancy check

Standards

RS	recommended standard (EIA)
RS-232-C	interface standard for DTE to DCE
-422	electrical standard for interfacing balanced circuits
-423	electrical standard for interfacing unbalanced circuits
-449	mechanical standard for connector pin assignments
X3.28	character-code control standard (ANSI)
1745	basic-mode control standard (ISO)
V.35	48-kilobit/second data-transmission standard (CCITT)
X.21	general-purpose DTE-to-DCE standard for public networks (CCITT)
X.25	interface standard for packet-switched service on public networks (CCITT)

□ The marriage of data communications and large-scale integrated-circuit technology has brought power, size, and cost savings to data-communications users and designers. Programmability provides flexibility in data rates, transmission formats, protocols, and character lengths—a feature made all the more important by the proliferation of new data services and new types of equipment.

The newest breed of LSI data-communications circuit, the data-link control chip, simplifies the implementation of standard data-communications protocols and control procedures, and continues the trend of integrating system functions into programmable metal-oxide-semiconductor LSI circuits dedicated to specific tasks. In most cases these chips can interface with 8-bit microprocessors, and some will even interface directly with 16-bit microprocessors and minicomputers.

To fully appreciate the power of these new chips, and to better understand their implementation, consider their major role in a data-communications system—establishing communications protocol.

Procotols provide order

A protocol is simply a set of rules that must be obeyed to ensure an orderly information exchange between two or more parties. In data communications, a protocol defines the rules for the electrical, physical, and functional characteristics of the communications link. Such a protocol contains the control procedures required to facilitate data transfer across the link's interfaces and to and from the user's applications programs.

Because of the proliferation of different data-communications protocols adopted in recent years by various standards-making organizations—the Electronic Industries Association, the American National Standards Institute, the International Standards Organization, the International Consultative Committee for Telegraphy and Telephony, and the U.S. Government—it has become difficult to identify the control functions associated with any single one. To remedy this situation, protocols have been divided into four levels, or layers (ANSI has chosen five), that define various functions and logic operations. Each level is designed to be functionally independent of the others, but each depends on the correct operation of the previous level to operate.

These levels, summarized in Table 1, form a hierarchy of protocols:

Level I contains the physical, electrical, and functional interchange used to establish, maintain, and disconnect the physical link between the data-terminal equipment (DTE) and data-circuit-terminating equipment (DCE) or between two DTEs.

Level II, the data-link-control level (Fig. 1), contains the functions to transfer data reliably over a single communications link. It provides control between two physical nodes in a network.

Level III, the communications-control level, defines the formatting and control procedures for end-to-end connections in a network (more than one data link). These procedures include message routing through the

TABLE 1: THE HIERARCHY OF PROTOCOLS		
Level	Function	Examples
I	physical link	electrical: RS 232 C, RS 422, RS 423, CCITT V.35 functional and mechanical: RS 232 C, RS 449, CCITT X.21[1]
II	data-link control	character-controlled: IBM Bisync, ANSI X3.28, ISO 1745 character-count: DEC DDCMP bit-oriented: IBM SDLC, ANSI ADCCP, ISO HDLC
III	path control	packet switching: CCITT X.25[2] front-end communications: IBM NCP, DEC NSP code-independent headings: ANSI X3-281
IV	system and user control	IBM SNA, UNIVAC DCA, NCA DNA, DEC DECNET, COMTEN CNS

[1] X.21 also encompasses levels II and III. It is a general-purpose interface for synchronous transmission on public data networks and has been implemented in the Nordic countries and Japan. IBM is evaluating X.21 and ANSI is considering it for adoption as American National Standard BSR X3.69.

[2] X.25 specifies X.21 level 1, HDLC level 2, and its packet-switching procedures for level 3.

network, flow control, and accountability from the originating node to the destination (target) node.

Level IV establishes the system control to identify the characteristics of the information being transferred—such as character code, character or data format of the information field, or peripheral-device control—and to coordinate the transfer of data between the user's applications programs and the operating system.

Bit-oriented protocols evolving slowly

With communications and software costs consuming an ever-growing portion of a data-communications system, the need for an efficient, reliable, and easy-to-implement level II procedure takes on increased importance. Having recognized this fact, ANSI, the ISO, and the U. S. Government have adopted a DLC protocol based on a bit-oriented concept called advanced data-communications control procedure, or ADCCP.

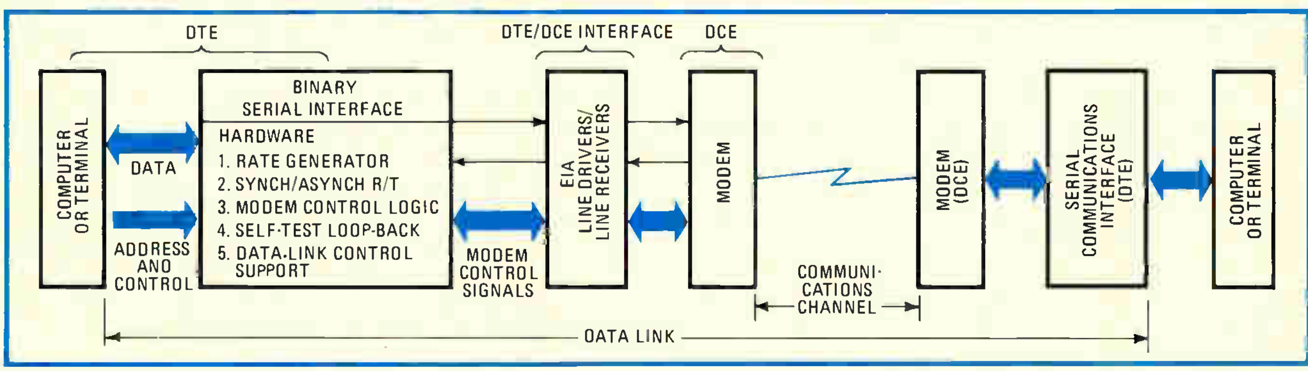
In a bit-oriented protocol such as ADCCP or the ISO's high-level data-link control (HDLC), messages are transmitted in frames, and all messages adhere to one frame format. Before the emergence of this type, character-controlled and character-count protocols were used in data communications. In these protocols, a header field specifies various control parameters and an information field contains communications control characters. The result is that data-link control procedures are sensitive to the information code set, and much software is required to interpret the control characters and character sequences or to maintain character counts.

Despite being more straightforward, bit-oriented protocols will not replace character-controlled ones overnight. Much hardware is in place today supporting the older protocols—particularly IBM Corp.'s character-controlled version, called binary synchronous communications, or Bisync.

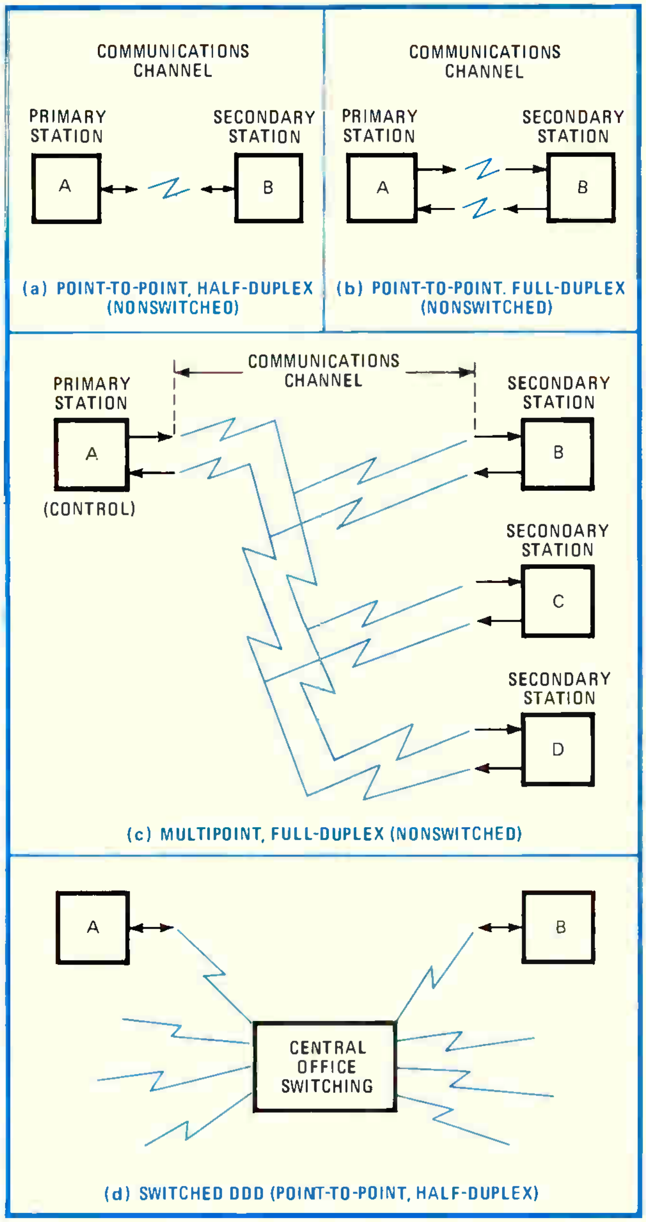
The implementation of a data-link control depends in part on the type of link configuration employed in the data-communications network. The link can be either balanced or unbalanced; physically, it can be point-to-point, multipoint, or switched (Fig. 2).

In the balanced link, there are two stations on a point-to-point link (leased-line or switched) with identical data-transfer and link-control responsibilities. Either party may initiate a transmission at the first opportunity. In half-duplex, two-wire operation, that opportunity occurs when the link is idle for a specified period of time. In full-duplex, four-wire operation, transmission may be initiated at any time.

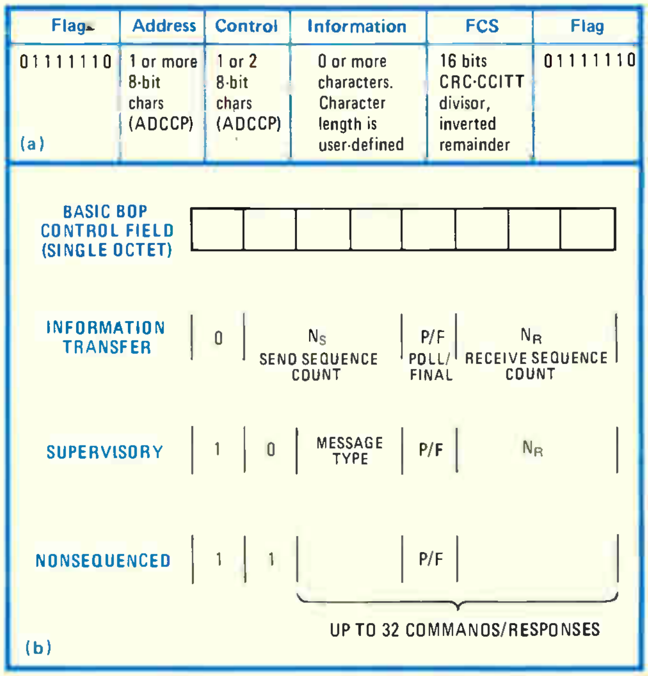
In the unbalanced link, one control (primary) station selects tributary (secondary) stations to receive and solicits transmission by polling each tributary. The secondary station must search for its address while receiving and supply its address when transmitting. However, looking for a secondary address can be a tremendous burden for a secondary station on a multipoint link: if the message format is not explicit, the secondary station software must continually monitor the line searching for its address, which is imbedded in the message header. An asynchronous response mode on an unbalanced link permits the secondary station to initiate a message (to the station it selects via its address field) without having obtained explicit permission from the primary station.



1. Linkage. Modems, serial communications interface, and communications channel are all part of basic data-communications link. Data-link controls are needed only for the link, not for the computer or its peripherals. The modem can also be a data-service unit for Dataphone digital service, a line driver and line receiver (modem eliminator), or an interface with a satellite or microwave channel.



2. Link configurations. The nature of the communications options dictates the choice of a DLC. On a point-to-point data link (a), communication takes place between two stations only. Information flows in one direction (half-duplex). Permanent lines can be leased for two-way (full-duplex) communications on a point-to-point link (b). In a multipoint configuration (c), one station is designated as the primary and the remaining stations act as tributaries or secondaries. The public telephone network is used in Direct Distance Dialed (DDD) service. Here half-duplex communication is centrally switched for a point-to-point conversation (d).



3. Frame format. With a BOP, only one frame format (a) is necessary. Each station attached to the link searches for the flag sequence and for an address sequence. For multipoint links, each station must detect a flag immediately followed by its address to activate the receiver. The heart of the BOP message is the control field (b). It determines message type and send/receive sequence counts.

The data-link control protocol is actually responsible for five individual functions. The first is framing of the message block—that is, locating the start and finish of a message by identifying groups of bits that act as message delimiters. Once framed, the message blocks require link management. This function controls transmission and reception on the link by, among other things, directing transmission, deciding who may transmit, identifying sender and receiver, and establishing and terminating a logical link connection between two stations.

Data-transfer and message integrity, the third DLC function, means transferring data sequentially and without error over the link. For better line utilization, a synchronous transmission format is almost always used. Errors are detected by parity checks (vertical and horizontal) or cyclic redundancy checks, the latter being capable of burst (multiple) bit-error detection, a common error of communications channels.

Requests for retransmission

When errors are detected, a request-for-retransmission scheme is used. This scheme may be of the stop-and-wait variety, in which a positive or negative acknowledgment is required after each message is sent, or a continuous "go back N" type, in which frames remain unacknowledged until a response is requested.

In "go back N," separate send and receive frame counts are maintained by the transmitter and the receiver, respectively. When an acknowledgment is requested, the receiver sends back its frame count, which is compared with the transmitter's frame count. If the counts are not equal, the difference N represents the number of frames that must be retransmitted. (A variation of "go back N" is the selected reject supervisory command in ADCCP—see "ADCCP vs SDLC," p. 109.) In addition to detection and requests for retransmission, time-outs are used to identify stations on a link that have not responded within a prescribed period. In that case, either the link or the station is down.

It is often necessary to transmit binary data, floating-point numbers, packed binary-coded-decimal data,

TABLE 2: COMPARING DLCs

FEATURE	BISYNC	DDCMP	SDLC	ADCCP
Full duplex	no	yes	yes	yes
Half duplex Message-formatted Link control	yes variable[1] control character, character sequences, optional header	yes fixed header (fixed)	yes fixed control field (8 bits)	yes fixed control field (8/16 bits)
Station addressing	header	header	address field (8 bits)	address field (8 bits to 00)
Error checking	information field only	header, information field	entire frame	entire frame
Error detection	VRC/LRC-8 VRC/CRC-16 CRC-16 CRC-12	CRC-16	CRC-CCITT	CRC-CCITT
Request for retransmission	stop and wait	go back N	go back N	go back N, selected reject
Maximum frames outstanding	1	255	7	127
Framing—start —end	2 SYNs terminating characters	2 SYNs count	flag flag	flag flag
Gaps between characters allowed	yes	no	no	no
Information transparency	transparent mode	inherent (count)	inherent (zero insertion/deletion)	inherent (zero insertion/deletion)
Control characters	numerous	SOH, DLE, ENQ	none	none
Character codes	ASCII EBCDIC Transcode	ASCII (control Character only)	any	any
Information field length	n X L	n X 8	n X 8	unrestricted
Bootstrapping capability	no	yes	yes	yes

Note: n = number of characters; L = character length = 6, 7, or 8 bits.
[1] Depends on physical link configuration and type of message (information, control, or acknowledgment).

unique specialized codes, or machine-language computer programs. In order to do so, all data, including the normally restricted data-link control characters, are treated only as specific bit patterns. But consequently, a way is needed to distinguish between the pure data and the control characters of the information code sets. This, the fourth function of data-link control, is called information transparency.

Finally, a data-link control procedure should be capable of bootstrapping. Secondary stations on an unbalanced link may not be able to configure themselves for data-communications operations. Bootstrapping provides a means for the primary station to set the initial states and control modes of all such secondary stations on an unbalanced link. It is done in a transient state, when no other communications are permitted.

BOPs increase efficiency

As noted earlier, bit-oriented protocols are straightforward when compared with the older character-controlled types. Their advantages include efficiency, reliability, and easy implementation in software. And with LSI data-link control chips, hardware implementation, too, is simpler. Using a bit-oriented protocol, data is transmitted bit by bit in synchronous format on either a half- or a full-duplex facility. BOPs can be employed on point-to-point, multipoint, or dial-up links. (In one case, IBM's SDLC, a loop-mode configuration is also possible.)

One frame format (Fig. 3a) is used for all messages and link configurations, as opposed to the numerous message formats needed for character-controlled protocols, and the control field (Fig. 3b) specifies only three message types—information transfer, supervisory control, and nonsequenced commands and responses. Positional significance is used in place of control characters to define the various fields of a frame. The defined fields are address (A), control (C), information (I), and frame check sequence (FCS). The information field length is variable and may be zero.

Besides the defined fields, only three bit sequences in a bit-oriented protocol have meaning: 01111110 equals a flag, which delimits the start and end of each frame. The closing flag of one frame may be the beginning flag of the next frame. Seven to 14 1s equals an abort, which prematurely terminates a frame when there is a problem at the transmitting station (a frame check sequence does not follow an abort). Fifteen or more 1s equals an idle, which identifies a link idle state in half-duplex operation.

ADCCP vs SDLC

Among standard bit-oriented protocols available today are the American National Standards Institute's ADCCP (advanced data-communications control procedure) and its identical International Standards Organization counterpart, HDLC (high-level data link control). IBM Corp., on the other hand, is supplying its own bit-oriented protocol, known as SDLC (synchronous data-link control). Although both ADCCP and SDLC employ the same basic format, special bit patterns (abort, flag, idle), zero insertion and deletion, and error checking, there are still significant differences between the two:

- ADCCP supports a balanced link configuration and normal and asynchronous response mode in an unbalanced link, whereas SDLC retains the concept of centralized control by supporting only the normal response mode on an unbalanced link.
- ADCCP permits recursive expansion of the address field (any number of octets greater than one) and an extended control field. The address field can be a single address, a global address, or a group of addresses. When the first bit of an address is 0, the following octet is an extension of the address field. The control field can be two octets. This increases the send (Ns) and receive (Nr) sequence counts to allow up to 127 outstanding frames—an advantage when using satellite links, where there are long delays.

In SDLC, the address and control fields are each one octet. The address field is the address of a secondary station or a global address. The control field permits up to seven outstanding frames.

- ADCCP provides a selected reject supervisory command that requests retransmission of single information frame, N_R. Information frames up to and including $N_R - 1$ are acknowledged. SDLC does not have this command.
- The greatest difference in the two is the number and type of nonsequenced control commands and responses. ADCCP has 12 commands, 7 responses defined with 4 additional commands, and 4 additional responses that are user-defined. SDLC encompasses 7 commands and 7 responses. Some of the commands and responses are different, and some are the same but with different names.
- The information field length must be a multiple of 8 bits in SDLC. In ADCCP its length is unrestricted.
- IBM has a loop-mode SDLC configuration for its 3650 retail-store system. This mode requires a 1-bit delay between receiver input and transmitter output for all stations on the loop. There is no provision for loop mode in ADCCP.
- IBM includes SDLC in its software for its level IV system network architecture, whereas the ADCCP user must define and implement his own level IV software.

A secondary station can use the asynchronous response mode to effect a line turnaround once the idle state has been detected.

Information code transparency in a bit-oriented protocol is achieved by a technique known as zero insertion and deletion, or bit stuffing and removal. Following opening flag transmission, a 0 is inserted whenever five successive 1s have been transmitted. The receiver, too, counts the number of 1s. When there are five, the sixth bit is deleted if it is a 0. In this way it is impossible for any bit sequence in a frame to be misinterpreted as a flag, an abort, or an idle. Character-controlled DLCs, on the other hand, require a more complex transparent mode of operation. This mode is initiated and terminated by specific sequences of characters, and to do this requires considerably more software.

Error checking in a bit-oriented protocol is on the entire frame (between opening and closing flags) using CCITT's CRC polynomial, $x^{16}+x^{12}+x^{5}+1$, as a divisor with the dividend preset to 16 1s and the inverted remainder transmitted as the frame check sequence. The 0s inserted to maintain transparency are not included in the FCS calculation. An error-free frame will yield the hexadecimal constant FOB 8 as the CRC remainder. In contrast, character-controlled DLCs only error-check the information field and do not check control messages or acknowledgments.

Full-duplex operation is facilitated by acknowledging a group of frames rather than each individual frame. Such acknowledgment will reduce line turnarounds in half-duplex operation. Also, with the "go back N" request-for-retransmission technique, frames can be outstanding (unacknowledged, unreceived, or being received) during transmission.

The number and type of commands and responses in bit-oriented protocols are modular, and the specific combination may be configured to best suit a given application. In fact, many include user-defined commands and responses in the nonsequenced control field.

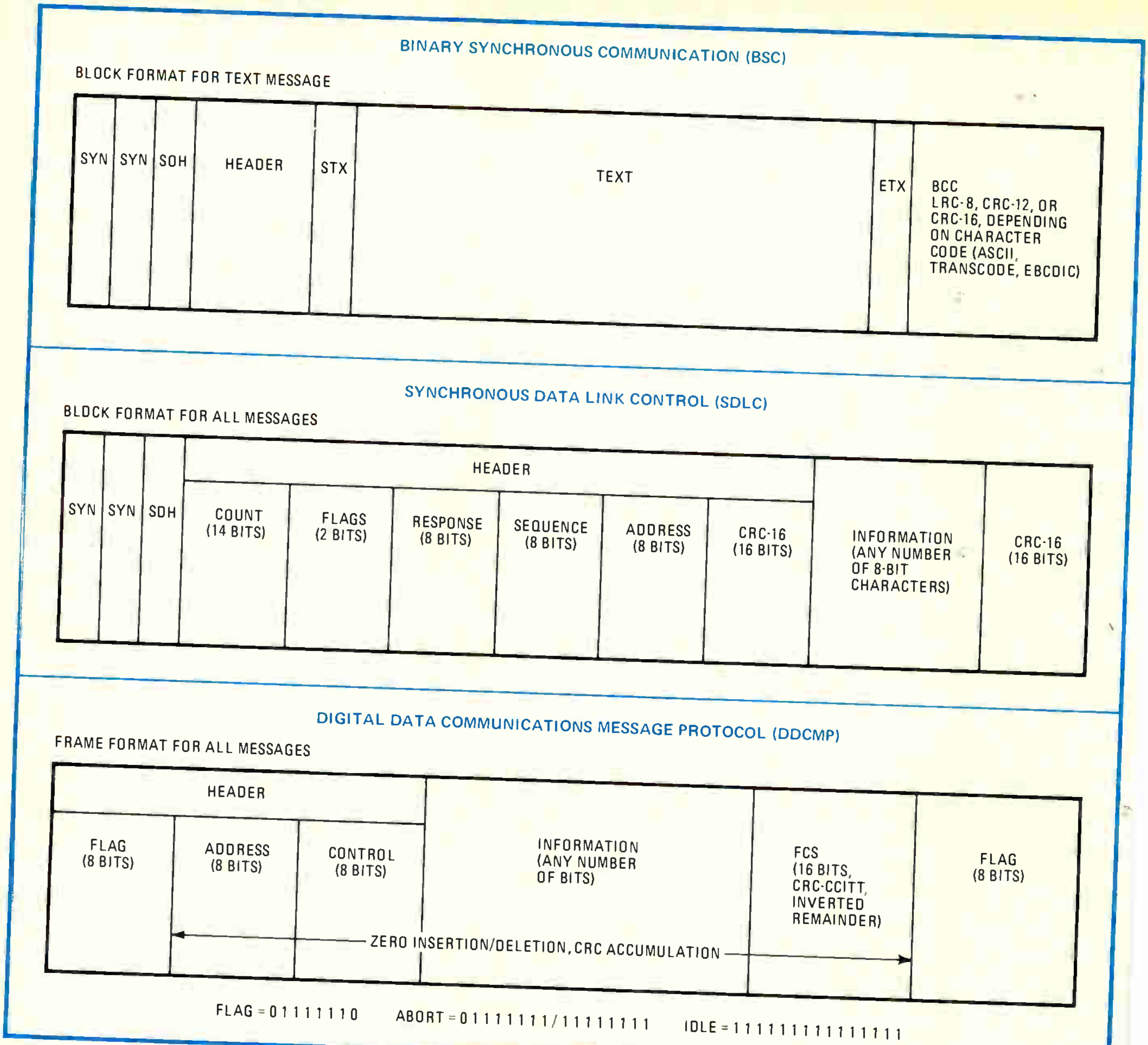
Table 2 compares ADCCP and IBM's SDLC with the same company's character-controlled Bisync and Digital Equipment Corp.'s character-count protocol, called digital data-communications message protocol, or DDCMP. Figure 4 shows the message blocks for the last three.

Reducing hardware needs

The data-link control chip is not the first LSI device to have a strong impact on data communications. It is in fact only the latest in a line beginning with the universal asynchronous receiver/transmitter (see Table 3). The basic task of all these LSI circuits is to assemble 5- to 8-bit characters from a received binary serial-data stream (receive) and to serialize characters into a transmitted sequence of binary pulses (transmit).

Many of the LSI data-communications circuits introduced in the past two years are bus-oriented: data, command, and status information are contained on a single 8- or 16-bit data bus for easy interfacing with microprocessors and minicomputers. Also, many operate from a single 5-volt power supply.

Besides the obvious physical advantages of their LSI makeup, these circuits also incorporate numerous functions that reduce a data-communications system's overall hardware requirement. Modem control is one such function. It is accomplished by controlling interchange signals between the binary serial interface (the data-terminal equipment) and the modem (data-circuit-terminating equipment). These signals may include request to



4. Block comparisons. The three different protocol schemes generate three different block formats. IBM's Bisync uses a character-controlled arrangement; DEC's DDCMP relies on a character-count procedure; and IBM's SDLC employs a bit-oriented protocol.

send, clear to send, carrier detect, data terminal ready, data set ready, and ring. The first three are necessary for half-duplex operation or controlled carrier multipoint environments (only one data conversion allowed on the line at a time), the last three for automatic answer on a dial-up telephone network or call establishment and disconnection. When not used as modem controls, the associated pins are available for general-purpose inputs or outputs if they are not coupled into the transmitter or receiver enabling logic.

Loop-back mode—a self-test capability—isolates defective equipment on the link, pinpointing communications problems or malfunctions. Many LSI circuits use this mode in conjunction with analog and digital modem loop-backs. Local loop-back internally loops the transmitted data and transmit clock back onto the receiver data and receiver clock, respectively. Remote loop-back does the reverse. In either case, the program at the source compares the received characters with the characters it has transmitted to verify correct operation of the link.

Perhaps the most important function of these circuits is data-link control support. Some support only one type of DLC, whereas others are multiprotocol and thus can handle several types (see "Why multiprotocol chips?" p. 111). The DLC chip supports at least one bit-oriented procedure and includes CRC generation and checking for simultaneous (full-duplex) transmission and reception. LSI circuits also relieve a central processing unit of high-speed interface tasks. Direct-memory-access control signals and internal first-in, first-out buffers are included in some devices, which may have data rates up to 2 megabits per second.

For LSI circuits supporting a bit-oriented protocol, a coding technique known as NRZI (non-return to zero inverted) can be used to effectively reduce cabling costs for limited-distance communications without modems. (Line driver and receiver ICs that meet the RS-422 specification can transfer serial data at speeds up to 100,000 bits per second at 4,000 feet. Packaged line drivers and receivers can extend this distance to a few miles.) NRZI coding inverts the line state whenever a binary 0 is encountered in the data stream. With line transitions guaranteed within the time it takes to transfer 6 bits, it becomes possible to recover the received clock from the received serial data. One DLC chip (the Intel 8273) does the clock recovery using a phase-locked loop. In any event, NRZI plus clock recovery logic eliminates the clock wire from source to destination.

Two LSI chips (the Signetics 2651 and National Semiconductor's NSC 8250) contain logic to generate receive and transmit clocks. This function is not needed when using synchronous modems, which supply both clocks.

The DLC chip unmasked

Because of the hardware requirements of zero insertion and deletion, of flag, abort, and idle generation and recognition, and of full-duplex CRC generation and detection, the DLC chip is extremely complex. Just to determine the closing flag and to error-check the received frame clock sequence requires a 33-bit receiver shift register, an 8-bit flag comparator, and a 16-bit FCS accumulator and comparator.

Table 4 examines the available and announced DLC chips. To interpret it, however, some understanding of the operation of bit-oriented types is needed.

The automatic extended address and extended control fields switch the character length (receiver or transmitter) from 8 bits to the length required by the information field. If the information field character length is 8 bits, nothing is done; if the length is less than 8 bits, the chip switches to the information field length just before transmitting or receiving the first information field character. Software or firmware is capable of doing this with little effort, considering that it has to interpret the extended address and control fields. (The chip's secondary

TABLE 3: LSI's ROLE IN DATA COMMUNICATIONS

LSI Circuit	Characteristics
UART	appends and deletes start/stop bits; generates and detects parity, line break; detects overrun, underrun, framing error. Receive clock frequency = 16X or 64X bit rate. Each character is resynchronized with respect to the start bit. Examples: WD1602, Moto 6850, NSC 8250, Harris 6402/3
USRT	transmit and receive a contiguous bit stream with the receive clock (1X) locked onto the received data. Character synchronization achieved by "hunting" for one or two SYN characters. SYN characters are inserted during gaps in transmission (underruns). Examples: GI, AMI 2350, Moto 6852, SMC Com 2601, NEC μPD379
USART	capable of synchronous or asynchronous operation. Microprocessor writes a configuration word or words to internal mode register(s). Modem controls. Examples: Intel 8251, Signetics 2651, WD ASTRO – 1671
DLCC	synchronous receiver/transmitter with hardware support of bit-oriented and possibly other DLCs. High-speed operation (microprocessor to 2M bits per second maximum), full duplex CRC generator/checker, zero insertion and deletion, flag and abort generation/detection, 8- or 16-bit data bus. Example: see table 4

Why multiprotocol chips?

Several data-link control chips support more than one data-link control procedure. These chips ease the problem posed by the increasing number of data-communications systems that must support both character-controlled and bit-oriented protocols within the same equipment.

In a multiline controller, each line protocol may be different. A multiplexer or data concentrator, for instance, might service character-controlled protocols on its low-speed terminal side and bit-oriented ones on its high-speed backbone link.

Protocol conversion is done in software or firmware. Many IBM computers and front-end processors support that company's Bisync and synchronous data-link control protocols. Using the same chip for different DLCs simplifies system design and capitalizes on the advantages of large-scale integration. Even if distinct DLCs are defined for given products, the diversified data-communications manufacturer or user can buy the same part and take advantage of volume purchasing, single-part qualification, incoming inspection, and inventory.

The multiprotocol DLC chip effectively prevents hardware obsolescence. When a new DLC procedure must be supported, the same printed-circuit board can be used if the DLC chip is reprogrammed. This advantage is analogous to that realized by using a programmable processor in place of hardwired logic.

As a good example, take the case of the changing DLC requirements in Telenet Communications Corp.'s level II implementation of CCITT recommendation X.25. This packet-switching protocol consists of three levels, with HDLC (now identical to ADCCP) specified for level II. Telenet, a packet-switched specialized common carrier, now embeds HDLC-formatted frames in Bisync transparent-mode messages. Later this year, it plans to support HDLC directly. It then must provide Bisync and HDLC hardware to customers using their packet-switched network. With a multiprotocol chip, this hardware could be the same.

There is one data-link control, CCITT X.21, that requires a character-controlled protocol for call establishment and a bit-oriented protocol for data transfer. X.21 has gained popularity because of its single five-pin DTE-to-DCE interface for level I. Its level II implementation can be facilitated by a multiprotocl DLC chip.

TABLE 4: AVAILABLE DLCCs COMPARED							
Feature	Signetics 2652	SMC 5025	Zilog SIO	Fairchild 3846	Motorola 6854	Intel 8273	Western Digital 1933
Maximum date rate (b/s)	1M/2M	500K	550K/880K	1M	660K/1M	64K	1M
Package pins	40	40	40	40	28	40	40
Data bus pins	8 or 16	8 or 16	8	8 or 16	8	8	8
Modem control/general-purpose I/O pins	none	none	4 per channel	6	4	10	6
Character length (bits)	1 – 8	1 – 8	5 – 8[1]	5 – 8[4]	5 – 8	8	5 – 8
System clock required	no	no	yes	no	yes	no	no
Separate receiver and transmitter interrupts	yes	yes	no	yes	no	yes	no
Receiver FIFO buffers	none	none	2	none	2	none	none
Transmitter FIFO buffers	none	none	none	none	2	none	none
Loop-back self-test mode	yes	yes	no	yes	no	yes	yes
Multiprotocol (Bisync, DDCMP)	yes	yes	yes[2]	yes	no	no	no
Bisync CRC handling	external	external	start/stop CRC-16	yes	n.a.	n.a.	n.
Secondary address comparison	yes	yes	yes	yes	no	yes	yes
Global address recognition	yes	no	yes	yes	no	yes	yes
Automatic extended address, extended control	no	receiver	no	yes[3]	yes	no	yes
Residual character handling	yes	yes	yes	yes	no	receiver	yes
Underrun line fill (BOP)	abort/flag	abort/flag	FCS-flag	abort/flag	abort	abort/flag	abort/flag
NRZI coding	no	no	no	yes	yes	yes	yes
Digital phase-locked loop	no	no	no	no	no	yes	yes
Short-frame rejection	yes	yes	no	no	yes	yes	no

1. 8-bit SYN character restricts character length to 8 bits in synchronous mode.
2. Supports asynchronous; 2 full-duplex channels.
3. Single address octet must have bit D = 1.
4. Transmit character length may be 1 to 8 bits.
n.a. = not applicable

address-compare is disabled during extended-address-field reception.)

The global address is a field of eight 1s (with 0s appropriately inserted or deleted) that is detected by those DLC chips selected to be secondary stations. Recognition of the global or programmed secondary station address activates the DLC chip's serial receive-data path to the data bus. This hardware address comparison is a valuable feature. Without it, the software for a secondary station on a multipoint link must monitor every message transmitted in order to search for its address.

Residual character handling is necessary when the last information field character length does not match the programmed character length. This is possible in ADCCP when a pure bit-stream information field is transmitted. In SDLC, when the information field length is not a multiple of 8 bits, a residual character must be transmitted to guarantee that the field is, in fact, a multiple of 8 bits. In either ADCCP or SDLC, the transmitter character length can be out of step with that of the receiver, a situation that may exist in multiplexer or data-concentrator applications. The DLC chip should be able to handle all these situations by transmitting and receiving a last data (residual) character of 1 to 8 bits.

When the controller cannot service the DLC chip's transmitter within the time it takes to transfer one character, the transmitted protocol frame must be aborted. The line fill performed by the DLC chip's bit-oriented protocol should be eight consecutive binary 1s. This abort bit pattern may be followed by an idle or by flags to retain link continuity. Some DLC chips can also line-fill with aborts or abort-and-flags.

Short-frame rejection prevents a received frame of less than 32 bits from being accepted. (Recall that a minimum frame consists of an 8-bit address, an 8-bit control, and a 16-bit frame clock sequence.) To accomplish it, DLC chips may ignore the short frame, automatically send and detect an abort, or activate an invalid frame interrupt.

The DLC chip, like all LSI serial receiver-transmitters, has two independent interfaces: one to the communications line and the other to the bidirectional data bus (see the left side of Fig. 1). Line driver and receiver ICs meeting RS-232-C, RS-422, or RS-423 electrical specifications are needed for each signal to and from the communications line interface. The bus interface is to a CPU for mode initialization, command generation, and status checking, and to a CPU, external FIFO, or DMA controller for character transfers.

Character transfers can be on an interrupt basis to a microprocessor if serial data rates are 4,800 bits per second or less. Faster speeds require DMA, FIFO, or microprogram polling using medium- or large-scale integrated bipolar processors. At 2 megabits per second, the fastest data rate of any DLC chip, 8-bit characters must be loaded and retrieved within 4 microseconds. Such high-speed applications are becoming more common in computer-to-computer links, master-controller–slave-peripheral interfaces, and high-volume communications utilizing AT&T's Dataphone digital service. □

How the bi-FET process benefits linear circuits

Op amps that combine bipolar and field-effect transistors on the same chip outperform purely bipolar chips at little extra cost

by Rod Russell and Tom Frederiksen, *National Semiconductor Corp., Santa Clara, Calif.*

☐ The new kid on the block in linear technology is the bi-FET process. Monolithic operational amplifiers built with this mixed process provide broader bandwidth, faster slewing, and higher input impedance than do standard bipolar devices, yet they are selling at only a slight cost premium.

Bi-FET is an appropriate acronym for these linear circuits, which combine bipolar transistors with junction field-effect transistors on one and the same silicon chip. A number of semiconductor manufacturers are already producing bi-FET integrated circuits in standard linear configurations besides op amps: analog switches, instrumentation amps, and even sample-and-hold circuits.

Emerging only a few years ago, bi-FET technology today accounts for about 5% of the total linear IC business. Moreover, the industrial market for linears is expected to double by 1980 and most of this increase should be in bi-FET products. Thus major semiconductor manufacturers are getting on the bandwagon and are turning their attention to innovations in this area.

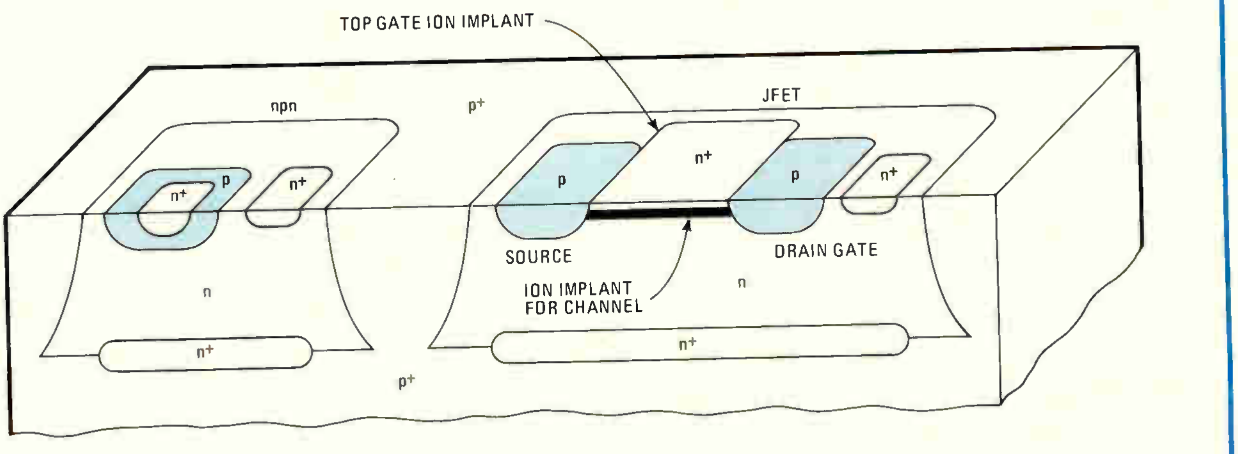
Bi-FET vs bipolar

Ion implantation makes the difference between bi-FET and standard bipolar linear processing. In the mixed-process devices (Fig. 1), one ion implant produces the p channel between the source and drain contacts, which are standard bipolar p-type gate base diffusions. A second implant produces the n-type gate region overlying this channel. The pinch-off voltage of a junction FET is roughly proportional to the total amount of dopant there is in the channel.

With diffusion processes, pinch-off voltage is very hard to control, and matching these voltages in two JFETs is nearly impossible. But implanting the channel virtually permits counting the number of dopant ions for a predictable channel Q, so that control over absolute pinch-off voltage and JFET matching are easily achieved. Besides minimum pinch-off voltage, low-concentration channel implants provide high JFET breakdown voltages.

In many linear circuits, the very low dc input bias current the JFET offers is, by itself, a tremendous advantage over strictly bipolar devices. Another benefit of these transistors—an even more important one in some applications—is the roughly order-of-magnitude improvement in frequency response.

Moreover, in op-amp circuits, slew rate may be improved by a factor of 20, even with no increase in bandwidth. The slew rate of a standard monolithic frequency-compensated op amp is proportional to the ratio of the quiescent bias current to the transconduc-



1. Basic structure. Because of ion implantation, bi-FET circuits can combine high-performance bipolar transistors with high-performance matched JFETs. One implant creates the p channel between source and drain contacts, another the gate region over this channel.

Mixed-process linears: a perspective

Since the first practical devices appeared some three years ago, mixed-process linears have steadily gained ground on their all-bipolar counterparts. These bi-FET and bi-MOS chips are clearly here to stay. About a dozen semiconductor manufacturers are now using the mixed technology for a variety of standard linear circuit functions, and the list is growing. Besides numerous operational amplifiers, the circuit functions include analog multiplexers, comparators, sample-and-hold circuits, analog switches, instrumentation amplifiers, and even the analog portions of data-converter chip sets.

Mixed-process devices combine field-effect transistors with bipolar transistors on the same silicon chip. The FETs most often are front-end devices, the bipolars are in the output stage. A bi-FET device mixes bipolars with p-channel junction FETs, whereas a bi-MOS device combines metal-oxide-silicon FETs with bipolars, a mixture that may even involve complementary MOSFETs.

In terms of input bias current, bandwidth, and slew rate, bi-FET and bi-MOS op amps perform nearly equally. However, bi-FET parts exhibit better noise characteristics and less offset-voltage drift. Bi-MOS devices, on the other hand, can handle inputs over the full range of the supply voltage, so they offer broad common-mode voltage capability. The chips are also processed differently. Bi-FET devices involve an ion-implant add-on, while bi-MOS parts are products of diffusion, requiring an extra masking step.

Because of the performance edge bi-FET technology offers, far more semiconductor manufacturers are making bi-FET chips. In alphabetical order, these vendors include: Advanced Micro Devices, Fairchild, Intersil, Motorola, National Semiconductor, Precision Monolithics, Signetics, Texas Instruments, and the latest entry by Analog Devices. Among the manufacturers of bi-MOS devices are RCA Corp., Harris Semiconductor, Siliconix, and again TI.

For the last year or so, the competition in bi-FET op amps centering on price versus performance has been vigorous. For example, last August, National and TI drastically slashed prices on their amplifier products, so that there is now only a difference of pennies between an economy bi-FET op amp and the industry standard bipolar op amp, the 741. As compared to the 741, which sells for 20 to 25 cents in quantity, TI offers its TL081 devices for 33 cents and National is asking 39 cents for its LF351 units. Moreover, National's higher-performance LF356 part is down to 75 cents, from its initial $2 plus.

But the standard versions of these op amps have fairly high input offset voltage, in the range of 10 to 15 millivolts, although both National and TI do offer selected versions with offset down to 2 or 3 mV. In contrast, besides second-sourcing a better-performing LF356, PMI is making an improved second-generation of bi-FET op amps, designated the OP-15, -16, and -17. These devices boast an input offset voltage of 500 microvolts maximum, and their input bias current is compensated for changes in temperature. Of course, the user pays a premium for these features, but as a result, instead of doubling for every 10°C rise in temperature, as is the usual case with JFETs, the bias current of the PMI chips doubles only approximately every 18°C. (Both National and TI have indicated they will also be making 0.5-mV-offset parts in the near future.)

Lucinda Mattera

tance of the input stages. So the key to obtaining high slew rate is to use first-stage gain elements that have a large ratio of biasing current to transconductance. Compared with bipolar transistors, JFETs require a larger biasing current to obtain the same transconductance, making them the better choice for the input stage.

The monolithic op amp

Unquestionably, standard monolithic bipolar op amps have proliferated through the years, and there now are a relatively large number of different devices available. The reason for this proliferation is the continuing introduction of circuit innovations to correct one or two operational deficiencies at a time. From the first successful monolithic op amp—the 709 (Fig. 2a) and its improved version, the newer popular 741 frequency-compensated unit—bipolar designs have used lateral pnp transistors to solve dc level-shifting problems. Since these transistors are relatively low-frequency devices, they limit overall frequency response. Still, bipolar npn transistors can be biased for good frequency response, but then the input current becomes undesirably large.

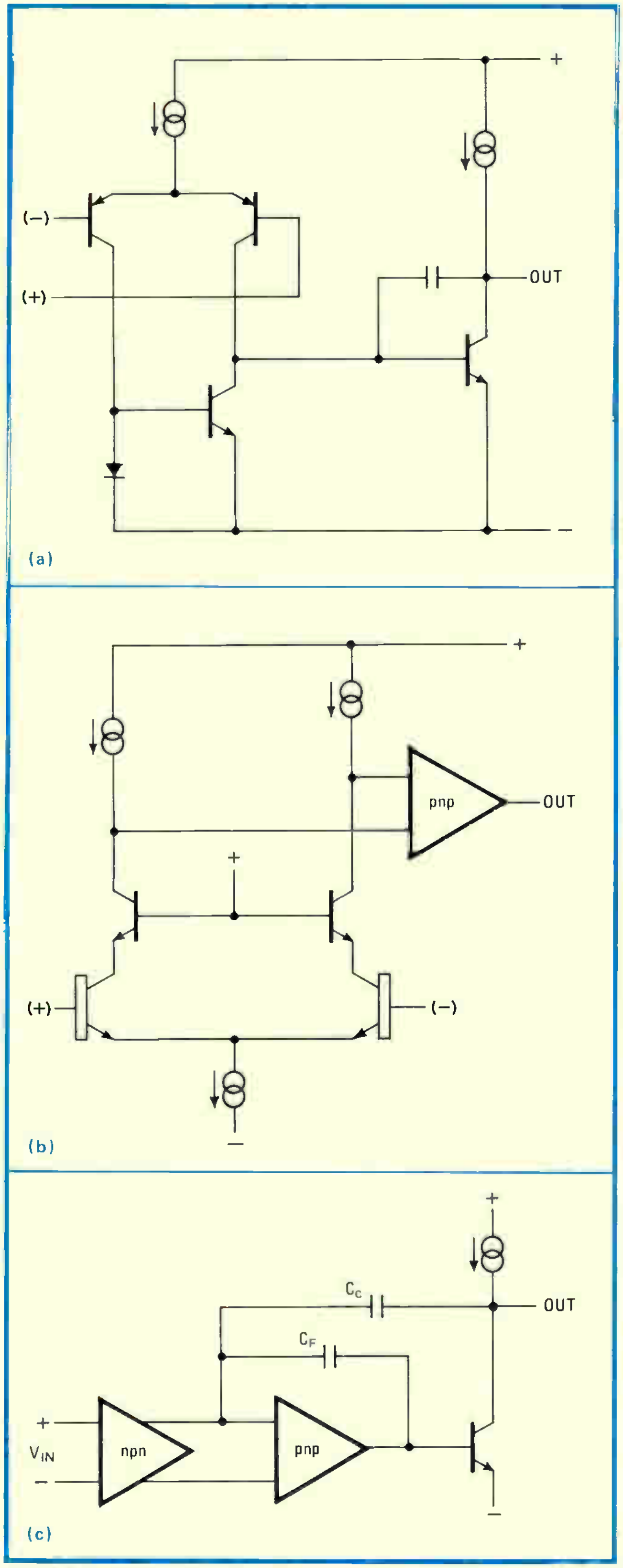
To improve input characteristics, semiconductor makers turned to super-beta npn transistors to come up with the 108-type op amp (Fig. 2b). Although these transistors have low breakdown voltage, they provide a beta as high as 10,000. Therefore, for a small sacrifice in additional circuit complexity to keep off high voltages, these devices are able to serve as excellent input transistors. Unfortunately, though, the lateral pnp transistors are still necessary, so that the speed of the op amp remains essentially unchanged.

The next improvement came with a circuit technique called feedforward, which results in the improved bandwidth and slew rate of the 118-type op amp (Fig. 2c). The idea is to feed the signal around the slow-responding pnp stage. Although this development significantly improves bandwidth, settling time and input bias current are relatively unaffected.

No matter what circuit tricks were tried, only a few parameters at a time could be improved. What was really needed was a high-speed replacement for the lateral pnp transistor, one that did not sacrifice breakdown voltage. The bi-FET process gives just such an active device. What results is an op amp that delivers excellent dc and ac characteristics while offering fast settling and low noise specifications.

The first bi-FET design

The basic design (Fig. 3) of the first viable bi-FET op amp, the LF-356, consists of a differential JFET input stage, followed by a differential bipolar stage for symmetrical bias-current loading. The input transistors are biased at less than I_{DDS} (the zero-bias drain current) to prevent excessive increases in input current should the differential input voltage become large. If a JFET's drain current increases beyond I_{DDS}, the gate-source junction of that device will actually become forward-biased.



2. Evolution. Monolithic bipolar op amps have proliferated because of the evolution of circuit innovations. For example, the 709 (a) incorporates lateral pnp transistors to solve dc level-shifting problems, the 108 (b) has superbeta npn transistors for better input characteristics, and the 118 (c) uses a feedforward technique to improve bandwidth and slew rate.

To simplify biasing in a standard bipolar op amp, a current mirror makes the conversion from a differential to a single-ended stage at the output of the first stage. But this approach does not work with a JFET differential input stage. Such a bipolar current mirror would yield much too large an input offset voltage when the JFET was biased for maximum slew rate. The low transconductance of this transistor actually causes the input to exceed the offset voltage of the mirror.

The biasing solution for a JFET front end is a different circuit approach. For similar biasing, well-matched JFETS also provide well-matched drain currents, so they are useful as current-source loads. A simple gate-source short provides two-terminal current source loads, with the matching depending only on the JFETS. Such diode-connected transistors act as the loads for the input stage, and a common-mode feedback loop biases the sources of the differential input stage. With JFETS, the same device type may be used for both the gain element and its current-source load—something that is out of the question with bipolars.

The common-mode feedback loop optimizes performance for both dc and ac operations. At dc, the 10-picofarad compensation capacitor looks like an open circuit, and the feedback to the sources of the input JFETS is common-mode. For ac inputs, the compensation capacitor will absorb the output current of the first stage. Since there is no place for ac to be absorbed at the other differential output, the common-mode loop must constrain this output current at zero. As a result, the entire differential input voltage is impressed across the gate-source terminals of the noninverting input JFET. This yields gain-doubling, differential-to-single-ended conversion for ac inputs.

