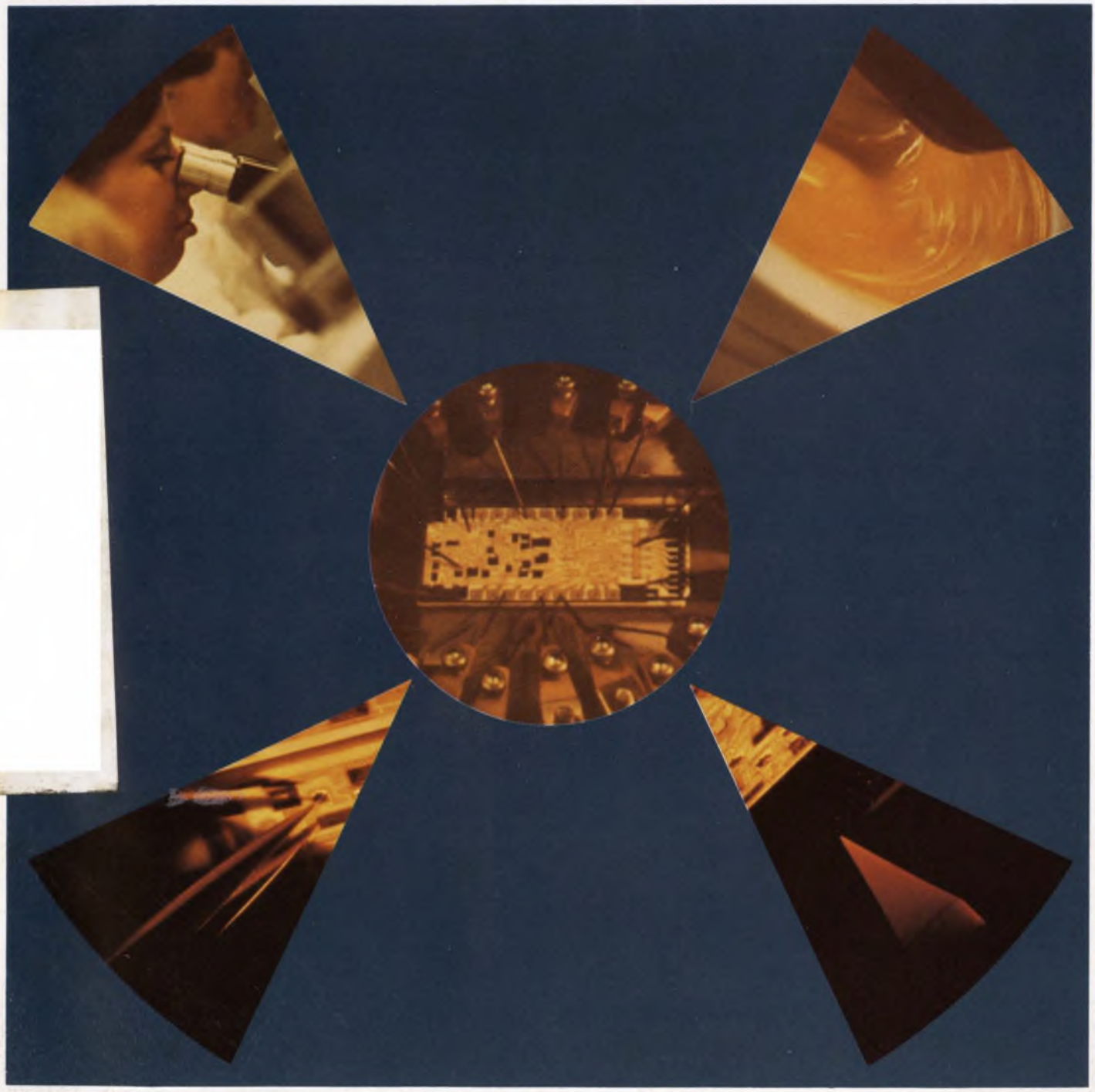
VOL. 23 NO. 15

# Electronic Design®

FOR ENGINEERS AND ENGINEERING MANAGERS

JULY 19, 1975

**Hybrid technology progresses** as new equipments and materials solve tough design problems. Improved inks, better printers, advances in bonding methods and functional circuit trimming raise hybrid yields and reliability and cut costs. Most packages are custom, though standards are emerging. See update on p. 24.