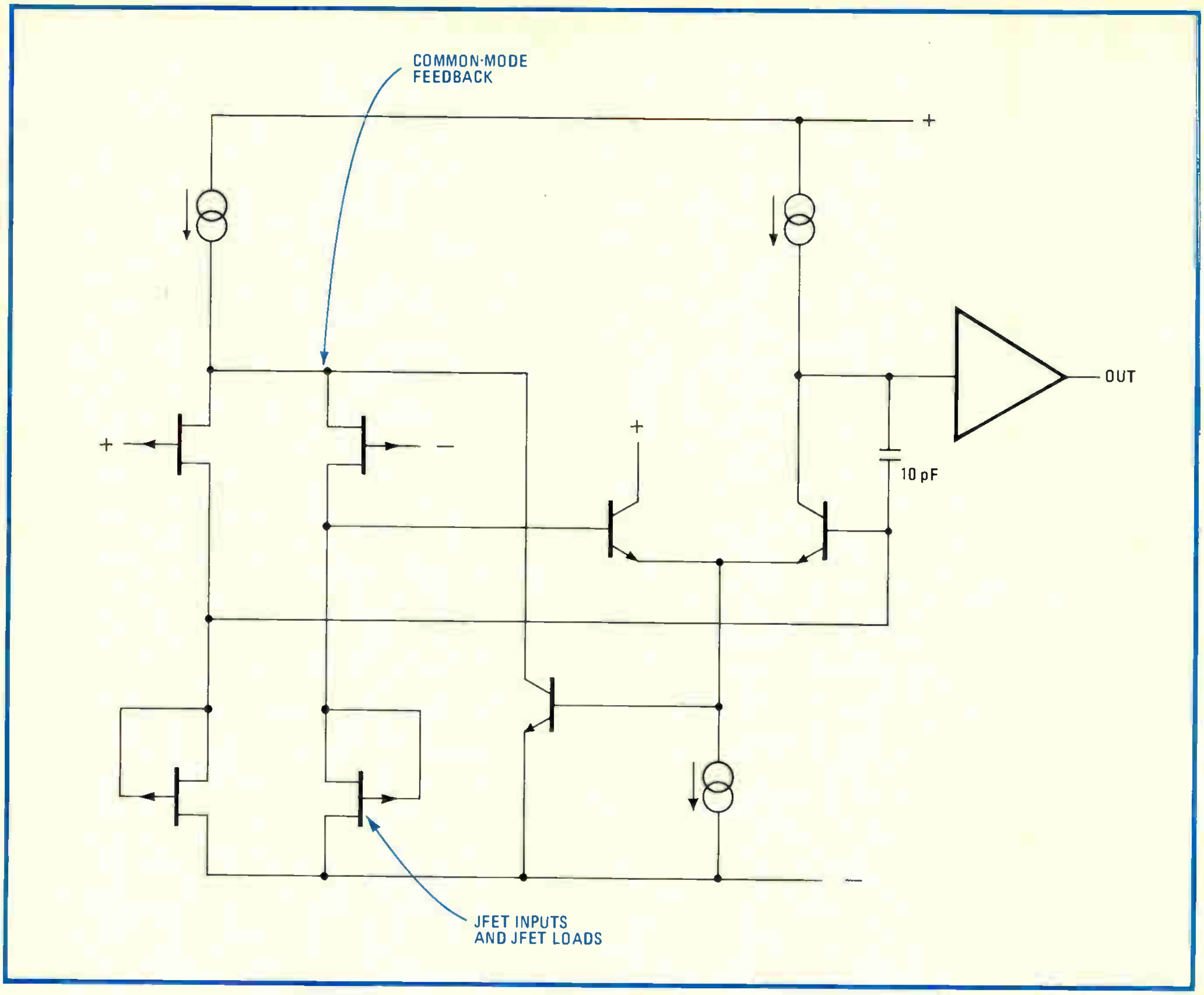
Enhanced stability

To make the stability of the op amp insensitive to large capacitive loads, even up to 10,000 pF, the LF356 contains a wideband composite JFET in its output stage. Many users say they are not driving capacitive loads since they are not working with peak detectors or sample-and-hold circuits. But they may be asking the op amp to drive 50 feet of coaxial cable. At 29 pF per foot, even only a few feet of low-impedance coaxial cable will affect the stability of many op amps.

Another less obvious benefit of the LF356 is its scheme for adjusting input offset voltage. In general, zeroing the input offset voltage of conventional bipolar op amps requires adjusting an external potentiometer. This device shunts the on-chip resistors in the emitters of the current mirror in the first stage. The result of this adjustment is a mismatch in the resistor temperature coefficients, so offset drift is increased. In addition, the signal path is affected, and both gain and common-mode rejection may also be degraded.

The LF356's offset-adjust circuits overcome these problems by using differential JFET currents to modify the dc biasing only. Typically, this technique permits holding offset drift to 0.5 microvolt/°C per millivolt of offset adjustment. The performance of many op amps, monolithic and hybrid, is an order of magnitude worse.

Since the same active devices that contribute to offset



3. High-performance bi-FET. The basic design for the front end of the first bi-FET op amp, the LF356, consists of a differential JFET input stage. A pair of matched JFETs make up this stage, followed by a differential bipolar stage for symmetrical bias-current loading.

voltage also contribute to noise voltage, an input stage designed for low offset voltage tends to produce low noise voltage as well. In the bi-FET op amp, the major contributors to noise voltage are the input JFETs and their JFET current-source loads. The equivalent noise resistance of these devices varies inversely with transconductance. Consequently, it is fortunate that the first-stage transconductance must be high for it to be possible to use a large enough value for the compensation capacitor to obtain effective pole-splitting. Minimizing the input currents of the second stage keeps the 1/f noise corner low, without degrading the frequency performance of the output stage.

A low-cost approach

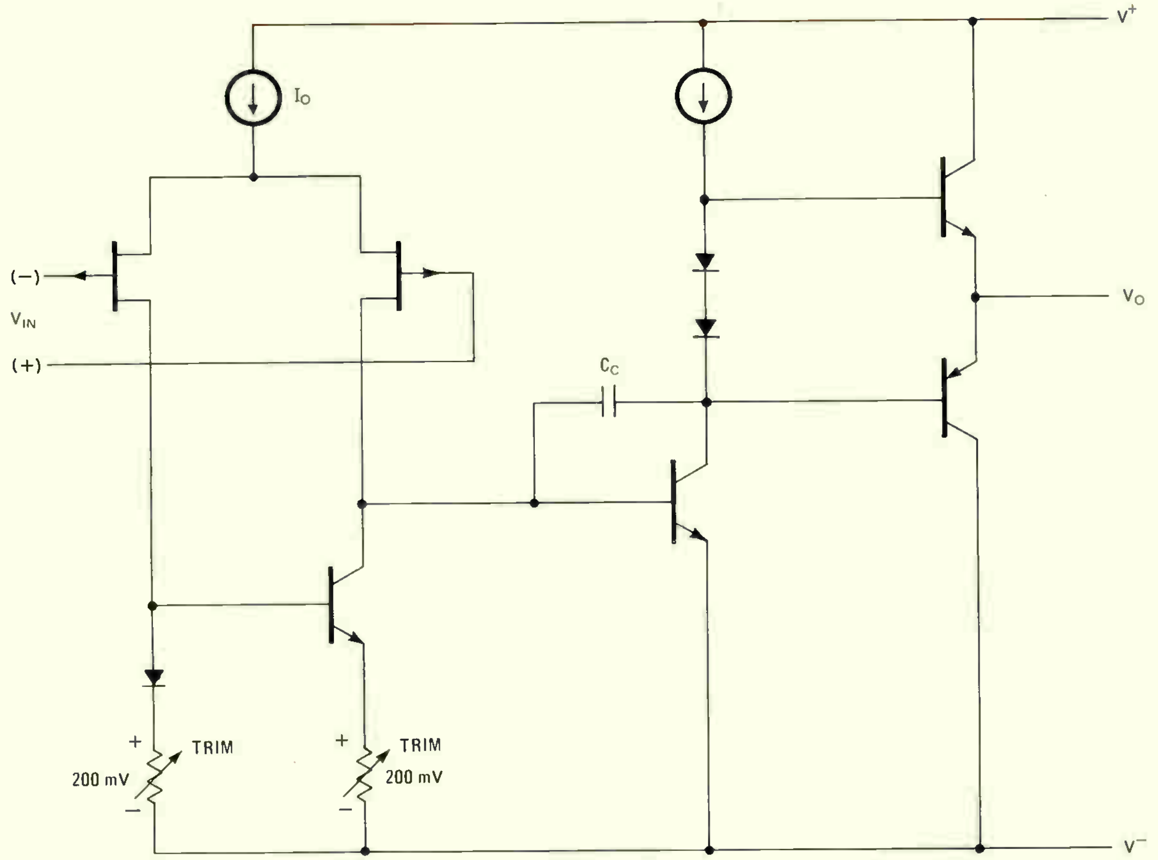
Bi-FET op amps may also be fabricated as less complex, smaller circuits not optimized to achieve low offset voltage. The trick in this case is to use area-consuming JFETs only in the first stage and then to adjust offset by laser-trimming the chip.

One offset-trim method involves opening up metal links across binary-weighted portions of the resistors in the emitters of the current mirror. A larger quiescent voltage is developed across these mirror resistors—by roughly an order of magnitude larger than in a 741 bipolar op amp. As a result, the offset and noise voltage contributions of the bipolar devices in the current mirror are no larger than those of the input JFETs.

What's inside

Figure 4 shows the basic circuitry for a typical low-cost trimmed bi-FET op amp like the LF351 single, LF353 dual, and the LF347 quad devices. When they are run off a constant bias current, their input JFETs have a transconductance that is independent of pinch-off voltage. To keep the bandwidth of the op amp independent of variations in the characteristics of the JFETs, the input bias current is set by a zener voltage and a resistor. Thus, despite their comparatively simple design, these trimmed bi-FET op amps provide large bandwidth, low current drain, short settling time, fast slewing, and the low input bias currents of JFETs.

Because of their broad bandwidth, bi-FET op amps make excellent building blocks for active filters. The



4. Low cost. Bi-FET op amps that are less complex and expensive than the LF356 are made by using laser trimming to adjust offset voltage right on the chip, instead of optimizing the design for low offset as with the LF356. A zener and a resistor set the input bias current.

active-component sensitivities of these filters are inversely proportional to the gain-bandwidth product of the op amps with which they are built. Broadband bi-FET devices, therefore, permit higher frequency operation and higher Q, as well as reduced sensitivities. Further, for low-frequency filters, the benefits of employing smaller-valued capacitors may be realized by impedance scaling, without creating dc voltage-biasing problems.

In data acquisition, an obvious application for a bi-FET op amp is as the output amplifier for a current-output digital-to-analog converter, thereby taking advantage of these devices' fast settling time and dc accuracy.

Another use

A less obvious d-a converter application for a fast-settling op amp is as the driver that keeps the bases of the reference current-source transistors properly biased. As the bits switch, any glitches that occur are coupled back to the output of this driver. The time required by the driver to recover from these abrupt disturbances can limit the settling time of the complete converter.

Moreover, the low cost of trimmed bi-FET devices, brings the advantage of JFET-input amplifiers to inexpensive systems. For example, the large power bandwidth and low noise of these chips make them ideally suited for use in audio applications as RIAA equalization preamps, tone controls, and room equalizers. In addition, even large input voltage swings can be handled with low distortion because of the low transconductance of the JFET input stage. Such performance is especially useful at high frequencies where the reduced open-loop gain of the op amp forces input signals to be larger.

Just a beginning

Undoubtedly, the advent of bi-FET technology is breathing new life into the linear IC world. It gives the circuit designer another tool, providing him with high-performance devices that sell for only slightly more than comparable bipolar parts. The best news of all is that the benefits of bi-FET technology are just the beginning. In the near future, further process innovations and new circuit designs will mean bi-FET op amps with significantly wider bandwidths, higher slew rates, and lower noise voltages. □

High-accuracy calibrator uses band-gap voltage reference

by Henno Normet
Diversified Electronics, Leesburg, Fla.

The Analog Devices' AD581J voltage reference can be used to build a low-cost and extremely accurate voltage calibrator for oscilloscopes that either do not have one built in or have one of inadequate accuracy. If this calibrator is battery-operated, the unit can be built for under $15.

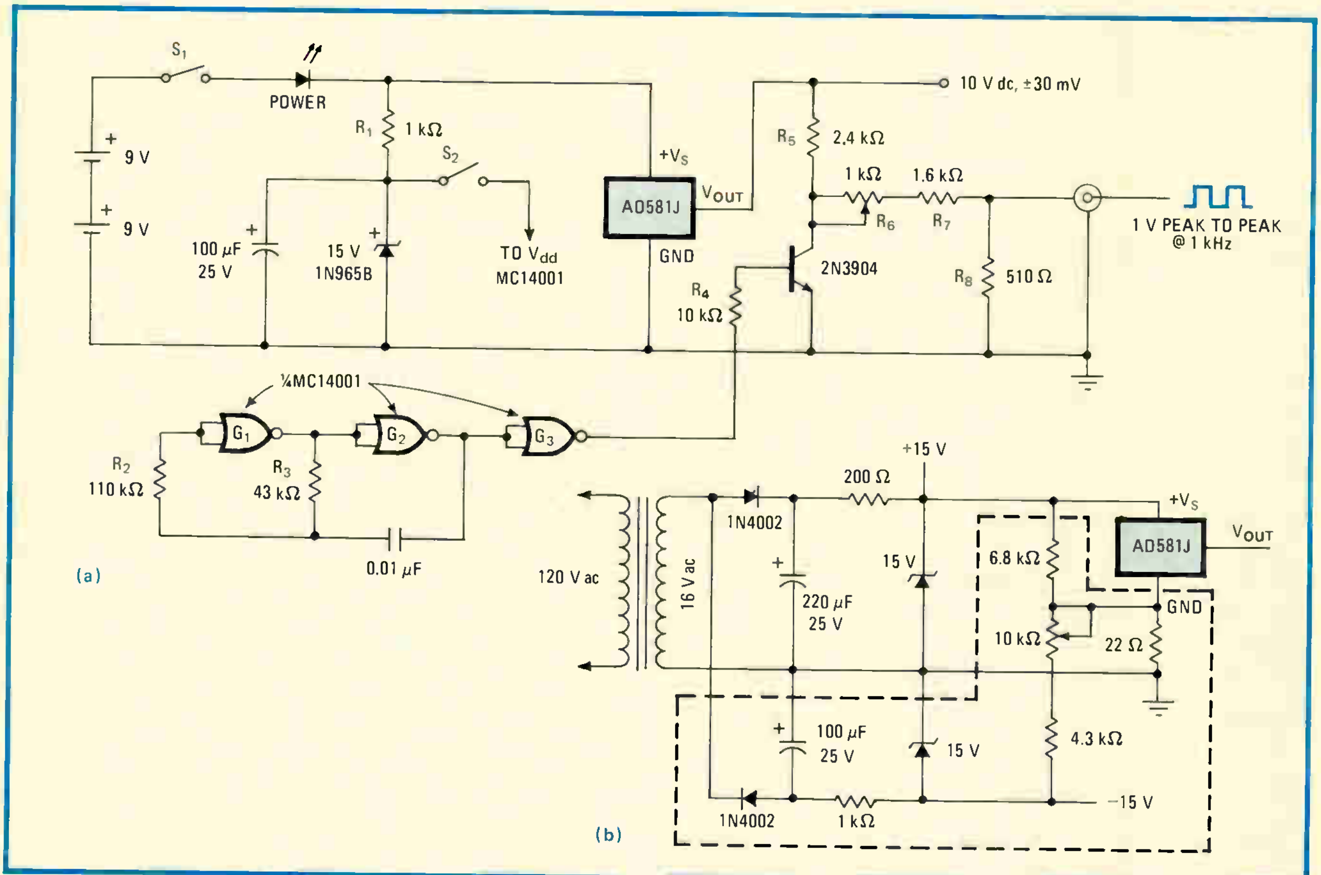
The calibrator generates a 1-volt peak-to-peak square-wave signal that is accurate to within better than 0.5%, owing its long-term accuracy to the band-gap technology used in the voltage reference. The reference voltages produced by the band-gap method are more temperature-stable than that produced by a zener diode, because the method makes use of the inherently constant potential that exists between adjacent electron energy levels in the semiconductor material of the integrated circuit itself. Here, the potential across selected energy bands is used to derive a 10-v reference that will vary no more than ±13 millivolts over the temperature range of 0°C to 70°C (for the 581L, the variation would only be 2.5 mv).

In this circuit, the output of a 1-kilohertz square wave is scaled to 1 v with the aid of the reference as shown in (a). An astable multivibrator, G_1–G_2, is used as the square-wave oscillator. R_2 compensates for input-threshold and power-supply variations, so that the duty cycle can be maintained at approximately 50%.

G_3 is used to improve the shape of the square wave that drives the 2N3904 switching transistor. The collector voltage for powering the transistor is derived from the band-gap voltage reference.

To eliminate the errors due to the transistor's offset voltage, R_6 is used to adjust the output for a collector swing of 0.005 to 1.005 v so that the difference voltage of 1 v peak to peak will appear at the output.

A dc digital voltmeter can be used for accurate adjustment of the output voltage, contributing to the ease with which the circuit can be calibrated. Accurate peak-reading ac voltmeters are not readily available, and



Precise amplitude. Scope calibrator generates 1-V square wave, accurate to within 0.5%, with aid of AD581J band-gap voltage reference (a). Unit may be powered by two 9-V batteries. Current drain is 6 mA. Ten-volt reference voltage is available at output jack for voltmeter calibration, etc. If more than occasional use is contemplated, the unit should be powered from the ac mains (b).

root-mean-square voltmeters will not yield accurate results if the output is not perfectly symmetrical (having a duty cycle of 50%).

To calibrate the circuit, it is necessary to open S_2, which disables the 1-kHz oscillator by removing the supply voltage to G_1–G_3. R_6 is then adjusted for an output voltage of 1.005 v. Then S_2 is closed, the input of G_1 is grounded and the output voltage is measured again. The difference between these two readings should be exactly 1 v. The two-step procedure should be repeated as necessary; R_6 should be adjusted for a voltage slightly removed from the 1.005 v originally set, then G_1's input grounded, and so on, until a difference voltag of 1.000 v is obtained.

Two 9-v batteries will provide many hours of opera tion. Battery drain is approximately 6 milliamperes Typical units will work well down to a supply voltage o about 12 v.

If more than occasional use is anticipated, the uni should be powered from the 120-v ac line, as shown i (b). A bipolar (15-v) supply is derived from the power-line voltage, and a fine-trim circuit added as show inside the dotted line, so that the set accuracy of th 581J's 10-volt output may be improved. □

In-range frequency detector has jitter-free response

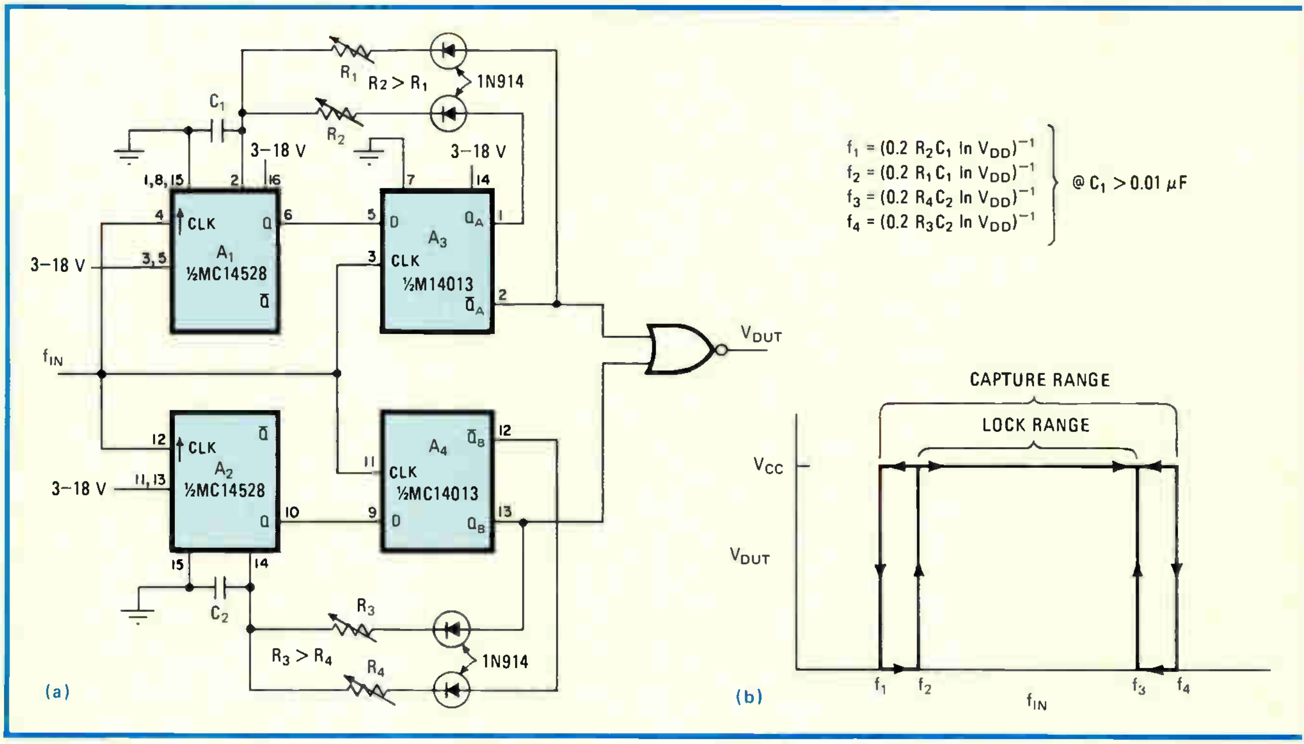
by A. J. Nicoll
Instromedix Inc., Beaverton, Ore.

This simple circuit will detect when an input signal falls within a specified frequency range and is thus ideal for use as an out-of-tolerance alarm or as a rudimentary phase-locked loop. It could also be called unusual, since it uses hysteresis to provide separate lock and capture ranges that eliminate the jitter of the circuit's logic-level output.

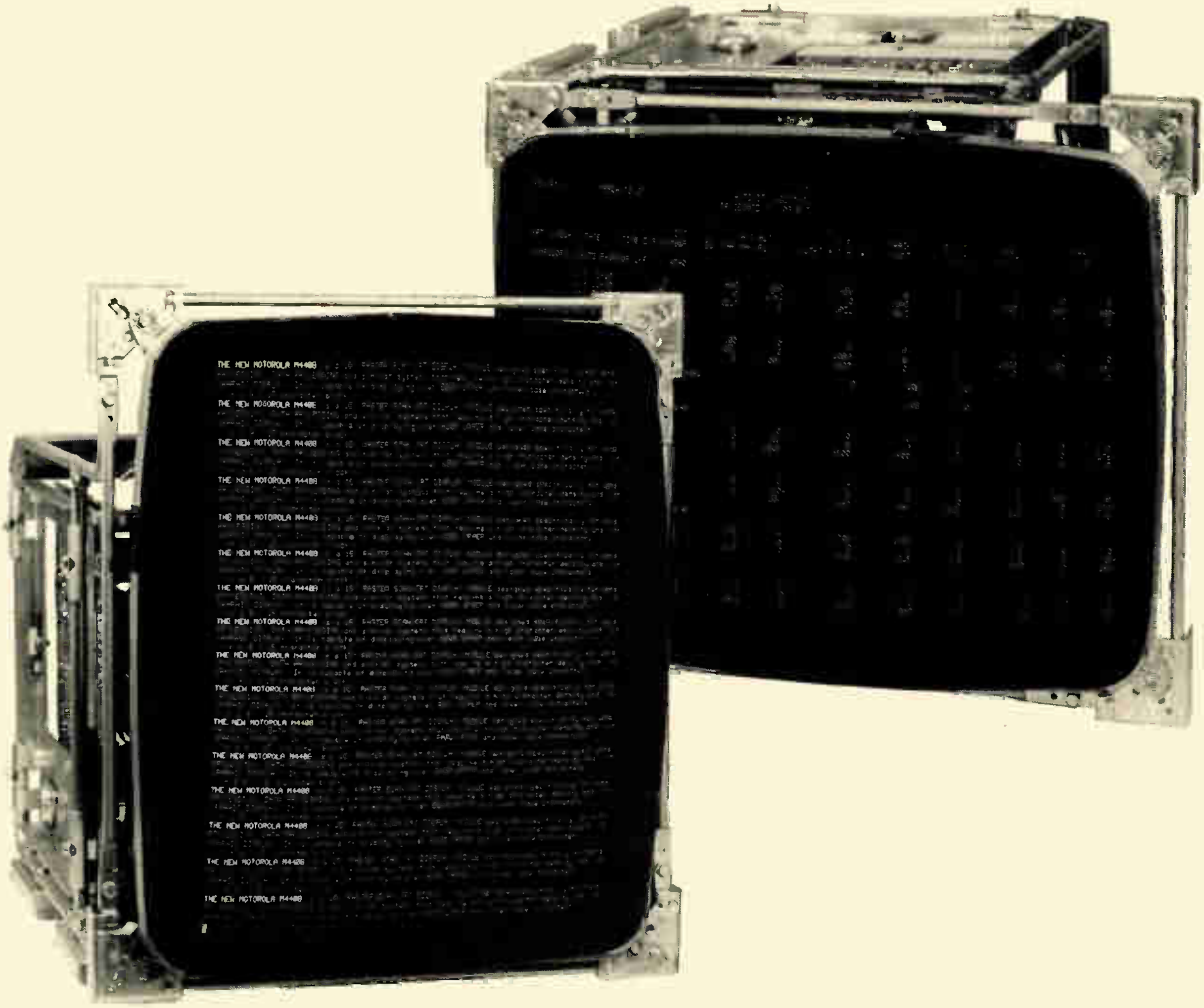
The diagram shown in (a) and the hysteresis curve shown in (b) help make the circuit's operation clear. A_1 and A_2 are two retriggerable one-shots. Their puls widths, and therefore their maximum frequency of oper ation, are controlled by R_1–R_4. Whether R_1 or R controls the width of A_1 and R_3 or R_4 controls the widt of A_2 depends upon the state of the A_3 or A_4 D-typ flip-flops.

Assume R_1 and R_4 are the controlling elements as a input signal of arbitrary frequency, f_{in}, arrives to trigge both one-shots simultaneously. The positive transition o f_{in} then fires A_1 and A_2, as shown. The next positive going transition will trigger both A_1 and A_2 again whil clocking the previous output states, which were gener ated before retriggering, into A_3 and A_4.

If this second transition occurs before either one-sho has returned to its time-out state, a logic 1 will b clocked into its respective flip-flop, changing the state o that flip-flop. Once the flip-flop moves from a 0 to a 1 the pulse width of the one-shot will be controlled by on



Within limits. Circuit (a) detects whether input signal is within user-set frequency range f_2–f_3 (b). Flip-flops enable selectable hysteresis s that circuit, once locked, will not change state until f_{in} moves below f_1 or moves above f_4. Lock and capture ranges are controlled by R_1–R_4 Hysteresis eliminates jitter that would normally occur at output if f_{in} were near f_2's or f_3's edges.



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of the two timing elements, R_2 and R_3.

The curve (b) shows more clearly how the lock and capture ranges are controlled by R_1–R_4, where f_1–f_4 are equal to the reciprocals of the pulse widths determined by C_1–R_1 or –R_2 and C_2–R_3 or –R_4. A_3 will move high when f_{in} rises above f_2, and it will not move back to its initial state until f_{in} falls below f_1. Similarly, A_4 will change from a 0 to a 1 when f_{in} rises above f_4, and it will change back to a 0 only when f_{in} falls below f_3. The amount of hysteresis acting upon f_1–f_2 and f_3–f_4 can be chosen by simply selecting the appropriate resistance values for R_1–R_4.

The NOR gate output moves high when f_{in} is within the set limits of f_2–f_3. It will not move low again until the input frequency falls below f_1 or above f_4. If desired, an OR gate can be used instead of a NOR gate, since both the Q and $\overline{Q}$ outputs are available in D-type flip-flops. ☐

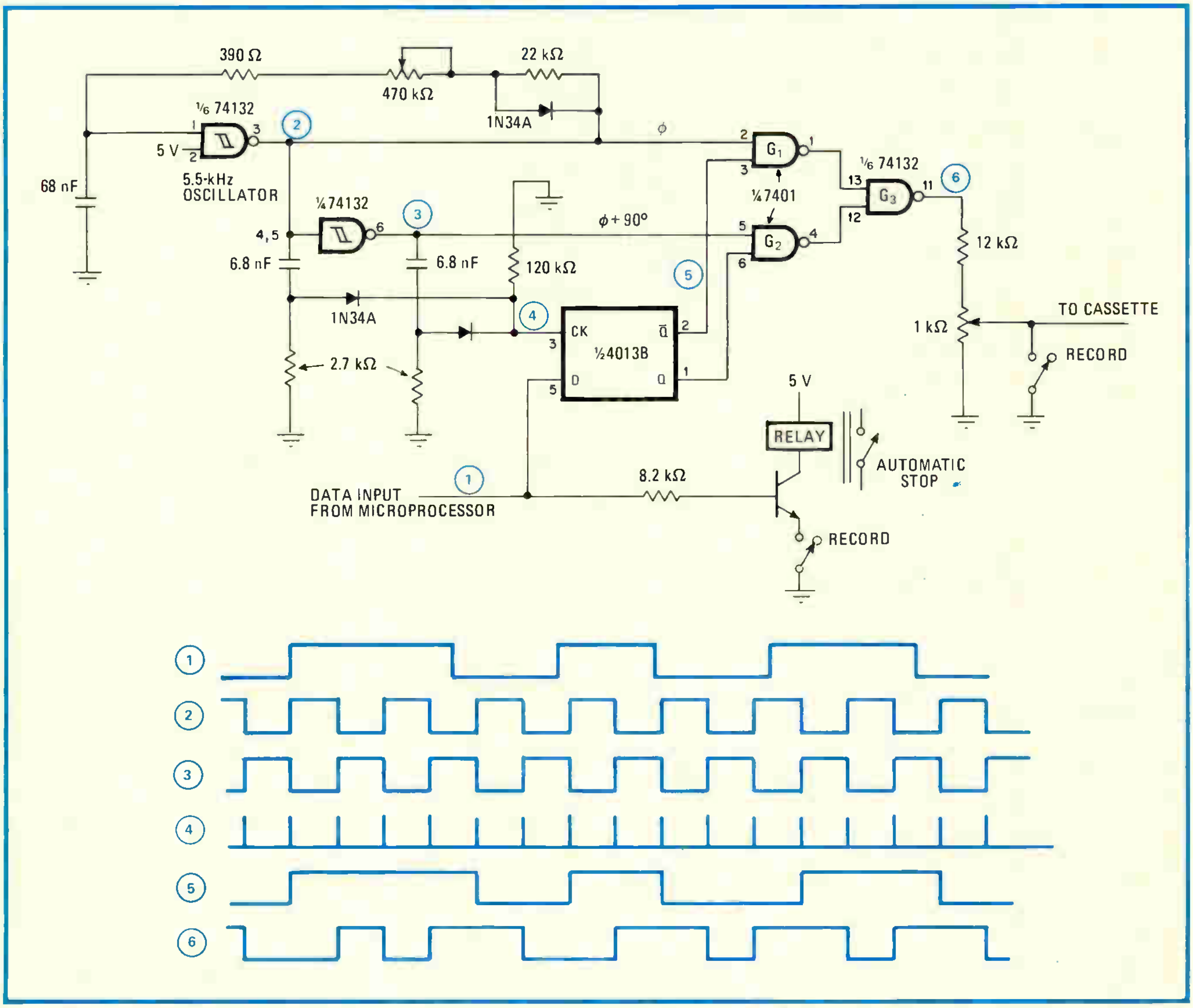
Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.

Processor-to-cassette interface helps slash data-storage cost

by Pawel Mikulski
Finlux Television, Lohja, Finland

It doesn't pay to buy an expensive mass-storage device to store data handled by an inexpensive microprocessor-based data system. Storing data on a cassette tape recorder or reading data from one is a viable alternative, however, and these low-cost interfaces will provide an economical solution to the data-storage and -retrieval problem for read/write speeds of up to 4,000 bauds.

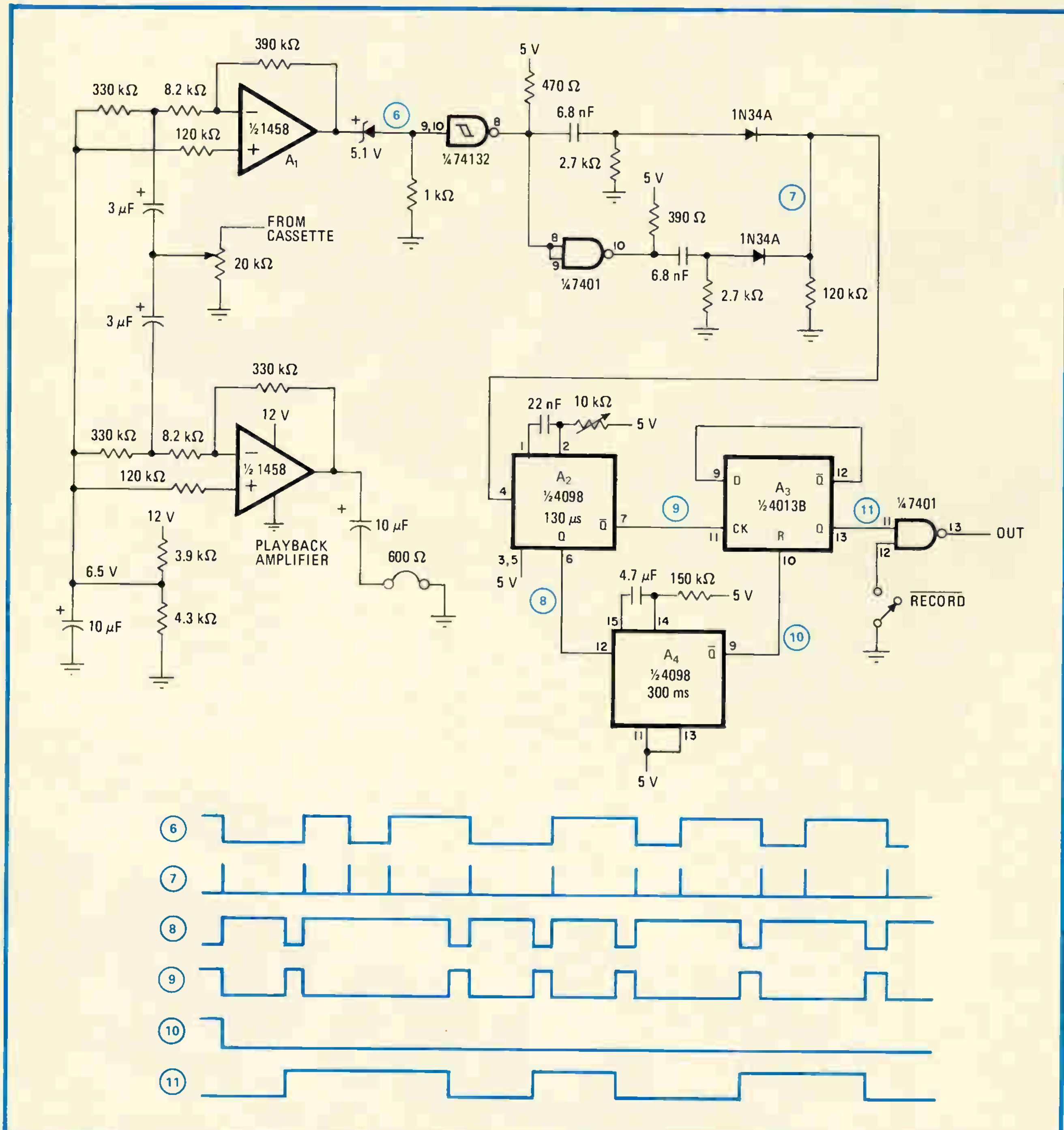
Microprocessor data is phase-modulated by the trans-



1. Inexpensive. Low-cost microprocessor-to-cassette interface can be used with tape recorder to form economical data-storage system. Interface converts input to pulse-modulated waveform so that data may be easily stored in cassette recorder.

mitter interface as shown in Fig. 1, in order that it may be stored in the recorder in a form that may be easily retrieved. The input signal drives G_1 and G_2 and, depending on the logic value (0 or 1), will determine if either phase ϕ or $\phi + 90°$ (both generated by a 5.5-kilohertz oscillator) appears at the output of G_3. This signal is then stored in the cassette. The transmitter timing diagram clarifies circuit operation.

Data played back to the receiver (Fig. 2) is applied first to A_1 and then to a Schmitt trigger/comparator (74132). A_2, a retriggerable one-shot, is fired on every rising and falling edge of the input signal and thus will stay high if the input signal pulses are separated by less than 130 microseconds. A_2 drives A_3, a D-type flip-flop wired as a T device, so that the output will be a replica of the data signal originally recorded. A_4 is a time-out one-shot, which moves high ($\bar{Q}$) if data input should cease for more than 300 milliseconds. Circuit operation can be clearly visualized with the aid of the receiver's timing diagram. □



2. Retrieved. Data is recovered after passing through receiver interface using process essentially inverse to one used at transmitter. One-shot A_2 is used to convert input signal to two complementary 130-μs waveshapes. One waveform drives a second one-shot, A_4, which in turn resets A_3, while the other waveform drives its clock input. Timing diagram details operation. Output is a delayed version of the original signal.

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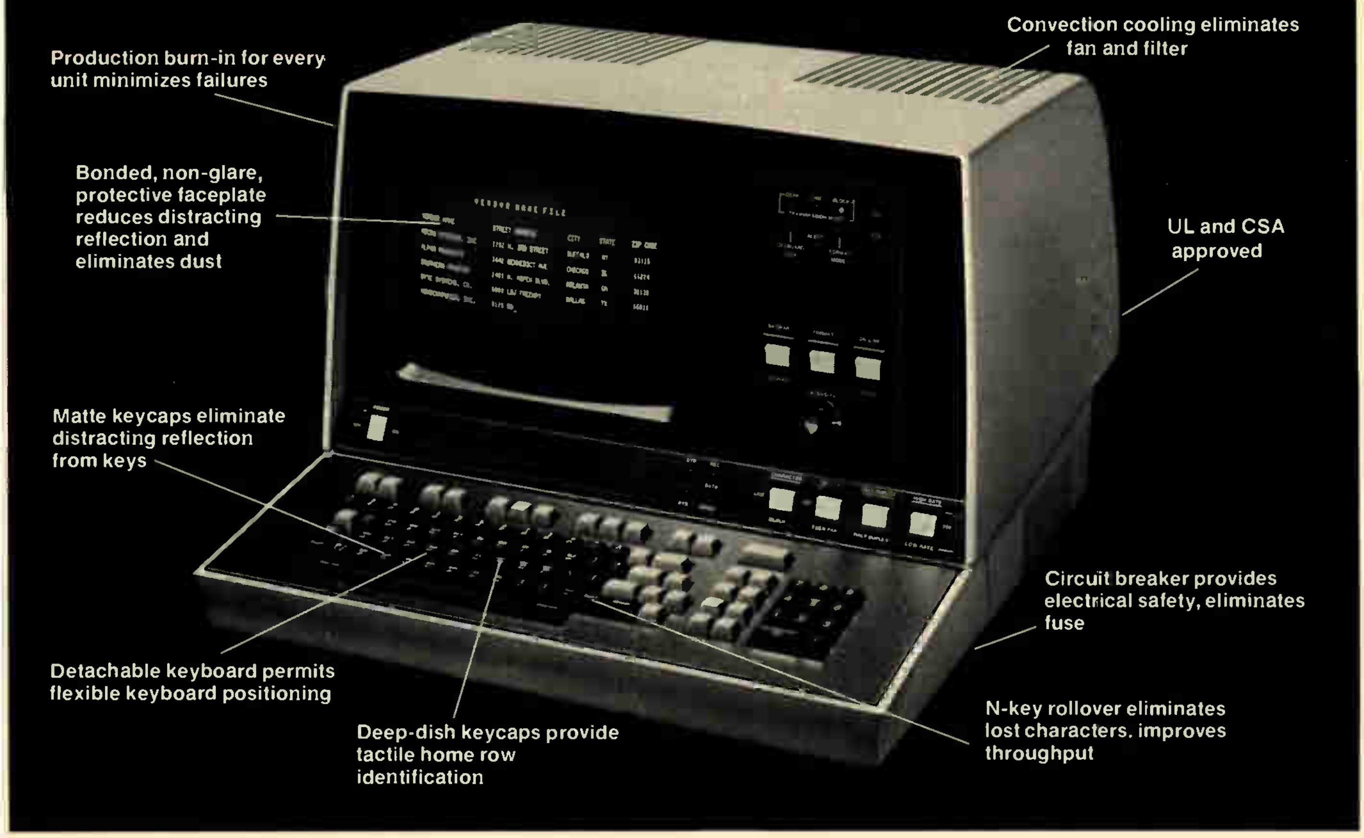

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Prototyping version of 6500/1 adds extra pins for access to internal bus signals and external memory

by D. Starbuck, D. Peeters, K. Hogan, and R. Eufinger, *Rockwell International Corp., Microelectronic Devices, Anaheim, Calif.*

☐ Assembly-line work certainly does go faster when an entire microcomputer is available on a single piece of silicon instead of on separate processor, memory, and timing and control chips that all have to be interconnected. But the process of designing and debugging such a single-chip system can move with frustrating slowness precisely because all those interconnections are hidden within the package. For that reason, the single-chip 6500/1 version of the 6500 8-bit microprocessor family comes in a 64-pin emulator model as well as a standard 40-pin production model.

No slouch in performance, the 6500/1 features the same instruction set and 13 modes of addressing as its predecessor, the 6502. But the two versions of the 6500/1 give it an edge over other one-chip computers.

Apart from pin count, the two packages are essentially identical. The emulator chip simply has the address, data, and control buses connected to bonding pads and made accessible externally through its 24 additional leads. At the prototyping stage, the user links them to the external memory being used for software development. Then, when satisfied the program is error-free, he or she can have it masked into the read-only memory of the production chip.

Such an approach is much more exact than building a breadboard of the one-chip metal-oxide-semiconductor microcomputer from other large-scale integrated circuits and transistor-transistor-logic devices. It is also superior to using the expanded bus of an expandable one-chip microcomputer and attaching memory and input/output devices to it; for the associated I/O ports are unavailable and must still be modeled, so that the software dealing with them will remain untried until the first masked-ROM part is delivered.

Finally, to further speed prototyping with the 6500/1, a third-generation development system is available. System 65 incorporates minifloppy-disk drives, can interface to high-speed terminals and printers, and may also be equipped with a personality subsystem that adapts it specifically to the 6500/1's requirements.

The production chip

But what are the capabilities of the basic 6500/1 chip that these development aids exist to serve? From Fig. 1, which diagrams its architecture and bus structure, it is evident that the 6500/1 contains all the components for a computer—clock, central processing unit, memory, and I/O section.

Its built-in oscillator can use any of three timing elements. An RC network is the least expensive, but the more popular crystal is also the most accurate. Alternatively, an external frequency source may be used if synchronization to other subsystems is required.

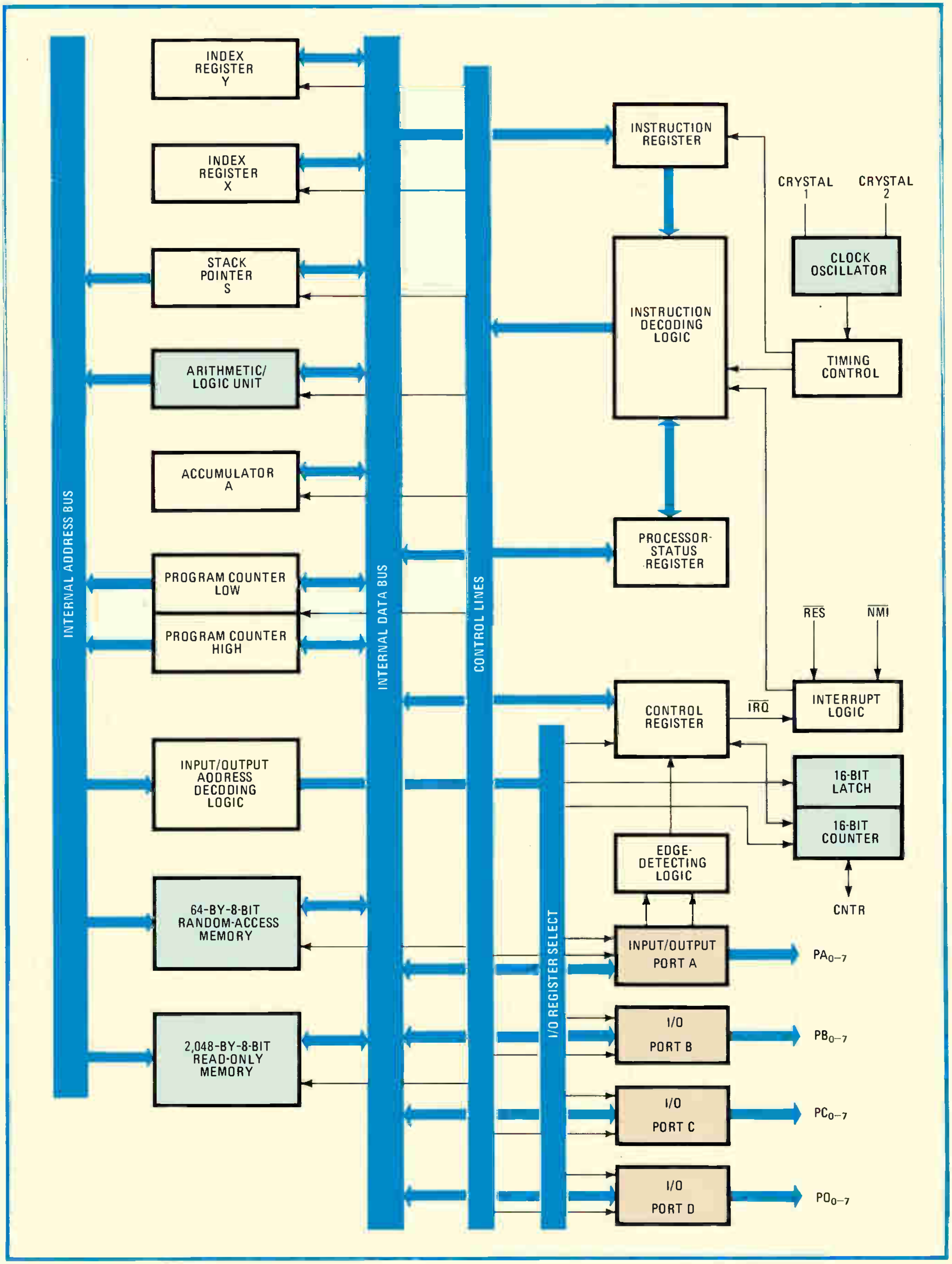
Different clock phases for timing are also generated by the internal logic of the device. The internal clock frequency is one half the frequency of the time-base source: a 4-megahertz crystal, for example, will operate the 6500/1 at its maximum frequency of 2 MHz.

An important goal of the design of the 6500/1 was to maintain software compatibility with programs already written for the 6502 microprocessor chip. The arithmetic and logic unit is therefore identical in both chips, though some of the signals to the 6500/1 ALU are different. The device's internal address bus uses only 12 signals to provide an address space of 0 to 4,192, since this is the limit of on-chip memory. Also, the control signals SYNC, RDY, and SO have been omitted in the one-chip device, since they are not made available externally. Otherwise, all the 6502's instructions and addressing modes have been retained unchanged.

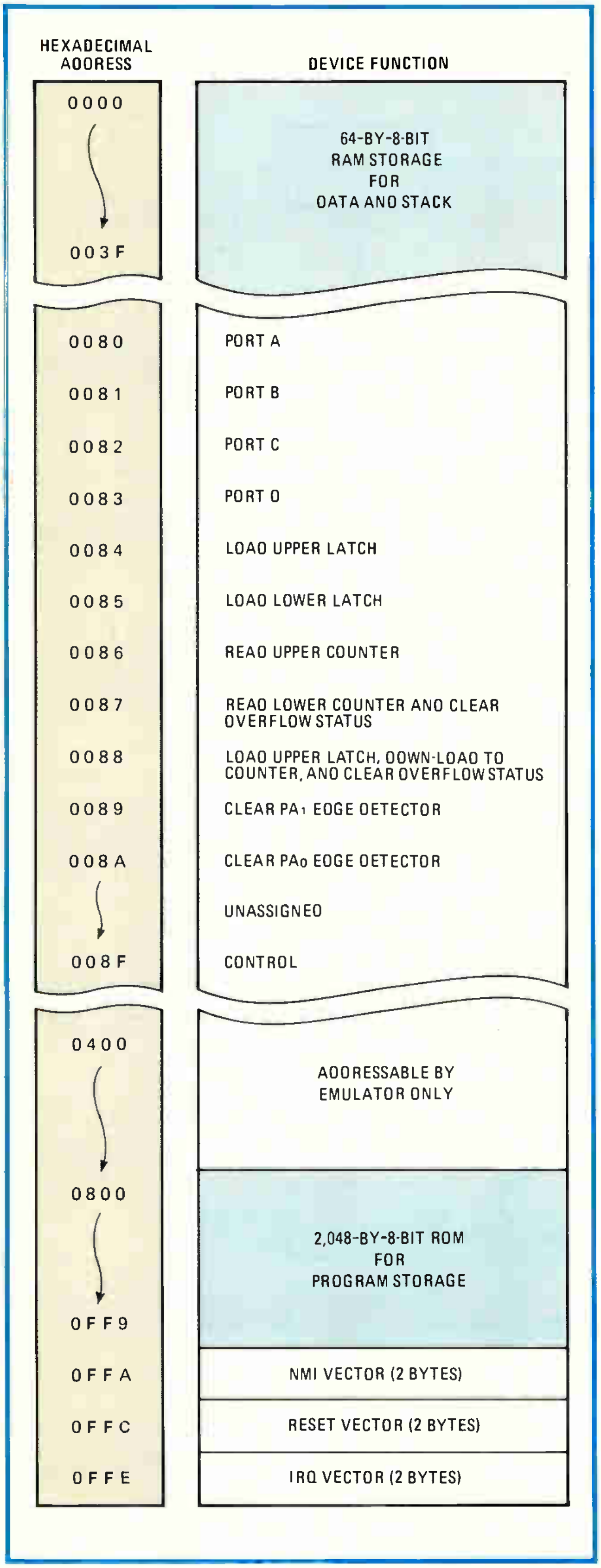
As in the 6502, the instructions in the 6500/1 are pipelined, with instruction fetches overlapping the execution of immediately preceding instructions. Each address is supplied as part of an instruction and can therefore access all the memory in the 6500/1 directly, so that there are no data-address-pointer registers to be manipulated. Also, instructions are shortened by one byte and one execution cycle by means of a zero-page addressing mode whenever the data involved is in the lowest 256-bytes of memory—a page that includes all the on-chip RAM and the I/O port addresses.

The 6500/1 has 2,048 bytes of mask-programmable ROM for storing instructions and constants. These 2 kilobytes occupy memory address space of 2,048 to 4,095 (800 to FFF in hexadecimal). The six high-order address locations are dedicated to the interrupt-request, reset, and non-maskable-interrupt address vectors, as shown in Fig. 2. Thanks to its ability to directly address all memory space, the 6500/1 can, unlike other single-chip microcomputers, store constant tables in its ROM.

The 64 bytes of RAM handle the storage and retrieval of modifiable data. Its own power-supply pin gives the



1. One-chip 6500. The 6500/1 contains all the makings of a computer—clock and associated timing circuits, arithmetic/logic unit and storage registers, four 8-bit input/output ports, and memory. There are 64 bytes of random-access and 2,048 bytes of read-only memory.



2. Address selection. The efficient addressing in the 6500/1 has random-access memory occupying the first 64 locations. Together with I/O, RAM is on page zero—the first 256 bytes—which can be addressed with a single instruction. There are 13 address modes.

RAM access to battery backup so that it can retain data in the event of a power failure. The RAM is addressed right up front, with addresses 0 through 63 (000 to 03F). This way, the efficient zero-page addressing mode deals with its data. Like the 6502, the 6500/1 uses a stack for subroutine- or interrupt-return information and for temporary storage. The associated stack-pointer address will be recognized by the address decoding as a zero-page address. The software should therefore be written to initialize the stack pointer to hexadecimal 03F, thus starting the stack at the top of the RAM. Subsequent pushes to the stack will cause the stack pointer to decrement, moving down through the RAM area.

Input/output

All input and output addresses in the 6500/1 become memory locations just as in other 6500-based systems. As is clear from Fig. 2, the address assignments are predetermined and all the decoding is built in. The I/O addresses follow the RAM addresses in the first page of address space, again for greater efficiency. There are three categories of I/O: peripheral and counter I/O and interrupt-request inputs. Associated with them is an 8-bit control register that contains 2 bits for choosing between the four counter modes as well as (to anticipate a little) three pairs of bits for handling three sources of interrupts.

For peripheral I/O, the 6500/1 has four 8-bit bidirectional ports (A, B, C, and D). Each pin within a port may be individually assigned an input or output function and in the latter role can drive a single TTL load. Figure 3 indicates how the 6500/1 makes this possible without using a direction register as several other devices have to do. The circuit for each line has an active transistor that can drive it to V_{SS} and a passive pullup transistor that normally holds it at V_{CC}. Initially all lines are pulled up to the high state by the resistor. Only in the high state can the lines accept inputs. A 1 input will cause no change in the line, whereas a 0 input overrides the passive pullup and drives the line low. When the microcomputer is using the line for an output, it either leaves the line in the normally high state for a 1 or drives its active transistor low for a 0.

Port A has in addition two special pins with edge-detecting logic that operate in parallel with the port's normal I/O functions. The logic associated with pin PA_0 detects an asynchronous rising edge, that associated with PA_1 a falling edge. When either edge is detected, a corresponding status bit is set in the control register. Consequently, with these two pins it is possible both to infer the value of the current input signal by reading port A and also, by reading the control register, to determine whether the signal has changed. Of course, the edge detected could be the result of either an earlier input or an earlier output signal. As will become subsequently apparent, this edge-detect capability is especially useful for requesting interrupts.

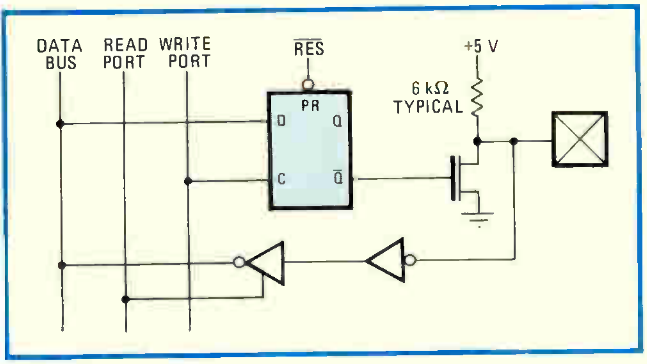
The 6500/1's versatile, 16-bit counter has four modes of operation (Fig. 4) selected by the first two bits in the control register. Linked to the counter is one bidirectional pin, CNTR, which functions as an output in one of the modes and an input in two of the other modes. Also associated with the counter are a 16-bit latch and timing and control logic. The program can load both the upper and lower bytes of the latch, cause the latch to download data to the counter, and read the two bytes of the counter.

In mode 0, the counter is free-running off the internal timer, busy counting the internal phase-2 clock. Power-on reset ($\overline{\text{RES}}$) automatically selects this mode, in which the CNTR pin remains in the high state.

Mode 1 is also free-running, but when the counter overflows, the CNTR pin inverts its state. This mode can be used to generate symmetrical or asymmetrical output waveforms. It can also synthesize a one-shot mode by switching after overflow from output-enabled to output high, as in the previous mode.

In mode 2 it becomes an external event counter, decrementing whenever a rising edge is detected on the CNTR pin. The maximum rate at which the edges can be detected is half the internal phase-2 clock rate.

Finally, mode 3 is suited to pulse-width measurement. Reading negative pulses, the counter will decrement with each internal phase-2 clock pulse as long as its CNTR pin is in the low state; counting stops when the CNTR pin goes high. This mode may be selected to stop the counter if the CNTR pin is left unconnected, since the internal pull-up device will then cause the input to always be in the high state.



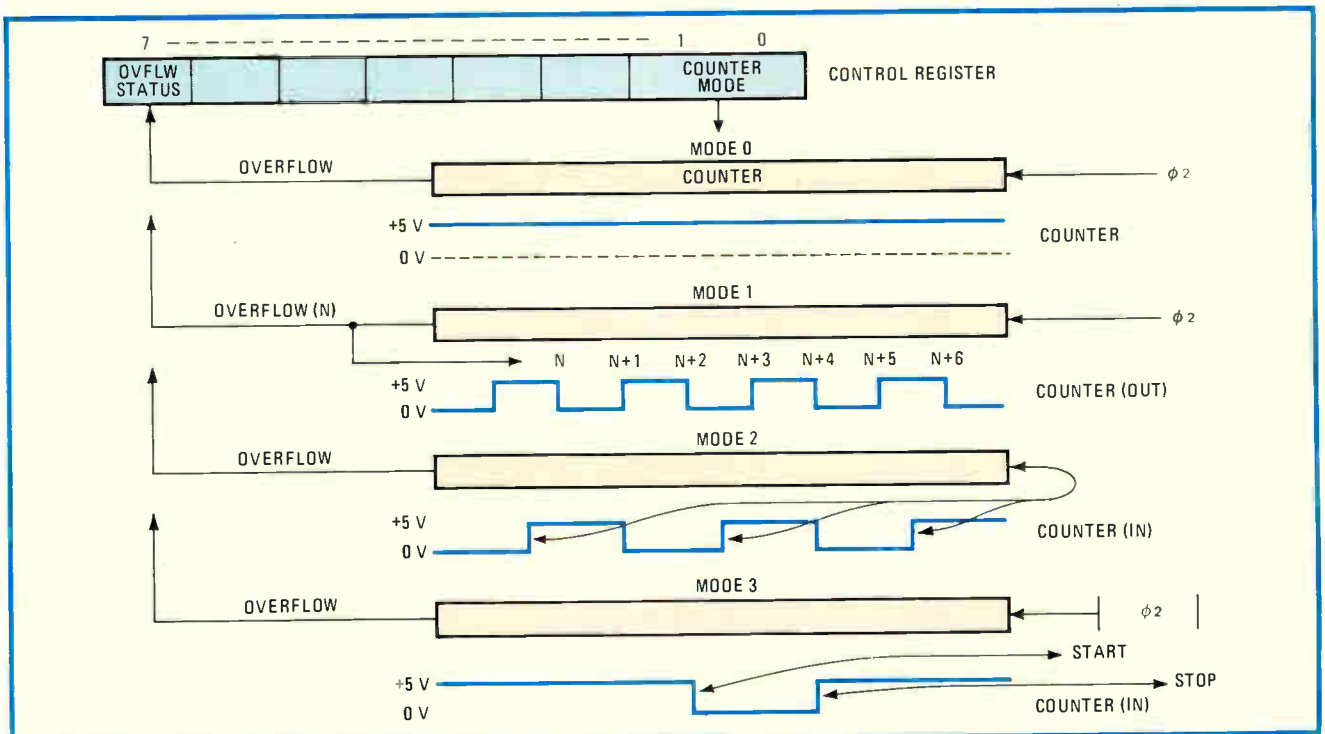
3. No direction. The bidirectional input/output lines require no direction register. Normally written to 1, an input is overridden by a 0, which latches the D-type flip-flop driving the transistor low. The 6-kilohm pull-up resistor can be omitted with a mask option.

Interrupts

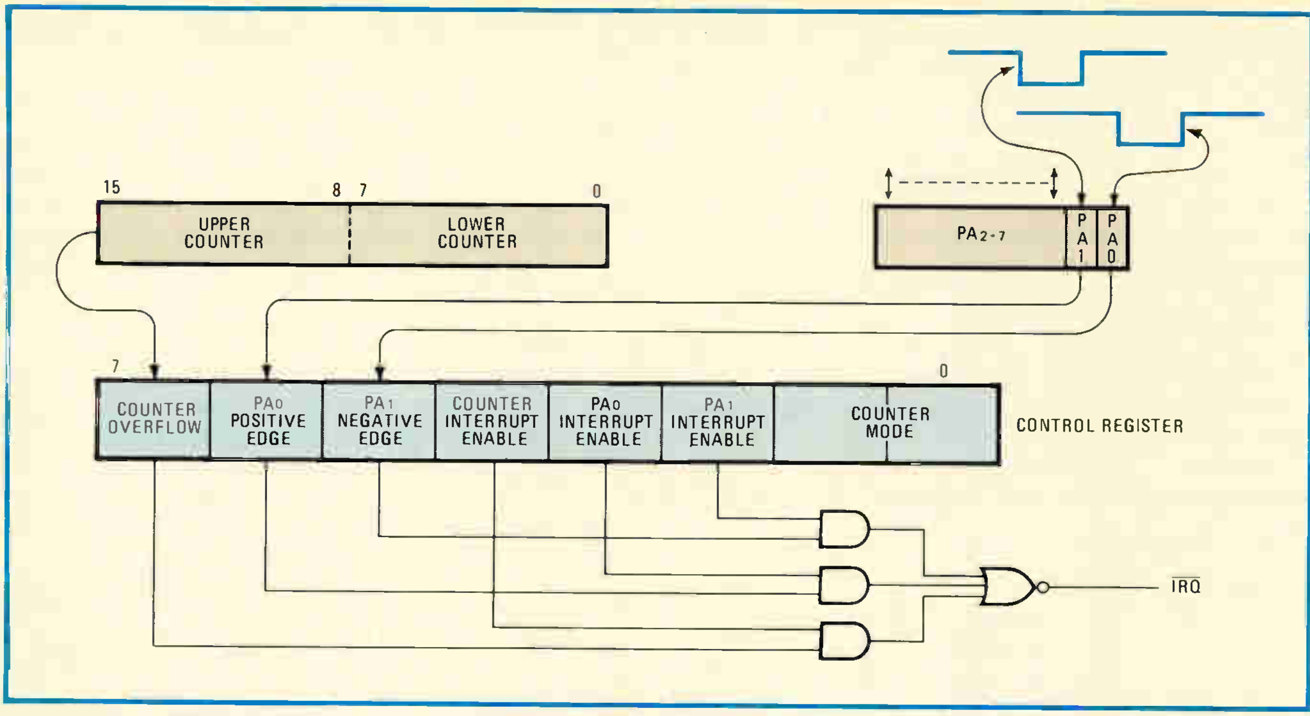
Like the 6502, the 6500/1 has two interrupt-request lines, $\overline{\text{NMI}}$ and $\overline{\text{IRQ}}$. Both are vectored interrupts that, when they are serviced, cause program-return and processor-status information to be automatically saved on the stack. The minimum interrupt response time is eight cycles until access of the first instruction of the service routine.

The $\overline{\text{NMI}}$ interrupt is used to request the higher-priority, non-maskable interrupt for critical events such as power failure. The more general-purpose interrupt is the $\overline{\text{IRQ}}$ line. Usually associated with one or more interrupting devices in a multichip 6502 system, it is basically the same in the 6500/1 except that the $\overline{\text{IRQ}}$ at the central processor is only available internally. External $\overline{\text{IRQ}}$ requests are made by means of the PA_0 or PA_1 edge-detecting circuit or by effecting a counter overflow: the different modes are shown in Fig. 5.

All $\overline{\text{IRQ}}$ requests may be enabled by clearing the interrupt-disable bit in the processor-status register. That done, each of the three sources of $\overline{\text{IRQ}}$ requests may be selectively enabled by the 3 bits in the control register. Whenever an enable bit and its associated status bit



4. The counter. The four-mode counter is programmed by 2 bits in the control register. Modes 0 and 1 are both free-running, the latter toggling the CNTR pin on overflow. Mode 2 counts down with each rising edge on CNTR, and in mode 3 CNTR gates the countdown.



5. Interrupts. The $\overline{IRQ}$ interrupt request originates from three sources that are each software-maskable: the rising edge at pin PA_0, the falling edge at PA_1, and counter overflow. The other interrupt, $\overline{NMI}$, is non-maskable and is used for critical events such as power failure.

are both true, an interrupt request will be made. The software routines for servicing interrupts read the control register's status bits to determine the interrupting source. Interrupt requests will remain until the software clears the interrupting status bit.

The emulator

The emulator version of the 6500/1 enables the designer to exploit all this capability with ease. The 64-pin package not only provides the access to internal bus signals that allows the use of external memory during the software development and prototyping phases, but it does this without detracting from any of the production version's capabilities or subtracting any of its features, except of course the masked ROM.

It also adds several control lines that can aid debugging. A typical prototype system may require as few as two components—the emulator and a 2716 programmable ROM. Since each of these requires only a 5-volt supply, only the supply for the final product is needed for the prototype. Most important, the electrical characteristics of the 34 I/O lines are the same as those of the production device.

From a software standpoint, the emulator appears to duplicate the production device. All memory- and I/O-addressing functions, CPU operations, and timing are identical. The only difference is that instructions reside in a memory external to the emulator so that modifications may continue until the program is finally ready for incorporation in masked ROM.

The additional signals available in the emulator package are the 8 lines of the data bus, the 12 lines of the address bus, the phase-2 clock signal, and the read/write control line for interfacing to external memory. The RDY and SYNC signals (not used in the production model) are also available on the emulator chip for debug control and monitoring.

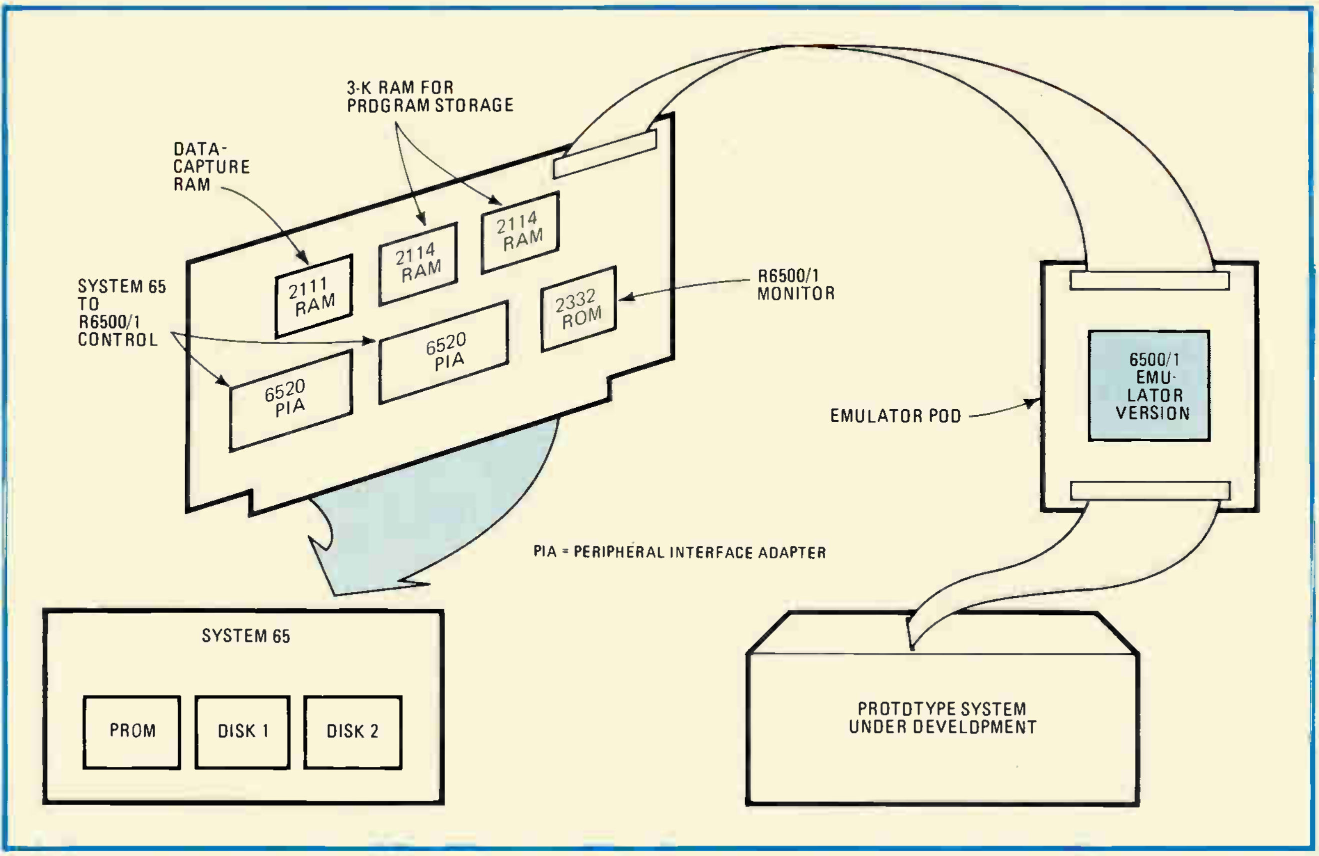
Because the address bus is available, the 6500/1 can operate with 3 kilobytes of external program memory from addresses 1,024 to 4,095 (400 to FFF in hex). During the prototyping stage, it is possible to include self-test programs in the extra, lower 1 kilobyte of memory. In addition, since the page-zero addresses of RAM and I/O are available, a digital analyzer or an external RAM may be used to capture data written to these locations for examination. Read operations from page-zero addresses only occur internally to the emulator rather than from the external data bus to ensure true RAM and I/O functioning.

Developing with the System 65

As for the System 65, it basically supports hardware and software development for the entire 6500 family of microprocessors. Itself a 6502-based system, it has dual minifloppy-disk drives and 16 kilobytes of static RAM, as well as assembler, editor, monitor, and file-management programs resident in ROM. The system may be connected to other terminals through current-loop or RS-232-C interfacing and to a dot-matrix printer for hard copy through a standard parallel interface.

Since instructions are consistent throughout the 6500 family of processors, the file management, text editor, and assembler can be used without modification in preparing software for the 6500/1. However, the monitor program used during debugging is contained in a ROM on the 6500/1's personality module and interfaces uniquely to the emulator version of the chip. Once this monitor has been entered, it remains in control until an exit command is given by the operator.

The commands used by the 6500/1 monitor are as far



6. System design. With the 64-pin prototyping version of the 6500/1 on an emulator board, external memory can be used in lieu of the chip's built-in memory. The memory board has a read-only-memory monitor that adapts the 6500/1 to the System 65 for development.

as possible the same as the 6502 monitor commands. All are of the self-prompting question-and-answer type used by the System 65. The monitor controls execution of 6500/1 programs by exercising the emulator device's extra control signals. It can force a restart to start the emulator as if power had just been turned on, and by using the RDY and SYNC lines it can single-step or halt execution. Examination and modification of the emulator's program memory is accomplished by accessing the personality module's RAM with the address assigned to the System 65. To examine the emulator's data memory and I/O, the monitor reads the capture RAM on the personality module; to modify the emulator's RAM or I/O, the monitor stores appropriate routines in the extra kilobyte of program RAM found only on the emulator, which it then forces to effect the changes by executing these routines.

Eight software breakpoints are provided for non-real-time debugging, plus one hardware breakpoint for real-time debugging. The program RAM may be write-protected to prevent the emulator from overwriting the data it stores. Writing into protected memory may still be done by the monitor program.

As errors are found, the text editor may be re-entered, corrections made to the source code, the assembler used to reassemble the program, and debugging resumed within a very short time. The fact that all these routines are ROM-resident means that no time is wasted on loading them into the system.

The personality card that matches the 6500/1 to the System 65 plugs into any slot available in the system. A typical development setup is shown in Fig. 6. On this board are:

- A 2332 4,096-by-8-bit ROM containing the 6500/1's monitor program and communicating only over the System 65 bus to the System 65's 6502 processor.
- Three kilobytes of RAM available to either the System 65 or the emulator for program storage.
- Additional RAM for capture storage of the emulator write operations to its on-chip RAM or I/O.
- Two 6520 programmable interface adapters, which control and monitor the emulator device activities and are available to the System 65 bus in a portion of the address range allotted for the personality module monitor ROM.
- Fast transistor-transistor logic to allow the hardware breakpoint, which causes a sync-pulse output on the System 65's oscilloscope connection, to operate while the emulator is executing in real time.

Drivers and receivers for the address, data, and control lines from the personality module are contained on the emulator pod module, which in turn is connected to a cable that terminates in a 40-pin plug. The plug mates with a 40-pin socket that is wired to the 6500/1 pin configuration used in the breadboard of the product under development. All of the I/O from the emulator is unbuffered, the better to simulate the eventual configuration. The 5-v power supply, as well as the reset signal, is provided by the System 65. The time-base source is a crystal on the emulator module. □

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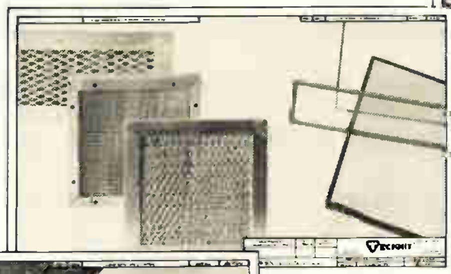

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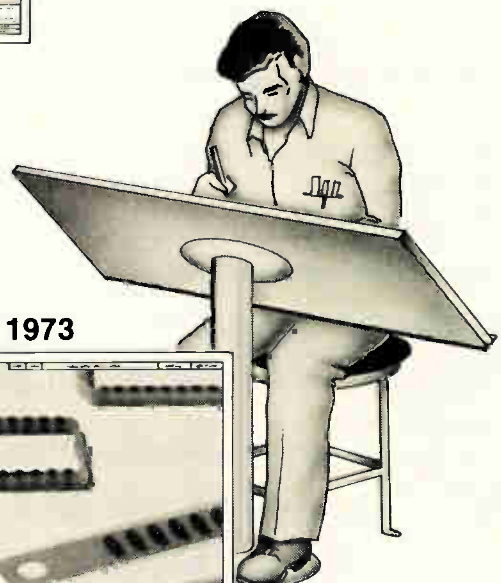

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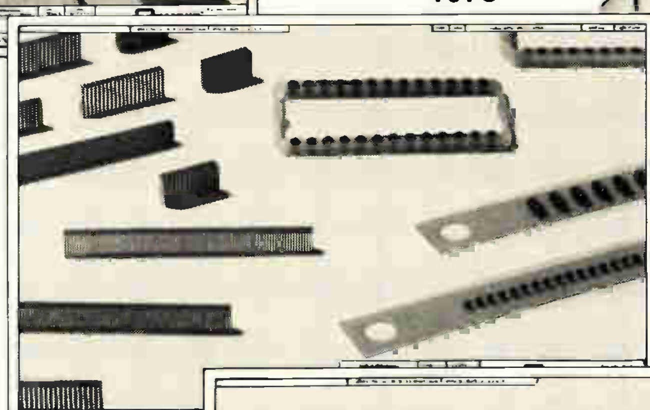

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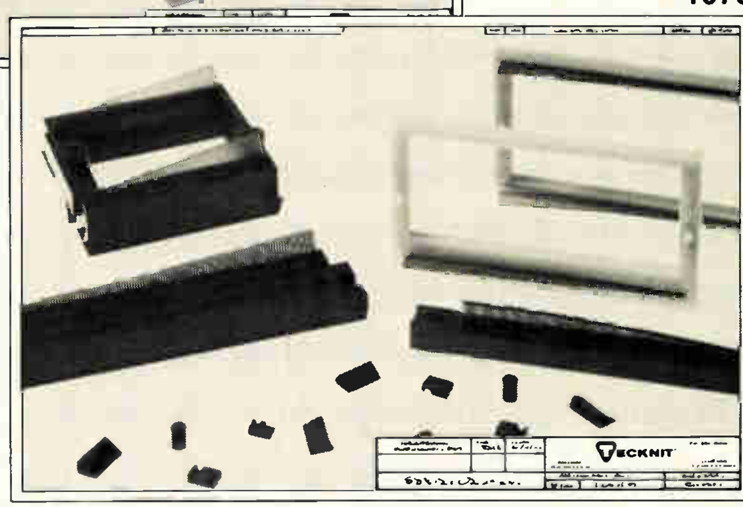

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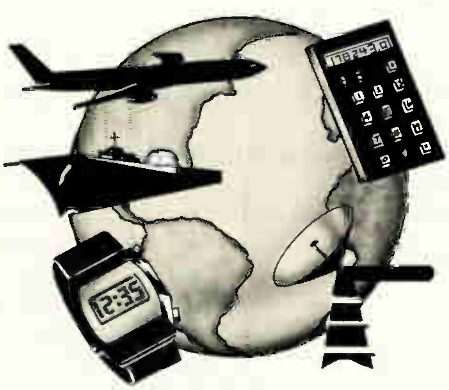

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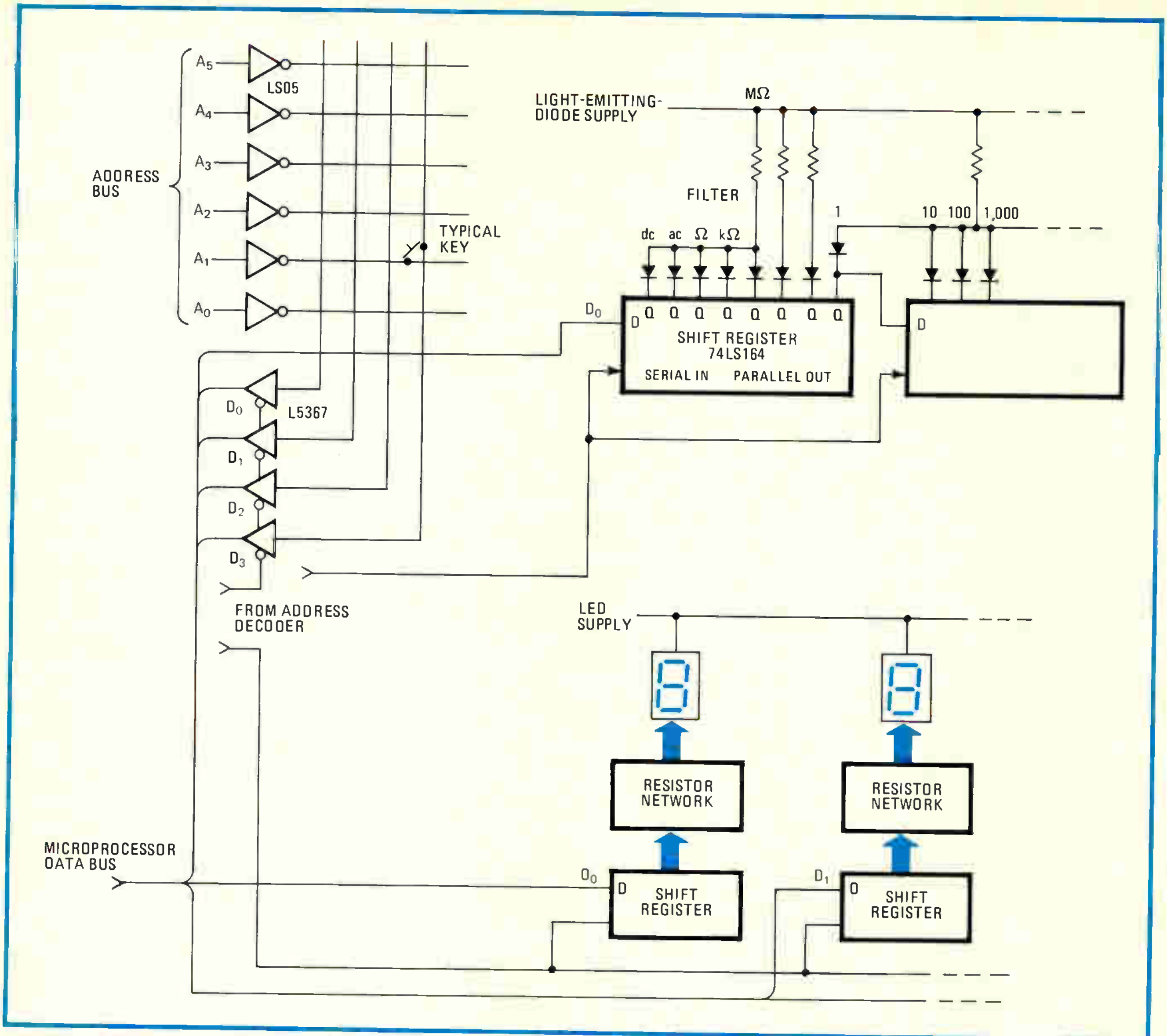


1. Slow but sure. Because much of the formatting, conversion and coding is done in software, the display/keyboard hardware in the 6000 comprises relatively few parts. Although execution is relatively slow, there is a net gain in versatility.

the display are not dependent on speedy execution.

Thus a software-intensive design approach can improve versatility. For instance, it increases the number of characters that can be displayed to over 30, which greatly clarifies certain higher math operations.

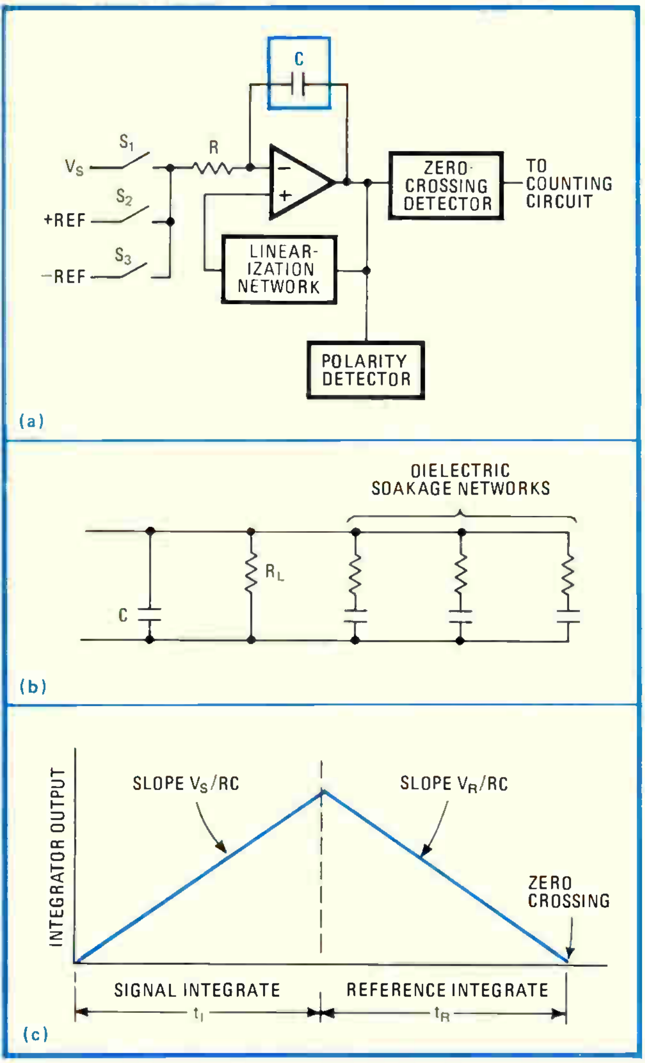
Configuring with software

Versatility also means the operator can reconfigure the instrument under software control. In the basic 6000, the microprocessor will calculate a dc/dc ratio. By adding an optional ac converter, ac/dc, dc/ac, and ac/ac ratios can be taken. Also, the user not only has the standard 10-volt reference range available, but can select almost any range usually available for the signal input. In fact, with both root-mean-square and ohms options, more than 70 combinations of ratio functions and ranges can be commanded from the keyboard or over the IEEE-488 interface.

Another area where versatility makes itself visible is the selectable integration times: five, all programmable from the IEEE-488 interface. Varying the integration time allows the 6000 to take measurements under special conditions, such as situations where the input voltage is only stable for a few milliseconds. The longest integration time, 100 ms, provides 6½-digit resolution, plus ample normal-mode rejection at 50, 60, and 400 hertz.

A microprocessor orchestrating the instrument does not in itself guarantee that versatility and utility can be achieved. If it must spend a quarter of its time trying to unjumble a poorly designed hardware-software interface, then throughput especially will suffer. The design goal was to optimize the surrounding hardware so that the microprocessor can go on to bigger and better tasks.

One common mistake of hardware designers is to assume that the microprocessor's data bus is the most efficient path for transferring control information. Actually, the data bus is best for data-dependent control information but unused or don't-care address lines are



2. Dual slope. A modified dual-slope circuit is the heart of integrating a-d conversion. A simplified circuit is shown in (a). Departure from linearity can be introduced by the capacitor C's leakage resistance and less-than-perfect dielectric (b). A compensating network can make the integrator output approach an ideal linear ramp (c).

much superior in terms of code length and speed when transferring data-independent control information. This technique is used where possible in the 6000 to improve throughput and to free more cycles for other tasks.

Selecting the microprocessor

Before the hardware-software interface could be defined in complete detail, a microprocessor needed to be selected. Since both number-crunching and control operations were required in the 6000, a general-purpose microprocessor was desirable. At that time, the Zilog Z80 and the MOS Technology 6500 were eliminated for cost and/or second-source problems. The internal architecture and speed of the Intel 8080 and the Motorola's 6800 were found to be comparable in terms of throughput and ease of programming. But the 6800 was the clear victor in the area of required power supplies and bus timing.

Six months into designing, the decision was made to move up to the 6802, which has an on-board clock driver and 128 bytes of random-access memory. The resulting computer board is less than 3 by 10 inches, yet it contains 640 bytes of RAM and 12 kilobits of read-only memory, plus address decoding for most of the hardware throughout the instrument.

Choosing the functions

With appropriate programming of the microprocessor and careful use of ROM and RAM space, a number of functions can be made available. After an investigation into some of the major uses of collected data in measurement systems, it was decided to offer such functions as offset and scaling into engineering units; capture of the minimum, maximum, and calculation of the average of a series of readings; sorting capability with as many as seven categories; and measurements in dBV and dBm. All were made available by appropriate programming of the microprocessor and the use of memory.

The offset and scaling function converts the reading into any desired units. It allows the user to do percent-error and scaling as in other instruments, as well as to correct his sensor for both offset and scale errors.

The minimum-average-maximum function, MAM, is useful for determining worst-case variations in a quantity, as well as for filtering the effects of noise. It can be left in operation for weeks at a time to determine the worst-case limits in a slowly changing quantity.

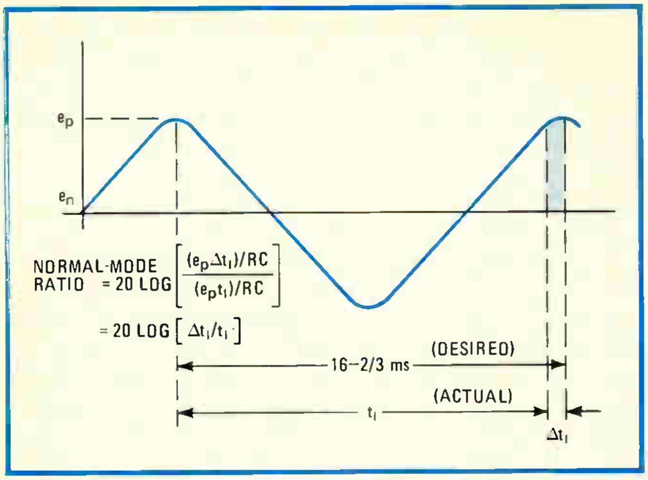
The high-low-limit function allows the user to enter between one and six limits, which are stored as category boundaries. When HLL is selected, each reading is then compared against these boundaries to determine in which category it is contained.

The decibel-measurement function provides a display in decibels referenced to 1 milliwatt into a 600-ohm load. If users choose, they can store a different resistor value from the keyboard and the dBm routine will use his entered value rather than 600 Ω. Most users will want to enter a 1-kilohm load, because this value of resistance will generate 1 mW when exactly 1 volt is applied. Thus they can measure and display decibels relative to 1 V, or the useful dBV measurement.

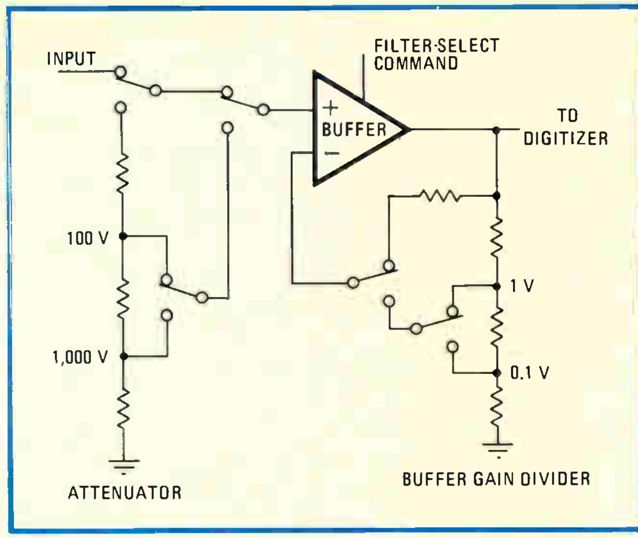
Many applications can be found in the areas of frequency analysis where, with the use of an ac converter, the dBV function can obtain audio-amplifier frequency response. A typical application might involve plotting the roll-off of an amplifier.

Here, the user would connect the excitation oscillator to the amp's input and connect its output to the 6000. After storing the R constant as 1 kΩ, he would then tune the source frequency to somewhere in the midband gain region of the amplifier. By storing the present reading as C in the math equation and selecting dB and MATH on the keyboard, the 6000 will then display exactly 0 dB. If the input oscillator frequency is then varied, it will be easy to read the −3-dB frequency or any other point of interest directly from the function generator and 6000's displays.

Internal operation of the decibel function is centered around a logarithm routine adapted from the power-series expansion, which requires the processing of at least six or seven terms to achieve the required 0.1-dB accuracy. To shorten the calculation time with



3. Normal-mode rejection. If the integration period is not identical to the power-line period, the system's rejection of power-line noise is adversely affected. An internal oscillator controls the integration period to ±.01%, essentially limiting normal-mode rejection to 48 dB with the expected 60-cycle line variations.



4. Stable elements. The accuracy of the 6000 depends on the design of the input attenuator and the stability of the isolating buffer amplifier, which also contains a selectable filter to combat noise.

the 8-bit microprocessor, Chebyshev polynomials and a specially developed compression algorithm are used. They reduce the number of operations under worst-case conditions to two multiplies and five adds, which greatly increases the speed of the decibel function.

Improving the dual-slope integrator

The integrating a-d conversion method selected for the model 6000 uses a modified dual-slope circuit because of its simplicity. Figure 2a is a simplified representation of the dual-slope integrator. Switch S_1 is closed during the signal-integrate period. At the transition from signal-integrate to reference-integrate, S_1 is opened and either S_2 or S_3 is closed, as determined by the polarity detector.

During reference integration, the capacitor discharges to zero at a rate of VR/RC volts/second. The defining relationship, assuming idealized components, is:

$$\frac{V_S}{RC} t_I = \frac{V_R}{RC} t_R$$

$$\frac{V_S}{V_R} = \frac{t_R}{t_I}$$

Note that the RC product cancels out, providing RC is constant during the measuring cycle. Maintaining a constant R is no problem, but maintaining a constant C requires a linearization network to compensate for the integrating capacitor, whose equivalent circuit appears as in Fig. 2b. The net result is to make the integrator output more nearly approach an ideal linear ramp for a step input (Fig. 2c).

Thus, with a properly compensated RC product, the converter accuracy depends just on the absolute accuracy of the reference voltage and the ability to accurately measure the integrating periods. In the 6000, the reference voltages are accurately determined to within 3 parts per million, with a 1-ppm/°C temperature coefficient and better than a 6-ppm stability for 90 days. This accurate, stable reference is achieved by using a premium-quality zener diode in a reference bridge.

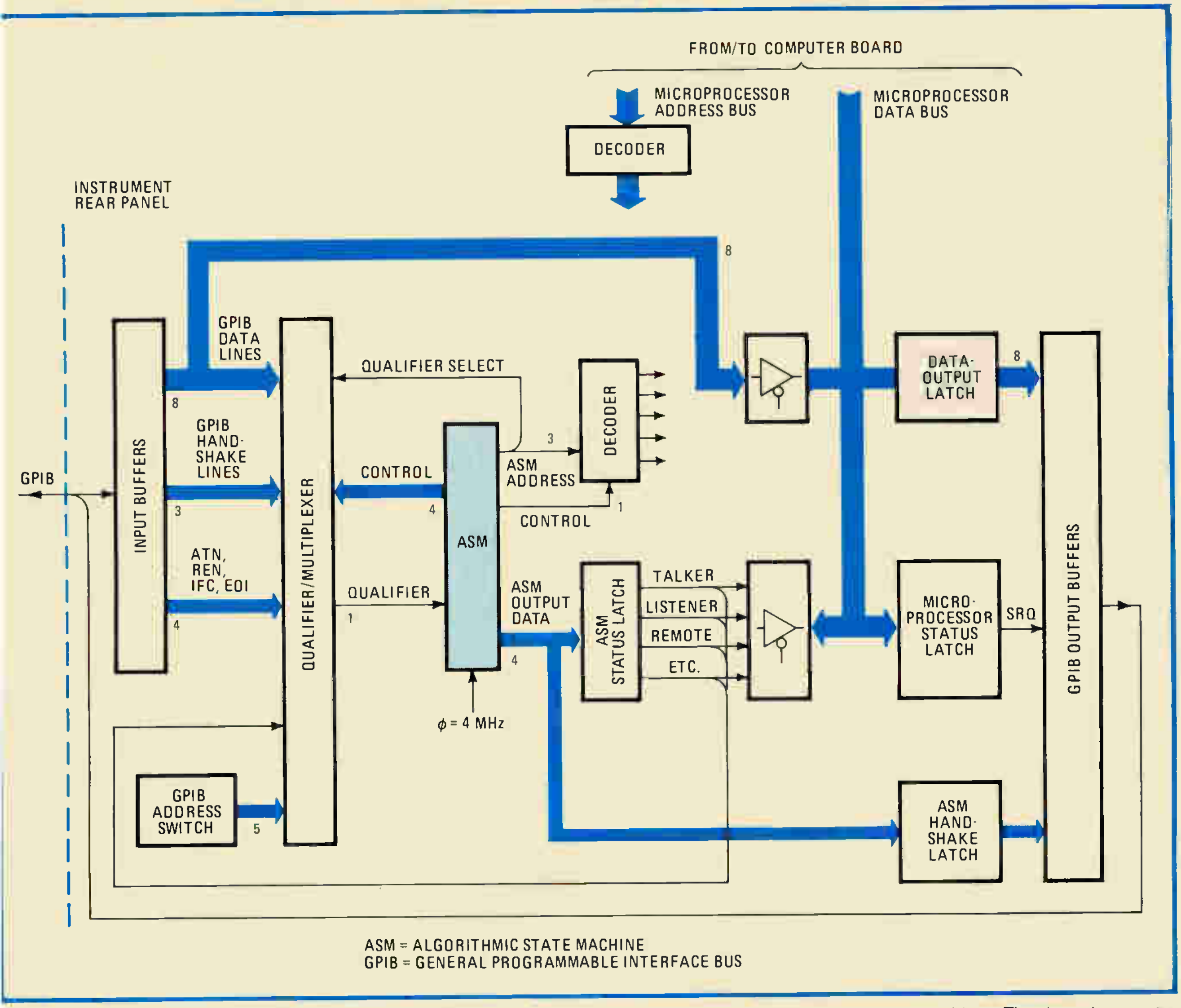
The time intervals in Fig. 2c, t_I and t_R, are determined by counting cycles of a crystal-oscillator frequency source. From the equation, it is apparent that the absolute value of the count rate is immaterial if it is stable over the measurement period. However, the normal-mode rejection does depend on the absolute accuracy of the oscillator. Thus it is necessary to use a crystal-oscillator circuit for accuracy and stability over time and temperature.

The crystal oscillator used in the 6000 has a basic accuracy of 1 : 10,000 or 0.01%. Assuming an exact line frequency, the minimum normal-mode rejection would be represented by the shaded area divided by the average area in Fig. 3. The 0.01% accuracy in frequency means the NMR at 60 Hz would be down at least 80 dB. However the actual NMR is specified to a minimum of 48 dB down, because the instantaneous power line frequency usually varies slightly from 60 Hz.

The basic 6000 also contains a signal-conditioning buffer amplifier (isolator) and an input attenuator. The isolator is a high-input-impedance, low-bias-current, potentiometric amp with selectable gains of ×1, ×10, and ×100. These gains correspond to the 10-, 1-, and 0.1-V ranges, respectively. The input attenuator offers −10 and −100 outputs for 100- and 1,000-V inputs. On these ranges, the input impedance seen by the signal source is 10 MΩ. Both the attenuator and gain resistor strings affect the basic accuracy of the instrument. Their values must be stable and accurately known.

Figure 4 is a simplified diagram of the isolator-attenuator system. Note that the isolator also contains a selectable filter for reducing undesirable noise effects.

With so many functions available, the instrument's accuracy depends on a number of elements. However, the 6000 uses both laboratory calibration and self-calibration. The primary accuracy elements—those that must be calibrated with the aid of other instrumentation—are in an easily removable reference module. This allows lab calibration of all operating functions to be performed either in the instrument or off line in a



5. Interface board. A self-contained IEEE-488 interface board is controlled by an algorithmic state machine. The board operates independently of the microprocessor. A BCD interface that occupies the same address space is also available.

metrology lab. Once the module's elements are calibrated, it may be used in any 6000 without affecting its certification. Thus instruments may be fully calibrated merely by inserting a new reference module.

Making calibration simple.

The lab-calibration process determines the actual values of the primary elements, such as the reference voltage and the gain and attenuation resistor networks. These elements are stored in a nonvolatile memory, which is a part of the reference module.

These stored constants are then used by the microprocessor system to make calibration corrections to subsequent measurement readings. Thus the primary elements need not be adjusted to exact values, so the number of adjustment potentiometers is drastically reduced. For example, the earlier model 5900, a 5½-digit, 0.001%-accuracy DVM has 14 pots in the basic model or 25 if the ohms-measuring option is installed. A model 6000 has only two pots, with or without the ohms option, and both are given a one-time factory adjustment.

In addition, the gain and attenuation resistor strings are made up of homogeneous matched resistors. This approach eliminates the need for trim pots with different temperature coefficients, thus enhancing resistor ratio tracking and stability.

In addition to the dc-voltage-measuring elements, the primary elements associated with the ohms measurement are in the reference module. These are resistors which, in conjunction with the reference voltage, generate accurate current inputs to the ohms amplifier.

The reference module also contains the ac-dc converters used in measuring ac voltages. These units must be calibrated for proper frequency response over the full measurement bandwidth.

The lab calibration procedure needs to be done only at infrequent intervals, say 90 days. However, drifts and changes in the secondary accuracy elements must be corrected for continually—but fortunately this may be done by self-calibration. The frequency of correction will depend on the length of time since power turn-on and on variations in ambient temperature. The self-calibration

The team that designed the 6000

Development of the series 6000 amplitude-measurement system covered so much ground in digital-multimeter design that, at one time or another, it involved seven engineers: half of Racal-Dana's engineering department. "It's probably the most ambitious project ever undertaken by the company," says Arch Conway, the engineering manager (left). He was development manager for the series 6000 when it got under way in September 1976, and he kept this post "because of its importance" when promoted in 1977. His background in developing the microprocessor-controlled model 9000 counter/timer in 1975 prompted the decision to put him in charge.

In organizing the project, Conway recalls, he called on seasoned engineers for the conventional areas, including analog and ac converters. But they needed help for digital hardware and software design. Given this assignment was Gregory R. Cruzan (right), a 1976 graduate of California Polytechnic of Pomona, Calif., where he was a member of the first class with extensive microprocessor exposure. "Cruzan had microprocessor experience even veteran engineers didn't have," says Conway.

In the subsequent year and a half, Cruzan came through on the job, designing about 80% of digital hardware and half the software for the 6000. Looking back, the 25-year-old thinks the major problem in building the instrument centered on the heavy real-time operating load put on it. "What I would do differently is make it less software-intensive and depend more on hardware for easing the real-time load," he says. About 60% to 65% of development time went into software, Cruzan estimates, but this could be lessened by a different tradeoff.

In practical terms, the results of this started to show up when the 6000 was assembled. "Getting it to operate in real time was a problem for a while," but normal adjustments got it going, he says.

Available components proved more than adequate to Racal-Dana's design plan, although Cruzan admits falling into a classical design trap. "We physically outgrew our memory space on the breadboards. If we hadn't upgraded with higher-density units, we would have ended up taking chips in the side."