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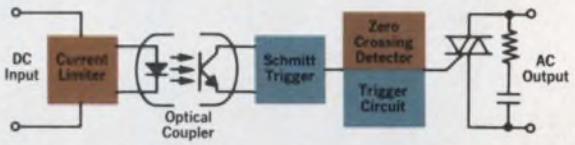


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INFORMATION RETRIEVAL NUMBER 3

# Electronic Design 15

VOL. 23 NO.

FOR ENGINEERS AND ENGINEERING MANAGERS

JULY 19, 1975


## NEWS



## TECHNOLOGY



## PRODUCTS



## DEPARTMENTS



**Cover:** Photos courtesy Beckman Instruments, Inc., Fullerton, CA


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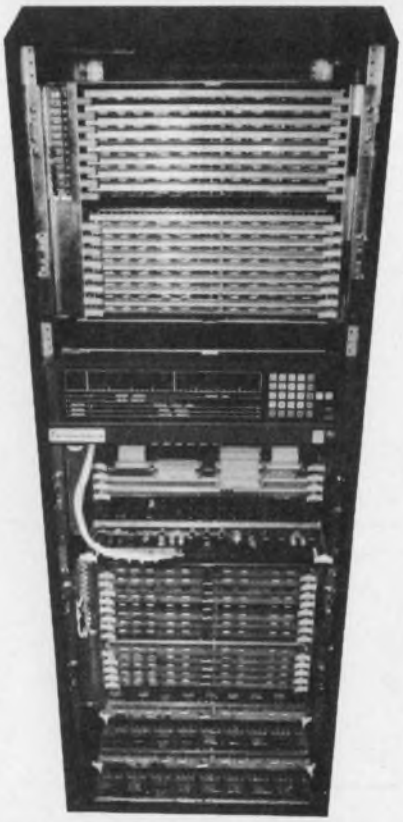

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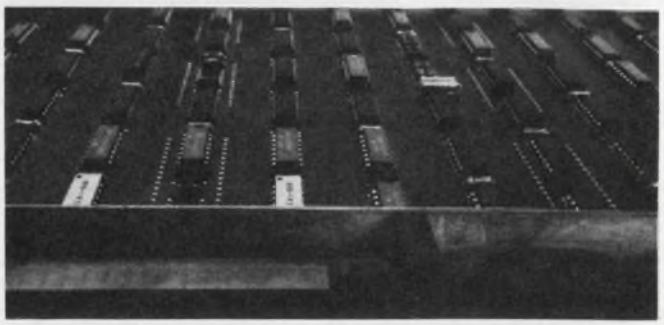

Multi-Wire Technology – a key to MEGAMINI performance.

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# Across the Desk

## Calculator evaluation found incomplete

John Ball's article "Reverse Polish or Algebraic" (ED No. 2, Jan. 18, 1975, pp. 50 and 51) didn't consider two important aspects of algebraic calculators. Since many algebraic systems include parentheses, this capability should be included in the analysis. Expressions such as (a ± b) × (c ± d) can therefore be evaluated with fewer key strokes and without the use of intermediate storage.

In addition, the algebraic sequences used in the article did not make maximum use of chaining capabilities, because of the desire to eliminate intermediate equals operations. As an example, the expression a ÷ (b ± c) * d was evaluated with the sequence b [±] c [×] d [=] 1/x [×] a [=]. Six key strokes were used. With chaining, it can be done in five with the sequence

b [±] c [×] d [÷] a [=] [1/x].

A review of all the sequences listed would undoubtedly show that the algebraic systems don't require substantially more key strokes than RPN.

*Dwight Jividen*
*Supervisor of ROM Programming*
Compucorp
12401 W. Olympic Blvd.
Los Angeles, CA 90064

## The author replies

The reason for leaving out algebraic entry systems with parentheses (call them AESP) is that more key strokes are usually needed with them than with just AES. Of course, an AESP calculator can work in AES—just avoid using [(] and [)]. Consider the example

(a ± b) × (c ± d).

This was line 20 in Table 1 in my article. AES needs seven key strokes, AESH eight and RPN five. The straightforward approach, with closed parentheses, uses eight key strokes and works on any AESP calculator. But in the form

a [±] b [×] [(] c [±] d [=]

the solution with five key strokes will work only on some.

You must read the fine print in the instruction book with each AESP calculator to determine exactly how it works. I therefore disagree with Mr. Jividen's statement that this expression "can therefore be evaluated with fewer key strokes" with use of AESP.

However, I concede that there are shorter algorithms that hadn't occurred to me for some of the entries in Table 1. Specifically, Mr. Jividen's suggestion cuts one key stroke from the AES algorithms in eight cases and from the AESH algorithm in one case. and it changes Table 2 to the following:

**Sum of number of wins × weights**

| | | | |
|---|---|---|---|
| RPN vs AESH | RPN 156 | AESH 30 | Ties 170 |
| RPN vs AES | RPN 54 | AES 0 | Ties 302 |
| AES vs AESH | AES 122 | AESH 31 | Ties 203 |

**Sum of key strokes × weights**

| | |
|---|---|
| AES | 1528 |
| AESH | 1626 |
| RPN | 1484 |

*(continued on page 10)*

**Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St. Rochelle Park, N.J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.**

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INFORMATION RETRIEVAL NUMBER 7

## ACROSS THE DESK

*(continued from page 7)*

This does not change the conclusions of the article.

*John A. Ball*
Harvard College Observatory
Harvard, MA 01451

## Misplaced Caption Dept.

"Boy, if TI finds out how we grow these crystals."

Sorry. That's Edouard Manet's "Lunch on the Grass," which hangs at the Louvre in Paris.

## Calculate while flying? It's up to the airlines

Washington Report, in the May 24 issue, stated that calculators had been banned for use aboard aircraft. Being a calculator manufacturer and not aware of this rule previously, we contacted the Federal Aviation Administration, which gave us the following information:

"At one time there was a proposal to prohibit electronic calculators aboard aircraft. However, this proposal has been dropped. The situation is the same now as it always has been. Electronic calculators are permitted for use board aircraft at the discretion and option of the operator."

We also contacted a few airlines, and in all cases they did allow the use of calculators aboard the aircraft.

*Robert Turner*
*Product Marketing Manager*
Hewlett-Packard Co.
Advanced Products Div.
19310 Pruneridge Ave.
Cupertino, CA 95014