The design team began using electrically programmable read-only memories of 512 words by 8 bits, jumped to a 1-K chip and ended up with a 2-K version. By the time the 6000 goes into volume production, it likely will have 4-K memory, he predicts. "A veteran engineer warned me that for instruments you take the alloted memory space and multiply by pi," he says, "and I should have listened."

But the company is greatly pleased with the performance of Cruzan and the other engineers. The young engineer is now as "experienced as anyone in the business at implementing microprocessors into instruments," says Conway.

In addition to Cruzan, other members of the design effort included Edward M. Billinghurst, analog circuitry; Lou Baridinio, ac converter; Nick Kapadia, parallel interface; Bruce King, software; and Michael Racelo, display software. "We were fortunate to have their skills to call on when we needed them," Conway says. **Larry Waller**

sequence is under the control of the 6802 microprocessor and is performed at intervals determined by the stored program. It may be inhibited or initiated under external control or from the keyboard to prevent any interference with measurement sequences.

At each step in the sequence, the data obtained is compared to preset limits. If any calibration measurement is outside the normal range, an error message is generated to warn the operator that the instrument may need attention before it goes out of spec. The corrections will continue to be made, but incipient failures can be detected before actual occurrence.

The 6000's hardware has been designed to allow the measuring circuitry to be disconnected from the input terminals and connected to the internal reference voltages to make calibrating measurements. All connections to the instrument remain in place; the procedure is entirely self-contained.

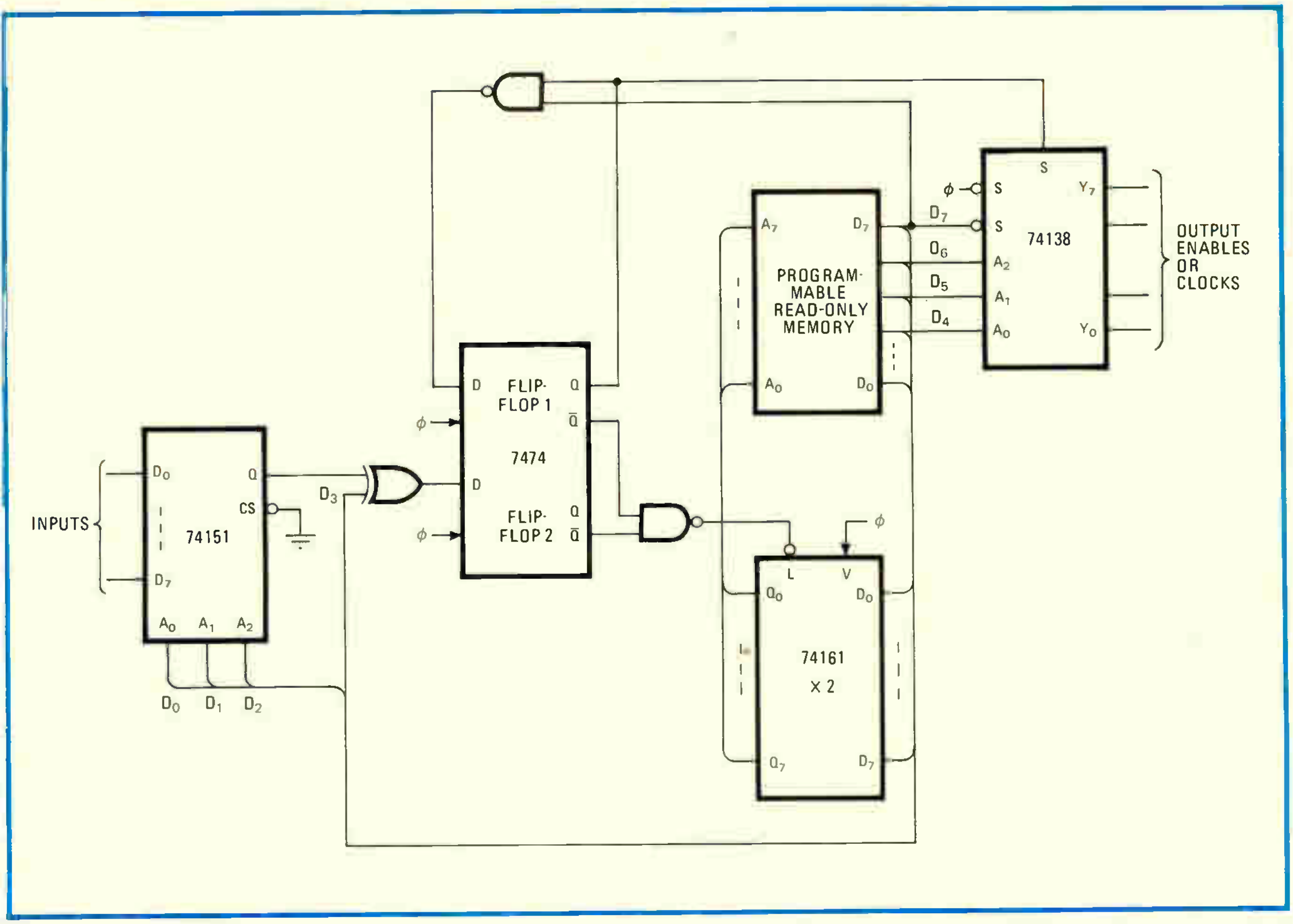
Self-calibration consists of inserting the known reference voltages or an NBS-traceable input short circuit into the isolator and comparing the measured result to the correct result. The deviations are stored in volatile RAM and then are used to correct actual readings of the inputs. The correction data are primarily offsets and scaling numbers.

The scale factors are a product of the gain and attenuation constants determined during lab calibration and constants relating to the integrator's input resistance. In Fig. 2a, the switches connecting the signal or reference voltages to the integrator are actually field-effect-transistor switches with a finite resistance. The self-calibration procedure determines the actual scale factors including the FET resistances, so that these transistors do not have to be matched sets. The instrument continually calibrates long-term changes of FET resistances and corrects for them.

Designing the system interface.

Systems people are likely to be one group that benefits most from the 6000's capabilities, and for this reason much attention was given to the systems interface. Either an IEEE-488 or a parallel binary-coded-decimal interface is available. They share the same motherboard connector in the unguarded section of the 6000 and occupy the same area in the microprocessor's 65-K address space.

Several requirements acted together to determine the characteristics of the 488 interface: increased user attention to bus-handshaking speed and response time; the need to put out readings from the optional high-speed



6. Sending data. The algorithmic state machine, a 256-word-by-8-bit variable-format design, has a microcycle time of 250 nanoseconds. It executes two types of microinstructions: store output and conditional jump, taking one and two microcycles, respectively.

digitizer at a respectably fast rate; and the need to insulate the microprocessor from moment-to-moment bus activity to improve throughput.

These requirements led to the design of a self-contained 488 interface card (Fig. 5), which is controlled by its own algorithmic state machine. It operates independently of the microprocessor and handles all interface commands on its own.

When a device-dependent message (such as function or range information) appears on the bus, the interface board sends an interrupt to the microprocessor, which then receives the byte and processes it. Sending data is also straightforward. The 6802 latches a byte into the output register, signals the algorithmic state machine, and waits for permission to latch the next byte.

The ASM is a 256-word-by-8-bit variable-format design (Fig. 6) with a microcycle time of 250 nanoseconds. Two types of microinstructions can be executed: store output and conditional jump. The store instruction requires one microcycle. Therefore it will execute in 250 nanoseconds.

The conditional jump requires two microcycles. During the first, qualifier select-and-control information is made available, along with a bit indicating the beginning of a two-cycle instruction. At the end of the first cycle, the qualifier is latched in the correct polarity to effect the conditional jump in the next cycle. During the second cycle, the jump address is placed at the parallel-load inputs to the counter and the latched qualifier from the previous cycle is allowed to determine whether a parallel load (jump) or an increment (continue) takes place.

Typical response times for the 488 interface board are well under 20 μs. The high speed of this interface allows digitizer output to the bus at more than 6,000 readings a second. This capability permits systems users to digitize fairly fast waveforms using a direct-memory-access transfer to the controller memory.

The interface hardware by itself can handle all the interface-related protocol, but it cannot act upon device-dependent messages. Instead it passes these along to the microprocessor. Having received a byte from the interface, the microprocessor then decodes it to decide what action should be taken.

The 6000 is also available with a parallel interface, allowing users of the model 5900 to move up to the 6000, in most cases. This interface permits programming of function and range via a parallel input port. Once the program has been latched, a read command can be initiated and a flag bit changes state when the output data becomes valid. Since this interface is designed to be pin-compatible with an existing voltmeter, the higher math functions are not programmable from the parallel input port. □

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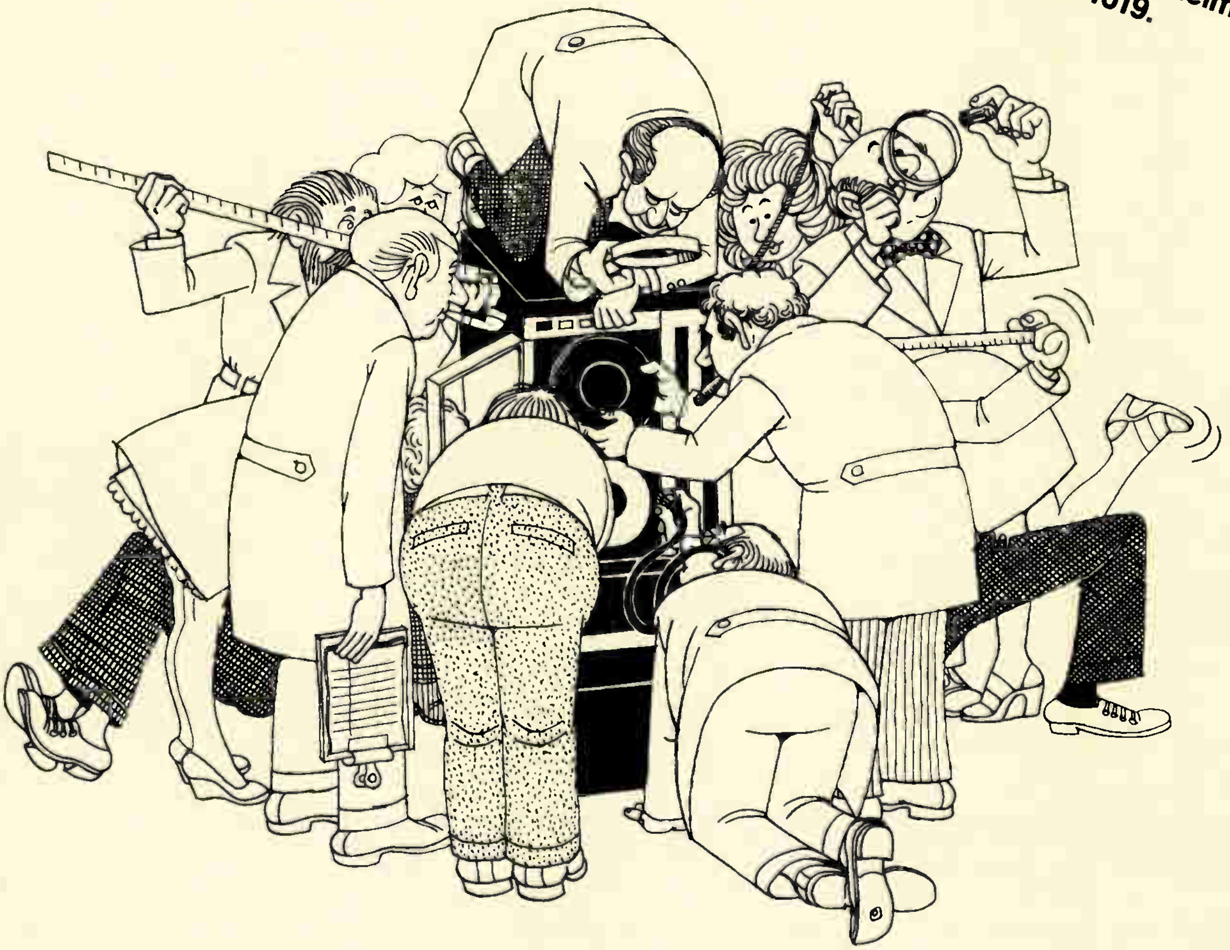

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Logic-state and signature analysis combine for fast, easy testing

Microprocessor-based tester enhances logic-state analysis with signature-analysis algorithm that operates on stored data to find hardware and software faults quickly

by Ira H. Spector, *Paratronics Inc., San Jose, Calif.*

☐ Logic-state and signature analyzers have successfully defanged some nasty testing problems found in servicing microprocessor-based products. But they have done so separately. Thus the next step up in pacifying problems of field-service fault-finding for microcircuitry is a combination: logic-state analysis enhanced by a signature-analysis algorithm that operates on stored data to identify faults within a system under test. By combining the two, it is possible to analyze collected data more quickly and to eliminate the need for special test-support circuitry within the microprocessor-based product.

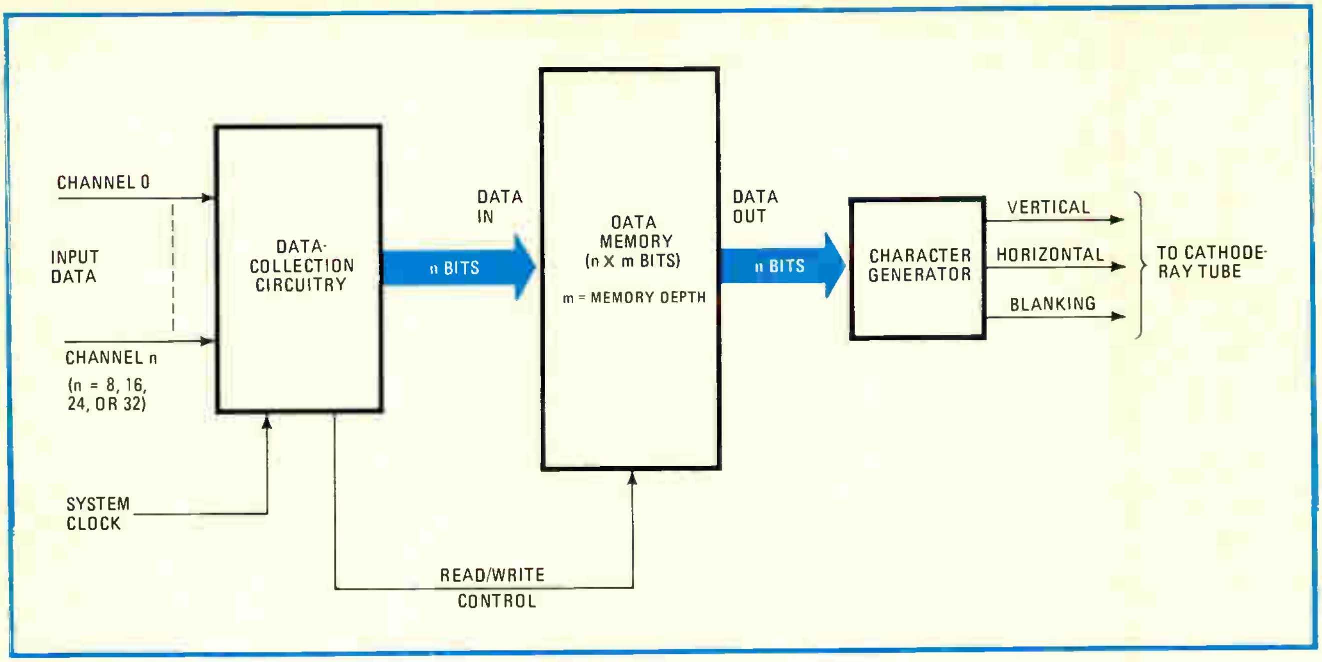
Logic-state analyzers (Fig. 1) are widely used to monitor sequential machine states and to help uncover many hardware problems such as soft address bits, missed flags, and intermittent control signals. In software debugging, the instruments have helped find programming errors, such as those responsible for sending the machine into some unwanted loop.

Spending time

However, these testers require the user to spend a great deal of time examining and analyzing captured data. The expenditure of time becomes even longer as manufacturers expand the instruments' triggering capability and memory size to increase the probability of localizing faults. This helps explain why they are not yet widely used in field-service or production applications where test time is often at a premium.

The need for simpler digital test equipment in field-service and production testing inspired Hewlett-Pack-

Fast service. Combining the best of two analyzer worlds, the model 532 captures 250 32-bit words of logic-state data and automatically computes and displays two associated signatures that identify faults in the microprocessor-based system under test.

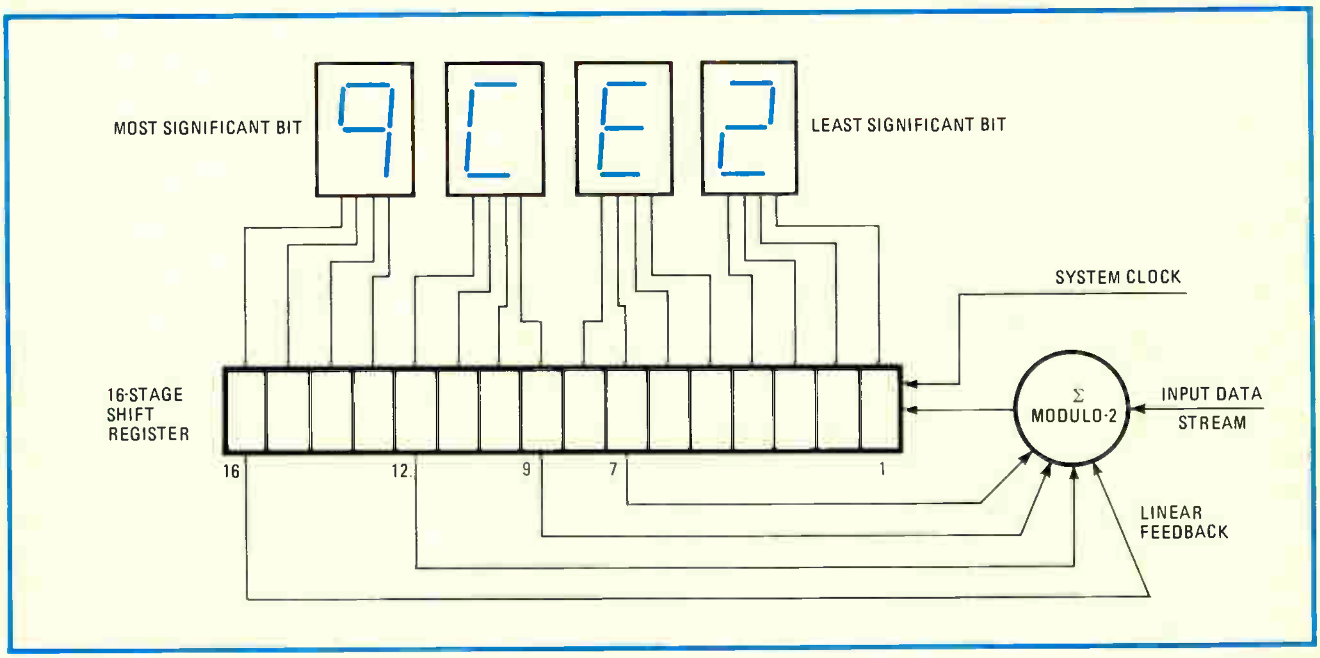


1. Localizing faults. In the basic logic-state analyzer, parallel data is clocked synchronously into a memory for later display in binary, hexadecimal, or octal notation. The instruments are widely used in monitoring sequential machine states and in software debugging.

ard's development of the model 5004A signature analyzer (Fig. 2). With a single-channel probe, this instrument captures a pulse train of digital events unique to the particular circuit node being examined. This pulse train, or serial bit stream, is fed to a linear-feedback shift register with tapped outputs driving a four-digit alphanumeric display. Each test node in a digital circuit thus is given an identifying four-character signature, much as each node in an analog circuit is characterized by an identifying voltage.

In operation, a series of signatures are computed for nodes in a known-good digital circuit and recorded on the corresponding schematic, in a troubleshooting guide, or even on the printed-circuit board itself. Circuit failures are isolated simply by moving the analyzer's probe from one test node to the next until the signature noted differs from the expected result. The component failure must be between the good and bad nodes. It is as simple as that, and a detailed understanding of circuit operation is not necessary at this point.

However, signature analysis currently works only for testing systems designed to accommodate it. For example, the system must supply a clock pulse to load the bit stream into the analyzer's shift register. It must also



2. Watching digits. In the basic signature analyzer, a single-channel probe catches a pulse train unique to the node under examination. Passing this train through a linear feedback register gives an identifying signature that can be compared with that of a known-good node.

A look at two signature-analysis algorithms

Signatures can be created from data streams using algorithms implemented in either hardware or software. The conventional single-channel signature analyzer employs a hardware technique based on a 16-bit linear-feedback shift register. The algorithm in the model 532 differs in two respects besides its implementation in software. It operates on parallel, rather than serial, data streams, and it operates on data that has already been collected, rather than in real time.

In the hardware approach, the feedback mechanism consists of a modulo-2 summation of selected taps of the shift register with the input serial data stream. This arrangement falls into the category of a cyclical redundancy check and is well documented in the literature of information theory.

Sampling signals that are supplied by the circuit under test precisely define the duration of the bit stream. When sampling is halted, a residue of the original serial data is left in the register. Because of the feedback, this residue, or signature, is as representative of events occurring at the beginning of the stream as it is of those at the end. [*Electronics*, March 3, 1977, p. 91.] To cite some of the error-detection properties of this technique:

- The probability is 1 (100%) that two identical serial bit streams will produce the same signature during testing.
- The probability is 0 that two serial bit streams will produce the same signature if they differ by precisely 1 bit.
- The probability is 2^{-16} or less that two serial bit streams will produce the same signature if one stream has multibit errors disclosed during testing.

For the software approach, the signature algorithm begins by zeroing the accumulator in the 532's microprocessor. The first word in the data memory is then added to the contents of the accumulator, generating a sum. The next word is added to this sum, generating a new sum plus a carry bit that is saved. This process, including adding in the carry, continues until all the data words contained in the memory have been processed. The final carry is discarded, and the resulting sum is a residue or signature of the memory contents.

Saving the carry at each step and adding it to the intermediate sum in the accumulator performs a function similar to the tapped bits in the linear-feedback shift register to the extent that this action ensures that all words in memory equally affect the outcome of the final signature. If the length of the data word is 16 bits, the error-detecting properties of the resulting four-digit signature are similar to those for the hardware approach.

upply specific start and stop signals so that the duration f the stream is defined and repeatable, and it must have rovisions for exciting normally static nodes while breakıg digital feedback paths in order to avoid signature mbiguities.

To accomplish this, the product's design must include pecial hardware and software to support the test instruıent: something that may not be feasible when board or ırogram space is at a premium. It is for this reason that he signature analyzer is not yet found in widespread use n the field.

Combining the two

The new model 532 logic-state and signature analyzer overcomes many of the problems of the two individual nstruments. It computes two four-digit hexadecimal ignatures after each data collection, one for each sepaately clocked 16-channel half of the analyzer's 32-bit-wide memory. After each collection, both 16-bit ıalves are processed, word by word, using a add-andcarry algorithm of the residue type (see "A look at two signature-analysis algorithms").

The resulting pair of four-digit hexadecimal signaures appears on the front-panel display of the instruıent. Also, it can be written out on an oscilloscope, along with a 16-word page of data (Fig. 3). In much the same way that the single-channel signature analyzer converts a complex serial bit stream into an identifying four-digit code, the 532 compresses the entire contents of its 32-bit-by-250-word data memory (8,000 bits total) into two four-digit words.

For a given test setup, the memory will contain a specific, repeatable set of data for which a unique signature pair can be calculated. As long as the system under test is operating properly, this setup will continually yield the same signatures. Once even one bit of the entire set of collected data changes, the associated signature comes up differently.

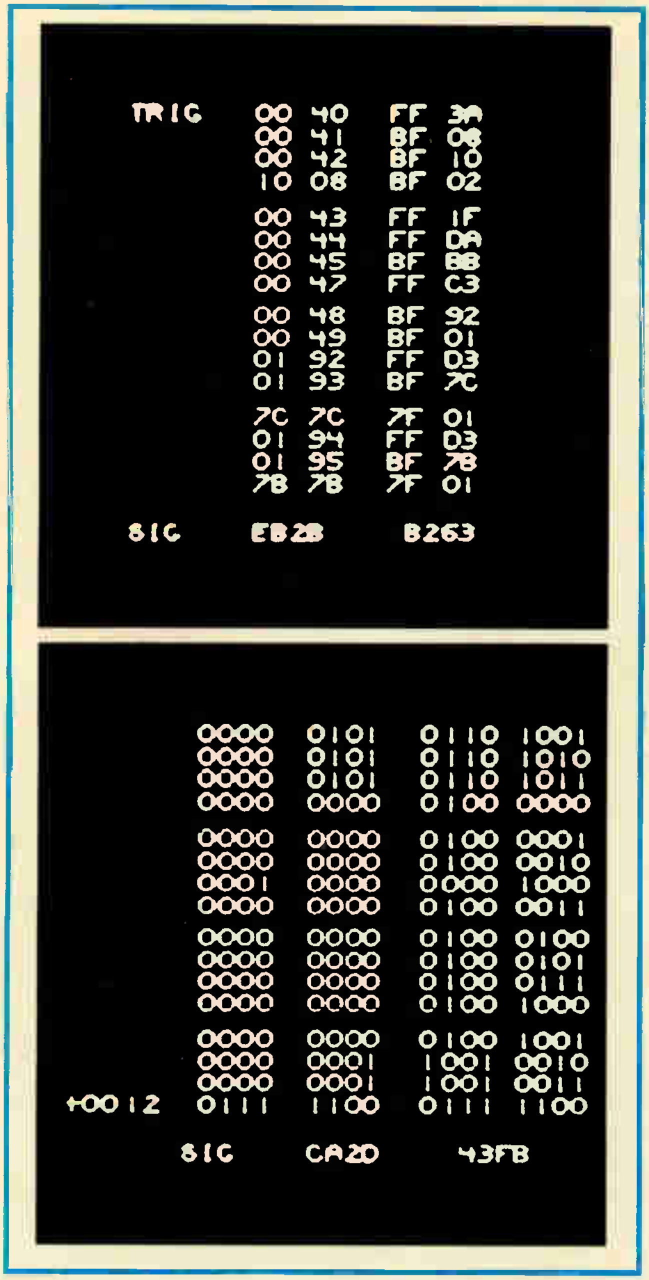
Since these signature calculations are performed on the data gathered by the 532 in its normal course of operation, no special hardware or software support features need be integrated into the system under test when it is designed. Also, the large amount of data collected by the instrument's memory, which would present a formidable analysis task for the user, is analyzed in a single stroke. This feature is particularly helpful when comparing sequential data collections in search of the problematic one.

The signature-analysis feature of the 532 can also be used to verify that the instrument itself is working properly. For example, it has a back-panel self-test port to accept the data-input probes. Each time the unit is turned on, a special routine is executed. If the resulting signatures are correct, the user is assured that the entire instrument is operational.

Operating the 532

A good example of the 532 in operation is a simple microprocessor-based controller. This unit is to be used in a relatively severe industrial environment, and it is the designer's job to determine if it will meet its performance specifications under simulated operating conditions. Random bursts of electromagnetic interference, variations in supply voltage, and changes in temperature are common examples of these conditions.

To assess the controller's susceptibility to operational failure, it is essential to view simultaneously as many critical signals as possible. In the test setup (Fig. 4), 32 signals are monitored: the 16-bit address bus, the 8-bit data bus, and eight status signals. The system is first



3. Identifying data. The data in the model 532 main memory can be displayed in the form of 16-word pages on a scope in hexadecimal (top) or binary (bottom), along with the identifying signatures.

operated under benign laboratory conditions to verify proper program execution and to compute a known-good signature pair. The designer need not calculate these signatures in advance, since the 532 does that. Thus, the measurement can be treated as empirical, just as it is when a signature analyzer is used alone.

With the expected four-digit codes recorded and the process controller's program in a loop mode, the designer can vary the environmental conditions while watching their effect on the displayed signatures. For example, a lowered supply voltage may increase the product's susceptibility to externally generated emi such that one or more of the data or status bits comes up in the wrong state. Then the associated signature will change.

Immediately the designer knows that the simulated environmental conditions are beginning to affect system performance, although the particular failure may not have been catastrophic. In fact, were it not for the use of logic-state signature analysis in the test setup, minor failures might even go unnoticed.

Adding auxiliary memory

In this controller example of a 532 at work, the sudden signature change indicates that a failure has occurred. What step of the program and which bit or bits of the associated data or status word are responsible? Without painstakingly recording and comparing the expected data with the erroneous collection, all the designer knows for sure is that an error has occurred. The location is still a question mark.

However, storing a set of known-good signatures and data in an auxiliary memory of the 532 turns precise identification of the problem area into a simple two-step process. The first is to capture data into the main memory from the system under test and compare the resulting signature pair with the expected values in the auxiliary memory. The instrument does this automatically, and any differences are flashed on the display. Once a difference is noted, the second step is a bit-by-bit comparison of the 8,000 bits of data in each of the two memories. Again, the 532 does this automatically, and any discrepancies are highlighted.

For example, if the failure is due to one of the status bits misbehaving in step 107 of the controller's program, the precise bit responsible is immediately evident. Investigating further, the designer might find that the corresponding address word, which is also displayed by the 532, has a number of lower-order bits change from all 1s to all 0s just as step 107 occurred. Perhaps the internally generated noise associated with the address transition has caused that particular status bit to fail. To find out, the analyzer's trigger output can trigger an oscilloscope on step 107 as the designer views the suspect circuitry with the scope's probes.

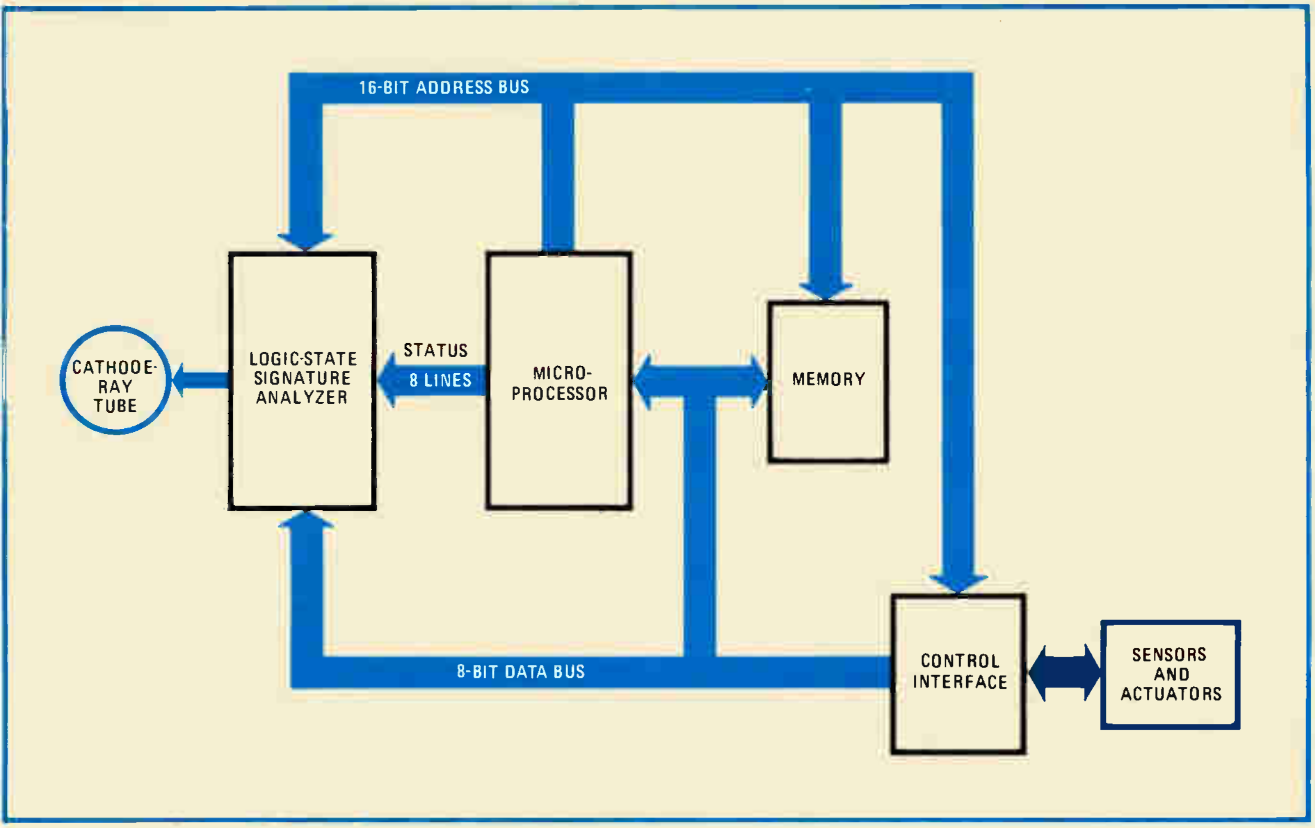
Using the 532 in the field

Combining auxiliary memory with logic-state analysis and signature analysis clearly makes the resulting instrument package more useful in field-service applications. This usefulness can be enhanced by a nonvolatile auxiliary memory that contains both the expected data and signature for a given application.

The 532's auxiliary memory incorporates seven programmable read-only-memory chips for nonvolatile storage, as well as a random-access memory for temporary storage. Each of these eight memory elements can store a complete 32-bit-by-250-word data collection and the corresponding signatures.

The contents of the main memory are transferred to the selected auxiliary memory element by a front-panel keystroke. In the case of the programmable ROMs, the instrument first checks to see if the selected device is blank before transferring the data and signature via internal programming circuitry.

Using this technique, the results of seven tests performed on a known-good system can be carried along



4. Checking a controller. In monitoring the performance of a microprocessor-based industrial controller, the 532 is first used with the product operating under laboratory conditions. Then it looks for signature changes as the environmental conditions are varied.

with the field engineer on a service call. To make the visit faster and easier, the 532 incorporates a learning mode in which the actual control settings used to collect the known-good data and signatures are automatically programmed into the auxiliary memory.

Replicating known-good data

When the field engineer wants to execute a particular test, the configuring of the instrument for that test—including setting up the triggering words, collection modes, clock or loop delays, etc.—is performed automatically. In this manner, he knows that the test performed on a known-good system can be replicated in the field. Otherwise there would be no positive way of knowing whether comparisons between field- and factory-generated data are truly valid.

The RAM in the auxiliary memory can also be useful in the field. If the seven basic tests in the PROMS are not enough to find the problem, additional tests may be down-loaded into the RAM over a telephone line, using a standard modem and the instrument's RS-232-C interface. Such a test would operate the same way as the tests in PROM. Test setup and execution are entirely automatic and under remote control. After new data is collected and compared with the stored values, the results of this comparison, including the associated signatures, can be sent back over the telephone line to the factory, which is better equipped to deal with difficult problems.

It has been said that it is sometimes easier to build a product than to test it. This is particularly true for microprocessor-based systems in which production test stations are complex setups that require highly trained personnel to operate them.

Where the logic-state analyzer and the signature analyzer may individually fail to satisfy the unique demands of the production-test environment, a combined instrument has a better chance for success. The logic-state signature analyzer offers a rapid go/no-go indication using its signature-analysis feature, automatic test execution, hardcopy output via its RS-232-C interface, and a broad monitoring capability of critical system signals. The 532 also includes an IEEE-488 interface for the execution of a series of production tests under the control of an external computer.

Circumventing limitations

The combined technique can circumvent some of the limitations of logic-state and signature analysis, particularly when teamed with an auxiliary memory. However, one should note that it is not as simple to use as the single-channel signature analyzer for finding a faulty component in a circuit.

The 532 is more of a general-purpose instrument in its analytic approach and does not rely on product-supplied hardware and software to support testing. Thus, bits flashing on the display will only have relevance for fault-isolation purposes to the user with an understanding of the circuitry involved. But, for a quick overview of system operation as well as an in-depth look into the complexities of the circuitry involved, the combination of logic-state and signature analysis is useful in a variety of test situations. □

Proper filter choice eliminates oscillations in dc-dc converters

by Joseph Perkinson
Semiconductor Circuits Inc., Haverhill, Mass.

Designers often call upon a low-pass LC filter to reduce system noise entering a high-efficiency dc-dc converter. But often as not, they end up with an oscillator instead, if the converter has a negative input impedance and the filter's values are inappropriate. The oscillatory condition can, however, be avoided if the converter's input impedance is known, because then it becomes possible to select components for the filter that will prevent it from exchanging energy with the converter, in effect preventing the converter from turning into a negative-resistance voltage generator.

Dc-dc converters that have an efficiency of 70% or higher and that accept input-voltage variations of 2:1 or greater are the most vulnerable to oscillation when there is a negative input impedance. Generally, this happens if the current measured at the input of a converter decreases as the input voltage increases. Although this impedance can be determined graphically from data sheets, it is better to determine it analytically since this yields a greater understanding of the problem. It can be done if the converter's efficiency is known and, according to the data sheet, remains fairly independent of input-voltage variations.

Such an analytical solution is less time-consuming and involves less lab work than using data sheets to determine the relation between the converter's input resistance and the LC filter's constants. (Note that, at low frequencies, the terms input impedance and input resistance may be used interchangeably.) Shown in (a) of the figure is a typical input characteristic of a typical dc-dc converter. The curve is a hyperbola, meaning that:

$$V \cdot I = P_{in} = \text{constant}$$

or:

$$dV/dI = -P_{in}/I^2 = -V^2/P_{in} = R \qquad (1)$$

Now assume that an LC filter is placed at the input of the converter. As shown in (b), the network the converter sees when looking back from its input is a parallel-resonant LC filter having an impedance at resonance of:

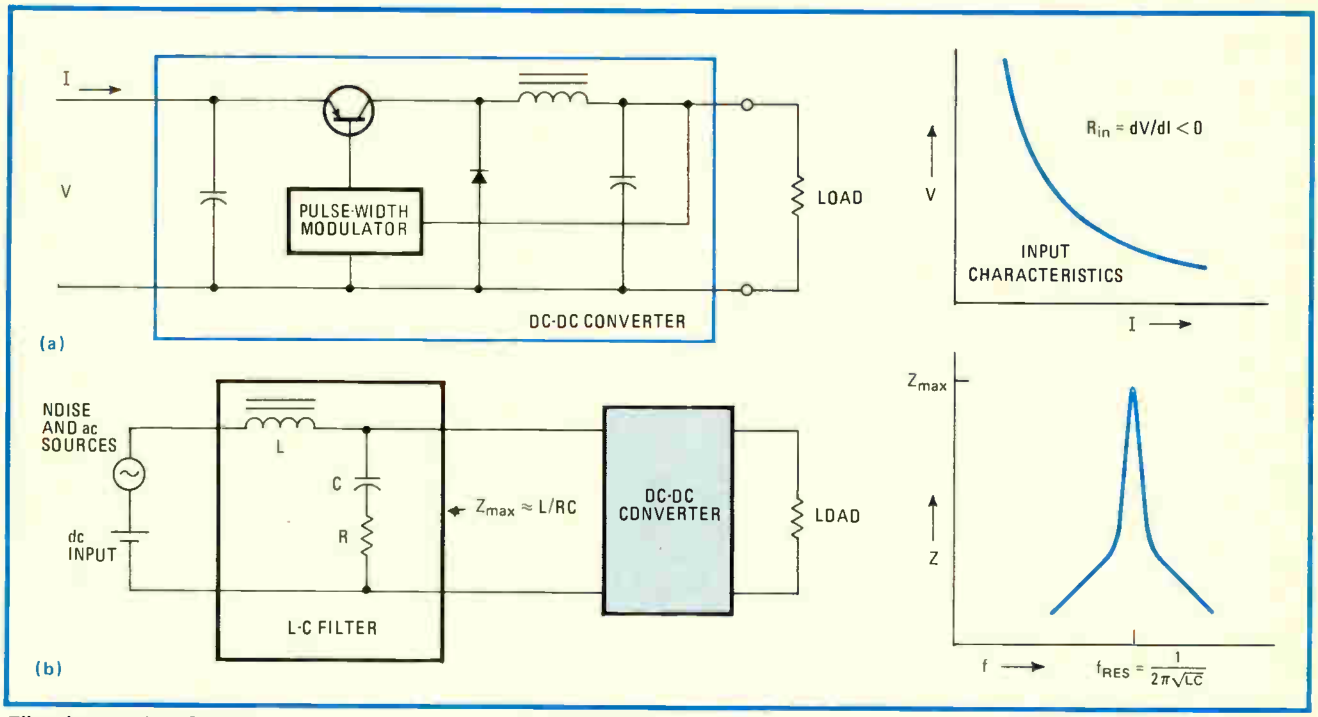
$$|Z_{max}| = L/CR \qquad (2)$$

where R is the equivalent series resistance of the capacitor and $|Z_{max}|$ represents the impedance of an undamped (medium Q) circuit.

The converter-filter impedance of the (parallel) is thus expressed by:

$$R_T = 1/(1/Z + 1/R_{in}) \qquad (3)$$

Oscillation results when $R_T < 0$. In other words, unless $L/CR < R_{in}$, the converter-filter combination will oscil-



Filter interaction. Switching dc-dc converter (a) exhibits negative input impedance, causes converter/noise-filter combination (b) to oscillate at f_{res} if $Z_{max} > R_{in}$. For proper filtering, and to eliminate the possibility of oscillations, filter's L-to-C ratio must be reduced.

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late at the resonant frequency of the filter, and this condition must be avoided.

An example will underscore the usefulness of Eq. 3. Assume that a dc-dc converter with an input power of 50 watts and an input voltage range of 10 to 40 volts has a negative input resistance. Also, assume that the dc power-distribution system limits the input ac currents to the converter to less than 20 milliamperes peak to peak at 20 kilohertz, but that the actual input current waveform has a 5-ampere peak amplitude at 20 kHz.

If the LC filter values are arbitrarily selected for L = 75 microhenries and C = 470 microfarads, the filter cutoff frequency will be about 850 hertz, which offhand would seem a suitable value for amplitude and noise reduction. But from Eq. 1, given V = 10:

$$R_{in} = -10^2/50 = -2 \text{ ohms}$$

and from Eq. 2:

$$|Z_{max}| = 5.33\Omega$$

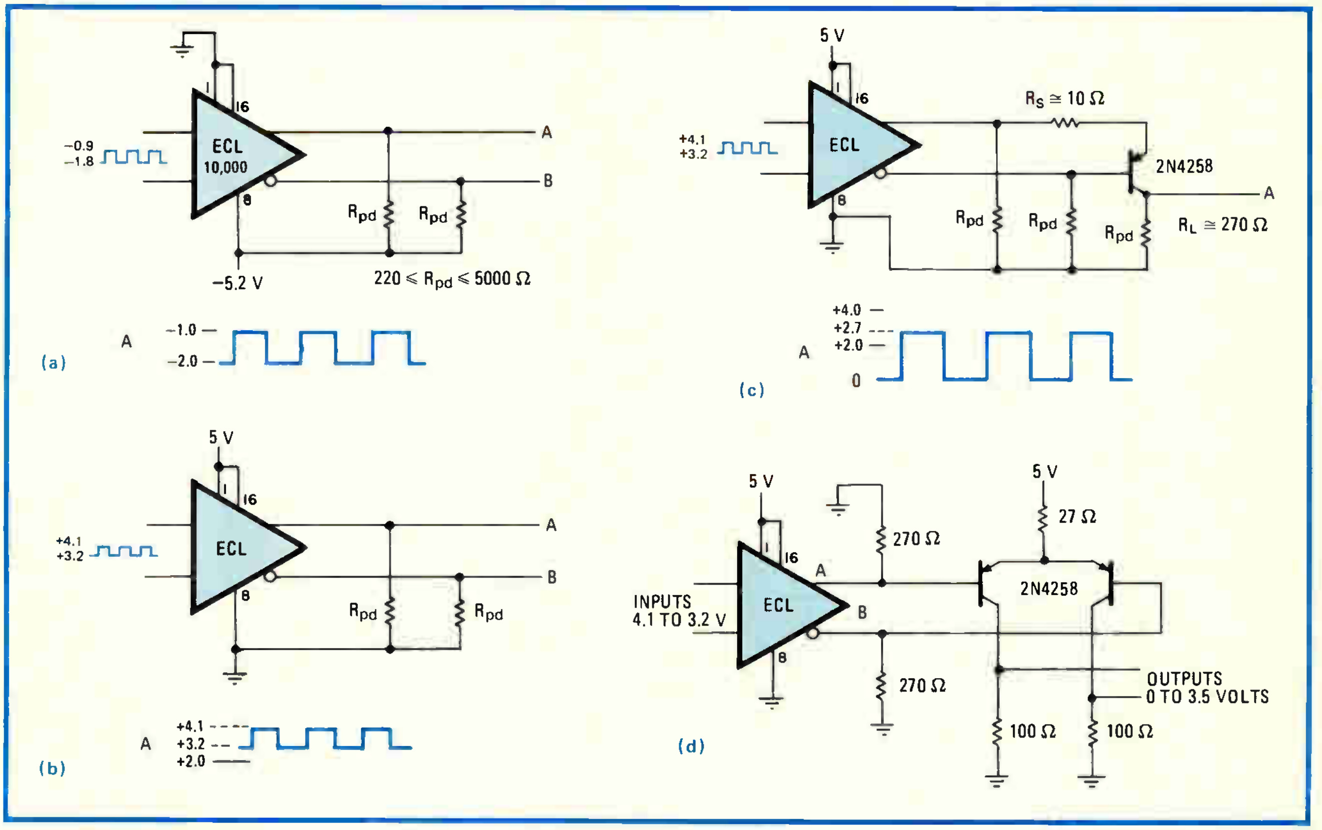
for R = 30 mΩ. Then $5.33 > |R_{in}| = 2$, and oscillation occurs. If the converter's input characteristic cannot be altered, then other values for L and C must be selected independently of the resonant frequency. □

Appropriate biasing mates ECL and TTL families

by William A. Palm
Magnetic Peripherals Inc., Minneapolis, Minn.

The speed and flexibility of emitter-coupled logic can be combined with the convenience of transistor-transistor logic in circuits that work over a wide range of frequencies. The easiest and most economical way to mate the two logic families is to adapt ECL to the 5-volt operation of TTL, since the rebiasing of ECL elements is easily accomplished. Then the circuits can be powered by a single supply voltage.

Emitter-coupled logic is costly and draws considerable power at higher frequencies. So there is little sense in using it throughout in such a circuit as a 100-megahertz counter/divider, for example, when the part of the circuit that operates at lower frequencies could be implemented with TTL. As shown in (a), the typical dual-output logic gate in the Motorola 10,000 series requires a supply voltage of −5.2 V, conventionally wired as shown in (a). ECL circuitry is so configured that such a



Evolution of an interface. Standard emitter-coupled logic is powered by at least one negative voltage, cannot drive or be driven by TTL (a). Re-biased ECL device generates positive output voltage, but not within proper TTL switching threshold range (b). Adding a transistor enables 0–2.7-V swing, suitable for TTL (c). Five-volt ECL gate and two transistors drive 100-ohm TTL loads at 0–3.5 V (d).

gate will operate if there is a supply voltage differential of 5 V between pin 8 and pins 1 and 16, independent of the actual values as long as they are within device limits. Thus, it is permissible to place a 5-V supply voltage at pins 1 and 16 and to ground pin 8 as shown in (b).

This arrangement is not suitable for driving TTL because an input of 3.2 to 4.1 V results in an output voltage swing at point A of only 3.2 V (logic 0) to 4.1 V (logic 1). But note that the voltage at B is the inverted output of A. By using both outputs and adding a transistor to shift the output swing levels (c), approximately 10 milliamperes is made to flow through the 270-ohm collector resistor at point A when the transistor is saturated. Thus there will be a 2.7 V drop across R_L when the transistor is on, and the voltage will go to zero when the transistor is off, enabling TTL elements (or any other elements, for that matter) to be driven.

The fourth circuit (d) is useful in applications where considerable speed and output current are required to drive a balanced load. There will be a 1-V drop across the 27-Ω resistor during the time each transistor conducts, and so 35 mA will flow through the 100-Ω collector resistors. Thus 3.5 V will be developed at each output. This circuit is suitable for driving a 100-Ω twisted-pair cable. □

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.

Calculator notes

HP-25 finds maneuverability constraints for large cabinets

by Robert P. Owen
Burroughs Corp., Pasadena, Calif.

As anyone who has struggled to fit a large piece of electronic equipment into an office knows, it's a good idea to calculate in advance the maximum size of cabinet that can pass through all the doors and corridors on the way to the equipment's final home. This program is a quick way of determining, given doors and corridors of specific widths, what is the largest cabinet that can pass through them or whether an existing cabinet will negotiate them successfully.

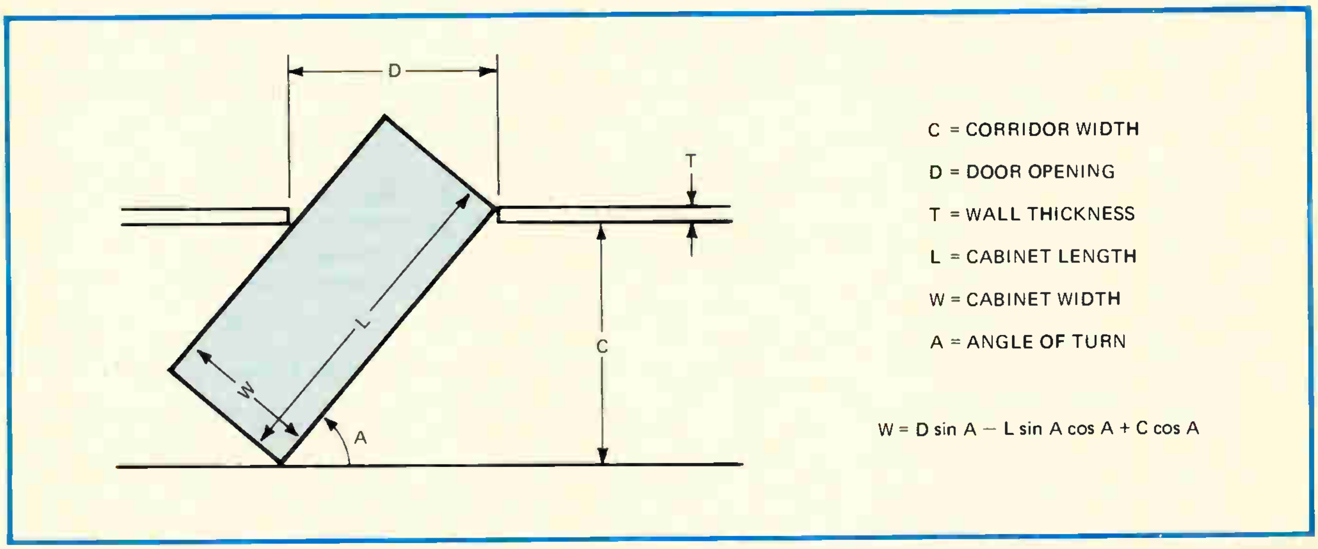
The plan in the figure shows the various widths, openings, and angles needed to solve the problem. The limiting factor that determines whether or not a cabinet is too large for an opening is its width. The relationship of this parameter to the others shown, when the cabinet is in its worst-case position, is:

$$W = D \sin A - L \sin A \cos A + C \cos A$$

Solving this equation with the HP-25 calculator pinpoints the maximum possible cabinet size for a given L, C, D, and T. Note that T (wall thickness) does not appear in the expression for W, although it is used in the application of the equation.

Unfortunately, the maximum value of W cannot be found directly, so that the equation must be solved repeatedly for incremental changes in A. To use the program, store the values of C, D, and T in registers R_1–R_3, specify L, and then execute the program.

Initially, W is set equal to C in lines 5 and 6 of the program and then is placed in R_5. Lines 26 and 27 determine if the current value of R_5 is indeed the maximum permissible value. If not, lines 31–39 determine if the cabinet has cleared the specified wall thickness. Calculations stop either when W is maximum or when the cabinet clears the door opening. Otherwise, the calculator updates A in 1° steps and places its current



Tight fit. HP-25 program finds the largest equipment-cabinet width, W, that just allows it to pass through door opening. Calculation stops when the maximum value of W is found or when it is determined that the cabinet corner just clears the wall.

value in R_4, then recalculates for W, placing its new value in R_5. The process is repeated until the program can end. To save needless iterations, an arbitrary initial angle of 31° is set by lines 2, 3, and 7 in the program. But for cabinets that are very long in relation to corridor width, it may be necessary to modify the program by using a starting angle of less than 31°.

The program should not be applied to cabinet lengths that are less than the corridor width. In these cases, of course, the cabinet will fit if W is not greater than D.

As an example, consider the case where it is desired to pass a 60-inch-long cabinet (L) along a 48-in.-wide corridor (C) and through a 30-in.-wide door passage (D) having 6-in.-wide walls (T). Keying the required values into the appropriate registers and executing the program reveals that W may be a maximum of 23.9 in., and the angle of turn required to fit the cabinet through the door is 58°. The entire calculation takes 3 minutes. □

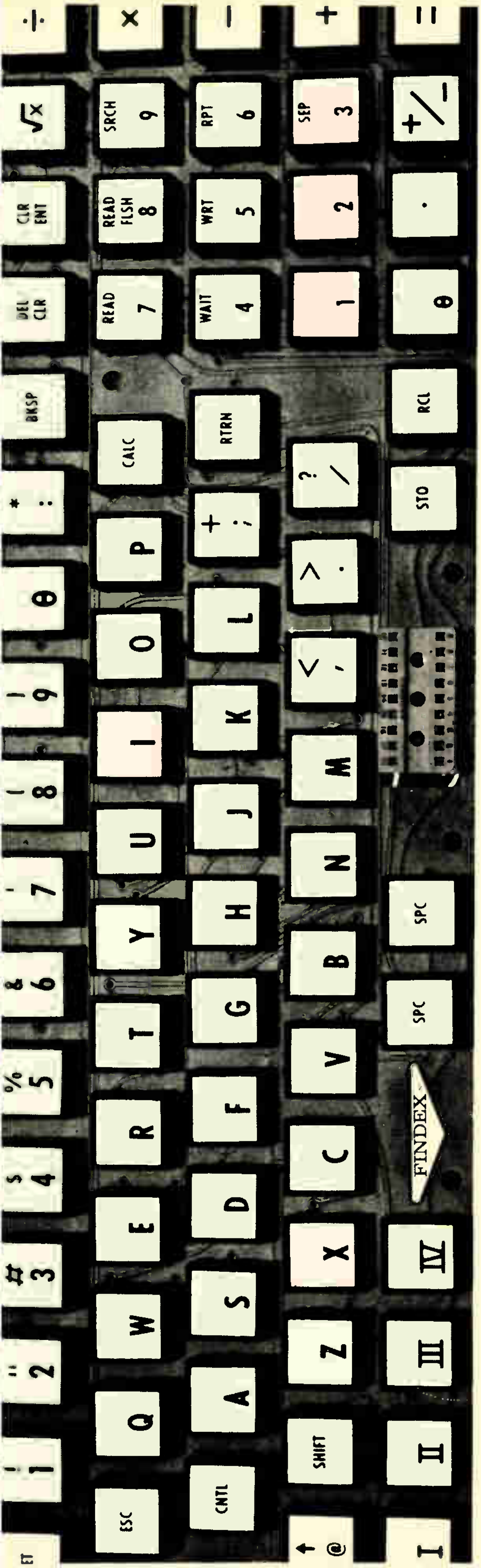
HP-25 CABINET-MANEUVERABILITY PROGRAM

Line	Code	Key
01	23 00	STO 0
02	03	3
03	00	0
04	23 04	STO 4
05	24 01	RCL 1
06	23 05	STO 5
07	01	1
08	23 51 04	STO + 4
09	24 02	RCL 2
10	24 04	RCL 4
11	14 04	f sin
12	61	x
13	24 00	RCL 0
14	24 04	RCL 4
15	14 04	f sin
16	61	x
17	24 04	RCL 4
18	14 05	f cos
19	61	x
20	41	–
21	24 01	RCL 1
22	24 04	RCL 4
23	14 05	f cos
24	61	x
25	51	+
26	24 05	RCL 5
27	14 41	f x<y
28	13 41	GTO 41
29	21	x ≷ y
30	23 05	STO 5
31	24 01	RCL 1
32	24 03	RCL 3
33	.51	+
34	24 00	RCL 0
35	24 04	RCL 4
36	14 04	f sin
37	61	x
38	21	x ≷ y
39	14 51	f x≥y
40	13 07	GTO 07
41	24 05	RCL 5

Registers	
R_0	L
R_1	C
R_2	D
R_3	T
R_4	A
R_5	W

Instructions

- Key in program
- Enter RUN mode
- Key in GTO 00
- Enter corridor width, door opening, and wall thickness (C), STO 1, (D), STO 2, (T), STO 3
- Specify cabinet length (L) in X-register stack
- Press R/S Cabinet width (W) will be displayed



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Engineer's newsletter

More on the TI-58's HIR instruction

Erik DeBenedictis of Caltech has discovered still more uses for the HIR instruction of the TI-58 calculator than those discussed on this page on April 13. He states that operation of the HIR instruction requires two instruction locations on the TI-58 and TI-59 calculators (both seem to treat it the same way). The first location contains the two-digit op code for HIR (82) and the second describes what operation will be performed on which register. It also consists of **two decimal digits, the left one being used by the HIR instruction to determine which of six functions it will perform on the register selected by the right-hand digit.** The register selected is from the pending operations stack, such that a 1 refers to the first entered operand, a 2 the second entered, and so on. The function chosen to be performed on the specified stack register is also done on the number in the display. If you let STACK refer to the selected stack register and DISP refer to the display register, the functions (in Algol notation) are:

Left digit	Function
0	STACK: = DISP
1	DISP: = STACK
2	NO-OP
3	STACK: = STACK + DISP
4	STACK: = STACK*DISP
5	STACK: = STACK – DISP
6,7,8,9	STACK: = STACK/DISP

These instructions are very difficult to enter into a program. The easiest general way to enter them is to use RCL 82, RCL DD, and then delete the RCL op codes.

Cascode capers continued

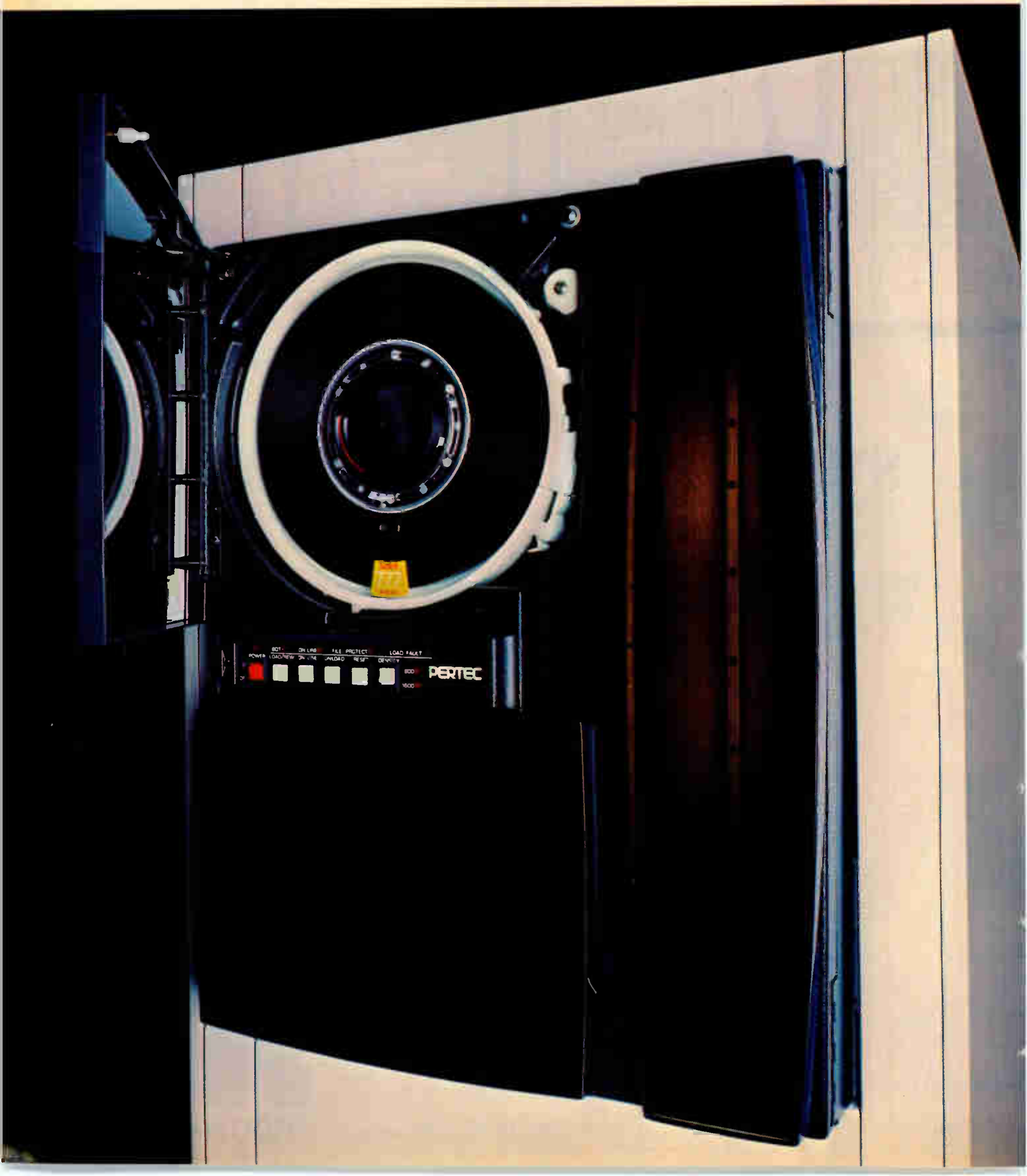
S. Ashok of Rensselaer Polytechnic Institute has a reply to John Carroll's comment on the use of cascode optocouplers in high-speed applications [*Engineer's Newsletter*, April 27]. He agrees that the cascode configuration would not improve speed in digital applications—being essentially an analog circuit technique with all the transistors operating in the active region, it obviously **will improve frequency performance only in small-signal, analog applications,** but perhaps he should have said this explicitly. In conclusion, Ashok says that tests with the 2N28 optocoupler show that even an unoptimized cascode optocoupler circuit improves bandwidth by a factor of at least five.

Computer cleans up electroplating

If you are in the business of electroplating small electromechanical parts and assemblies with gold, nickel, or copper, the disposal of solid and gaseous wastes has to be a problem. A new computer-controlled electroplating system for electrical contacts has been designed by engineers at Bell Labs and Western Electric that radically improves all aspects of present-day electroplaters. Completely self-contained, the line carries out all chemical processes in small, totally enclosed cells instead of in the large open vats of conventional systems, **cutting gaseous exhausts by 97% and chemical waste by 90%.** Gold use is halved and output has increased 600% at a Western Electric plant in Dallas. For further information, contact S. E. Bleecker at Bell Laboratories, Mountain Avenue., Murray Hill, N. J. 07974.

Jerry Lyman

TOUCH COMPETITION:



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version time of 25 microseconds means the AD571 will serve well as the core converter for high speed data acquisition systems.

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Circle 159 on reader service card

See Products newsletter, p. 245

Fiber-optic connectors match singles

Amphenol series 801 is capable of handling single or multiple optical fibers in standard receptacles

by Bruce LeBoss, New York bureau manager

To date, connectors for fiber-optic cables have been able to interconnect only bundles of fibers, as opposed to single fibers, leaving much to be desired in system performance. But now engineers at Bunker Ramo Corp.'s Amphenol RF operations, have developed the series 801 connectors for efficiently coupling even single optical fibers. Employing standard receptacle and plug shells that meet MIL-C-83723, the circular eight-channel, environmentally sealed fiber-optic connector (see photo) terminates a range of cable sizes, from small single fibers having a diameter of 0.005 inch to large bundles measuring 0.046 in. across.

Moreover, total accumulated losses are held to a maximum of 1.5 decibels per contact, claims Lee E. Eichenseer, marketing vice president at Amphenol's RF operations. This is done by holding the end separation between 0.0001 and 0.0013 in., keeping the center lines of the transmitting and receiving fibers to 0.0002 in. per channel, and maintaining an angular displacement of less than 1°.

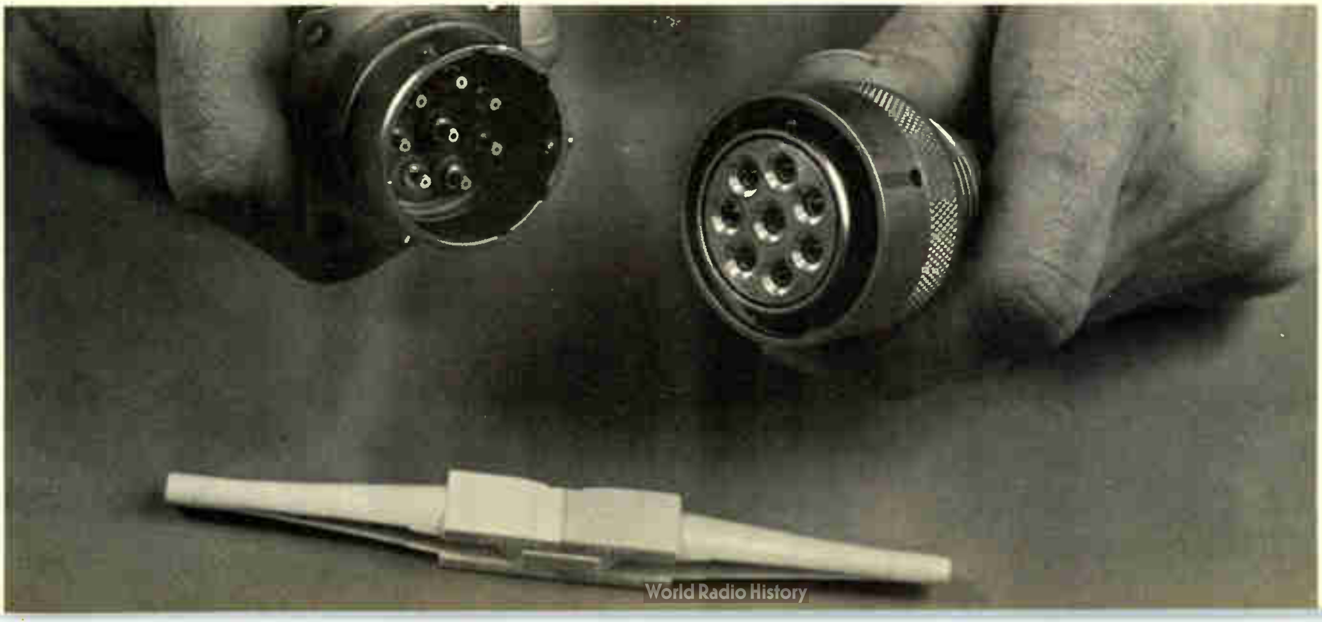
"Variations in the axial direction of the fiber-optic connector must be controlled more tightly" than in an electrical connector, says Eichenseer, because the light from a transmitting fiber is in the form of a cone and "the amount of light coupled into the receiving fiber will decrease as the fibers move away from one another." Misalignment of the fiber cores creates most loss, while angular misalignment adds slightly to the total accumulated loss.

Key to keeping these losses down is the series 801's optical alignment system, consisting of a spring retainer and an alignment bushing that is captured in the plug shell and allowed to "float" in the individual contact cavities. The polymeric bushing has cross-slotted ends to enable the slightly smaller inside bore to comply with the larger contact outside diameters; such a design "eliminates loss due to variations in the contact's stainless steel body," notes product marketing manager John T. Morrocco

The retainer has two sets of slots, set at 90° to one another and perpendicular to the cylinder's axis, enabling the retainer to act as a spring to preload the contacts and absorb any axial build-up in component tolerances. What's more, overall length of the alignment bushing is held to a precise dimension, so that there is a minimum gap between the polished faces of the contacts.

According to Eichenseer, series 801 connectors can be supplied with multiples of channels numbering either more or less than the eight shown here, and with combinations of single fibers, bundles, and power within the same connector. Tools for installing and removing contacts and polishing the optical faces are also available. A typical eight-channel connector for 0.005-in.-diameter fibers, with a precision positioning disk to hold small fibers in place, will sell for \$125 to \$150. An eight-channel connector for 0.015-in. fibers, not needing the disk, will cost \$80 to \$100. Delivery is 16 to 20 weeks, after receipt of order.

Amphenol RF Operations, Bunker Ramo Corp., 33 East Franklin Street, Danbury, Conn. Phone (203) 743-9272 [338]



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Circle 163 on reader service card

Up-down counter cuts parts count

C-MOS 4-digit counter chips have built-in decoder and driver and can be controlled by mechanical switches or computer

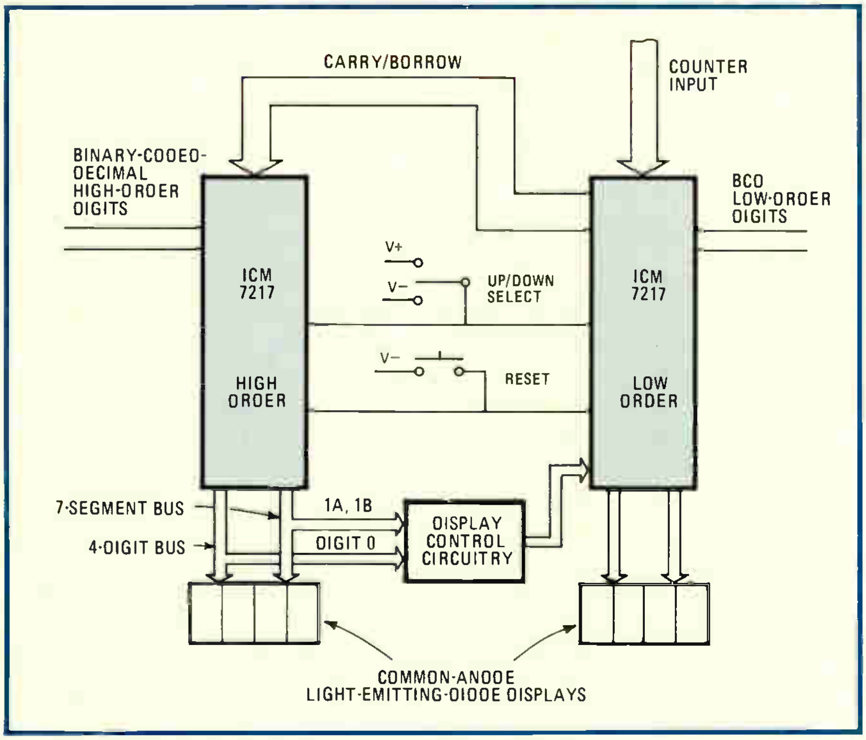
By Robert Brownstein, San Francisco field editor

Intersil's counter-on-a-chip series packs a lot of functional versatility onto a single 2.92-by-3.38-mm slab of silicon. The C-MOS family's eight presettable up-down counters feature stable registers, direct drive of seven-segment light-emitting-diode displays, and carry/borrow, comparator-equal and zero-count outputs—plus a transistor-transistor-logic–compatible binary-coded decimal input/output port.

There are two versions of the chip: the ICM 7217 for hardwired instruments that employ thumbwheels, toggle switches, and such; and the ICM 7227, which interfaces with microprocessor-controlled systems.

Where more than four digits are required, the carry/borrow output of one chip can be used as the count input for another, thus allowing a user to string them together serially. A display-control pin provides means to disable the segment drivers by connecting the pin to the positive supply pin, or inhibit the leading-zero blanking by connecting the pin to the negative supply pin. Normal operation—drivers enabled with leading-zero blanking—occurs when the pin is left floating, in which case it is self-biasing.

In the 7217, counter presetting and register loading are controlled by pins which take three-level inputs.



Up-down eight-digit counter. When two 7217 four-digit devices are used in tandem, the low-order stage's carry/borrow bit becomes the high-order stage's input.

If the pins are left floating, the display is enabled with the BCD I/O port outputting to the display. Depending on which line is pulled to V+, the data on the BCD I/O lines will be loaded into the register or the counter. Pulling the load-counter pin to V− forces the BCD port into a high-impedance mode; whereas pulling the load-register pin to V− puts the chip in power-down status, and the display can be used for other purposes. While in the power-down mode, the chip continues to count, and the carry/borrow, comparator-equal, zero-count, up-down, reset, and store functions continue to operate normally.

The 7227, which is almost functionally identical to the 7217, handles control of the BCD I/O port, store, and up-down counting differently. In the 7227 the store, up-down, select code 1, and select code 2 pins form a 4-bit control-word input for a microprocessor. When the SC 1 and SC 2 taken together have a 00 code, store and up-down states can be changed without causing a data transfer. Data transfers follow nonzero codes.

In the lowest power mode—the 7217 is rated at 600 μA maximum and the 7227 at 500 μA maximum. The display drivers for the common-anode devices will supply a minimum of 170 mA. Intersil guarantees a 2-MHz maximum count input frequency.

The counters are available from stock. In quantities of 100 or more, the 7217s are typically $6.63 each, the 7227s $7.30 each.

Intersil Inc., 10900 N. Tantau Ave., Cupertino, Calif. 95014. Phone (408) 996-5100 [339]

ENLIGHTENMENT

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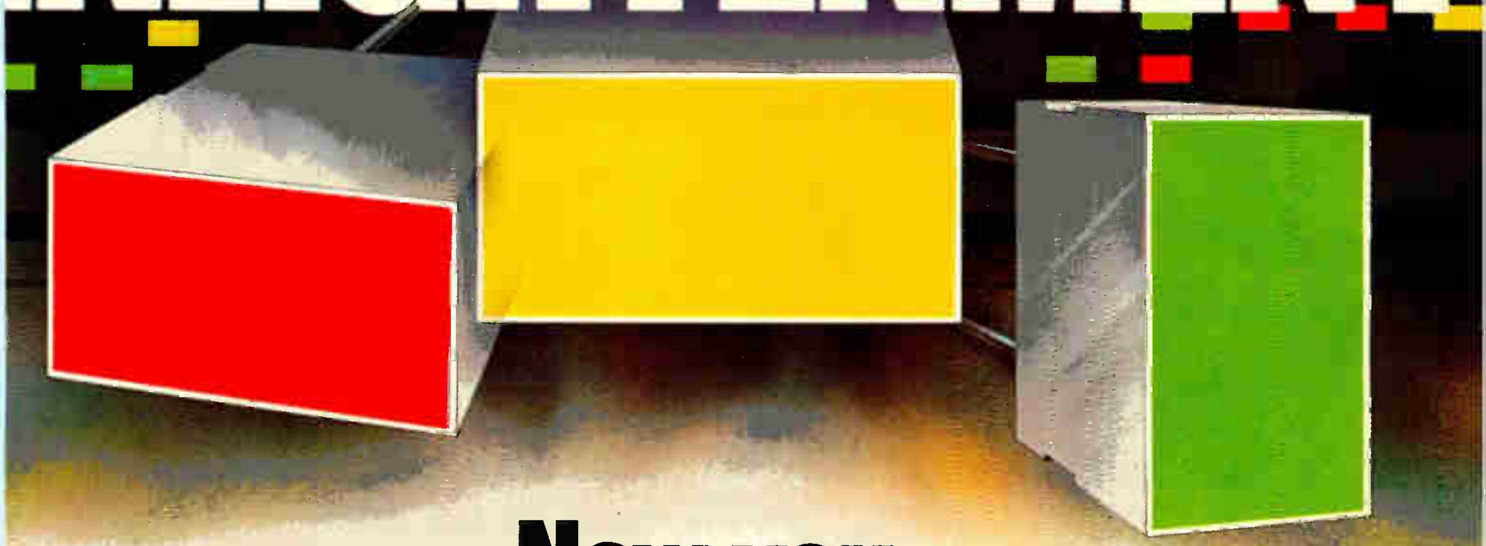

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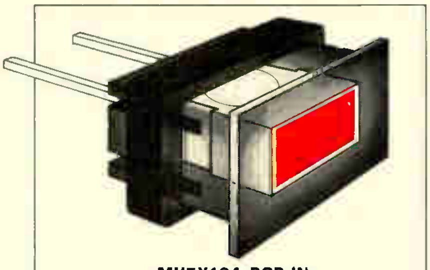
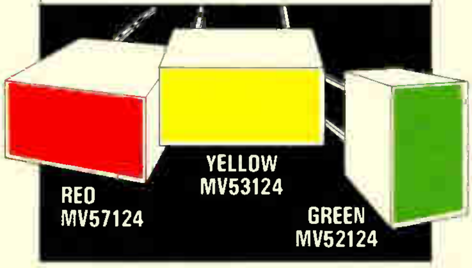


MV5X124 POP-IN

Black panel grommets are available which easily adjust for professional finish mounting.



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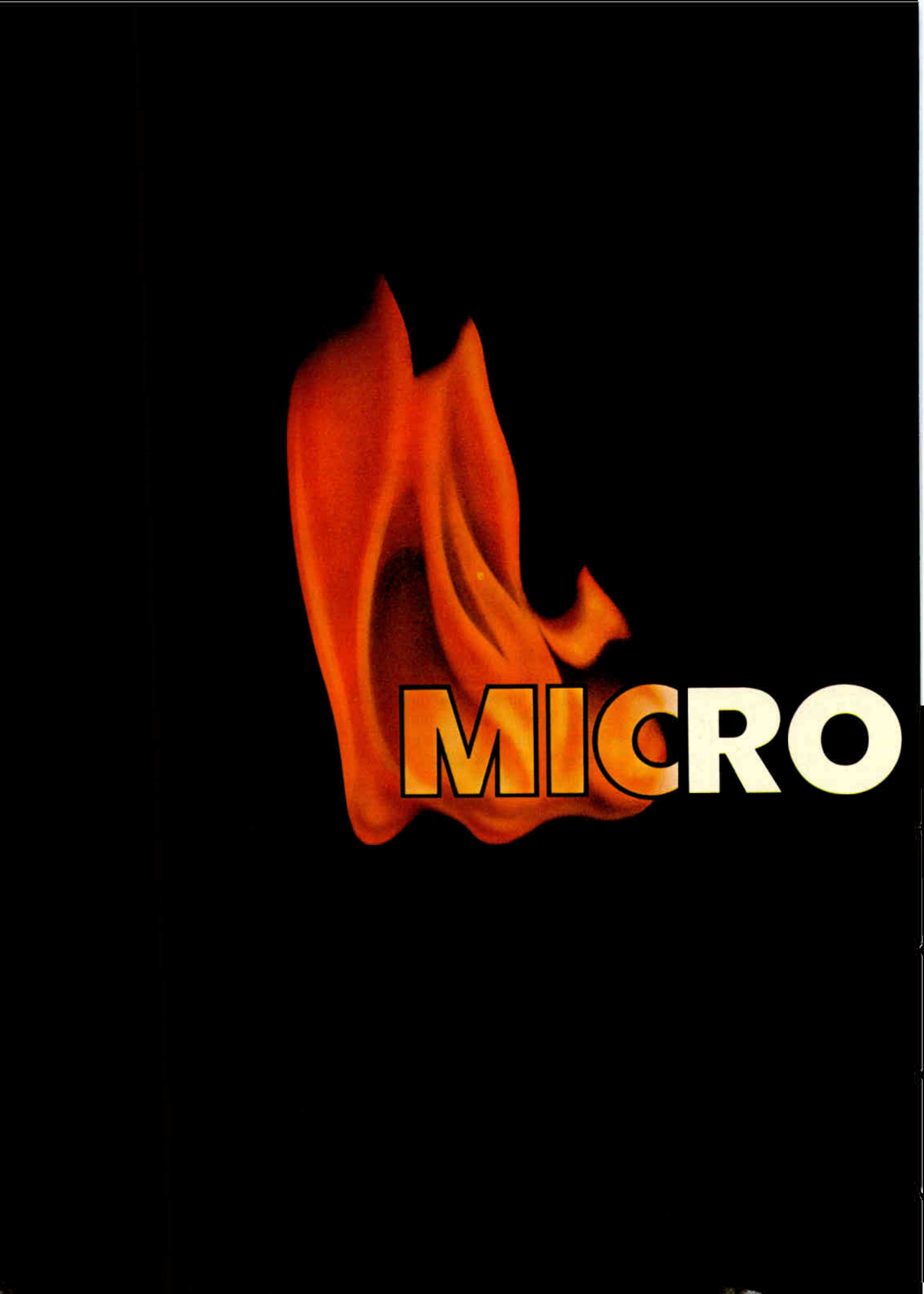
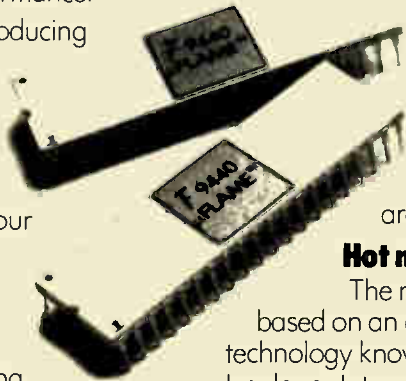

MICRO

The microprocessor that thinks it's a minicomputer can now evaluate itself.

Not too long ago, Fairchild introduced 9440 μFLAME™ — the world's first 16-bit bipolar microprocessor that executes a minicomputer instruction set with minicomputer performance.

Now we're introducing SPARK-16 — a double-sided pc board designed to evaluate the 9440 μFLAME CPU. The newest addition to our μFLAME family can also be used as a stand-alone microcomputer for applications requiring small amounts of memory.



Before we give you the details on SPARK-16, let us bring you up-to-date on μFLAME: The 9440 μFLAME microprocessor is a complete minicomputer CPU on one chip, packaged in a 40-pin DIP.

Major applications for this device include OEM data processing in a variety of computing control and instrumentation environments; telecommunications PBX and PABX switching installations; and distributed intelligence, distributed multiprocessing and front-end (terminal) processing.

Where there's flame there's fire.

Fairchild is also introducing its FIRE™ (Fairchild Integrated Real-time Executive) software. FIRE I is an initial software package for the 9440 that includes the required development aids: diagnostics, a bootstrap and binary loader (FIRELOAD), and an interactive entry and debugging program (FIREBUG).

In addition, the μFLAME microprocessor can execute the Data General NOVA 1200 instruction set. FIRE software such as text editor, symbolic debugger and business BASIC are also available now.

Hot new technology.

The new microprocessor is based on an advanced form of I²L technology known as I³L® (Fairchild's Isoplanar Integrated Injection Logic). It provides the combined advantages of bipolar high-speed and MOS packing density and power dissipation. In addition to the I³L circuitry on the 9440 chip, there is conventional TTL circuitry which allows TTL interface with other logic, PROMs and RAMs.

A spark of genius.

The new SPARK-16 pc board is loaded with features including a 16-bit 9440 μFLAME CPU, 4K words of RAM, 2K words of Autoload PROM, Memory control with DMA capability, interface logic for a Teletype or RS232C, 100-pin connector with 9440 Bus, connector for TTY/RS232C, control switches (Autoload, Continue, Halt and Reset) and display. SPARK-16 requires only a single 5 V, 4.0 A power supply and a TTY or CRT terminal. The single board price is $995.00. If you would rather do it all yourself, we can also supply you with a 9440 + FIRE I software for $550 (single unit price).

Only the beginning.

More sophisticated FIRE software, board level hardware and LSI support circuits will become available throughout the year. The software will include a floppy disk operating system, disk operating system and a FORTRAN compiler. New LSI circuits will include a 16K TTL dynamic RAM; a memory control with control, refresh and DMA capabilities; and an I/O bus controller.

For 9440 parts and SPARK-16 boards, contact your Fairchild sales office or representative. Or, for more immediate results, call your nearest Fairchild office.

France: Fairchild Camera & Instrument S.A., 121 Ave. d Italie, 75013 Paris. Tel 331 584 55 66. Telex. 0042 200614. **Italy:** Fairchild Semiconduttori S.P.A. Via Rosellini 12, 20124 Milano. Tel: 02 6 88 74 51 Telex: 36522. **Germany:** Fairchild Camera & Instrument (Deutschland) GmbH, 8046 Garching Hockbruck, Daimlerstr. 15, Munchen Tel 089 320031. Telex 52 4831 fair d. **England:** Fairchild Camera & Instrument (UK) Ltd., 230 High St., Potters Bar, Hertfordshire EN6 5BU Tel 0707 51111. Telex 262835. **Sweden:** Fairchild Semiconductor AB Svartengsgatan 6, S-11620 Stockholm. Tel: 8-449255. Telex 17759.

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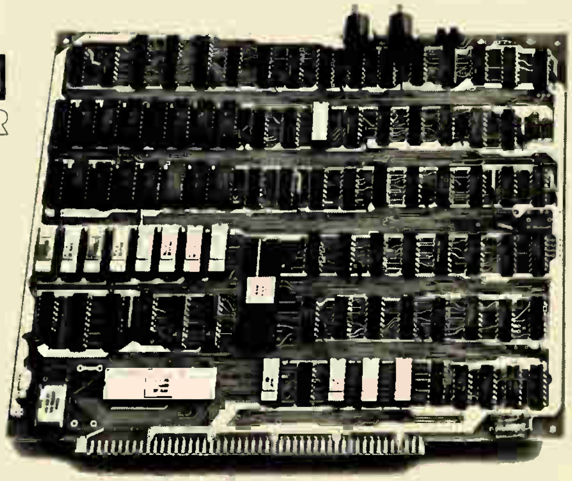
FLAME™ MICROPROCESSOR



SPARK-16

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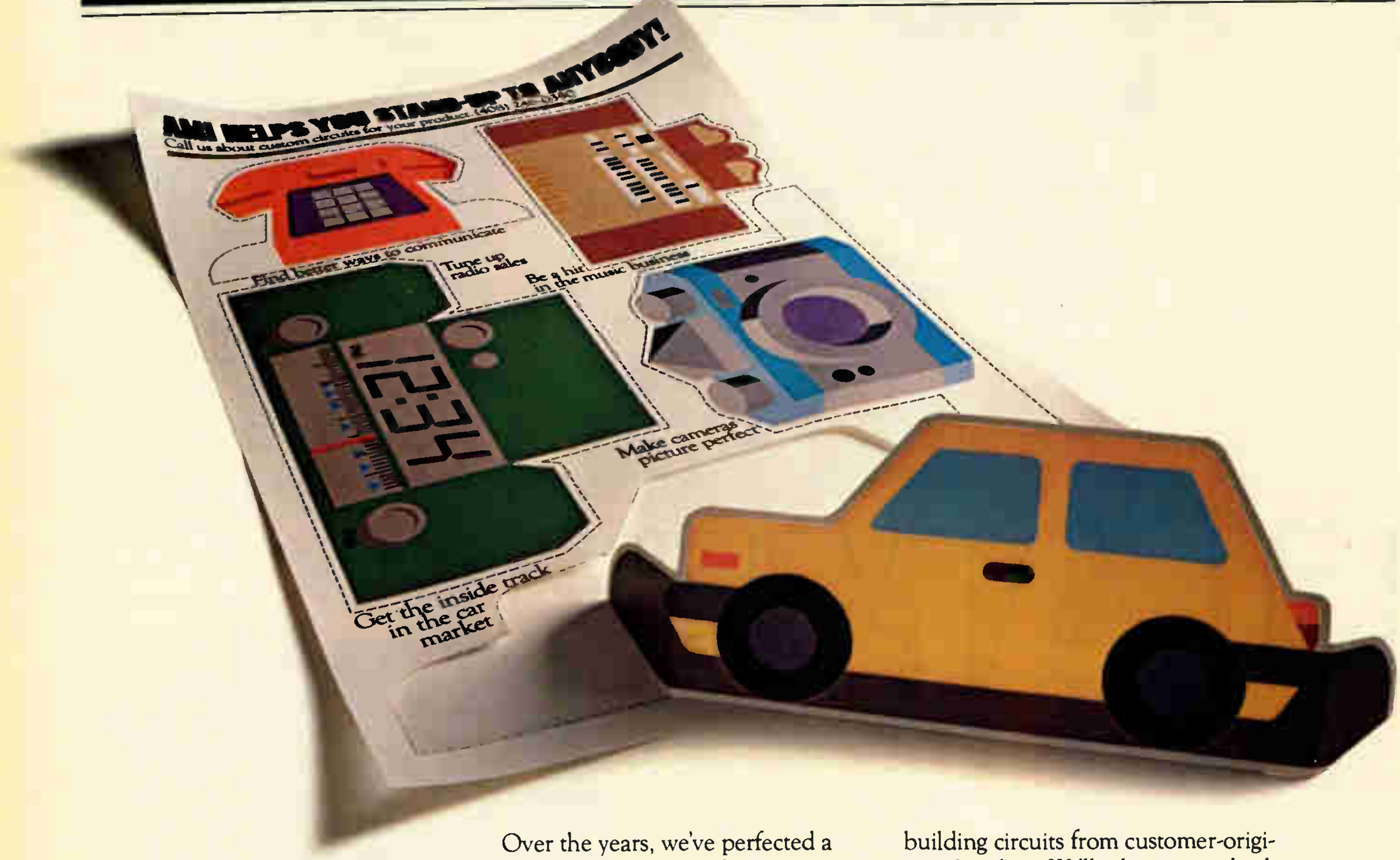

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Semiconductors

Static RAM boasts power-down mode

AMD device requires less operating power than do other 2102 replacements

To quadruple density and halve power dissipation per memory bit, engineers may choose among a number of 1,024-by-4-bit replacements for the venerable 2102 series of 1,024-by-1-bit static random-access memories. A new contender is the 9124, which Advanced Micro Devices is promoting as a power saver.

The new RAM joins Intel's 2114, made without a power-down feature, and American Microsystems' 5406/2114, which employs its V-groove metal-oxide-semiconductor technology to get good speed and power specifications [*Electronics*, March 30, p. 116].

Key feature of the 9124 is an automatic power-down mode that needs neither clocks nor refreshing. The new chip requires 40% less operating power than the 2114 and upwards of 60% less when it is in the standby or power-down mode, entered when the chip-select pin goes high and deselects the device. When selected by a low on the chip-select line, the 9124 automatically powers up with no performance penalty, according to Jeffrey M. Schlageter, manager of MOS RAM design and development.

Compared to a 9114 (second source to a 2114), the write pulse width and chip-select access time of the 9124 are longer though both have address access times of 200 nanoseconds. The 9124's write pulse width is 150 ns compared to the 9114's 120 ns, and the chip-select access times are 185 ns versus 70 ns, respectively.

"These differences present no real obstacle to using a 9124 in place of a 9114 or 2114," Schlageter states. What is significant is the power savings, he says.

For a 4,096-by-16-bit memory block built with 9124s, the power dissipated would be 2.4 watts, instead of the 8 W that would be used by 9114s. Whereas standard 9124s draw a maximum of 100 milliamperes and only 20 mA in the standby mode, selected parts achieve 70-mA maximum and 15-mA standby current.

The power-down feature is the result of isolating portions of the circuitry from the supply whenever the RAM is deselected. Other portions, where such isolation might adversely affect memory retention, remain connected at all times.

"It is a simple scheme, and users have expressed no lack of confidence in the principle," Schlageter says. In fact, he expects that other suppliers will follow with their own versions of automatic-power-down static RAMs.

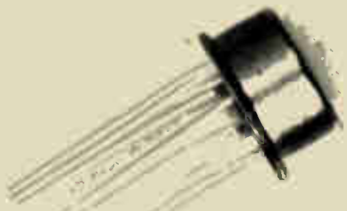
For the 9124, AMD used an advanced n-channel process but without resorting to the extra complexity or masking layers associated with it, Schlageter says. The result is that the chip is only 23,000 square mils in area, he observes, and "we expect faster parts in the future."

AMD is offering samples of the 9124 now. The price for 200-ns versions of the chip will be $13.35 in 100 and-up quantities.

Advanced Micro Devices Inc., 901 Thompson Place, Sunnyvale, Calif. 94086 [411]

Monolithic op amp has low bias voltage

Offering a powerful combination of very low offset voltage and low offset-voltage drift and input bias

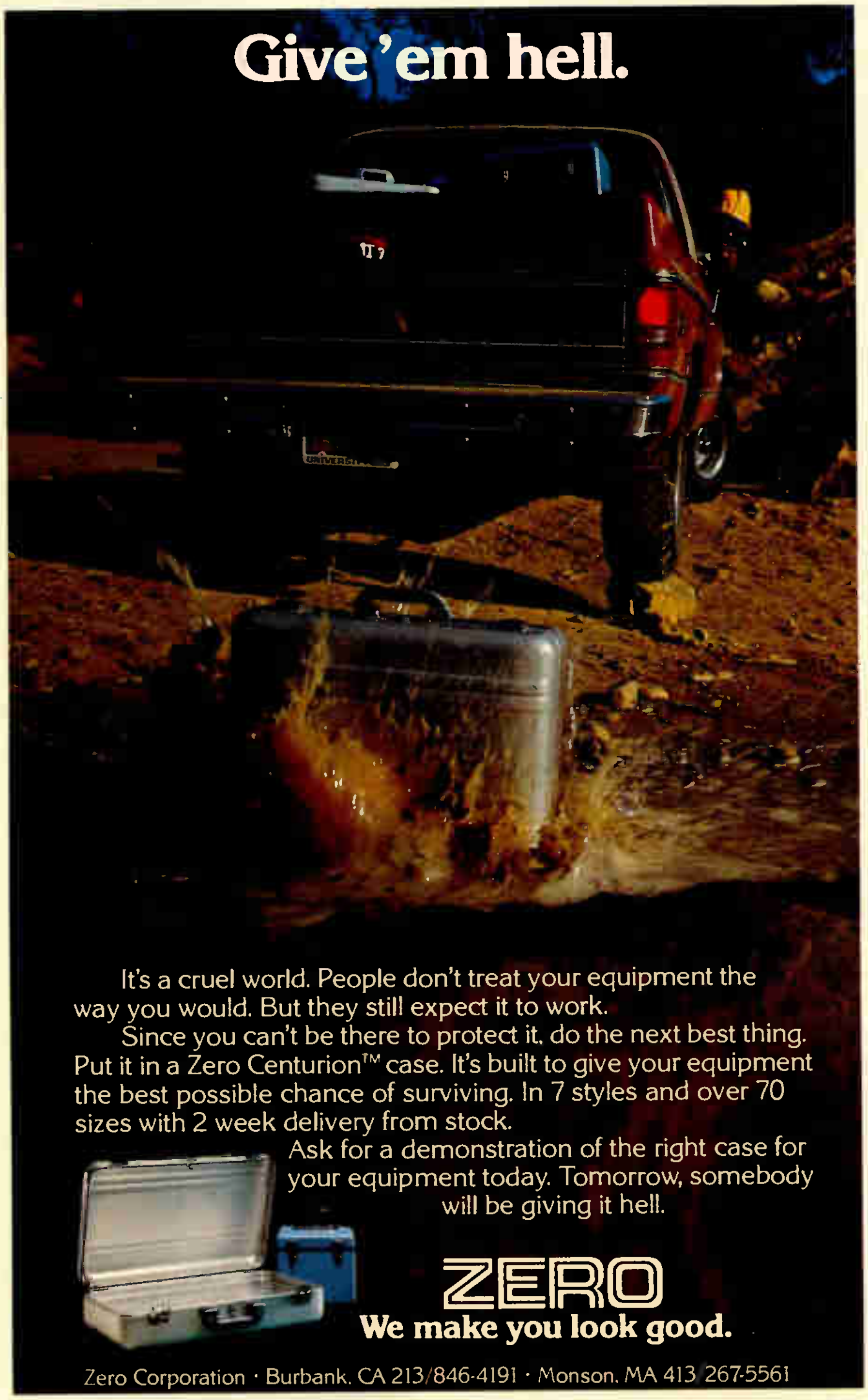


current, one version of a precision bipolar monolithic operational amplifier, AD517, has a maximum input offset voltage of 25 μV, the lowest at present available without using nulling potentiometers.

In addition, that version features a maximum offset drift of 0.5 μV/°C and a maximum input bias current of 1 nA. The device's performance is comparable to that of available bi-FET amplifiers at room temperature, but its input currents decrease to less than 0.5 μA, rather than increase, at temperatures of 70° C and above. The AD517 is available in five versions, including one processed and screened to MIL-STD-883, level B, for precision stable references, followers, bridge instruments, and analog computation circuits.

Designed for the temperature range from 0 to 70° C, the AD517L is priced at $11 in quantities of 1,000. Another version, with slightly relaxed tolerances, AD517J, sells for just $3.50 in thousands. Delivery is from stock.

Analog Devices Semiconductor Division, 829 Woburn St., Wilmington, Mass. 01887. Phone Doug Grant at (617) 935-5565 [413]



Interface chip takes burden off microprocessor

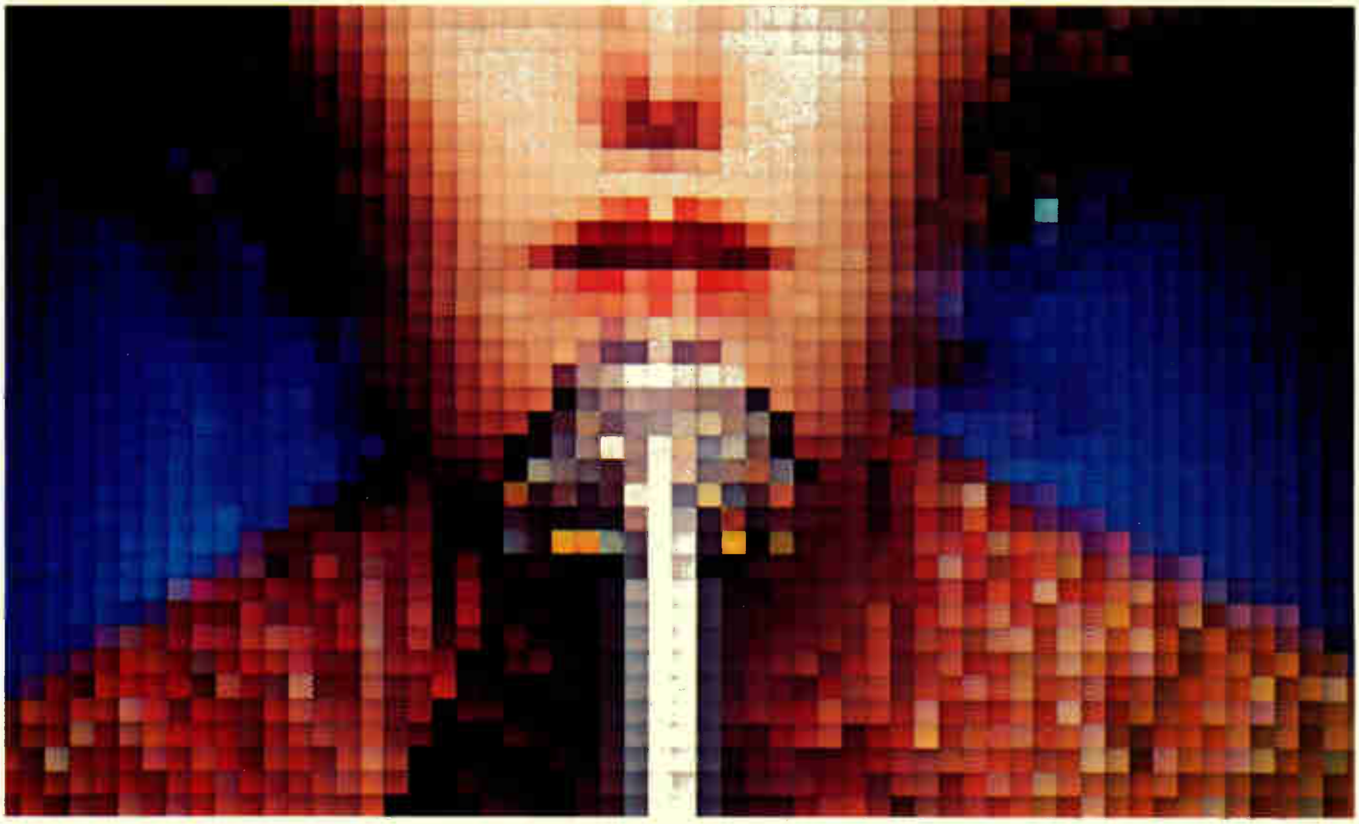
Fabricated by n-channel silicon-gate technology, the INS8250 functions as a serial data input/output interface in a microcomputer system. Its functional configuration can be controlled by the system's software by means of a three-state 8-bit bidirectional data bus, thus reducing the need for other kinds of devices and the time spent by the microprocessor in interfacing tasks.