*Ed. Note: Mr. Turner is correct.*

*(continued on page 14)*

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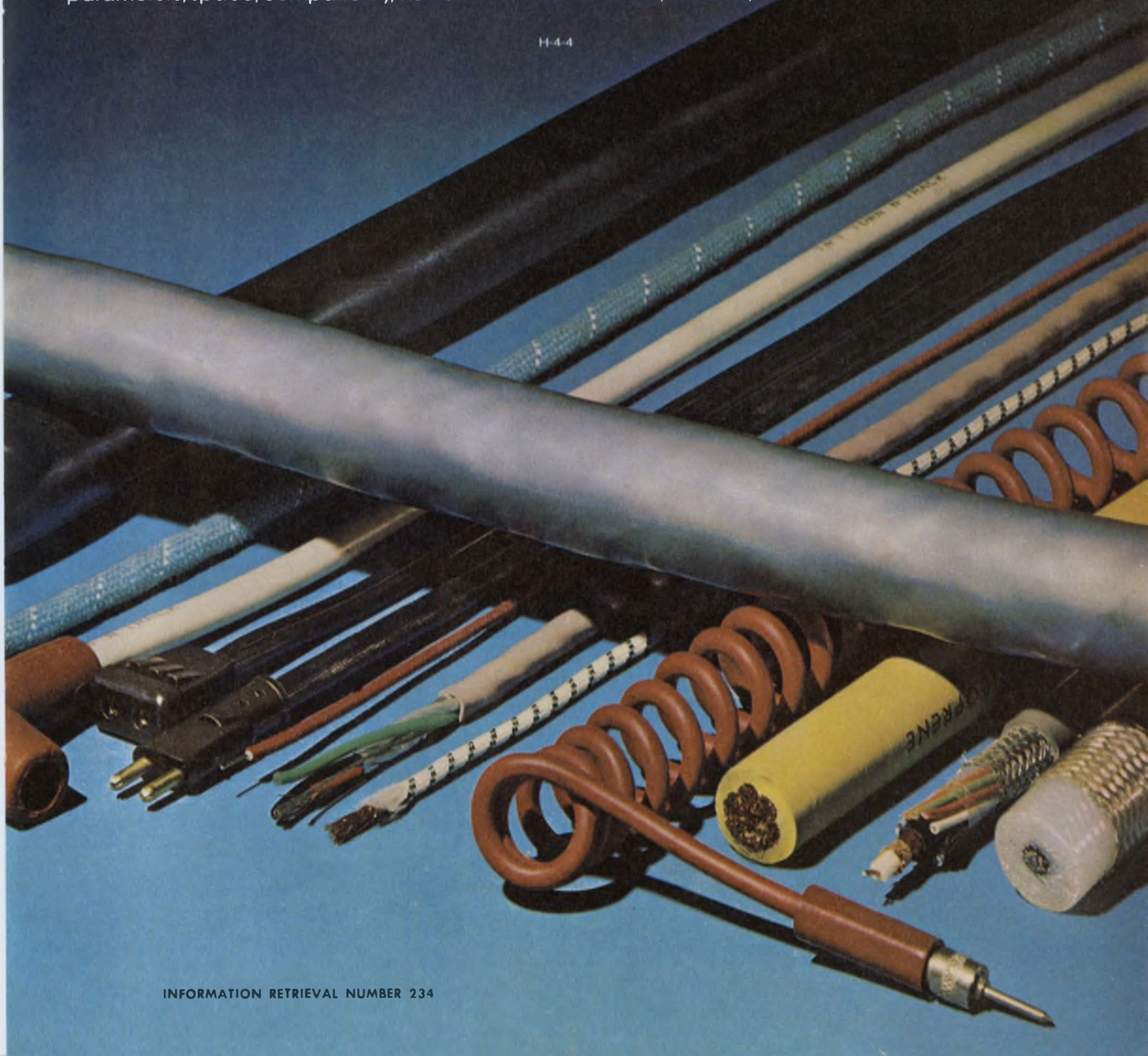

INFORMATION RETRIEVAL NUMBER 234

*(continued from page 10)*

*in that the airlines can allow the use of portable electronic calculators in flight. They do so on their own responsibility, and are in compliance with Federal Aviation regulations. In effect, the FAA is standing aloof. It will not give blanket approval to portable electronic calculators, nor will it officially ban them by name.* ELECTRONIC DESIGN *was misled by an FAA news release.*

## Idea Killers

"It's against company policy."

"That's beyond our responsibility."

"That has already been tried in . . . ."

"No one would ever accept that."

"We're not quite ready for that."

"It was tried years ago and . . . ."

"But what would you do about . . . ."

"I considered that once myself, but . . . ."

"It's great but ahead of its time . . . ."

"But it may make our other products obsolete."

"Top management would never go for it."

"Has anyone else ever tried it?"

"It won't work in our industry."

"It's not feasible."

"It would be too expensive."

"I remember reading about something like that."

"It's not new, it reminds me of . . . ."

"It would be too impractical . . . ."

"That would never work because . . . ."

"Let's hold it in abeyance."

"We've never done it that way before."

In the U.S: Put it down on one sheet of paper.

In Japan: Where are the case studies?

In Finland: Have they tried it yet in Sweden?

In England: Has ICI tried it yet?

The universal idea killer: . . . . Silence.



## Logic design program corrected by author

Subroutine MINIM in the article "Bypass Multivariable Karnaugh Maps" (ED No. 21, Oct. 11, 1974, pp. 86-91), for use in both combinational and sequential logic-circuit synthesis, contains an error. As published on p. 90, the subroutine hangs in a loop if ID = 2. The following changes are needed to avoid this:

The statements after line 41 should be

```
41 FORMAT ('b', 35x,
   '***NONE***')
42 IID1 = IID1-2
   IF(IID1·EQ·ϕ) GO TO 2ϕ
   RETURN
   END
```

Note: b represents a blank.