The device performs serial-to-parallel conversion on data characters received from a peripheral device or a modem and parallel-to-serial conversion on data characters received from a central processing unit. The CPU can read the complete status of the INS8250 at any time during functional operation. Status information reported includes the type of transfer operations being performed by the chip, as well as any error conditions.

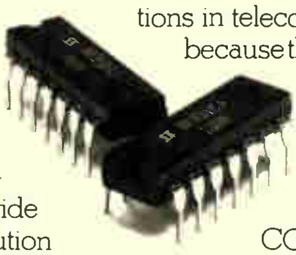
In addition to providing control of asynchronous communications, the chip contains a programmable baud generator capable of providing a clock signal for driving the internal transmitter logic. Also included is a complete modem-control capability and a processor-interrupt system that can minimize computing time required to handle a communications link.

Address setup time for the INS8250 is 110 ns while address hold time is 10 ns. Read access time is 450 ns; write data setup time is 200 ns. The unit operates from a

Spread the word. Siliconix announces CODEC.



Siliconix introduces the ultimate man/machine interface: CODEC. Our DF331 coder is a high-speed serial output A/D converter — a complete subsystem-on-a-chip. Its counterpart, the DF332 decoder, converts high-speed digital bit streams into analog signals. Both devices operate logarithmically, giving our CODEC a wide dynamic range: 12-bit resolution (±1 bit) for low-level signals, and 8-bit accuracy for high-level signals.



Designing with Siliconix' CODEC is a cost-effective solution to the problem of vocal interface with computers. Siliconix CODEC minimizes external component requirements and system costs: serial output and sample-and-hold circuitry are all on-board. And CODECs will have many applications in telecommunications because they meet all D3 specifications and are compatible with the μ255 law for companding. A key CODEC specification: signal to distortion is 28dB (Pin=−45dBmO) max.

Our CODEC set continues the Siliconix tradition of providing products that link the analog world to digital systems. We've been manufacturing monolithic analog-to-digital converters for five years. And we're currently supplying the instrumentation industry with the latest in technological advances, such as our LD120/LD121 series 4½ digit A/D converters, high-speed analog switches, and logic compatible VMOS transistors. Experience and expertise make Siliconix the logical source for CODECs. Spread the word. For details, call or write Siliconix, 2201 Laurelwood Road, Santa Clara, CA 95054; (408) 988-8000.

Siliconix

The Siliconix connection:
Innovative products linking the analog world to digital systems.

single 5-V power supply with a maximum current of 80 mA.

In 100-unit quantities, the device is priced at $8.50 and delivery is from stock.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. Phone (408) 737-5956 [414]

TI seconds Motorola on sensing circuit

The MC3423 is designed to protect electronic circuitry from voltage transients and loss of regulation by triggering an external crowbar silicon controlled rectifier. Introduced by Motorola, the integrated circuit is now also being produced by Texas Instruments.

The protective mechanism may be activated by sensing an overvoltage at one of the device inputs or by applying a high-level transistor-transistor-logic signal to another input. Separate outputs are available to drive the crowbar circuit and to provide a logic pulse to an edge-triggered indicator or power control circuitry. The MC3423 also offers an internal current source that can be used to charge an external capacitor used to avoid noise triggering.

With a 2.6-V internal voltage reference and a temperature coefficient of typically 0.06%/°C, the MC3423 can operate in the temperature range from 0 °C to 70° C. It is offered in an eight-pin plastic or ceramic package and in quantities of 100, or more it is priced at $0.79 in plastic and $1.08 in ceramic. Availability is from stock.

Texas Instruments Inc., Inquiry Answering Service, P. O. Box 5012, M/S 308 (Attn: MC3423), Dallas, Texas 75222. Phone Dale Pippenger at (214) 238-5908 [415]

PLL circuit offers highly stable performance

With a temperature stability of 20 ppm/°C, the XR-2212 phase-locked loop circuit is about five times more stable than previously avail-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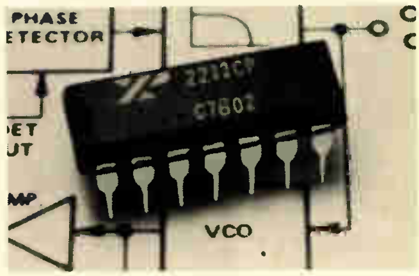
able PLLs. The monolithic device consists of a preamplifier, a phase detector, a voltage-controlled oscillator, and a high-gain differential amplifier. The differential amp can be used either as an audio preamp for detection of frequency modulation or as a high-speed sense amp for frequency-shift-keying demodulation. With these characteristics, the circuit should find use in frequency-synthesis, data-communications and control-system applications.

In addition to improved temperature stability, the circuit offers a frequency range of 0.01 Hz to 300 kHz, and it can accept either digital or analog signals with amplitudes between 2 mV and 6 V peak to



peak. The supply voltage may range between 4.5 V and 20 V.

In a 16-pin dual in-line plastic package, the XR-2212 is priced at $3 each for quantities of 100 or more. Delivery is from stock.

Exar Integrated Systems Inc., P. O. Box 62229, Sunnyvale, Calif. 94088. Phone Brooks Hamilton at (408) 932-7970 [416]

Fast PROMs offer quick fuse programmability

With a proprietary platinum-silicate-fuse technology, the AM27S family of low-power Schottky programmable read-only memories can be rapidly programmed. Typically, a 4,096-bit memory can be programmed in less than 1 second with a 50-ms pulse. Maximum access times for members of the family are in the range from 40 ns to 60 ns. Included are 256-bit, 1,024-bit, 2,048-bit, and 4,096-bit memories, all of which come with either open-collector or three-state outputs. The

Now you can get fast two-week turnaround on programmed 8048 Single Chip Microcomputers, 8041 Universal Peripheral Interfaces, and 8355 ROMs for 8085-based designs. Here's how. Send us your program object code with your first order for 250 or more pieces. Fourteen days ARO we'll ship 25 programmed one-time-programmable components.* Then six to eight weeks later we'll begin volume shipments of mask-programmed parts. There's no extra charge for this service that enables you to verify your program and get your first units into the field quickly. And if you need even faster turnaround, you can program our pin-compatible EPROM devices in your own lab in less than 5 minutes. For more details call your local Intel sales representative.

*This same service is available on Intel® 2616/2316E 16K ROMs.

intel delivers.

4-K device is the first of its kind with edge-triggered full registers on the output. In addition, two chip enables are provided. One contains an edge-triggered register to allow the synchronous busing of several units to increase word length and expand control. The other allows fast asynchronous control of the output enable to let other devices talk to the instruction bus.

Prices for the PROMS begin at $1.95 for the 256-bit unit.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086. Phone E. Sopkin at (408) 732-2400 [417]

Audio transistors broaden safe operating range

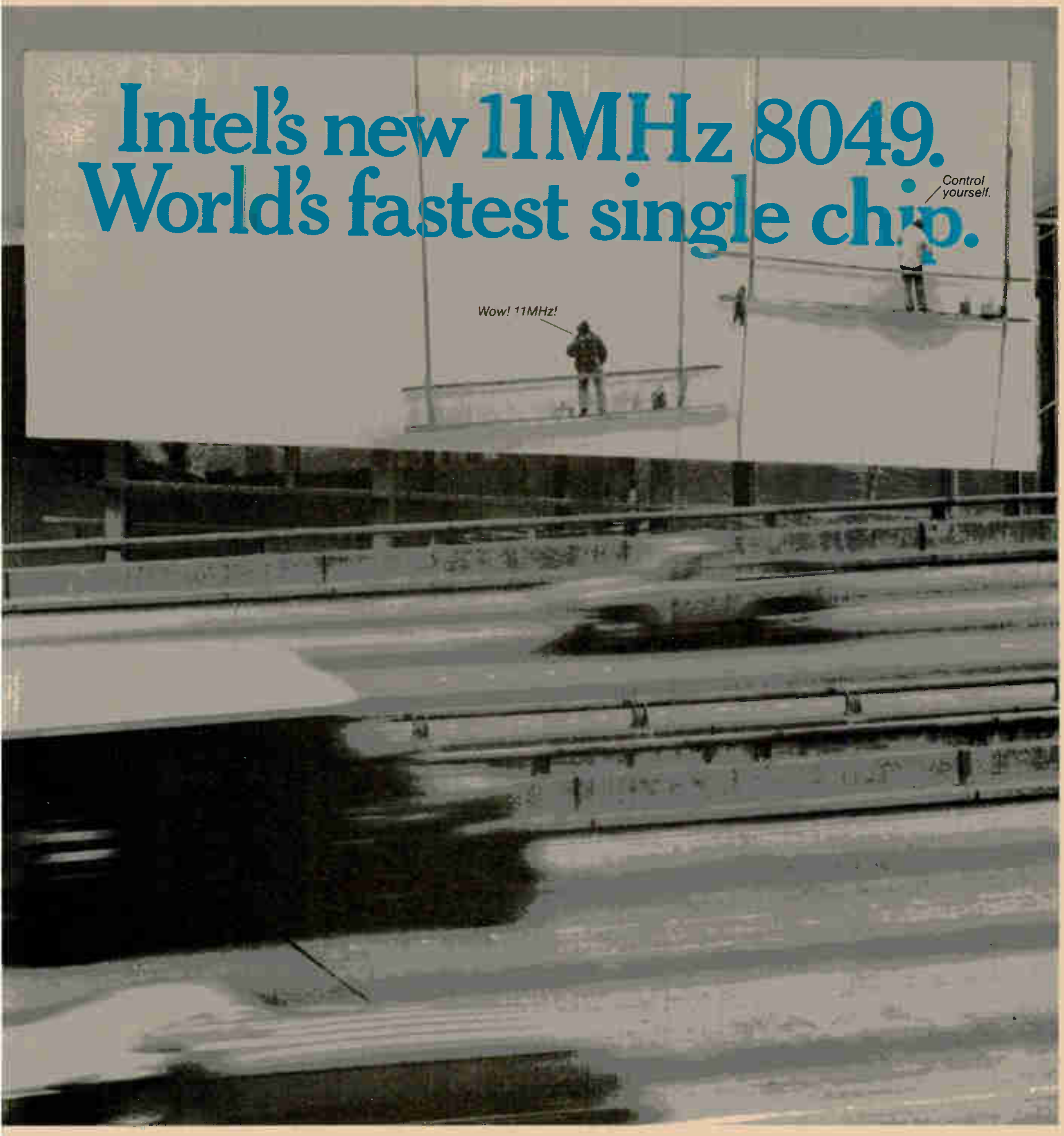
The TOP-3 family of high-power audio transistors has 50% greater safe operating area than other comparable units. The increase has been achieved through the use of a floating-emitter construction.

In addition to the standard emitter diffusion, an added diffused region around the emitter's periphery serves as the floating emitter. The base region forms a ballasting resistor that minimizes the localized concentration of emitter current and as a result increases transistor reliability and helps improve the thermal characteristics.

The transistors have a gain bandwidth product of 7 MHz. With a collector-emitter voltage of 5 V and a collector current of 1 A, the dc current gain ranges from 40 to 200; with the same collector-emitter voltage and a collector current of between 3 and 7 A, depending upon the type of transistor, the dc current gain is less than 20 or less than 15. Peak collector current is between 8 and 15 A for the family and collector power dissipation is between 60 and 100 W at 25° C.

The transistors, in TOP-3 packages, can be interchanged with JEDEC TO-3 type devices.

Electronic Components Division of Panasonic Co., One Panasonic Way, Secaucus, N. J. 07094. Phone Bill Bottari at (201) 348-7276 [418]



At 11MHz our 8049 is the world's fastest single-chip microcomputer. It's the higher performance brother of our industry standard 8048 and includes 2K bytes of ROM, 128 bytes of RAM, an 8-bit timer, 27 I/O lines and a 1.4 μsec instruction cycle. Perfect for high speed control applications such as line printers and cassette drives. The 8049 is pin compatible with the 8048, for easy upgrades.

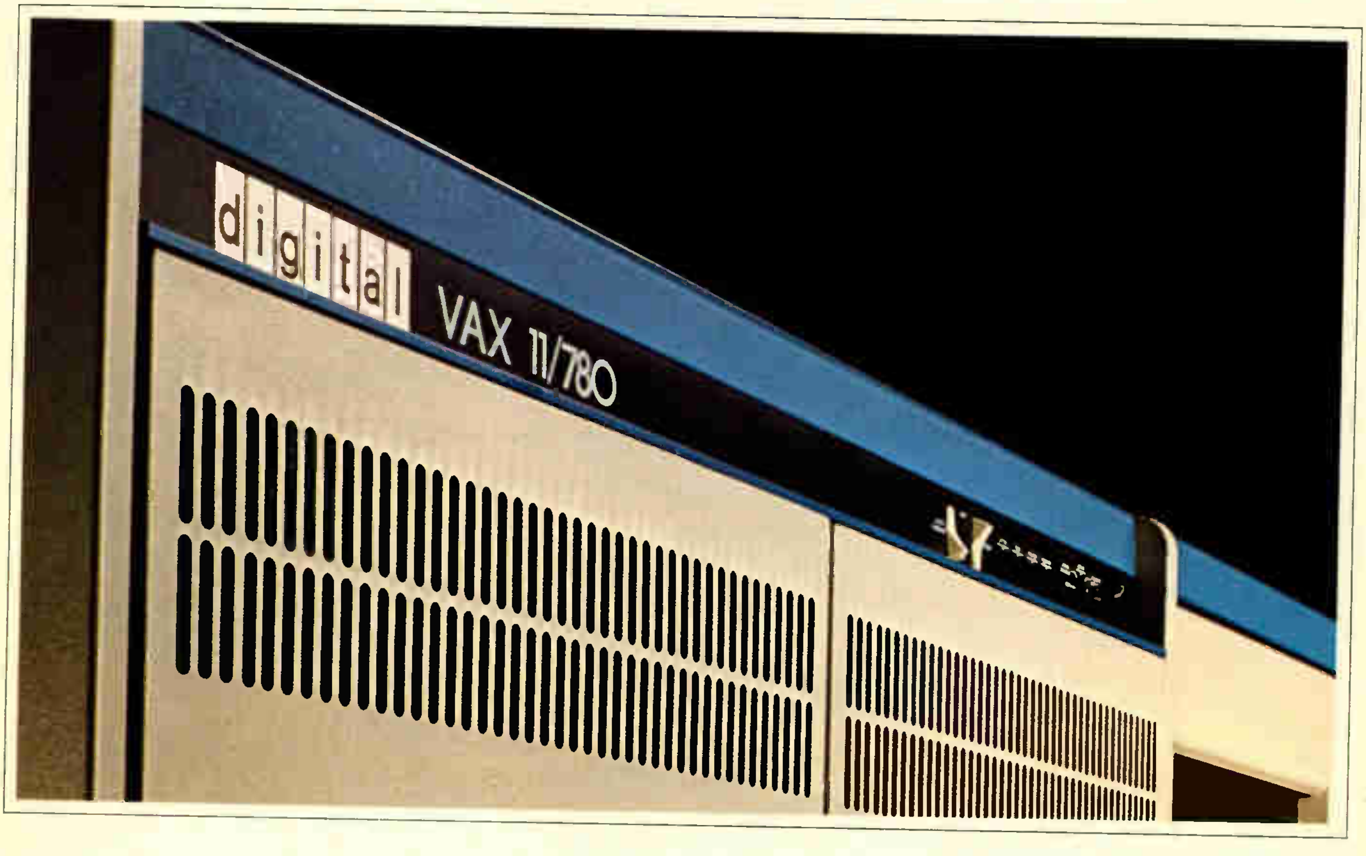
And, of course, it's backed by the most comprehensive development support available.

Best of all, Intel is delivering the 8049 in production quantities now. For more information contact your local Intel representative or Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051. Telephone: (408) 987-8080.

intel delivers.

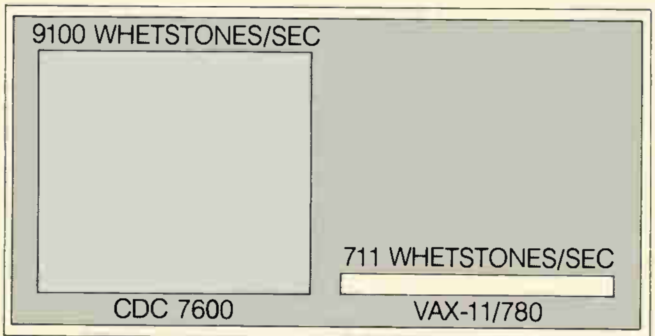
Circle #177 for more information

Digital's $141,000 VAX vs. a multi-million dollar CDC 7600.

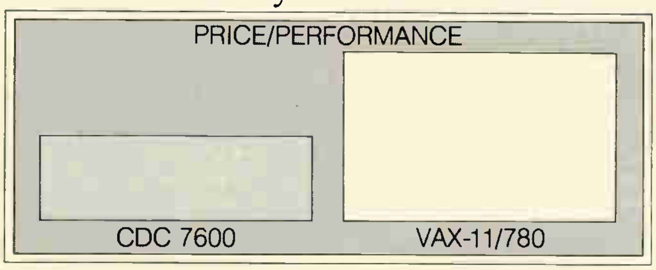


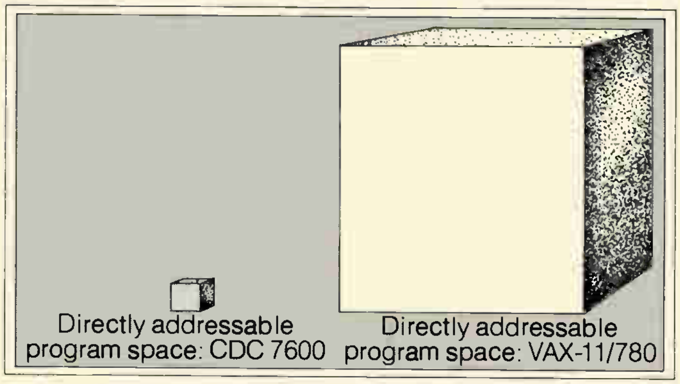
VAX wins two out of three.

Round one to the 7600: Speed. The 7600 is still the speed king of the world with 9100 Whetstones per second.



Round two to VAX: Price/Performance. The 32 bit VAX is the world's fastest mini. A $141,000 VAX system runs 711 double precision Whetstones. That's one twelfth the speed—at one twenty-fifth the cost. A dozen VAX systems could equal the throughput of one 7600—and you'd still save literally millions of dollars.





Round three to VAX: Program size. Virtual addressing and a gigantic 32 bit address size, compared to the 18 bit address size of the CDC 7600, allows VAX a directly addressable program size that is—are you ready?—1000 times larger than the CDC 7600.

Get the VAX facts: Get mainframe FORTRAN performance without waiting in a batch queue—or paying batch prices. If you have an application in aerospace computation, signal processing, simulation, educational computing, industrial automation, or any other big FORTRAN job, get the VAX facts today. Write for your copy of the VAX-11/780 brochure and complete technical summary.

Digital Equipment Corporation, PK3-2/M18, 129 Parker St., Maynard, MA 01754. European headquarters: 12, av. des Morgines, 1213 Petit-Lancy/Geneva. In Canada: Digital Equipment of Canada, Ltd.

digital

Digital Equipment Corporation, PK3-2/M18, 129 Parker St., Maynard, MA 01754

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VAX PRICES APPLY IN U.S. ONLY.

Circle 179 on reader service card

Subassemblies

Sample-and-hold is rapid and right

Datel's 12-bit hybrid gives half-bit accuracy without sacrificing conversion time

High speed, accuracy, and an uncommitted input amplifier combine to make a new sample-and-hold circuit attractive for high-speed 12-bit analog-to-digital converters and data-acquisition systems. The SHM-6 is a thin-film hybrid circuit featuring an acquisition time of 1 μs with an accuracy of within 0.01%—½ bit out of 12—for a 10-V input change.

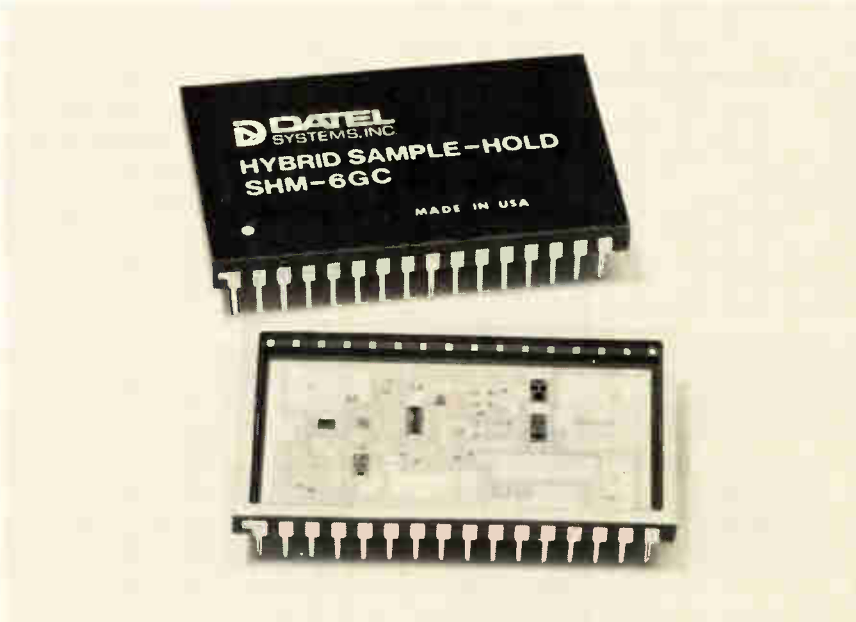
The open-loop input amplifier permits external connection for gains of ± 1 to ± 10. This feature is not offered in competitive units approaching the circuit's acquisition speed, says Eugene Zuch, product marketing manager for data-conversion products, at Datel Systems.

To get the high speed and accuracy, he says, it was necessary to design the input and output amplifiers with discrete components, since monolithic amplifiers would not meet the speed and accuracy requirements. He points out that the a-d converters with which the SHM-6 will be used have conversion times of 8 μs, "and we wanted the sample-and-hold to be much faster than that, so we're adding only 1 μs to the conversion time."

The circuit uses a high-impedance input transconductance amplifier to drive an internal metal-oxide-semiconductor hold capacitor of 400 pF. Zuch points out that internal capacitors are not often included in hybrid sample-and-hold circuits, but that their use allows a hold-mode droop rate of 10 μV/μs—"a good tradeoff for the speed and accuracy of this device," he says.

The input amplifier has an open-loop gain of 10^6 and an input impedance of 100 MΩ, with a common-mode rejection of 74 dB minimum. Laser trimming provides an input offset voltage with a typical rating of ± 2 mV or a maximum of ± 5 mV. A high-impedance field-effect-transistor input device, with a ± 10-V output capability of ± 50 mA, is used in the output amplifier.

Some of the other important dynamic specifications include a 5-MHz bandwidth with a gain of 1, an aperture delay of 20 ns, and an aperture uncertainty of 2 ns. For that gain, no



additional parts are needed; negative input is simply connected to output.

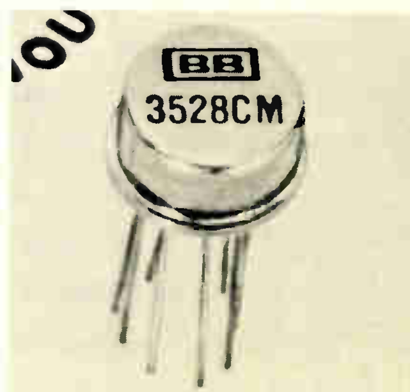
Four models, in 32-pin dual in-line packages, are available. In quantities of 1 to 24, a 0°C-to-70°C unit is priced at $129; a hermetically sealed, full-military-temperature-range part has a price of $209. Delivery is four to six weeks after receipt of order.

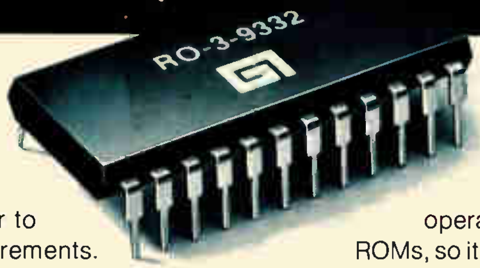
Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone (617) 828-8000 [381]

Bias current for FET op amp is only 75 fA max

Extremely low bias currents are the boast of the 3528 series of field-effect-transistor operational amplifiers. The three op amps in the series, designated AM, BM, and CM, have maximum input bias currents of −300, −150, and ±75 femtoamperes (10^{-15}A) measured after warmup and without a heat sink. Input offset voltages are similarly small; they are only 500 μV for the AM and CM, and 250 μV for the BM. Maximum offset voltage drift is between 5 and 15 μV per °C. With these specifications, the FET op amps should perform quite well in their intended applications: measuring the very small current signals of photometers, selective ion detectors, long-term integrators, and low-droop sample-and-hold circuits.

Unity gain bandwidth with small signal is 0.7 MHz, typically, while the full power bandwidth with a load resistance of 2 kΩ is a minimum of 5 kHz. Slew rate with the same load is





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For more memory, two mask-programmable chip-select inputs simplify memory expansion. Or, you can plan on our pin compatible 64K ROMs which will be available later this year.

Write or call for our free 1978 Product Guide and for proven, service-supported "high volume" ROM performance, contact General Instrument Microelectronics, Ltd., Regency House, 1/4 Warwick Street, London W1R 5WB, Telephone 01-439-1891.

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a minimum of 0.3 V per μs, while settling time to 0.1% of final value is typically 150 μs.

The design of the operational amplifier protects it from damage due to shorting of the output, either to ground or to the positive or negative dc supply voltages required. Rated power supply voltages are ±15 V dc. Maximum internal power dissipation is 500 mW.

To obtain maximum operation from the unit, shielding of the input leads is required. The amplifier case can be connected to a guard pattern surrounding the input leads to provide this shielding, according to the company.

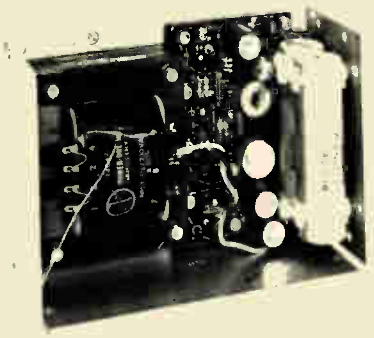
In quantities of 100 or more, the FET op amps range in price from $9.90 to $17.50.

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85734. Phone Bill Stacy at (602) 746-1111 [383]

Power supplies fill gap between 30 and 60 W

Designed to satisfy power requirements that fall between the industry standards of 30 and 60 W, five additions to the Hi-vol series of dc power supplies have voltage/current ratings of 5 V at 9.0 A, 12 V at 5.1 A, 15 V at 4.5 A, 24 V at 3.6 A, and 28 V at 3.0 A. The units should find application in data processing, microcomputer, industrial, and instrumentation applications.

Standard features include 115/230 V ac ±10% input acceptance and ±0.05% line and load regulation. Maximum output ripple



is 3.0 mv peak to peak, while full load operating temperature specifications are 0 °C to 50 °C, derated to 40% at 70 °C.

The supplies measure 7 by 4.87 by 3.10 in. and weigh 6 lb. The units cost $64.95 each, except for the 5-v supply, which has built-in overvoltage protection and costs $69.95, according to the manufacturer. Delivery is from stock.

Power-One Inc., Power One Dr., Camarillo, Calif. 93010. Phone Fred Adams at (805) 484-2806 [387]

Dc-to-dc converters are the smallest 9-W units

The Power line of dc-to-dc converters measures only 0.875 by 1.75 by 0.375 in., making them the smallest units available in their power range. There are 26 different models, which include devices that accept inputs of 5, 12, 28, and 48 v dc and provide single and dual outputs in the 5-, 12-, and 15-v dc ranges. Both regulated and unregulated devices are available; regulation of 1% or less can be obtained.

In quantities of 100 and above, the units sell for approximately $65 each.

Integrated Circuits Inc., 13256 Northrup Way, Bellevue, Wash. 98005. Phone Stan Hochman at (206) 747-8556 [386]

Module makes light work of digital scale design

Modules 166 and 167 contain a bridge power supply, an instrumentation amplifier, and a voltage-to-frequency converter—practically all the elements needed for a strain-gage digital scale.

The supply's output is adjustable from 4 to 10 v. The amplifier gain can be set between 10 and 1,000, and the converter's maximum output is either 10 kHz for the 166 or 100 kHz for the 167. Units are priced at $98.

Calex Manufacturing Inc., 3305 Vincent Rd., Pleasant Hill, Calif. 94523. Phone (415) 932-3911 [388]

A NEW SERIES OF CMOS GATE ARRAYS FROM INTERDESIGN.

MCA An ideal array for integrating combinational decoding and gating circuitry to free up circuit board real estate, lower assembly costs, and improve product reliability. With 100 gates available, you can integrate up to 224 inverters, 56 exclusive OR gates, or 28 D flip flops. Very reasonably priced, too.

MCB Designed specifically for larger circuit integration requirements. A 150 gate array permits integration of up to 18 MSI packages resulting in PC board savings of almost 27 square inches. Proven CMOS technology insures low power consumption, ease of interface with TTL or CMOS, and an operating range from 3 to 15 volts.

MCC A medium sized chip with 200 logic cells and 44 I/O devices. Along with integration of random and combination logic, the MCC can be used to build custom counters and registers tailored to meet specific systems requirements. For example, ripple counters with 50 binary stages are a snap. And at a very affordable price!

MCD A true LSI gate array with 400 logic cells and 50 I/O's. The buss oriented architecture with 30 three-state outputs and four 8-bit register/counters fits neatly into microprocessor side car applications. And if logic integration is your goal, think of the space and money you can save with a chip this size!

Your Own Custom CMOS Chip!
Start designing today! Breadboard your CMOS circuit and then convert it to an IC layout using our CMOS Design Manual. The price is only $25 and that includes layout sheets, functional overlays, and personalized applications support. After layout, we'll tool your IC and deliver 20 prototypes in 4 weeks. And at a cost of only $2800.

To learn more about modernizing your designs with CMOS gate arrays, write or call us today. Interdesign, 1255 Reamwood Drive, Sunnyvale, CA 94086, 408-734-8666.

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Circle 189 on reader service card

OUR OS4000 TAKES OVER WHERE TUBE STORAGE LEAVES OFF.

The Gould OS4000 digital memory oscilloscope extends your capabilities beyond the limits of conventional storage tube technology.

With the OS4000, stored transients do not deteriorate and are clearly displayed at will indefinitely — as long as you choose to keep the data. Stored trigger points allow you to display pretrigger signals as well as the signal itself. You see what actually caused the signal.

Digital storage also offers you four useful options: 1) Fully automatic operation, 2) analog and digital output for hardcopy, 3) higher resolution through expansion of stored traces, 4) the ability to generate complex wave forms.

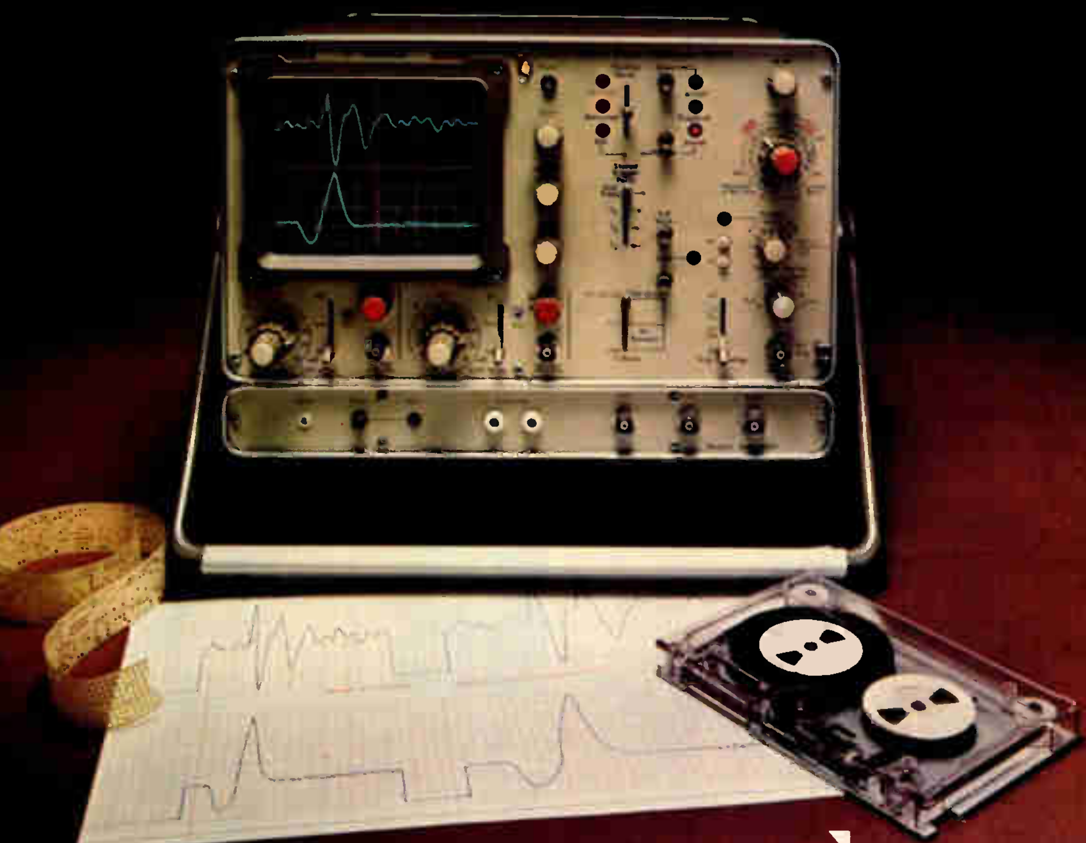
The OS4000 can enhance the effectiveness of traditional dual trace displays by simultaneously displaying real time and stored traces without the amplitude restrictions of a split beam storage tube. Both signals have optimum brightness to help you draw the critical inferences from close comparisons. At low frequencies there is no irritating flicker or C.R.T. glow.

Rated at 10 MHz for conventional operation the OS4000 utilizes an 8 bit x 1024 word RAM, with a sampling frequency of 1.8 MHz. Normal/refreshed/roll modes are standard.

With a multitude of new applications in general electronics, medical electronics, research laboratories and transducer related measurement situations, Gould's OS4000 simply outclasses every tube storage scope on the market. But even though the OS4000 represents a step forward in storage scope technology, it is both easy to use and extremely affordable.

For more information contact Gould Inc., Instruments Division, 3631 Perkins Ave., Cleveland, OH 44114. In Europe contact Gould Advance LTD., Roebuck Rd., Hainault, Essex, CB10 1EJ, England.

For brochure call toll free (800) 325-6400. Ext. 77. In Missouri: (800) 324-6600.



Example of expanded output (1:2)

GOULD

device and 2001 for the TC meter provide selection of any of 10 input channels. Channels 0 through 4 accept signals from one type of sensor; channels 5 through 9 are for a different type.

Option 2002 provides four thumbwheel switches that can set limits at which a relay closes and an LED lights. Thus, for example, four-point control and monitoring of system process is achievable.

Option 2009 is a snap-on 5-hour rechargeable power supply. Option 2003 permits calibration of any thermocouple thermometer, as well as providing portable power.

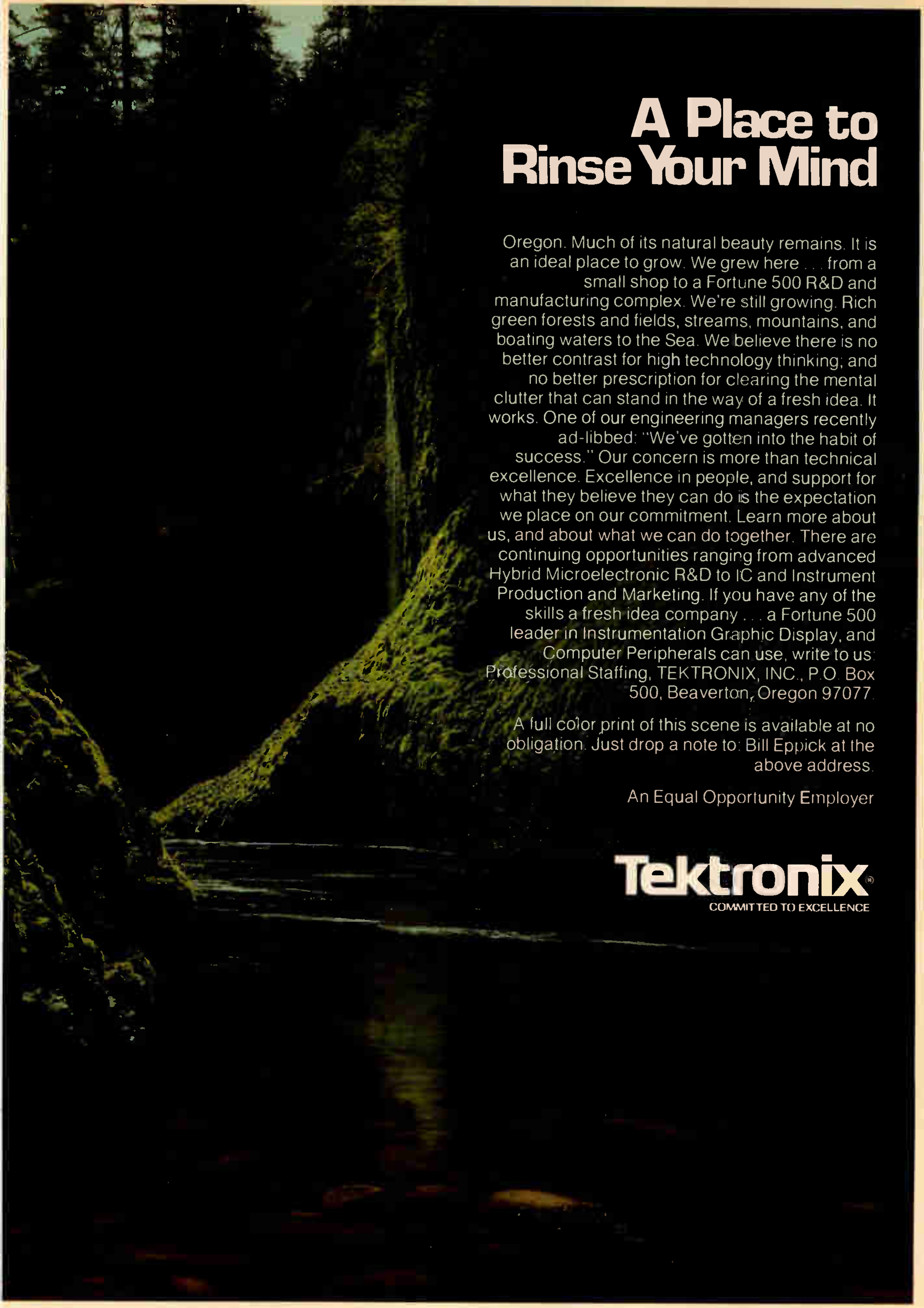
The price for either model is $695 and options range from $150 for option -006 to $350 for snap-on 2002 or 2003.

John Fluke Manufacturing Inc., P. O. Box 43210, Mountlake Terrace, Wash. 98043. Phone (800) 426-0361 [371]

Pulsed actuator has light touch

The series 92100 actuator is a small, dc-pulse-controlled device that has a maximum linear shaft travel of 0.5 in., achievable in 0.004-in. steps. The shaft can apply a maximum force of 15 oz and can be extended to its maximum length in as little as 0.3 second. These capacities make the actuator useful as a control device in many microprocessor-based applications, such as automotive cruise control and carburetion systems.

Basically, the 92100 consists of a stepper motor that has been modi-


A Place to Rinse Your Mind
Oregon. Much of its natural beauty remains. It is an ideal place to grow. We grew here . . . from a small shop to a Fortune 500 R&D and manufacturing complex. We're still growing. Rich green forests and fields, streams, mountains, and boating waters to the Sea. We believe there is no better contrast for high technology thinking; and no better prescription for clearing the mental clutter that can stand in the way of a fresh idea. It works. One of our engineering managers recently ad-libbed: "We've gotten into the habit of success." Our concern is more than technical excellence. Excellence in people, and support for what they believe they can do is the expectation we place on our commitment. Learn more about us, and about what we can do together. There are continuing opportunities ranging from advanced Hybrid Microelectronic R&D to IC and Instrument Production and Marketing. If you have any of the skills a fresh idea company . . . a Fortune 500 leader in Instrumentation Graphic Display, and Computer Peripherals can use, write to us: Professional Staffing, TEKTRONIX, INC., P.O. Box 500, Beaverton, Oregon 97077.
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fied by the incorporation of an internally threaded rotor fitted with a screw shaft. Energizing each of the unit's two coils with a 12-v dc pulse in the proper sequence extends or retracts the shaft in linear increments of 0.004 in. per pulse. Another similarly modified stepper motor offers 6- to 8-lb forces.

The unit is approximately 1 in. in diameter and weighs about 1.5 oz. In quantities of 100 pieces, it sells for $14.50; production runs will lower prices considerably. Prototype units are available.

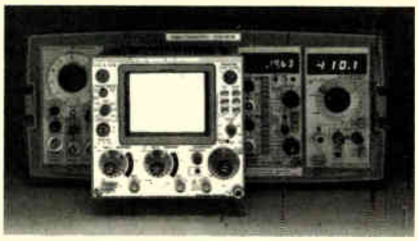
North American Philips Controls Corp., Cheshire Industrial Park, Cheshire, Conn. 06410. Phone (203) 272-0301 [373]

Optical encoder provides computer-compatible output

The model GC 30 series of optical absolute shaft encoders, with integral electronics and light-emitting diodes, supply an output that is directly compatible with many types of popular integrated circuits. The devices do not require any external signal-conditioning or signal-decoding networks.

Output format is continuous parallel Gray code; both positive and negative logic models are available. Resolutions of up to 10 bits with an accuracy of 3.0 minutes of arc are offered with standard input power requirements of 5 v dc ±5% at 300 mA maximum. Purchasers may choose input powers of 10, 12, or 15 v dc at 175 mA maximum.

These size 30 servo-housed units



beam modulation input—both of which are also in the rear—this allows interconnection with other TM 500 plug-in modules, such as pulse generators, function generators, digital and universal counters, digital multimeters, a logic analyzer, and others. With the SC 503, users should be able to assemble measurement systems that are well suited for medical or biophysical applications, as well as for a variety of electromechanical measurements.

The SC 503 is priced at $2,200, and delivery is 15 weeks from receipt of order.

Tektronix Inc., P. O. Box 500, Beaverton, Ore. 97077. Phone Bob Down at (503) 644-0161, Ext. 6011 [353]

Fractional-N technique used to synthesize and analyze

The fractional-N technique, which provides excellent frequency resolution [*Electronics*, April 27, p. 107], has been used to produce both a spectrum analyzer and a synthesizer that is also a function generator and a sweeper.

The HP 3325A synthesizer can generate sine waves, triangles, square waves, and ramps, including sweep. As a synthesizer, for example, it delivers sine waves from 1 mHz to 21 MHz with 1-μHz resolution below 100 kHz and 1-mHz above. The unit is fully programmable either digitally from the front panel or by remote control from HP's IEEE-488 bus. The unit is priced at $3,000, and delivery is in 90 days.

The HP 3585A 40-MHz spectrum analyzer has a measurement range from −137 to +30 dBm and it can measure power line sidebands that are greater than 80 dB down. Its spurious-free dynamic range is greater than 80 dB with full-scale inputs of −25 dBm to +30 dBm. Center frequency and span settings have 0.1-Hz resolution and 0.1-ppm-per-month stability over the entire operating range, making possible use of a 3-Hz bandwidth resolution for close-in analysis even at 40 MHz. It is priced at $17,500, and delivery is from stock.

Hewlett-Packard Co., Inquiries Manager, 1507 Page Mill Rd., Palo Alto, Calif. 94304 [355]

NiCad-powered multimeter reads true rms for 40 hours

Using a liquid-crystal display, the model 258 4½-digit multimeter can measure true rms values of ac voltages and currents continuously for as long as 40 hours when it is powered by rechargeable nickel-cadmium batteries.

The instrument's sensitivity is 10 μV, and its accuracy is within 0.05% of input for one year without recalibration. The measurement ranges handled by the full-function instrument, to name a few, are: 10 μV to 500 V and 10 nA to 2 A between 30 Hz and 20 kHz, and ±10 μV dc to ±1,000 V dc.

Measuring 1¾ by 5½ by 3½ in., the meter sells for $295 and comes with carrying case, rechargeable battery pack, battery charger, and test leads. Optional accessories include a high-voltage probe, bench stand, clamp-on ac current probe, and a leather or fiberglass carrying case.

Data Precision Corp., Audubon Road, Wakefield, Mass. 01880. Phone Robert Scheinfein at (617) 246-1600 [358]

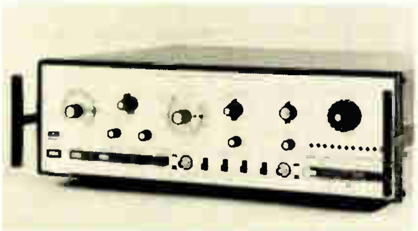
Circle 203 on reader service card →

able $575. Delivery begins in July.
Hewlett-Packard Co., Inquiries Manager, 1507 Page Mill Rd., Palo Alto, Calif. 94304 [351]

Function generator offers wide range and choice

The model 737 is an extremely versatile function generator. Over a frequency range of 0.0001 Hz to 30 MHz, it creates triangular, square, and sine waves and pulses. It allows single-cycle or continuous waveforms to be triggered either manually or by an internal or external signal. Frequency can be varied linearly or logarithmically. Pulses can have a maximum height of 15 v peak to peak, a minimum duration of 17 ns, and rise and fall times of less than 10 ns.

The output amplifier delivers a maximum open-circuit output of



30 v p-p. Fixed attenuator settings in additive steps of 10, 20 and 30 dB provide a maximum attenuation of 60 dB, while the variable-amplitude control adds a further 20 dB. A dc offset voltage provided is variable over the range ±7.5 v and is unaffected by attenuation settings.

The model 737 is priced at $1,295, and delivery is four weeks after receipt of order.

Exact Electronics Inc., 455 S. E. 2nd Ave., Hillsboro, Ore. 97123. Phone Joe Foster at (503) 648-6661 [354]

Programmable generator can be interfaced to computer

Designated the model 3002, this generator produces signals between 1 kHz and 520 MHz with a frequency

accuracy of 0.001% and a stability of 0.2 ppm per hour over its entire frequency range. The unit is frequency-programmable and, with the model 3911 general-purpose interface bus converter, is IEEE-488-1975-compatible. It can be operated in a-m and fm modes using either external modulation or internal 400- or 1,000-Hz frequencies.

Options for the model 3002 include level programming, external frequency reference, reverse power protection, and low-level leakage. The base price for the generator is $3,300, and delivery is 6 weeks after receipt of order.

Wavetek Indiana Inc., 66 North First Ave., Beech Grove, Ind. 46107. Phone Mario Vian at (317) 783-3221 [356]

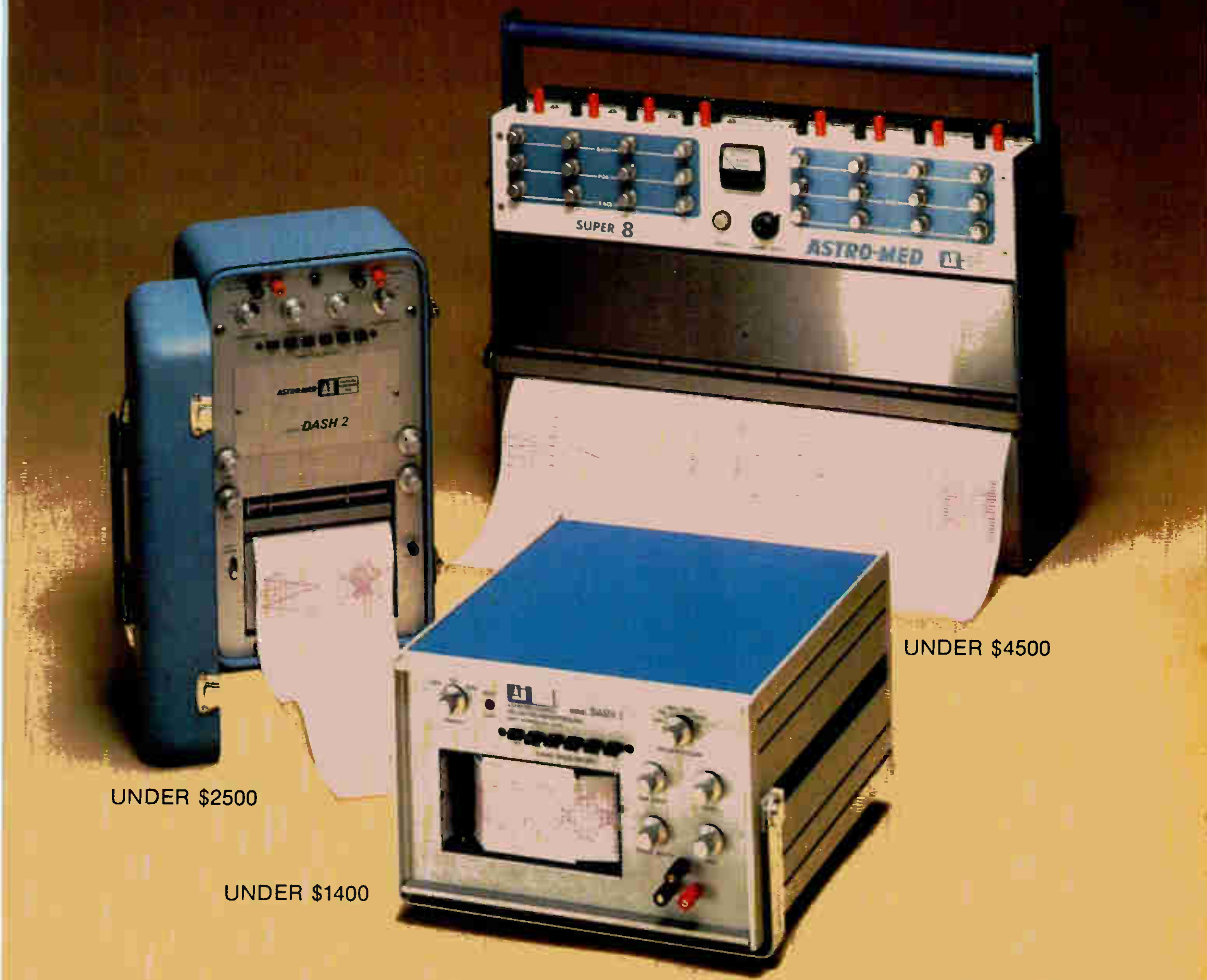
Plug-in scope stores signals for up to 4 hours

An addition to the TM 500 series of modular test and measurement instruments, the SC 503 is a 10-MHz dual-trace storage oscilloscope that can hold signals for up to 4 hours on its bistable-phosphor cathode ray tube. The unit can also be operated in an auto-erase mode, which allows the user to select a viewing time ranging from 1 to 10 seconds, and in a nonstorage mode.

The normal stored writing rate for the oscilloscope is 50 cm/s, which can be enhanced to 250 cm/s by trading off storage time. The device offers auto, normal, and single-sweep triggering, a variable trigger hold-off, and trigger viewing. The SC 503's sensitivity is 1 mv/div.

Inputs to both channels can be switched from the front panel to a rear connector. Together with an internal trigger connector and a

ASTRO-MED



Battery Powered Recorders

. . . with the super accuracy of the Pathfinder™ **position feedback** galvanometer . . . clean, skip-free tracings on low cost thermal paper . . . portability . . . rechargeable battery in Dash I and Dash II. The Super 8 is optionally available for 12VDC operation (battery not included) or for 110/220 line power.

For complete details ask for catalog.

Ai ®

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Atlan-tol Industrial Park/West Warwick, R.I. 02893/(401-828-4000)

Circle 197 on reader service card

are priced from $395 for a 5-bit model to $550 for a 10-bit encoder. Delivery takes six weeks.

Disc Instruments Inc., 102 E. Baker St., Costa Mesa, Calif. 92626. Phone Everett McElroy at (714) 979-5300 [374]

Linearizing a-d converter gives processor heat data

With on-board linearizing circuitry for purchaser-specified type J, K, T, E, R, or S thermocouples, the model SL110 linearizing analog-to-digital converter allows any of the manufacturer's series 100 scanners and the user's 8-bit microprocessor to communicate with each other over an 8-bit bidirectional bus. Up to 160 channels can be interrogated and controlled using a single bus. All processor connections are compatible with transistor-transistor and complementary-metal-oxide-semiconductor logic at +5 v; on-board control logic allows the microprocessor to control scanning and linearization and to detect cable breakage at any analog input.

Sample rates of up to 40 channels

per second are achievable, and scan rates of approximately 15 channels per second can be obtained, allowing for scanner filter settling and maximum a-d conversion time of 24 ms. Linearization error is less than 0.1% of full scale.

The unit plugs into a standard 6.25-in. card slot. Its overall dimensions are 6.25 by 10.45 by 0.97 in., and its price is $445.

San Diego Instrument Laboratory, 7969 Engineer Rd., San Diego, Calif. 92111. Phone John Martin at (714) 292-0646 [375]

FORT

Light – the information medium

'ransmission and Optical Fiber Department

NUMBER ONE with its nanufacturing program

esheathed single fiber - LD O2

ecifications :

ʌaterial	Silica
ʌttenuation	5 to 10 dB/km
ʌumerical aperture	18 to 20°
ʔassband	300 MHz/km
Duter fiber dia	120 μ ± 5 μ
ʔable O D	0.9 mm ± 0.1 – 0
ʌax available length	1500 mm

ɔtical cable with 3, 7 19 silica fibers TIS LD

ɔtical cable with 7 silica fibers TIS ZMO7 and TIS PZO7

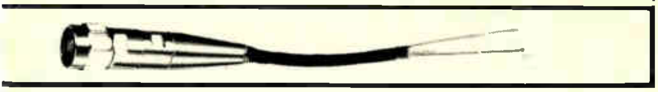
ecifications :

• Material	Silica
• Attenuation	15 to 50 dB/km
• Numerical aperture	32°
• Passband	> 150 MHz/500 m
• Outer fiber dia	400 μ ± 10 μ
• Cable O D	6 mm
• Max available length	500 mm
• Tensile strength	25 kg
• Radius of curvature	80 mm

ɔtical cable with 19 glass fibers TIS-MD 19

ecifications :

• Material	Glass
• Attenuation	< 100 dN/km
• Numerical aperture	57°
• Passband	> 100 MHz/100 m
• Outer fiber dia	105 μ ± 5 μ
• Cable O D	6 mm
• Max available length	250 m
• Tensile strength	25 kg
• Radius of curvature	80 mm

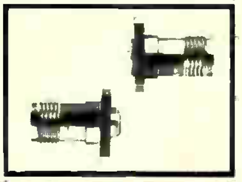


L OUR CABLES can be delivered WITH or WITHOUT CONNECTORS

TRANSMITTER-RECEIVER ASSEMBLIES for fiberoptic cables

Type TIS ZM and MD with connectors

System for LOGIC, ANALOGUE, DIGITAL, transmission



FORT
Z.I. de la Gaudrée - 5, rue Lambert
91410 DOURDAN (France)
Tél. (1) 492.94.63+
Télex : TXFRA 270105 F REF. 643

TQS FORT
RHEINGAUSTRASSE 83 85
62000 WIESBADEN 12 W GERMANY
Tel (0 61 21) 28 35

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24100 BERGAMO ITALIA
Tel (035) 222 571

FORT IS MARKETED IN 14 COUNTRIES

Circle 257 on reader service card

THE VERY ATTRACTIVE SOVIET-MADE MINI-COMPUTERS NEWS

SM-1 SYSTEM

∗ Ideal for real-time single-level automated process control systems

∗ Also readily fits as a low-level component into large sophisticated hierarchies, with the ASVT-M and ES

∗ A valuable tool in engineering calculations, too

with

– appreciable speed of up to 400,000 addition-type ops per second

– a comprehensive system of checks and diagnostics, automatic self-recovery after failures, automated initial program-loading and starting

and also

full software and input/output interface compatibility with M-6000/M-7000 ASVT-M Processors,

plus the Instruction List readily expandable with both standard additional instruction sets and User's special instructions

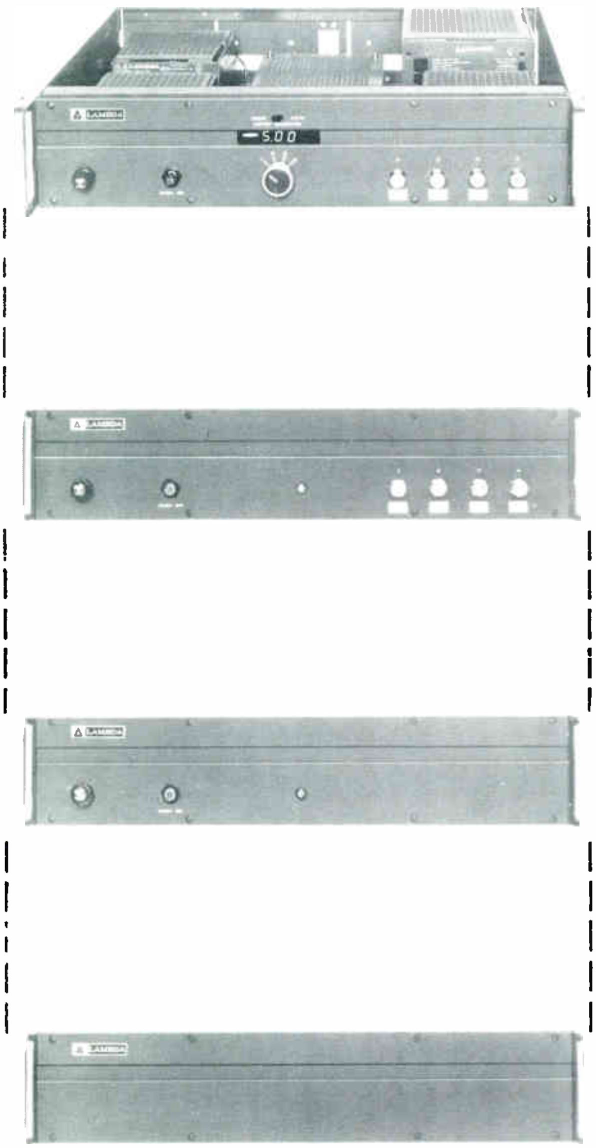
TECHMASHEXPORT

35 Mosfilmovskaya
117330 Moscow, USSR
Telephone 147-15-62
Telex 7568

Circle 258 on reader service card

CUSTOM POWER SUPPLIES

LAMBDA MAKES IT EASY FOR YOU TO ORDER



Built to your requirements

Lambda custom power supplies are designed to your requirements, and we have made it very simple for you to specify within our 16 standard configurations. By calling your nearest Lambda office you can tell us what we need to know:

1. To give you a firm price quotation on the number and type of custom units you require.
2. To design and build these supplies to the parameters you select.

No engineering charge

There is no engineering or set-up charge for designing your custom power supply. This is one more reason why Lambda can offer you a custom product at a lower cost than if you built it yourself.

Wide range of options

Lambda offers you a custom power supply with up to 4 outputs, in 4 package sizes and 4 front panel configurations for each package size. (Call your nearest Lambda office for your system requirements.) Choose one of the group of 5 regulation, ripple and temperature coefficient specifications for each output and we will determine which package size you need. From the descriptions on the following pages, also enter on the Request for Quotation Form the front panel configuration which best meets your monitoring and control requirements.

Three week delivery

Your custom power supply, assembled, wired, and ready to operate will be shipped within 3 weeks after receipt of your order.

5 year guarantee

Every custom power supply is covered by Lambda's comprehensive 5 year guarantee (when five year guaranteed power supplies are used) which includes labor as well as parts. Guarantee applies to operation at full published specifications at end of 5 years.

PACKAGE SIZE J

3½″ x 19″ x 14″ • up to 8 outputs • and for any single output up to 150V, up to 90A

CONFIGURATION 1

Blank panel. Economical when power supply will be remotely controlled. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.

CONFIGURATION 2

Panel with on/off switch for AC input, pilot light and fuse. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.

CONFIGURATION 3

Panel with on/off switch for AC input, pilot light and fuse plus voltage controls (up to 4 potentiometers provided). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.

CONFIGURATION 4

Panel with on/off switch for AC input, and fuse, plus voltage controls (up to 4 potentiometers provided) and metering panel (up to 4 supplies monitored, monitoring up to 70A up to 99.9V per supply). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.

Example

Package J, Configuration 1 provides a completely wired, assembled, ready-to-use, customer power supply consisting of:

One **LJS-10-5-OV** (5V @ 10A with built-in OV)	$202
One **LCSA-01** (0-7V @ 2.0)	134
One **LCSB-02** (0-18V @ 2.0)	177
One **LRA-14** rack adapter	75
Blank front panel, cables, and assembly labor	80
Total Price	$668

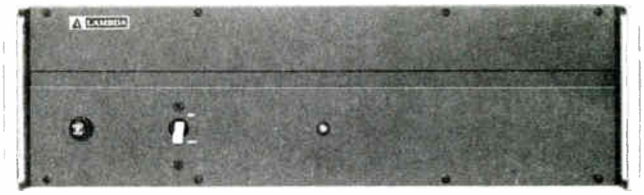
Call your nearest Lambda office for your custom system requirements.

PACKAGE SIZE K

$5^3/_{16}$ x 19″ x 14″ • up to 8 outputs • and for any single output up to 150V, up to 135A

CONFIGURATION 1
Blank panel. Economical when power supply will be remotely controlled. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.

CONFIGURATION 2
Panel with on/off switch for AC input, pilot light and fuse. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.



CONFIGURATION 4
Panel with on/off switch for AC input, and fuse, plus voltage controls (up to 4 potentiometers provided) and metering panel (up to 4 supplies monitored, monitoring up to 70A up to 99.9V per supply). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.

Example
Package K, Configuration 2 provides a completely wired, assembled, ready-to-use custom power supply consisting of:

Three **LJS-11-5-OV** (5V @ 20A with built-in OV)	$247.00
One **LRA-15** rack adapter	75.00
Panel, AC on/off, indicator light, fuse, cables, and assembly labor	100.00
Total Price	$916.00

Call your nearest Lambda office for your custom system requirements.

PACKAGE SIZE L

3½″ x 19″ x 21″ • up to 8 outputs • and for any single output up to 150V, up to 140A

CONFIGURATION 1

Blank panel. Economical when power supply will be remotely controlled. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.

CONFIGURATION 2

Panel with on/off switch for AC input, pilot light and fuse. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.

CONFIGURATION 3

Panel with on/off switch for AC input, pilot light and fuse plus voltage controls (up to 4 potentiometers provided). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.

CONFIGURATION 4

Panel with on/off switch for AC input, and fuse, plus voltage controls (up to 4 potentiometers provided) and metering panel (up to 4 supplies monitored, monitoring up to 70A up to 99.9V per supply). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.

Example

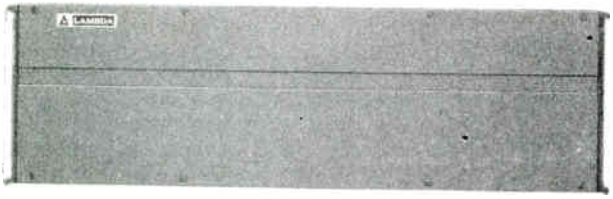
Package L, Configuration 3 provides a completely wired, assembled, ready-to-use, custom power supply consisting of:

Two **LGS-6-12-OV-R** (12V @ 37.5A with built-in OV)	$594
One **LRA-16** rack adapter	95
Panel, AC on/off, indicator light, fuse, cables, voltage potentiometers and assembly labor	170
Total Price	$1453

Call your nearest Lambda office for your custom system requirements.

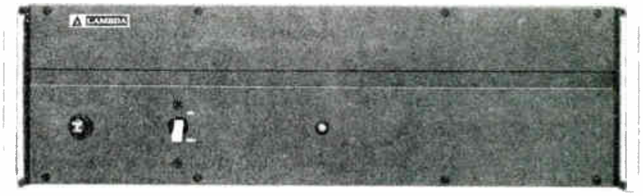
PACKAGE SIZE M

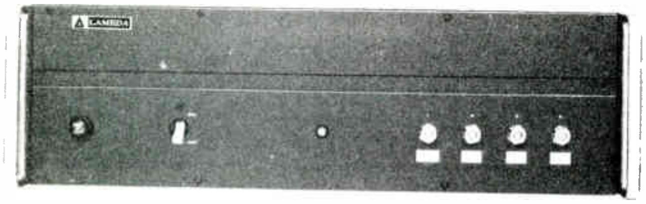
$5^3/_{16}''$ x 19″ x 21″ • up to 8 outputs • and for any single output up to 150V, up to 220A



CONFIGURATION 1
Blank panel. Economical when power supply will be remotely controlled. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.

CONFIGURATION 2
Panel with on/off switch for AC input, pilot light and fuse. Maximum of 8 outputs (up to 4 power supplies) with AC input wiring provided through barrier strip on rear of rack adapter. Customer to provide necessary wiring for dc outputs available at rear of rack.





CONFIGURATION 3
Panel with on/off switch for AC input, pilot light and fuse plus voltage controls (up to 4 potentiometers provided). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.

CONFIGURATION 4
Panel with on/off switch for AC input, and fuse, plus voltage controls (up to 4 potentiometers provided) and metering panel (up to 4 supplies monitored, monitoring up to 110A up to 99.9V per supply). Maximum of 4 outputs with AC input wiring provided through barrier strip on rear of rack adapter and DC output wiring provided through barrier strip on rear of rack adapter. Power supply nameplates at output barrier strips and at front panel potentiometers.

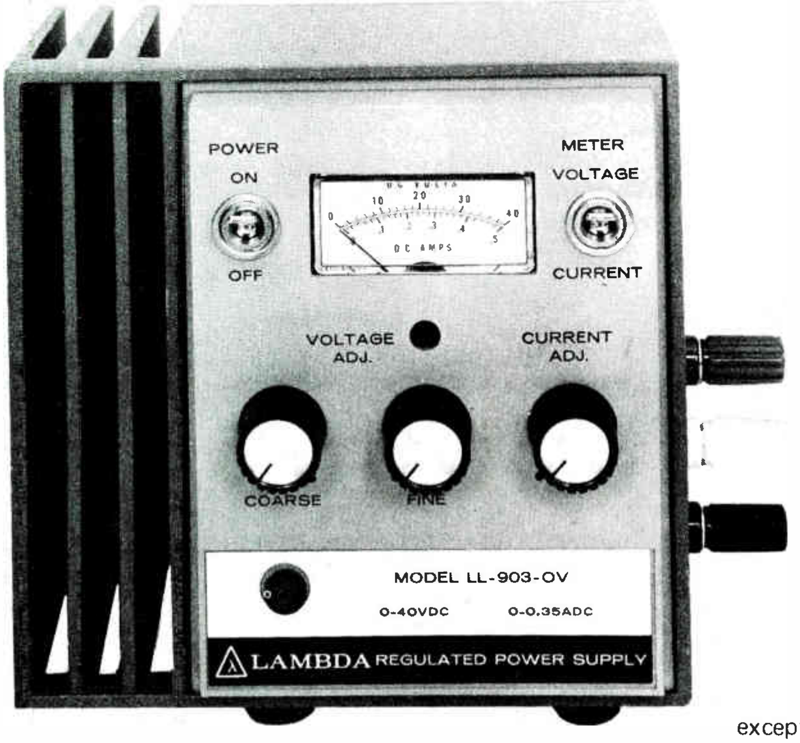
Example
Package M, Configuration 4 provides a completely wired, assembled ready-to-use, custom power supply consisting of:

Two **LGS-5-5-OV-R** (5V @ 45A with built-in OV)	$440
Two **LGS-5-12-OV-R** (12V @ 24A with built-in OV)	440
One **LRA-17** rack adapter	95
Digital Meter, panel, AC on/off, indicator light fuse, voltage potentiometer, cables, and assembly labor	430
Total Price	$2285

Call your nearest Lambda office for your custom system requirements.

LL SERIES
I-C REGULATED
BENCH POWER SUPPLIES

for general purpose laboratory use



LL Series I-C Regulated Power Supply

Multi-position lies flat or stands erect

LL SERIES BENCH TYPE SUPPLY
5⅝" x 5½" x 3⅞"

MODEL	ADJ. VOLT. RANGE VDC	CURRENT RANGE (1)	PRICE(2)
3 models with built-in tracking overvoltage protection			
LL-901-OV	0-10	0-1 amp	$152
LL-902-OV	0-20	0-0.65 amp	152
LL-903-OV	0-40	0-0.35 amp	152
LL-905	0-120	0-65 ma	152

REGULATION: Line: 0.01% + 1 mV Load: 4 mV

RIPPLE: 250 uV RMS

NOTES:

(1) Consult factory for operation at 400 Hz or temperatures above 50°C. Ratings apply 0-50°C.
(2) All prices and specifications subject to change without notice.

Outstanding Features

All-silicon DC power supply using integrated circuit to provide regulation system

except for input and output capacitors, rectifiers, and series regulation transistors

Regulation

line: 0.01% + 1 mV
load: 4mV

Ripple

250 uV RMS, 1 mV pk-pk

Convection cooled

Multi-position operation

lies flat or stands erect

Die-cast aluminum construction

Weight

less than 6 lbs.

No overshoot

on turn-on, turn-off or power failure

Adjustable current limiting

0 to 110 % of rating

Controls

course voltage adjust, fine voltage adjust, current adjust, ON/OFF switch, meter function switch

Built-in tracking overvoltage protection models available

SPECIFICATIONS OF LL SERIES

DC output
voltage ranges: 0-10V, 0-20V, 0-40V, 0-120V.

Regulated voltage
regulation, line	0.01% + 1mV
regulation, load	4 mV
ripple and noise	250 uV RMS 1 mV pk-pk
temperature coefficient	(0.015% + 300 uV) /°C

AC input
line	105-132 VAC 47-440 Hz (current ratings based on 57-63 Hz) derate current 10% for 50 Hz operation. 187-242 VAC, 205-265 VAC, 45-440 Hz, see "AC Input Option"
power	LL-901-OV, 30 Watts; LL-902-OV, 32 Watts; LL-903-OV, 32 Watts; LL-905, 15 Watts

Ambient operating temperature range
continuous duty from 0° to + 50°C

Storage temperature range
-40°C to +85°C

Overload Protection
Electrical

external overload protection: automatic electronic current limiting circuit limits the output current to a preset value, thereby providing protection for load as well as the power supply. Automatic current limiting is adjustable from 0-110% of rating.

Overvoltage protection
built-in tracking overvoltage protection on LL-901-OV, LL-902-OV and LL-903-OV.

Input connections
heavy-duty, 3-wire line cord provided.

Output connections
5-way binding posts on side panel.

Meter
dual function meter measures voltage or current output as selected by meter function switch on front panel.

Controls
DC output controls

course voltage adjust, fine voltage adjust and current adjust on front panel. On models LL-901-OV, LL-902-OV and LL-903-OV adjustment of voltage control allows overvoltage protector to track voltage output automatically.

Power

on-off switch on front panel.

Meter

function switch to measure output voltage or current.

Multiposition operation
lies flat or stands erect

Physical data
Size

5 5/8"W x 5 1/2"H x 3 7/8"D

Weight

5 lbs. net, 7 lbs. ship

Accessories
pot covers. See catalog.

Options
AC input

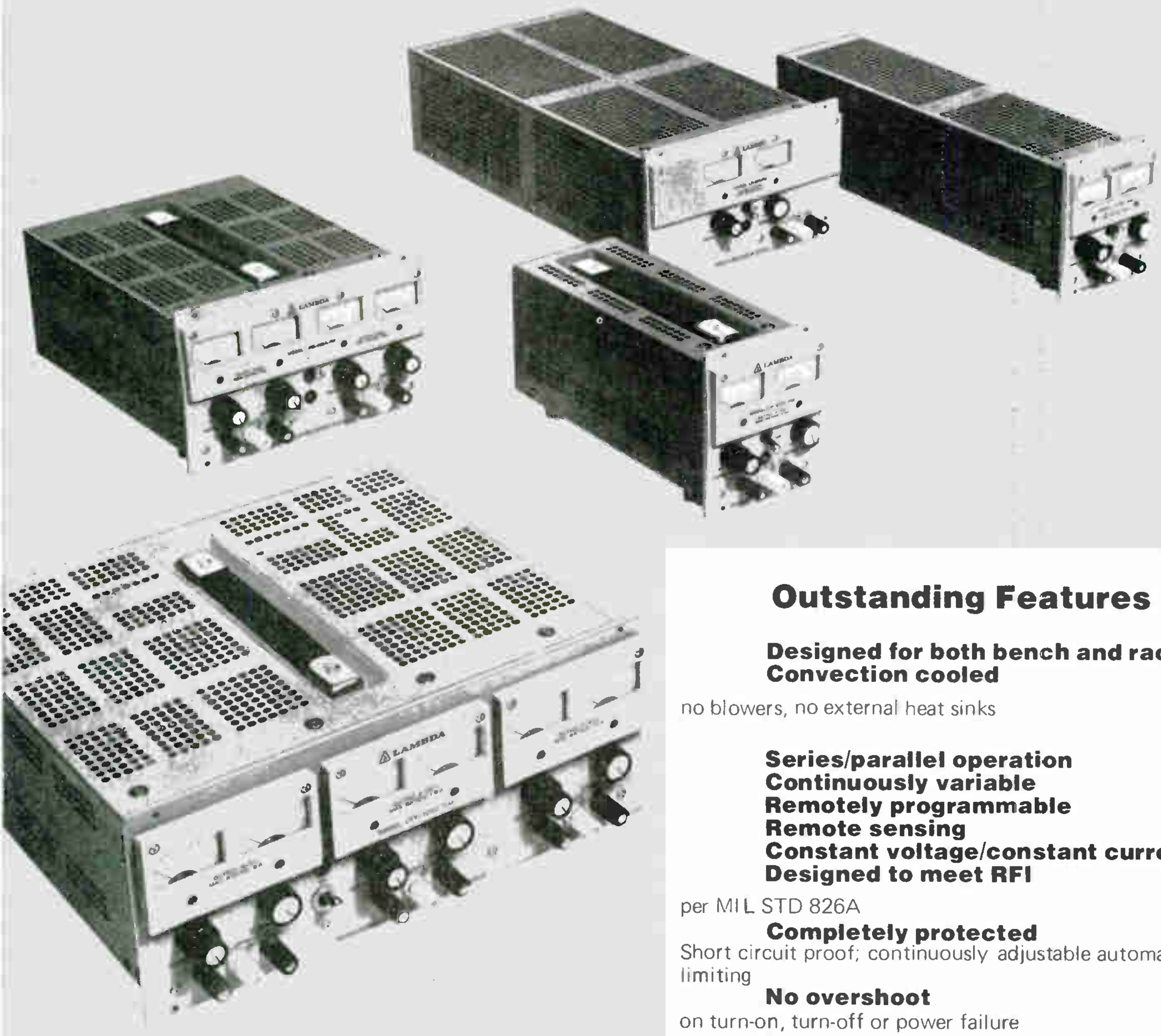
Add suffix:	For operation at:	Price
–V	187-242 VAC, 47-440 Hz	$20
–V1	205-265 VAC, 47-440 Hz	$20

Derate current 10% for 50 Hz operation

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

LP SERIES SINGLE-OUTPUT POWER SUPPLIES
LPD SERIES DUAL-OUTPUT POWER SUPPLY
LPT SERIES TRIPLE-OUTPUT POWER SUPPLY

for general purpose laboratory and test equipment use.



Widest selection of laboratory supplies with big-system features and capabilities for bench or rack use.

Outstanding Features

Designed for both bench and rack use.

Convection cooled
no blowers, no external heat sinks

Series/parallel operation

Continuously variable

Remotely programmable

Remote sensing

Constant voltage/constant current

Designed to meet RFI
per MIL STD 826A

Completely protected
Short circuit proof; continuously adjustable automatic current limiting

No overshoot
on turn-on, turn-off or power failure

Features of dual and triple output models

6 models with independent DC outputs offer widest choice
up to ±250 VDC, up to 5 Amps. Either output may be plus or minus, or both outputs may be plus or minus.

Series/parallel operation
of outputs yields two times the voltage or two times the current – up to 500 Volts or up to 3.4 Amps.

Auto series/auto parallel (master-slave)
permits tracking to a common reference

Separate meters
provide simultaneous monitoring of both voltage and current.

LPT SERIES TRIPLE OUTPUT MODEL

MODEL	REGULATION[5]	RIPPLE (RMS)	VOLTAGE RANGE (VDC)[4]	MAX CURRENT, AMPS AT AMBIENT OF: [1] 30°C	40°C	50°C	60°C	DIMENSIONS	[2][3] Price
LPT-7202-FM	0.01% + 1 mV	500 uV	0-7	5.0	4.5	4.0	3.5	5 3/16" x 12 1/2" x 11"	$642
			0-20	1.5	1.35	1.2	1.0		
			0-20	1.5	1.35	1.2	1.0		

LPD SERIES DUAL OUTPUT MODELS

MODEL	REGULATION[5]	RIPPLE (RMS)	VOLTAGE RANGE[4] Per Output/ Outputs in Series VDC	MAX CURRENT, AMPS AT AMBIENT OF: [1] Per Output/ Outputs in Parallel 30°C	40°C	50°C	60°C	DIMENSIONS	[2][3] Price
*LPD-421A-FM	0.01% + 1 mV	500 uV	0- ±20/0-40	1.7/3.4	1.5/3.0	1.3/2.6	0.9/1.8	5 3/16" x 8 3/8" x 10 3/32"	$449
*LPD-422A-FM	0.01% + 1 mV	500 uV	0- ±40/0-80	1.0/2.0	0.85/1.7	0.7/1.4	0.55/1.1	5 3/16" x 8 3/8" x 10 3/32"	449
*LPD-423A-FM	0.01% + 1 mV	500 uV	0- ±60/0-120	0.7/1.4	0.6/1.2	0.5/1.0	0.4/0.8	5/3/16" x 8 3/8" x 10 3/32"	449
LPD-424A-FM	0.01% + 1 mV	500 uV	0- ±120/0-240	0.38/0.76	0.32/0.64	0.26/0.52	0.20/0.40	5 3/16" x 8 3/8" x 10 3/32"	449
LPD-425A-FM	0.01% + 1 mV	1 mV	0- ±250/0-500	0.13/0.26	0.12/0.24	0.11/0.22	0.10/0.20	5 3/16" x 8 3/8" x 10 3/32"	535

LP SERIES SINGLE OUTPUT MODELS

0-10 VOLTS

MODEL	REGULATION[5]	RIPPLE (RMS)	MAX CURRENT AMPS AT AMBIENT OF: [1] 30°C	40°C	50°C	60°C	DIMENSIONS	[2][3] Price
*LP-410A-FM	0.01% + 1 mV	500 uV	2.0	1.8	1.6	1.4	5 3/16" x 4 3/16" x 10"	$251
*LP-520-FM	0.01% + 1 mV	500 uV	5.0	4.7	4.3	3.7	5 3/16" x 4 3/16" x 15 1/2"	310
*LP-530-FM	0.01% + 1 mV	500 uV	10.0	9.0	8.0	7.0	5 3/16" x 8 3/8" x 15 5/8"	449

0-20 VOLTS

MODEL	REGULATION	RIPPLE	30°C	40°C	50°C	60°C	DIMENSIONS	Price
*LP-411A-FM	0.01% + 1 mV	500 uV	1.2	1.1	1.0	0.8	5 3/16" x 4 3/16" x 10"	$251
*LP-521-FM	0.01% + 1 mV	500 uV	3.3	3.0	2.6	2.3	5 3/16" x 4 3/16" x 15 1/2"	310
*LP-531-FM	0.01% + 1 mV	500 uV	5.7	5.3	4.7	4.0	5 3/16" x 8 3/8" x 15 5/8"	433

0-40 VOLTS

MODEL	REGULATION	RIPPLE	30°C	40°C	50°C	60°C	DIMENSIONS	Price
*LP-412A-FM	0.01% + 1 mV	500 uV	1.0	0.90	0.80	0.60	5 3/16" x 4 3/16" x 10"	$251
*LP-522-FM	0.01% + 1 mV	500 uV	1.8	1.6	1.4	1.2	5 3/16" x 4 3/16" x 15 1/2"	310
*LP-532-FM	0.01% + 1 mV	500 uV	3.0	2.9	2.7	2.3	5 3/16" x 8 3/8" x 15 5/8"	433

0-60 VOLTS

MODEL	REGULATION	RIPPLE	30°C	40°C	50°C	60°C	DIMENSIONS	Price
*LP-413A-FM	0.01% + 1 mV	500 uV	0.45	0.41	0.37	0.33	5 3/16" x 4 3/16" x 10"	$251
*LP-523-FM	0.01% + 1 mV	500 uV	0.9	0.8	0.7	0.6	5 3/16" x 4 3/16" x 15 1/2"	316
*LP-533-FM	0.01% + 1 mV	500 uV	2.4	2.2	2.1	1.8	5 3/16" x 8 3/8" x 15 5/8"	482

0-120 VOLTS

MODEL	REGULATION	RIPPLE	30°C	40°C	50°C	60°C	DIMENSIONS	Price
LP-414A-FM	0.01% + 1 mV	500 uV	0.20	0.18	0.16	0.12	5 3/16" x 4 3/16" x 10"	$278
LP-524-FM	0.01% + 1 mV	500 uV	0.5	0.45	0.4	0.35	5 3/16" x 4 3/16" x 15 1/2"	353
LP-534-FM	0.01% + 1 mV	500 uV	1.2	1.0	0.9	0.8	5 3/16" x 8 3/8" x 15 5/8"	535

0-250 VOLTS

MODEL	REGULATION	RIPPLE	30°C	40°C	50°C	60°C	DIMENSIONS	Price
LP-415A-FM	0.01% + 1 mV	500 uV	80 mA	72 mA	65 mA	60 mA	5 3/16" x 4 3/16" x 10"	$310

NOTES:

* Overvoltage protection available as an accessory. Each output requires separate OV accessory — add $35.00 for each output. See page 23.

(1) Current rating applies over entire voltage range. Ratings based on 57-63 Hz operation.
(2) Prices are for metered models. LP and LPD series models are not available without meters.
(3) All prices subject to change without notice.
(4) LPD, LPT Series models require one LH-OV for each output.
(5) See next page for full specifications

SPECIFICATIONS OF LP, LPD & LPT SERIES

DC output
voltage ranges shown in tables.

Regulated voltage

regulation (line or load)	0.01% + 1mV for line variations from 105-132 VAC or for load changes from no load to full load.
current range	as shown in table
remote programming resistance	200 ohms/volt nominal
remote programming voltage	volt per volt
ripple and noise	500uV RMS, 1.5mV pk-pk (either plus or minus terminal grounded.) LPD-425-A-FM model only 1mV RMS, 3mV, pk-pk.
Temperature coefficient	(0.015% + 0.3mV)/°C-LP, LPT models (0.015% + 0.5mV)/°C-LPD models

Constant current
(current regulated line and load)

Automatic crossover

voltage range	as shown in tables
current range	min: 45mA or 1% whichever is greater (LP-530-FM — LP-534-FM, LPT models only) all other LP models and LPD models 5mA or 1% whichever is greater. max: as shown in tables.
regulation (line or load)	less than 0.2% or 5mA whichever is greater.

AC input
105-132 VAC; 47-440 Hz. Ratings based on 57-63 Hz. 187-242 VAC; 205-265 VAC. See "AC Input Option."

Ambient operating temperature range
continuous duty from 0° to +60°C

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

Overload protection
Thermal
Thermostat, automatic reset.

Electrical

external overload protection	adjustable, automatic electronic current limiting, settable to 105% of rated current.
internal failure protection	provided by fuse

Input and output connections
covered terminal block on rear of chassis; five-way binding posts on front panel. On LPD, LPT Models one set of five-way posts is provided for each output.

Meters
voltmeter and ammeter. For LPD, LPT Models, each output has a separate voltmeter and ammeter.

Controls
DC output controls
coarse and fine voltage and coarse and fine current adjust provided on front panel of all LPD, LPT models for each output. On all other LP models coarse and fine voltage adjust and single current adjust controls are provided.

Power
on-off switch, front panel.

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

Physical data

Series	Weight Lbs net	Weight Lbs ship	Size (Inches)
LP410A	7	10	5 3/16 x 4 3/16 x 10
LP520	14	18	5 3/16 x 4 3/16 x 15 1/2
LP530	25	30	5 3/16 x 8 3/8 x 15 5/8
LPD	13	16	5 3/16 x 8 3/8 x 10 3/32
LPT	24	29	5 3/16 x 12 1/2 x 11

Panel finish
tan glass-filled, flame-retardant nylon panels.

Accessories
rack adapters, overvoltage protectors, pot covers, blank panels. See page 23.

Options
Ac input

Add suffix	for operation at:	Price Qty 1-14	Price Single Model Qty 15 & up	Price Mixed Model Qty 15 & up
–V	187-242 VAC 47-440 Hz	12% or $30*	10%	12% or $30*
–V1	205-265 VAC 47-440 Hz	12% or $30*	10%	12% or $30*

*Whichever is greater

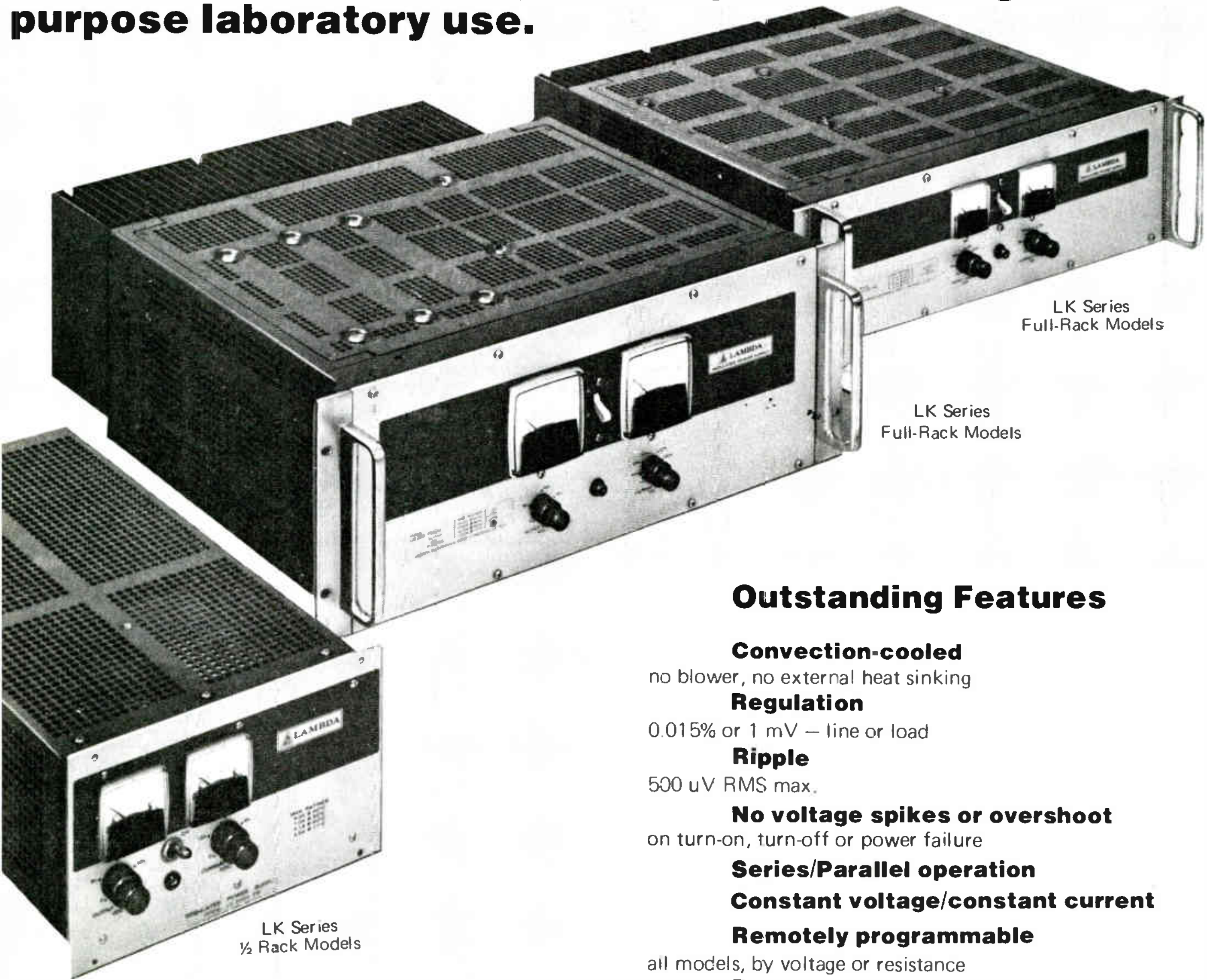
For 50 Hz operation derate current 10% on all models

Fungus proofing
add suffix "-R" to model number and add 10% or $25.00 to the price (whichever is greater).

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

LK SERIES HIGH CURRENT POWER SUPPLIES

for automatic test equipment, systems, and general purpose laboratory use.



LK Series
Full-Rack Models

LK Series
Full-Rack Models

LK Series
½ Rack Models

All silicon convection-cooled power supplies
for bench or rack use

Outstanding Features

Convection-cooled
no blower, no external heat sinking

Regulation
0.015% or 1 mV – line or load

Ripple
500 uV RMS max.

No voltage spikes or overshoot
on turn-on, turn-off or power failure

Series/Parallel operation

Constant voltage/constant current

Remotely programmable
all models, by voltage or resistance

Remote sensing
eliminates effect of power output lead resistance on DC regulation

Meet mil, environment specs.
vibration: MIL-T-4807A
shock: MIL-E-4970A Proc. 1 &2
humidity: MIL-STD-819 Meth. 507
temp. shock: MIL-E-5272C (ASG) Proc. 1
Altitude: MIL-E-4970A (ASG) Proc. 1
marking: MIL-STD-130
quality: MIL-Q-9858

LK SERIES

Three high current, all convection-cooled power packages

0-20, 0-36, 0-60 VDC and up to 66 Amps.

0-20 VOLTS

MODEL	REGULATION	RIPPLE (RMS)	MAX. CURRENT, AMPS AT AMBIENT OF:(1) 40°C	50°C	60°C	71°C	DIMENSIONS	PRICE (2)(3)
LK-340-A-FM	0.015% or 1 mV	500 uV	8.0	7.0	6.1	4.9	5 3/16" x 8 3/8" x 16"	**$ 562**
LK-341-A-FM	0.015% or 1 mV	500 uV	13.5	11.0	10.0	7.7	5 3/16" x 8 3/8" x 16"	**728**
LK-350-FM	0.015% or 1 mV	500 uV	35.0	31.0	26.0	20.0	5 3/16" x 19" x 16 1/2"	**1011**
LK-360-FM*	0.015% or 1 mV	500 uV	66.0	59.0	50.0	40.0	7" x 19" x 18 1/2"	**1573**

0-36 VOLTS

LK-342-A-FM	0.015% or 1 mV	500 uV	5.2	5.0	4.5	3.7	5 3/16" x 8 3/8" x 16"	**$ 562**
LK-343-A-FM	0.015% or 1 mV	500 uV	9.0	8.5	7.6	6.1	5 3/16" x 8 3/8" x 16"	**728**
LK-351-FM	0.015% or 1 mV	500 uV	25.0	23.0	20.0	15.0	5 3/16" x 19" x 16 1/2"	**1011**
LK-361-FM*	0.015% or 1 mV	500 uV	48.0	43.0	36.0	30.0	7" x 19" x 18 1/2"	**1573**

0-60 VOLTS

LK-344-A-FM	0.015% or 1 mV	500 uV	4.0	3.5	3.0	2.5	5 3/16" x 8 3/8" x 16"	**$ 610**
LK-345-A-FM	0.015% or 1 mV	500 uV	6.0	5.2	4.5	4.0	5 3/16" x 8 3/8" x 16"	**728**
LK-352-FM	0.015% or 1 mV	500 uV	15.0	14.0	12.5	10.0	5 3/16" x 19" x 16 1/2"	**1091**
LK-362-FM*	0.015% or 1 mV	500 uV	25.0	24.0	22.0	19.0	7" x 19" x 18 1/2"	**1573**

*AC INPUT 188-238 VAC STANDARD

OVERVOLTAGE PROTECTOR ACCESSORIES

ADJ. VOLT. RANGE VDC	MODEL	FOR USE WITH	PRICE
3-24	LH-OV-4	LK-340-A-FM, 341-A-FM	**$35**
3-47	LH-OV-5	LK-342-A-FM, 343-A-FM	**35**
3-70	LH-OV-6	LK-344-A-FM, 345-A-FM	**35**
3-70	Add "-OV" to Model No.	LK-350-FM to 352-FM	**100**
3-70		LK-360-FM to 362-FM	**135**

NOTES:

(1) Current rating applies over entire voltage range.
(2) Prices are for metered models. Non metered models available at same price. Models LK-360-FM, LK-361-FM, and LK-362-FM, which are metered models, not available without meters.
(3) Overvoltage protection up to 70 VDC as a built-in option for full-rack models. To order, add suffix "-OV" and add $100.00 to price of models LK-350-FM, 351-FM, 352-FM. For models LK-360-FM, 361-FM, 362-FM, add $135.00 and order by adding -OV to model number.
(4) Chassis slides for full rack models: add suffix "-CS" to model number and add $70.00 to the price, except for models LK-360-FM, LK-361-FM and LK-362-FM, for which add $120.00.
(5) **All prices and specifications subject to change without notice.**

SPECIFICATIONS OF LK SERIES

DC output

voltage ranges shown in tables.

Regulated voltage

regulation line or load	0.015% or 1 mV whichever is greater for line variations from 105-132 VAC, (or 188-238 VAC LK-360-FM series); or for load changes from no load to full load.
remote programming resistance	200 ohms/volt
remote programming voltage	volt per volt
ripple and noise	500 uV RMS; with either pos. or neg. terminal grounded.
temperature coefficient	0.015%/°C

Constant current

(current regulated line and load)

Automatic crossover

voltage range	as shown in tables.
current range	minimum—5% of 40°C rating. maximum — as shown in tables.
regulation, line	less than 10 mA or 0.1% whichever is greater for Input Variations of 105-132 VAC (188-238 VAC LK-360-FM series).
regulation, load	less than 10 mA or 0.1% whichever is great — from 0 to rated VDC load voltage change.

AC input

105-132 VAC, 47-63 Hz. (188-238 Vac, 47-63 Hz LK-360-FM Series only). For operation at 50 Hz derate output current by 10%. 187-242 VAC, see AC option.

Ambient operating temperature range

continuous duty from 0°C to +71°C with load current ratings shown in tables.

Storage temperature range

-55°C to +85°C

Overload protection

Thermal

thermostat; automatic reset when over-temp. condition is removed.

Electrical

external overload protection: adjustable, automatic electronic current limiting circuit limits the output current to the preset value, thereby providing protection for load as well as power supply. Current limiting settability to 105% of rated current. internal failure protection: provided by fuse.

Input and output connections

terminal block on rear of chassis

Meters

voltmeter and ammeter on all models.

Controls

DC output controls

coarse and fine voltage adjust and coarse and fine current adjust on front panel.

Power

on-off switch, front panel, — ½ rack models; circuit breakers, front panel — full-rack models.

Remote Sensing

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

Physical data

Series	Weight Lbs net	Weight Lbs ship	Size (Inches)
LK-340-AFM	35	41	5 3/16 x 8 3/8 x 16
LK-350-AFM	95	125	5 3/16 x 19 x 16 1/2
LK-360-AFM	135	170	7 x 19 x 18 1/2

Panel finish

brushed aluminum clear anodized panels with grey inlay (standard).

Accessories

rack adapters LRA-1, LRA-2 (LK-340 series only) chassis slides, over-voltage protectors, pot covers, blank panels. See page 23.

Options

AC input

For LK-340, LK-350 Series Only

Add suffix	for operation at:	Price Qty 1-14	Price Single Model Qty 15 & up	Price Mixed Model Qty 15 & up
–V	187-242 VAC 47-63 Hz	12% or $30*	10%	12% or $30*
–V1	205-265 VAC 47-63 Hz	12% or $30*	10%	12% or $30
For LK-360 Series Only				
–V1	205-265 VAC 47-63 Hz	12% or $30*	10%	12% or $30*

*Whichever is greater

For 50 Hz operation derate current 10% for all models

Fungus proofing

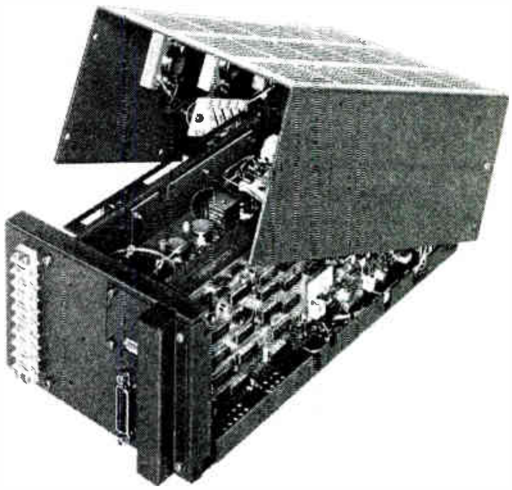
add suffix "R" to model number and add 10% to price.

Guaranteed for 5 years

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

LF-9-04 POWER SUPPLY
LF-9-04-GPIB POWER SUPPLY

The most advanced automatic test equipment power supplies on the market today



Now Lambda offers two power supplies for your automatic test equipment power supply requirement. It provides plus or minus 0-50 volts at 2 amperes DC with the following features:

Features

LF-9-04	LF-9-04-GPIB
8, 12, or 24 bit BCD programming or ASCII programming 0.01% regulation, line or load A 2 msec programming time for full voltage compliance 15 mV accuracy for 50 V BCD programming 30 mV accuracy for 50V of ASCII programming Resolution 50 mV (BCD) at 50 V; 100 mV for ASCII 100% sinking capability ripple—10mV pk-pk (BCD) on 50 Volt range; 20 mV for ASCII optical isolation current limit flag busy ready flag Current limit programming current over-ride zero over-ride inverted/ noninverted input zero adjust worst-case overshoot—1 volt transient response—1.2 msec unique digital circuitry designed with CMOS	IEEE Standard 488-75 interconnector bus ASCII programming 0.01% regulation, line or load A 2 msec programming time for full voltage compliance 30 mV accuracy for 50V of ASCII programming Resolution 100 mV at 50 V 100% sinking capability ripple—20 mV pk-pk on 50 Volt range optical isolation Current limit programming zero adjust worst-case overshoot—1 volt transient response—1.2 msec unique digital circuitry designed with CMOS

Ordering Information

Model	Price	Model	Price
LF-9-04	$1000	LF-9-04-GPIB	$1200

DC output

Volt (VDC)	MAX AMPS AT AMBIENT OF: 40°C	50°C	60°C
0 to ± 49.95	1.98	1.8	1.6

Output range

X1 range: ± 9.99V in 10 mV steps
*X5 range: ±49.95V in 50 mV steps
X10 range: ASCII only – selected automatically (0- to ±49.9 V in 100 mV steps

Source or sink

1.98 amps continuous

Regulated voltage

regulation line........................0.01% – for line variations 105-132VAC (see AC input option)
regulation load (all ranges)..................... 0.01% – for load variation of 0 to full load.
ripple and noise.................... X1 range: 2.0 mV pk-pk max
*X5 range: 10 mV pk-pk max
X10 (ASCII): 20 mV pk-pk max
temperature coefficient....... Voltage
X1 range: .005%/°C+35 μV/°C
*X5 range: .005%/°C + 0.115 mV/°C
X10 range: (ASCII only) .005%/°C + .215 mV/°C
Current
All ranges: 500 μA/°C

Constant current operation

Current Range: 1% to 99% of full scale
Regulation line . . . . 1 mA max
load . . . . 20 mA max

AC input

105-132VAC, 47-440Hz. For 187-242 or 205-265 VAC see AC input option.

Ambient operating temperature range

continuous duty from 0° to 60°C with load current ratings shown in table.