Also, include the following statement just before N1J = N:

IIS1 = ID.

*(continued on page 16)*

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*(continued from page 14)*

Subroutine MINIM in the article properly after these changes are made.

Eq. 10 on p. 89 contains a typesetting error. Correct it as follows:
f(U, V, W, X, Y, Z) =
0-1--1 + ---0-+ -1-11- + --1111.

A prepunched card deck or magnetic tape copy may be purchased by sending $60 to Troy Nagle, Electrical Engineering Dept., Auburn University, Auburn, AL 36830.

In the article "Reduce State Tables by Computer" (ED No. 22, Oct. 25, 1974, pp. 122-127), the unnamed program segment in the bottom right column of p. 125 is part of subroutine ISSM on p. 126. Take statements 15 through RETURN on p. 125 and place them just before statement 62 on p. 126 (after GO TO 7).

*Troy Nagle*
*Associate Professor*
Auburn University
Dept. of Electrical Engineering
207 Dunstan Hall
Auburn, AL 36830

## Analogic sets record straight

A product feature in the March 1 issue presented erroneous information about Analogic's MP-2912A a/d converter ("A/D Converter Module Keeps Speed High but Cuts Costs by 50%," ED No. 5, p. 80). The unit price of the MP2912A is $450, not $595. The article also states that the Analog Devices ADC-1103 has the best gain tempco—only 10 ppm/°C max. However, Analogic's MP-2912A has a 7 ppm/°C max gain tempco.

*Russ Hawkins*
*Director, Marketing Communications*
Analogic Corp.
Audubon Rd.
Wakefield, MA 01880

*Ed. Note: Readers who want more information about the MP-2912A, please Circle No. 315.*

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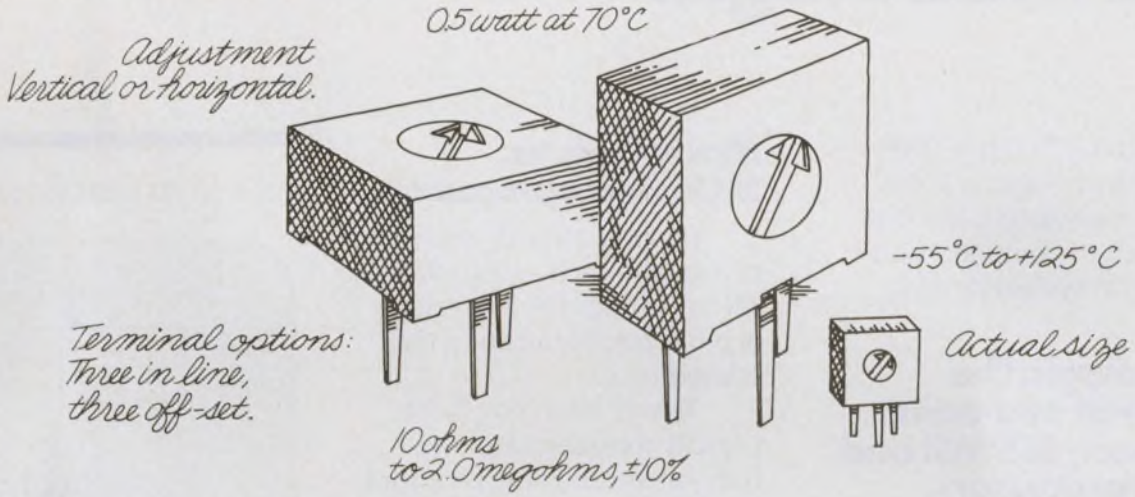


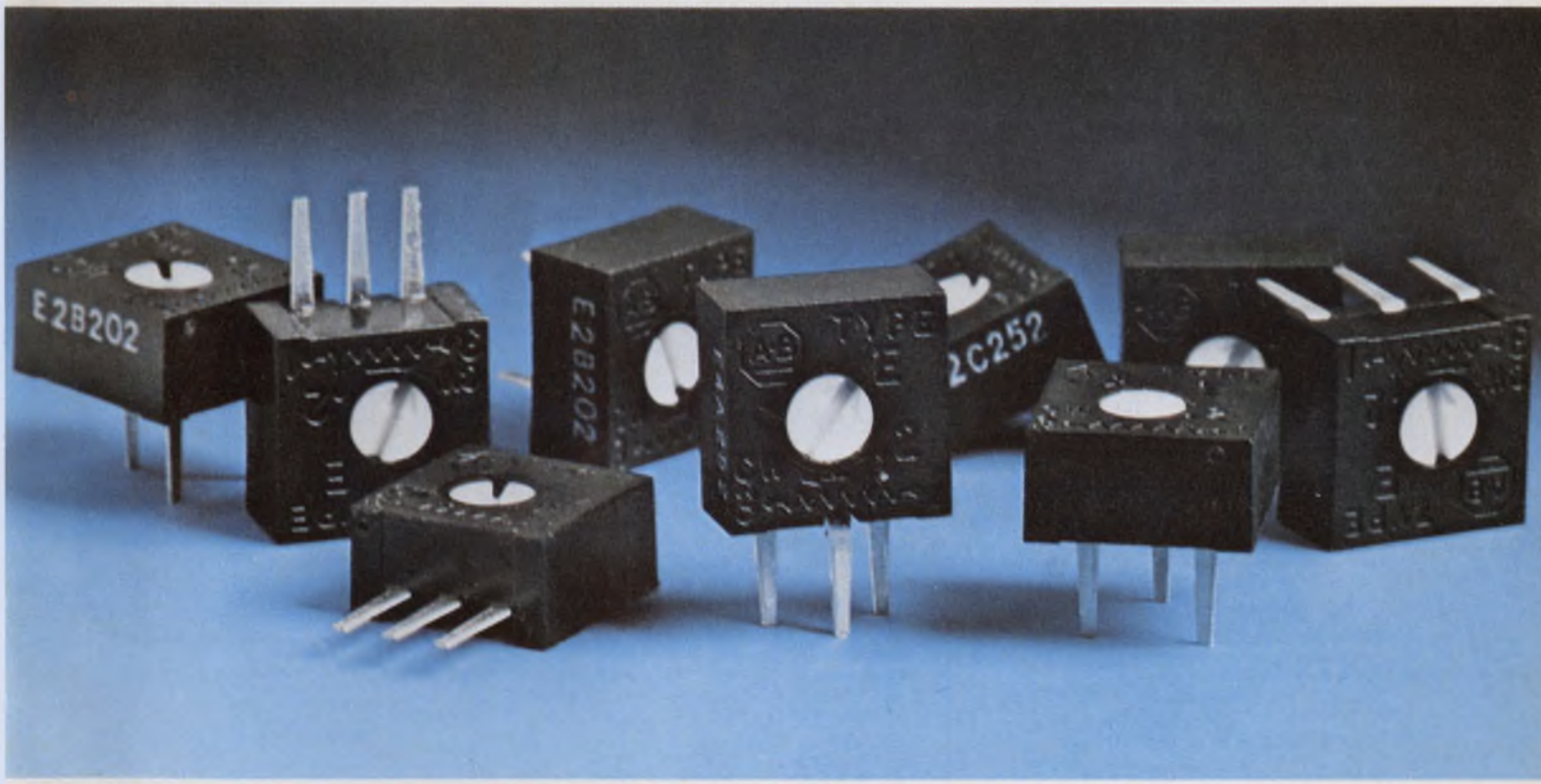


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INFORMATION RETRIEVAL NUMBER 12