Storage temperature range

–55°C to +85°C

Basic accuracy

(at 25°C, 115VAC input and no load)................................ Voltage
X1 range: 3 mV
*X5 range: 15 mV
X10 range: 30 mV (ASCII only)
Current
All ranges: 10 mA

Resolution.................. Voltage

X1 range: 10 mV
*X5 range: 50 mV
X10 range: 100 mV (ASCII)
Current
All ranges: 20 mA

Transient response

1.2 msec to within .05% of full scale for 90% load change

*BCD only

Overshoot

Worst case overshoot 1 volt under any conditions

Input data word:

A 24 Bit data word is used comprising of 12 bits BCD voltage programming, 8 bits BCD current and one bit each for gain, polarity and current limit override. Data word may be accepted in 3, 2, or 1 sequential segments of 8, 12, 24 bits, or ASCII to make up the 24 bits. Current is programmed as a percentage of full scale.

Programming time:

see graphs on next page

Data validity

10 μsec

Data loading

Logic Levels–all 0 to +5V. One CMOS load per line. Compatible with TTL or DTL
Interface requirements:
CMOS – direct
DTL – direct
TTL – direct, with a 10K pull up resistor on each data line to +5V bus.

Control lines

One TTL or DTL buffer per line
Data Flag – CMOS input
Zero Override – requires sinking of 15mA, compatible with DTL or TTL buffers
Final Transfer Pulse – CMOS input

Output flags

1. Current Limit Flag – optical coupler, conducting when in current limit.
2. Busy Ready Flag – open collector, logic zero when ready to accept new data.

Cooling

Convection-cooled, no heatsinks or blower necessary

Mounting positions

one mounting position on horizontal plane
Input/output connections through heavy duty barrier strip and connector

Physical data

Model (Package 9)	Size (inches)	Weight lbs net	lbs ship
LF-9-04	4 15/16 x 7 1/2 x 14	20	22

Options

AC input

Add Suffix	for operation at:	Add to Price
–V	187-242 VAC, 47-440 Hz	12%
$-V_1$	205-265 VAC, 47-440 Hz	12%

Accessories:

rack adapters LRA-10, LRA-11. Overvoltage protectors, chassis slides, blank panels.

Guaranteed for 5 years.

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

SPECIFICATIONS OF LF-9-04-GPIB

DC output

Volt (VDC)	MAX AMPS AT AMBIENT OF: 40°C	50°C	60°C
0 to ± 49.95	1.98	1.8	1.6

Output range

X1 range: ± 9.99V in 10 mV steps
X10 range: selected automatically (0- to ±49.9 V in 100 mV steps

Source or sink

1.98 amps continuous

Regulated voltage

regulation line........................0.01% — for line variations 105-132VAC (see AC input option)
regulation load (all ranges).....................0.01% — for load variation of 0 to full load.
ripple and noise.................... X1 range: 2.0 mV pk-pk max
X10 : 20 mV pk-pk max
temperature coefficient .... Voltage
X1 range: .005%/°C+35 μV/°C
X10 range:
.005%/°C + .215 mV/°C
Current
All ranges: 500 μA/°C

Constant current operation

Current Range: 1% to 99% of full scale
Regulation line . . . . 1 mA max
load . . . . 20 mA max

AC input

105-132VAC, 47-440Hz. For 187-242 or 205-265 VAC see AC input option.

Ambient operating temperature range

continuous duty from 0° to 60°C with load current ratings shown in table.

Storage temperature range

−55°C to +85°C

Basic accuracy

(at 25°C, 115VAC input and no load)................................Voltage
X1 range: 3 mV
X10 range: 30 mV
Current
All ranges: 10 mA

Resolution

.... Voltage
X1 range: 10 mV
X10 range: 100 mV
Current
All ranges: 20 mA

Transient response

1.2 msec to within .05% of full scale for 90% load change

Overshoot

Worst case overshoot 1 volt under any conditions

Input Data Format:

Data is entered in bit-parallel, byte-serial format as specified by IEEE Std. #488. The 24 programming bits contain 12 bits BCD voltage programming, 8 bits BCD current programming and one bit each for gain, polarity and mode. The valid data format is ASCII.

Programming time:

see graphs on next page

Data Loading:

Logic levels ("0" ⩾ + 2.0V; "1" ⩽ + 0.8V) and interface requirements are as specified in IEEE Std. #488.

Data Input Lines:

DIO-1 thru 8 as specified in IEEE Std. #488.

Control Lines:

ATN, EOI, IFC, NRFD, NDAC, DAV, SRQ, REN* as specified in IEEE Std. #488. All control and data input lines are accessed through 24-pin GPIB connector on back panel. The SRQ line is activated by a current overload condition while in constant voltage mode or overvoltage limit condition while in constant current mode. Mode of operation programmed with mode bit.

*REN is not a usable function for the LF-GPIB and is terminated in a logical "0".

Cooling

Convection-cooled, no heatsinks or blower necessary

Mounting positions

one mounting position on horizontal plane
Input/output connections through heavy duty barrier strip and connector

Physical data

Model (Package 9)	Size (inches)	Weight lbs net	lbs ship
LF-9-04-GPIB	4 15/16 x 7 1/2 x 14 5/8	20	22

Options

AC input

Add Suffix	for operation at:	Add to Price
$-V$	187-242 VAC, 47-440 Hz	12%
$-V_1$	205-265 VAC, 47-440 Hz	12%

Accessories:

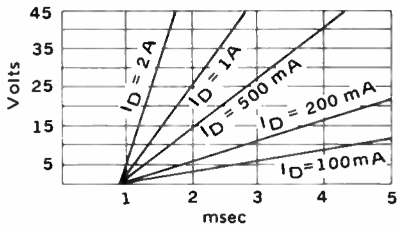
rack adapters LRA-10, LRA-11. Overvoltage protectors, chassis slides, blank panels.

Guaranteed for 5 years.

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

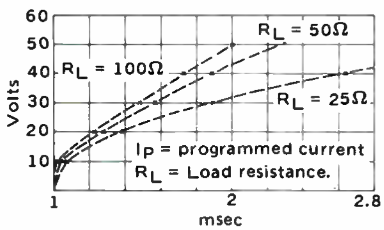
SPECIFICATIONS OF LF-9-04, LF-9-04-GPIB

Programming Time mSec Vs Programmed Voltage Step (Constant Current Load)

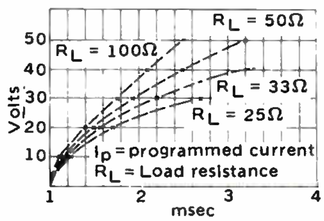


I_D = DIFFERENCE BETWEEN PROGRAMMED CURRENT AND LOAD CURRENT APPLIES TO CONSTANT CURRENT NON-CAPACITIVE LOAD

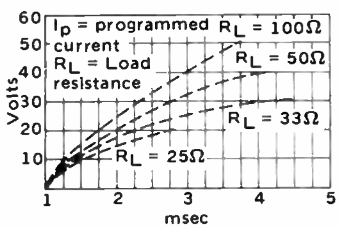
Programming Time mSec Vs Programmed Voltage Step (Resistive Load)



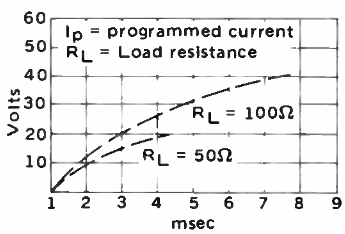
Ip = 2.0A
100% Full Load



Ip = 1.5A
75% Full Load

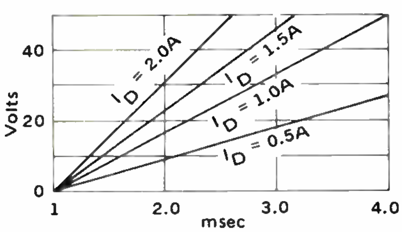


Ip = 1.0A
50% Full Load

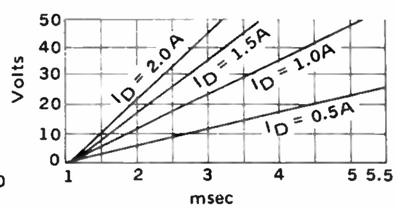


Ip = 0.5A
25% Full Load

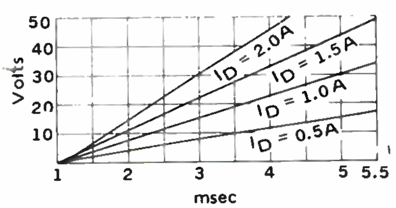
Programming Time mSec Vs Programmed Voltage Step (Capacitive Load)



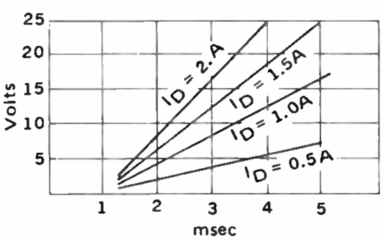
C_L = 25 mfd
Load Capacitance



C_L = 50 mfd
Load Capacitance



C_L = 100 mfd
Load Capacitance



C_L = 200 mfd
Load Capacitance

I_D = Difference between programmed current and constant load current.

DEFINITION OF TERMS:

Resolution:
Minimum programmable change

Basic Accuracy:
Maximum deviation from programmed value at 25°C constant temperature, 115 VAC and no load.

Programming Time:
Time, after data entry, required for the supply to settle within 0.05% full scale.

Data Flag:
Customer generated 3.3 μsec minimum pulse, beginning at least 2 μsec after date is presented, to signal that data is available and ready for processing.

Final Transfer Pulse:
Customer generated 2 μsec minimum pulse beginning at least 300 μsec after first data flag, to transfer data from input shift register into storage and the DAC's. This pulse is internally generated by the system for ASCII.

Data Validity:
Minimum time for which data must remain present after data flag.

Transient Response:
Time required for supply to return to within 0.05% full scale of programmed value, for 90% change of load.

Overshoot:
Magnitude of voltage by which output may exceed programmed value or fall below zero volts during turn-on, turn-off, voltage to current limit crossover or current limit to voltage crossover and programming.

Zero Override:
Input signal pulse programs output of power supply to zero volts. This signal is also activated when input data plug is pulled out. Zero override is a system feature that may be utilized in an emergency by forcing the output to zero volts from any previous state. When in that mode the output will be kept at zero ±50 mV max. While the output ripple will be limited to 15 mV pk-pk max.

Output Flags:
System generated signal, available to the user through the input data connector.

SUMMARY OF THE IEEE STD. #488

See Specifications of LF-9-04-GPIB

IEEE Standard #488 specifies a system for the interconnection of as many as 14 pieces of test equipment on a single 24-wire bus controlled by a central processing unit. The bus consists of 8 bidirectional data lines, 8 command lines and 8 ground lines. Data is transferred along the bus via a specific 3-wire "handshake" process. This process greatly reduces the possibility of lost data since any one operation must be confirmed by all addressed units before the following operation may commence.

The address system allows the controller to identify the units which are to transmit or receive data while allowing the other units on the bus to function uninterrupted. The service request (SRQ) line provides each module on the bus with the ability to inform the controller if a particular condition in that module warrants attention or service.

Listed below are the designations of the 8 command lines and a brief function description for each:

1. **ATN (ATTENTION)** — This line is used to call the attention of all units on the bus (i.e., all units are listening). All command instructions must be given under this signal.
2. **IFC (INTERFACE CLEAR)** - This line is used to set the interface—parts of which are contained in all units on the bus—at a known quiescent state.
3. **SRO (SERVICE REQUEST)** - This line provides a means for each unit on the bus to indicate to the controller that a condition exists which may require attention or service.
4. **EOI (END OR IDENTIFY)** - This line is used to indicate the end of a particular multiple-byte transfer sequence.
5. **REN (REMOTE ENABLE)** - This line is used to select between two alternate sources of device programming data (i.e., computer control or local control).

The remaining three commands comprise the three-wire "handshake" process. This process utilizes interlocking command sequences to transfer each data byte across the interface. These sequences can only proceed at the rate of the slowest addressed unit on the bus, thus assuring that all units on the bus can completely assimilate the data.

6. **DAV (DATA VALID)** - This command is used by the "talker" to indicate that the data on the DIO signal lines is valid and ready to be processed.
7. **NRFD (NOT READY FOR DATA)** - This line is used by the "listeners" on the bus to indicate whether or not they are ready to process the next byte of data.
8. **NDAC (NOT DATA ACCEPTED)** - This line is used by the "listeners" on the bus to indicate that the data on the line has been processed and can now be removed.

Consult Factory For:

A. Application information using BCD as input format.

B. Application information using IFC as an emergency shutdown.

ACCESSORIES

Overvoltage Protectors Accessories

Adj. Volt. Range VDC	Model	For Use With	Price
3-24	LH-OV-4	LP-530-FM, LP-531-FM, LK-340A-FM, LK-341A-FM, LP-410A-FM, LP-411A-FM, LPD-421A-FM, LR-602A-FM, LP-520-FM	$ 35
3-47	LH-OV-5	LP-532-FM, LK-342A-FM, LK-343A-FM, LP-412A-FM, LPD-422A-FM, LP-531-FM, LP-521-FM, LP-522-FM	35
3-70	LH-OV-6	LP-533-FM, LK-344A-FM, LK-345A-FM, LP-413A-FM, LPD-423A-FM, LP-523-FM, LP-413A-FM	35
	Add "-OV" to power supply model number	LK-350-FM, LK-351-FM, LK-352-FM,	100
		LK-360-FM, LK-361-FM, LK-362-FM	135

Adjustable Crowbar type (Mounting provisions provided 2 terminal connections.)

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Data handling

Ampex joins Winchester drive club

While Winchester-technology disk drives are not new, they are for Ampex Corp.'s Data Products division. Until now, Ampex's drives were all of the removable-media type, but that is changed with the appearance of the new DF-900.

Ampex does not see the Winchester product competing with the removable-media drives. "On the contrary," declares Mike Kirby, Memory Products division senior product manager, "there are applications for both within the same system." Kirby sees the DF-900 expanding the present market base; the demand for fixed-media drives has risen meteorically compared with removable media drives.

The drive is available with a storage capacity of 12.5, 37.6, 62.7, or 87.8 megabytes. It uses the same pair of heads on the same oxide-coated disks as the accepted IBM 3340, and it employs modified frequency modulation, or MFM, for the double-density recording of data.

The disks spin at a rate of 2,964 rpm with an average latency time of 10.12 ms average access time is 40 ms, and the nominal data-transfer rate is specified at 885,000 8-bit bytes per second.

All of the drive's electronics are on two printed-circuit boards. An Intel 8048 provides drive-motor control, servo positioning, support, and automatic drive diagnostics. A set of toggle switches and light-emitting-diode panel lamps on the edge of one board allows users to initiate random seeks or read/writes and determine the origin of any functional problem.

Wherever the timing requirements of the system are stringent, as in the read/write system electronics, emitter-coupled-logic circuitry is employed. But random-logic support for the 8048 is implemented with small- and medium-scale transistor-transistor-logic integrated circuits.

Volume shipments of the DF-900 are expected by August, Kirby says. For quantities of 100 or more, the price of the new drives starts at $3,450 each and increases by $150 for each extra disk up to $3,900 for the 87.8-megabyte version.

Ampex Corp., 401 Broadway, Redwood City, Calif. 94063 [361]

Computers cost up to 21% less

Five new microprocessor-based business computers by Randal Data Systems give higher performance and cut system prices as much as 21% over earlier comparable machines. These machines, complete with all operating hardware, range from the new top of the line, the Link 550 at $44,990, down to the lowest, the Link 140, for $13,350. Software packages are separate items, designed for specific types of businesses, starting at $2,600 and going up to about $6,300.

At the top of the line are two 500 series machines with hard-disk storage, cathode-ray-tube displays, and printers. The 550 offers three terminals as standard hardware, 50 megabytes of internal memory, a 110-character-per-second printer, and 50-million-character drive—features that in the past cost at least $45,900 in the Randal line. The cheaper Link 540 has fewer terminals, selling for $37,900. A faster optional printer, at 125 lines per minute, boosts the price to $41,900. The 540 can use up to 5 terminals, the 550 up to 10; and both can drive multiple printers.

At the low end, the Link 140 retails for a basic $13,350, featuring

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11/70s with a total storage capacities of 128 kilobytes to 4 megabytes. Using the identical interface signals and cables, the monolithic system is completely hardware- and software-compatible with the DEC minicomputer, requires only 115- or 220-v ac power, and has optional error-correction capability.

A 32-K-by-16-bit MK 8004 is priced at $4,800, a 32-K-by-16-bit MK 8005 at $1,690, and a 64-K-by-18-bit MK 8011 at $4,300. All three will be available next month, and discounts are available to original-equipment manufacturers.

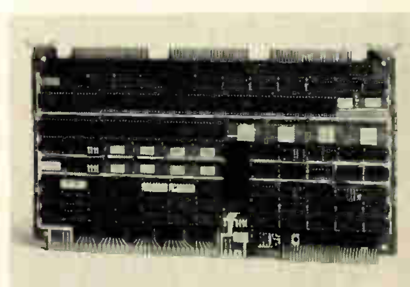
The MK 8601, with 128 kilobytes of memory and the error-correction option, is priced at $9,100. This series is available now.

Mostek Corp., 1215 W. Crosby Rd., Carrollton, Texas 75006. Phone Bill Smith at (214) 242-0444, extension 2552 [364]

MLZ-80 brings floppy interface onboard

A general-purpose microcomputer employing a 4-kilobyte static random-access memory and up to 8 kilobytes of read-only memory, the MLZ-80 contains a floppy-disk-drive controller capable of handling up to four single-density drives. The computer, at the heart of which is a Z80-type microprocessor, contains logic for Intel SBC-80 multibus compatibility, power-on-jump logic, and the Z80 vector interrupt system. Users must devise their own bus priority systems.

Mounted on a 6.75-by-12-in. printed-circuit board, the device requires power from +5-, +12-, and −12-v dc supplies. The basic MLZ-80, without read-only memory and



input/output line drivers and terminators, is priced at $1,475. A large number of options, including ready-to-run systems and software support, are available.

Heurikon Corp., 700 W. Badger Rd., Madison, Wis. 53713. Phone Chris Priebe at (608) 255-9075 [365]

System 25 lets user buy for now, grow later

The System 25 is a disk-based word-processing system available in three models, each with successively larger storage capacities. Starting with the model I, users obtain at least 1.25 megabytes of data-storage and the ability to interface with up to six peripherals, such as work stations and printers. The model I consists of a master word-processing unit and a disk drive.

Model II has a maximum storage capacity of 2.5 megabytes, model III one of 5 megabytes. Each of these models can accommodate 14 peripheral devices. The System 25 is compatible with the System 10A, System 20, and the System 30. It costs $12,100.

Wang Laboratories Inc., 1 Industrial Ave., Lowell, Mass. 01851. Phone (617) 851-4111 [366]

Smart terminal combines low cost with versatility

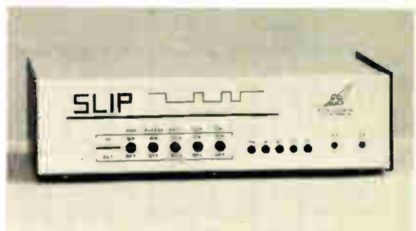
Fully user-programmable, the MDT 400 series is a single-cabinet, low-cost intelligent terminal system that can be used for a variety of distributed data-processing applications, including source data entry, text processing, and data communications. The unit contains a cathode-ray tube with 16-by-18 format that can be scrolled through its 2,560-character buffer, an integral mini-disk with 87,000-byte capacity in IBM soft-sector format, an 8-bit microprocessor, and random-access memory. Low- and medium-speed character printers are available for use with the terminal, as are program development systems to support programming in assembly or high-level languages.

Model 401 has 8 kilobytes of RAM and a price of $4,275. The larger model 402 has 16 kilobytes of RAM and sells for $4,500.

Compugraphic Corp., 80 Industrial Way, Wilmington, Mass. 01887. Phone John Pryke at (617) 944-6555 [367]

Plotter controller takes data from different sources

The Serial Language Independent Plotter controller (SLIP) is a microprocessor-based X-Y plotter interface that can accept data from a terminal, a host computer, or a standard RS-232-C serial communications system. The user program need only output a list of the integer coordinates to be plotted; the device can function independently of any formatting constraints imposed by the programming language. The X and Y outputs from the SLIP may be selected to accommodate the input requirements of most plotters. The unit also adjusts pen velocity.



The SLIP is priced at $1,465, and delivery is from stock or at most one week.

Special Systems Inc., 8045 Newell St., Silver Springs, Md. 20910. Phone (301) 587-2260 [368]

Packaging & production

Fixture tests MSI, LSI on cards

In-circuit tester applies signature-analysis technique to complex digital chips

Printed-circuit boards today are often densely packed with many digital devices, a smattering of analog interface devices, plus medium- or large-scale integrated circuit—memories, synchronous and asynchronous receiver/transmitters and of course, microprocessors. These complex devices must be in-circuit-tested—actually a form of testing electrically isolated active and passive components for value, placement, shorts, and opens. Alternately, they must be put through time-consuming processing on expensive logic-board test fixtures.

However, most existing in-circuit testers from companies like Zehntel, GenRad, Teradyne and Faultfinders are basically for testing analog and small-scale integrated circuits. Now a new in-circuit test system introduced by Zehntel is able for the first time to isolate and functionally test MSI and LSI devices on a printed-circuit board.

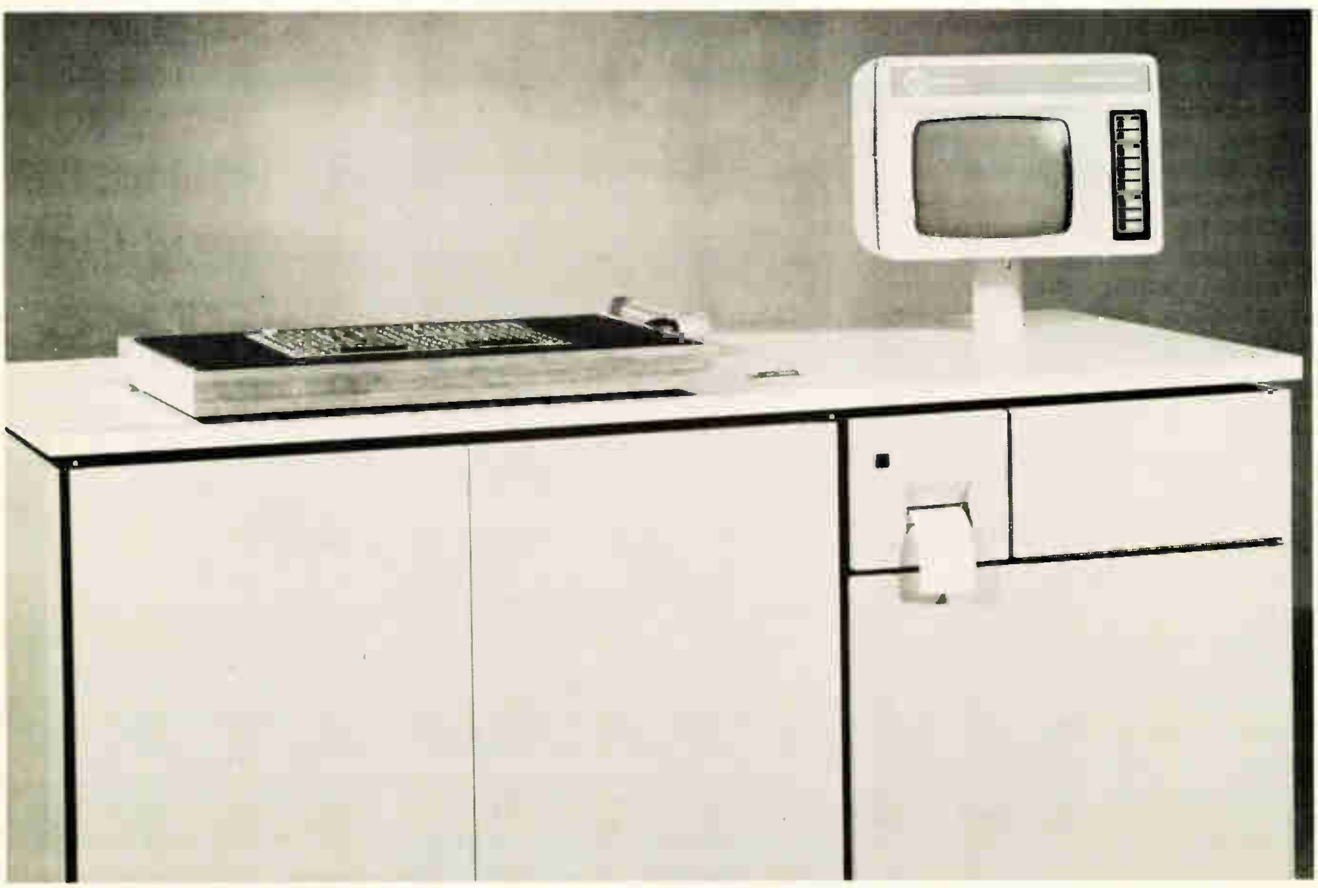
The Troubleshooter 800 (TS-800) uses an ingenious signature analysis format to generate stimuli through its bed-of-nails fixture and to record the unique output signature that sets acceptance criteria for the individual IC. With this technique, no special criteria for board design are required. Digital feedback paths are electrically broken, and only minimal programming is required.

Zehntel's programmers are in the process of developing in-circuit software for four popular microprocessors—the 6800, 8080, 6100, and F8. Moreover, like other in-circuit testers the TS-800 will automatically inspect all analog boards and the analog portion of digital boards, using the standard isolated-measurement technique.

In programming, the system uses an improved high-level, intuitive test language, which is simple to apply in practical test situations. Hardware and software is provided to generate test programs automatically and to debug the generated program on the initial test of a known good board. Included is a full operator-interactive edit mode for giving the final touches to the program.

The new test system with an Intel SBC-80 controller and a dual floppy-disk storage undoubtedly will find acceptance with automotive, home-appliance, and other high-volume users of pc boards. The tester costs will be about $100,000 for a 200-point system. The 200 points refer to the number of spring contacts present in the built-in vacuum-actuated bed-of-nails fixture.

To accommodate the needs of



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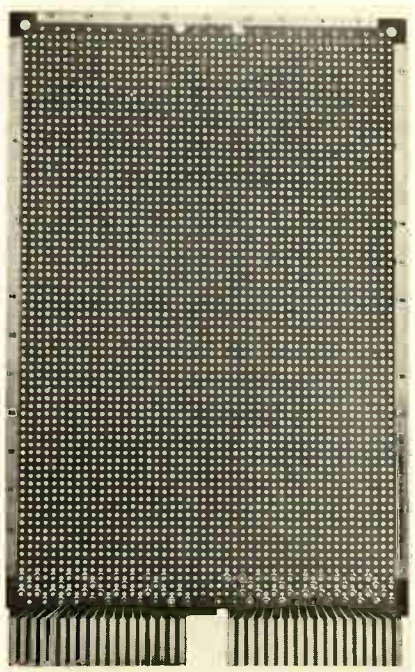
the purchaser, test fixtures with as many as 1,024 points can be built.
Zehntel Inc., 2440 Stanwell Drive, Concord Calif., 94520. Phone (415) 676-4200 [391]

Prototyping board fits Heath, DEC computers

The model 4607 is a general-purpose circuit board that permits users to construct custom interface circuits for use with the popular Heath H-11 microcomputers and Digital Equipment Corp.'s LSI-11, PDP-8, and PDP-11 minicomputers. In form, it is comparable to DEC's double-height extended-length module, measures 8.430 by 5.187 by 0.062 inches, and has etched contacts spaced to fit the 36-pin connectors used in Heath and DEC computers.

The board's array of 0.042-in.-diameter holes spaced on 0.1-in. centers allows a great degree of freedom in the placement of discrete components or sockets for dual in-line packages. Permanently etched row and column markings permit permanent location identification. Pin terminations and edge strips on the epoxy-glass composite boards are hot-solder-plated while card-edge contacts are gold-flashed nickel plated to ensure long life.



In quantities of 10 or more, the boards are priced at $12.76 each. Delivery is from stock.
Vector Electronic Co., 12460 Gladstone Ave., Sylmar, Calif. 91342. Phone (213) 365-9661 [393]

Solder applicator can be automatically run on line

With the model ESP, liquid solder dots as small as 0.005 inch can be accurately and repetitively applied. The unit can be adapted for automatic in-line control, and output air pressure, pulse time, and the size of the disposable needle used all may be adjusted to yield dots and stripes of different sizes.

Basic to the system is a 7¼-by-8½-by-2⅝-in. cabinet that houses the pressure and duration controls and supplies air pressure to the syringe through a 6-foot hose. With this come two 10-cc and two 30-cc syringes, three pairs of disposable needles of different gauges, two syringe adapters, a syringe storage stand, and a foot pedal to control operation.

The applicator works in two modes. An operator may preset the unit for a given period of application and pressure, which he initiates with the foot pedal, or he can press a button and vary the period of application with the pedal.

Complete with accessories, the ESP is priced at $325 and is available from stock.
Electron Fusion Devices Inc., 997 Waterman Ave., East Providence, R. I. 02914. Phone Jim McGovern at (800) 556-3484 [396]

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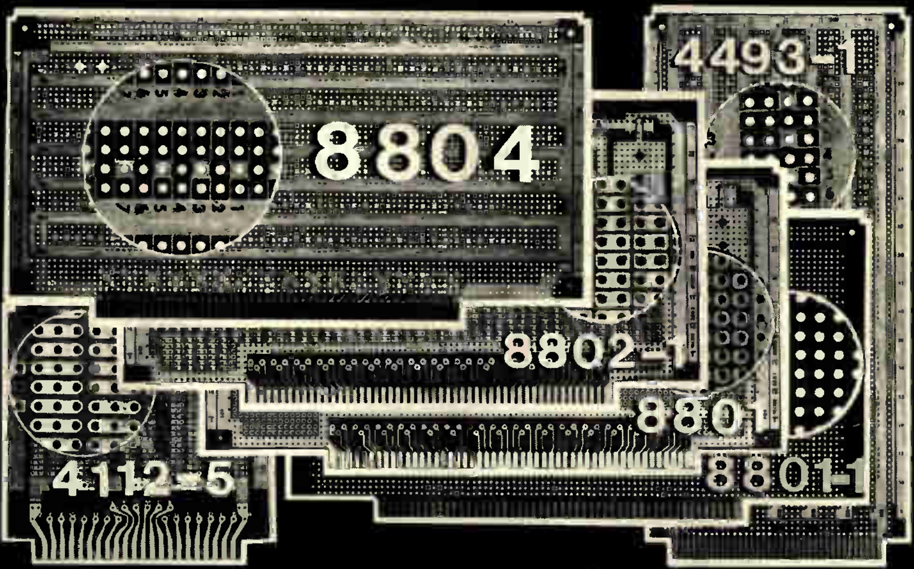
8801-1, $14.95. No pads – just holes. 50/100 contacts at .125". S-100 size.

*S-100 size is 5.3" high by 10" wide.



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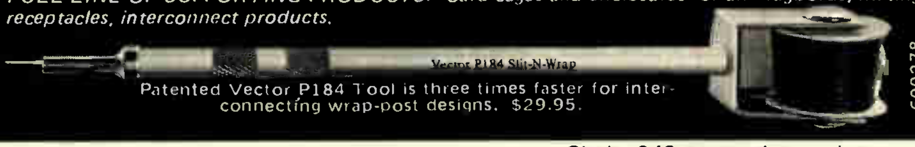

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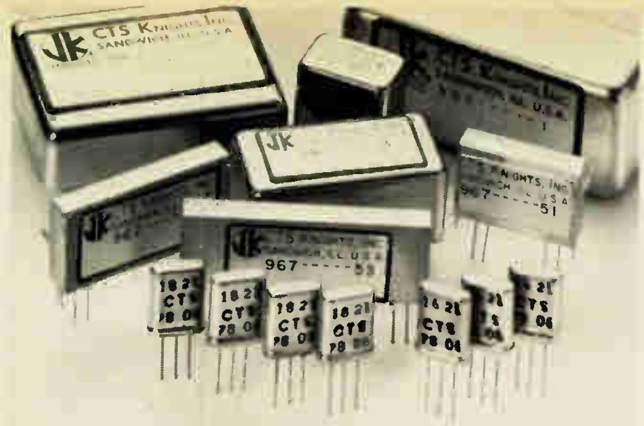

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Products newsletter

Burr-Brown to unveil dual-isolated dc-dc converter

For industrial controls, medical equipment, data-acquisition equipment, and test gear applications, a new isolated dc-dc converter is due out soon from Burr-Brown Research Corp., Tucson, Ariz. It features high breakdown voltage (8 kV test) and a small package (27.9 by 27.9 by 7.6 mm). **The 722 converts a single 5-to-16-V dc input into a pair of bipolar output voltages of the same value as the input voltage.** Available in a 20-pin dual in-line package, the converter will sell for $22 in quantities of 100 to 299.

Second generation of V-MOS power FETs on the way from Siliconix

Power field-effect transistors built with the V-groove MOS technique could be in line for application in off-line switching power supplies. **Siliconix Inc. of Santa Clara, Calif., has announced the VN45JA that crosses the 400-V hurdle (at 4 A continuous).** In addition, the firm is getting set to bring out the VN84GA, a 12.5-A, 80-V device and the VN86HF, rated at 80 V and 2 A—both also V-MOS power FETs. Because die size for these two is the same as for previous units, the price will remain the same—$1.13 in 100-and-up quantities.

German millivoltmeter goes for performance, price improvements

The West German instrument house, Rohde & Schwarz, is putting on the international market a high-performance radio-frequency millivoltmeter that should get attention in the U. S. **To sell for under $2,000, the URV4 can measure voltages ranging from 300 μV to 1 kV and voltage levels from −57 to +73 dBm over a frequency range from 10 kHz to 2 GHz.** The meter has two displays as well—one is a digital readout of either decibel levels or voltage values, and the other's an analog light spot indicating decibel levels only.

Here comes a C-MOS version of the 555 timer

The 555 timer, which is probably one of the most widely used ICs, will soon be available in volume for the first time as a complementary-metal-oxide-semiconductor device from Intersil Inc. of Cupertino, Calif. The new ICM 7555 and ICM 7556 (C-MOS substitute for the 556) are exact equivalents of the popular bipolar ICs. **As is to be expected, their advantages are lower supply current, typically 80 μA for the 7555 and 160 μA for the 7556, plus the capacity to work with higher-resistance timing elements than the bipolar timers.** These assets make the new C-MOS parts especially attractive in applications for battery-powered, portable instruments.

Color graphics terminal joins Tektronix line

Just introduced from Tektronix Inc. of Beaverton, Ore., is a new color graphics terminal, the 4027, part of the 4020 raster-scan product line. The system features a 13-inch cathode-ray tube, virtual bit mapping, and multipage paging. **Hard copies of the display can be made in color by means of a 4662 or 4663 X-Y plotter.** The 4027 software can provide portions of the display one color at a time, so that by mounting a red pen on the plotter and calling up the red portions, then a blue pen and calling up the blue, and so on for the other colors, the operator can produce a complete representation of the color display.

A heat-stabilized nylon resin, Zytel ST 801 HS, is believed by Du Pont to be the toughest engineering plastic yet developed. Its tensile strength at 23°C (73°F) is 7,500 psi when dry and 6,000 psi at 50% relative humidity. Under the same two conditions, its Izod impact strength is 17.0 ft-lb/in. and greater than 20.0 ft-lb/in., respectively. It has a Rockwell hardness of 112 when dry. These properties make the material desirable for use in automotive engine compartments, power-tool components, and electrical hardware, which are subject to high service temperatures and high impacts. It also has good resistance to solvents, oils, greases, gasolines, and other industrial chemicals, and can replace polycarbonate in nontransparent applications. The resin sells for $1.60 per pound in truckload quantities.

Du Pont Co., Room 36559-PA, Wilmington, Del. 19898 [475]

Ferrite transformer cores are suited for use in ultrahigh-voltage inverters, ultrahigh-frequency oscillators, tuning inductors, and other specialized applications where conventional commercial tolerances are unacceptable. They have a better than ±0.001 dimensional tolerance and display a better than ±10% magnetic property. Fabricated from 100% homogeneous ferrite materials, they can be supplied in all sizes and configurations in production quantities. Prototypes take two weeks.

Ceramic Magnetics Inc., 87 Fairfield Rd., Fairfield, N. J. 07006 [477]

New literature

60-page catalog. Specifications, dimensions, and ordering information are given for solid-state models, as well as for electric (standard and miniature), predetermined, mechanical, and conveyor counters. Durant Digital Instruments, 901 South St., Watertown, Wis. 53074. Circle reader service number 423.

Liquid-crystal displays. "Liquid Crystal Displays—Principles of Operation, Construction, and Application," a six-page application note, describes the sections that make up a liquid-crystal display and how they are put together, explains how to create the drive signal that makes them work, and suggests five ways of mounting LCDs. Beckman Instruments Inc., Technical Information Section, Helipot Division, 2500 Harbor Blvd., P. O. Box 3100, Fullerton, Calif. 92634 [424]

High-temperature effects. Data on the effects of exposure of polytetrafluoroethylene-insulated cables to elevated temperatures is given in a 12-page bulletin. To prevent failure of the outer conductor, which would permanently increase the cable's outer diameter and thus permanently decrease its capacitance, centigrade temperatures must not exceed the maximum values listed in the bulletin. Also described are the dimensions, materials, normal impedance and tolerances, inside bend radiuses, and dielectric strengths of 13 types of semirigid coaxial cables. MicroDelay Division, Uniform Tubes Inc., Collegeville, Pa. 19426 [425]

Elastomers. "An Engineers' Guide to Elastomer Selection," a 40-page brochure, summarizes the properties of most rubber and synthetic rubber compounds and includes a chemical resistance chart. Minor Rubber Co., 49 Ackerman St., Bloomfield, N. J. 07003 [427]

Synchro converters and encoders. A 30-page catalog, "Synchro Converters/Displays/Encoders," describes 30 products that meet the requirements for synchro/resolver or shaft

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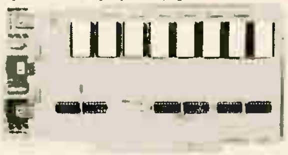

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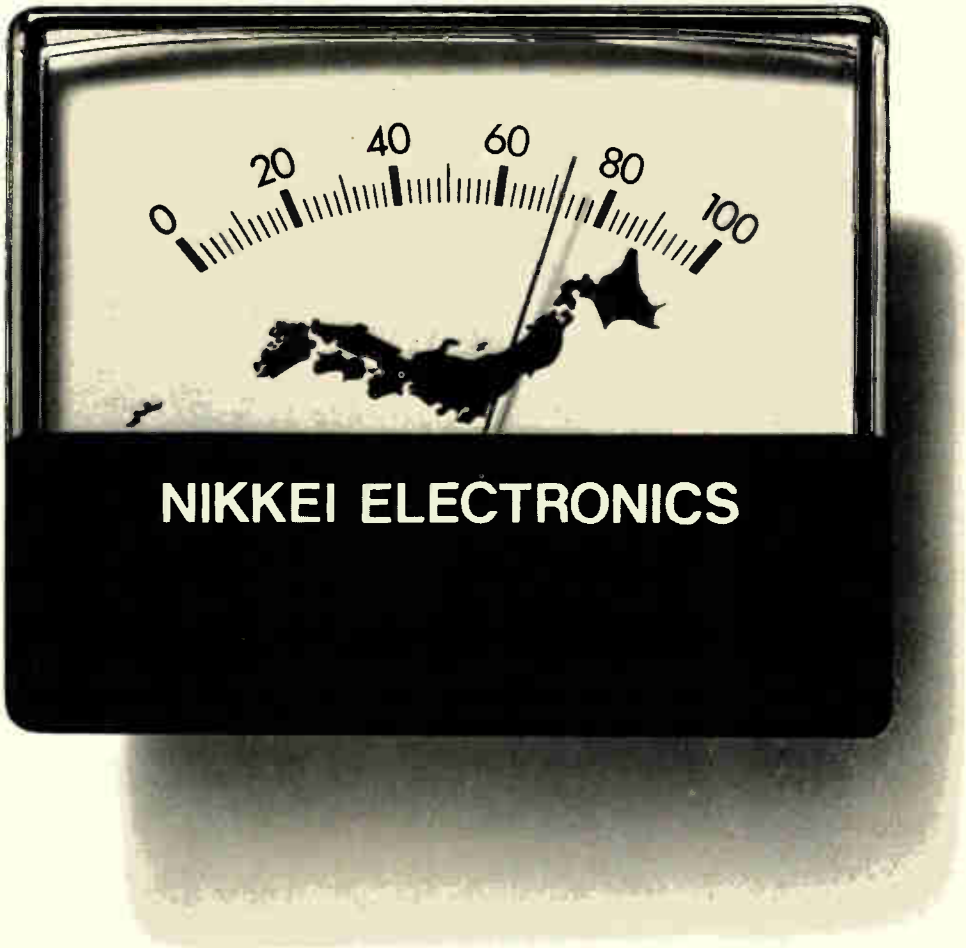
interfacing. Some of the products include multispeed synchro-to-digital, multispeed digital-to-synchro, and multiplexed synchro-to-digital converters. Computer Conversions Corp., 6 Dunton Ct., East Northport, N. Y. 11731 [426]

Reed switches. Electrical, operating, magnetic, and physical characteristics for a line of reed switches is

given in a 12-page catalog. Details for their operation with permanent magnets, including proximity motion, rotation, and shielding, are provided along with recommendations for physical modifications. Hamlin Inc., Lake and Grove Streets, Lake Mills, Wis. 53551 [428]

Stepping-motor controls. Specifications and descriptions for 16 types of stepping-motor controls are provided in a 28-page catalog. Translators and preset indexers in modular, open-chassis, and packaged form are some of the products covered. Speed versus torque curves and connection diagrams are also presented. The Superior Electric Co., 383 Middle St., Bristol, Conn. 06010 [429]

Profile-measuring system. A profile-measuring system with a digital readout, which can check turbine and propellor blades, die and broach profiles, thread forms, and bearing races not measurable by conventional methods, is described in an eight-page brochure available from Rank Precision Industries Inc., 411 E. Jarvis Ave, Des Plaines, Il. 60018 [430]



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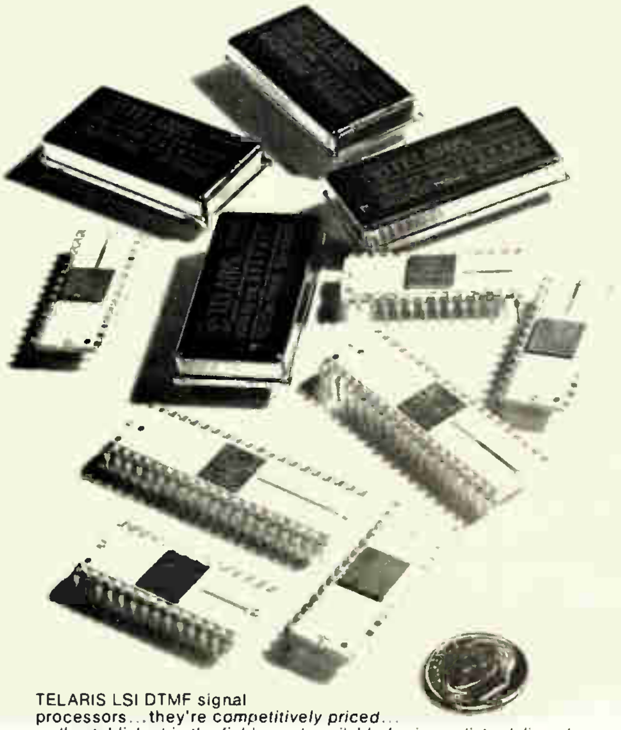
TELARIS DTMF SIGNAL PROCESSORS

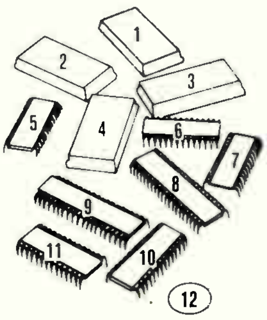
A design solution before it's a problem.



TELARIS LSI DTMF signal processors...they're *competitively priced*... *well established in the field*...*and available for immediate delivery!* Featuring an optimum mix of micro-electronic technology, TELARIS Dual Tone Multi-Frequency signal processing components are the popular choice of design engineers who have an eye for building tomorrow's ultimate system today.

What's more, TELARIS DTMF signal processors offer a wide range of uses in such areas as telephone central offices, PBX, key systems, radio telephones, paging receivers, industrial control, security systems, accounting/banking systems, patient monitoring, aircraft and railway systems, TV receivers, channel selectors ... the list goes on!

By incorporating TELARIS DTMF signal processors into a particular design, highest performance to cost, highest density and reliability, plus the lowest power consuming functional building blocks available is obtained. Additionally, these components are ultra-compact in both size and weight and have a long life span.



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For a complete catalog, application assistance and the name of a TELARIS representative near you, contact TELARIS Telecommunications, Inc., now!

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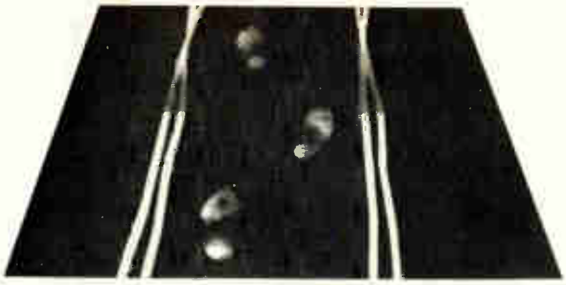

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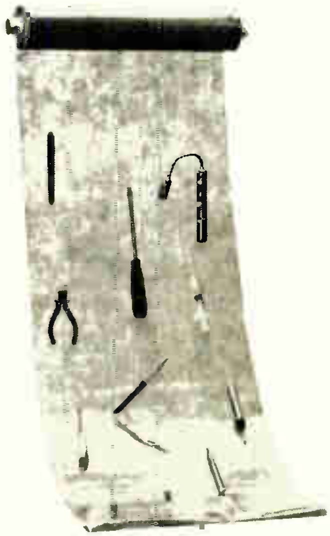

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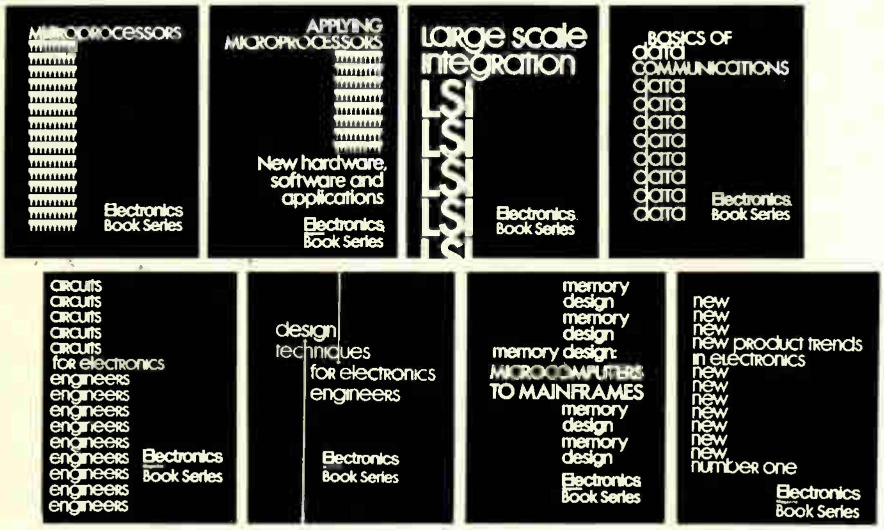

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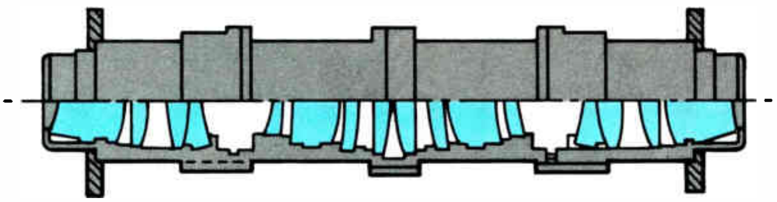
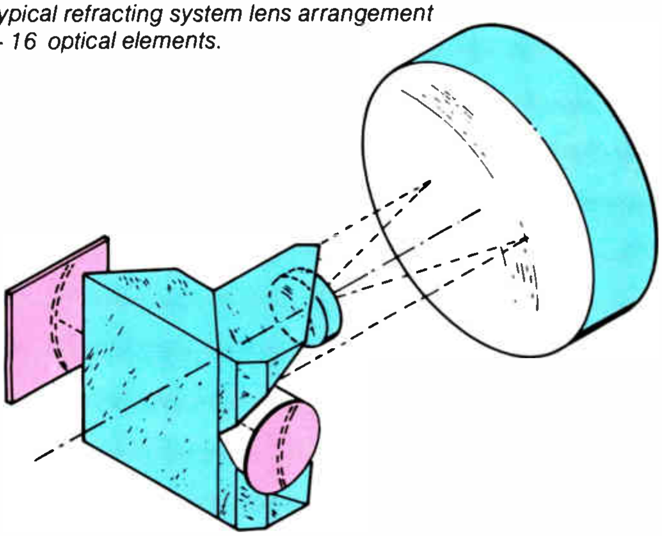


Typical refracting system lens arrangement — 16 optical elements.



The MICRALIGN all-reflecting folded projection system — three optical elements.

Compare these two lens systems. Until Perkin-Elmer introduced the Micralign Projection Mask Alignment System five years ago, all manufacturers of projection systems used refracting optics. Most still do.

Complex refracting optics

Refracting optics can involve as many as 16 separate lenses. Such complexity has several drawbacks. In spite of antireflection coatings, the individual lenses scatter light. Imperfections in the glass scatter light. And all this scattered light affects image quality. It limits the use of negative photoresist. In addition, standing wave effects make the system hard to use.

Simple reflecting optics

Note the contrast with the Micralign reflecting optical system. Its simple design employs only three reflective elements, no refracting lenses. Scattered light is near zero. Ghost images are eliminated, image quality is enhanced.

This all-reflecting system has no chromatic aberrations. The optics are telecentric, maintaining magnification at 1:1 even if the focal planes shift. Either positive or negative photoresist is practical.

Reflecting optics combined with advances in electronic and mechanical designs have made the Micralign instrument the choice of 65 semiconductor manufacturers at 100 sites worldwide. Learn more about how the Micralign instrument can bring efficiency and economy to your operations. Write Electro-Optical Division, Perkin-Elmer Corp., 50 Danbury Road, Wilton, CT 06897. Or phone 203-762-6057.

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