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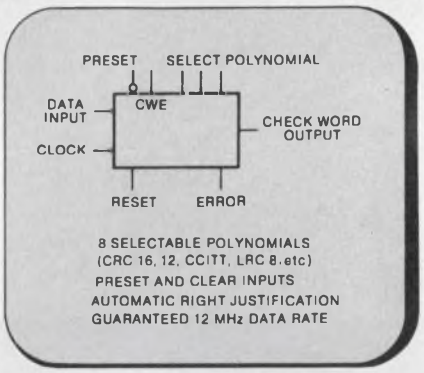
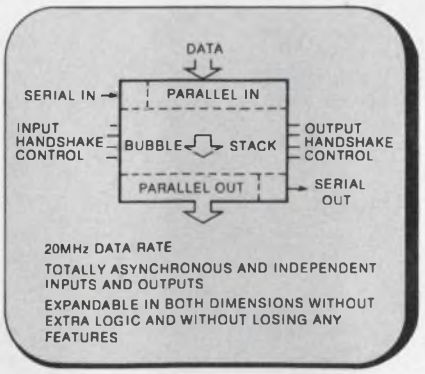
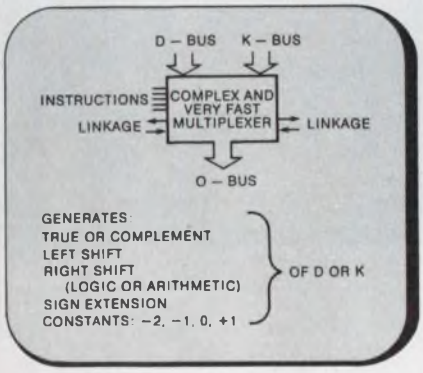



**The 9401 Cyclic Redundancy Check Generator/ Checker** is an advanced tool for implementing the most widely used error-detection scheme in serial digital data handling systems. A 3-bit control input selects eight different generator polynomials, including CRC-16 and CRC-CCITT, as well as their reciprocals (reverse polynomials). Separate Clear and Preset inputs are provided.

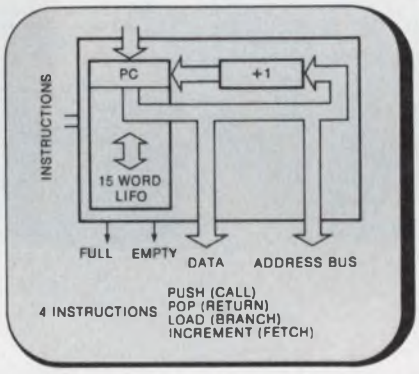



**The 9403 FIFO Buffer Memory** is a high-speed expandable fall-through type with totally independent and asynchronous inputs and outputs. Organized as a 4-bit wide by 16-word deep "bubble stack," it has four bits parallel and bit-serial data inputs and outputs. Complete "handshake" control signals are provided for unambiguous operation in asynchronous systems. It is intended for disk and high-speed communications applications with data rates of up to 20 MHz.

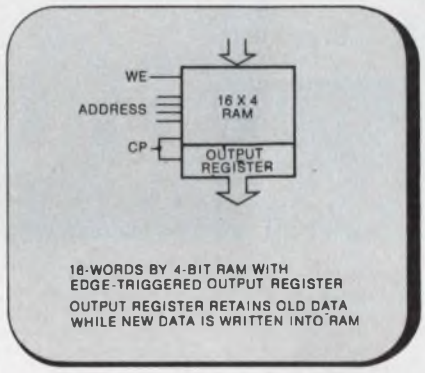
## FUNCTIONAL BUILDING BLOCKS



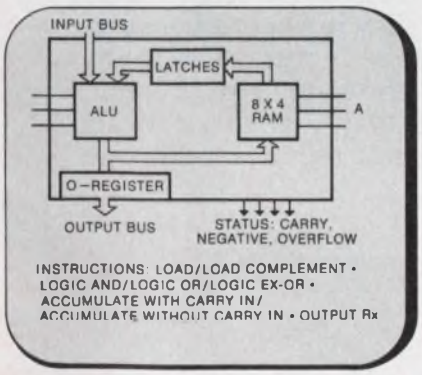

**The 9404 Data Path Switch (DPS)** is a very fast combinatorial array for closing data path loops around arithmetic logic networks (like the 9405 ALRS). A 5-bit instruction word selects one of the 32 instructions operating on two sets of 4-bit data inputs. Four linkage lines are available for expansion in 4-bit increments. The delay is less than 30ns over 16 bits. Samples available August.



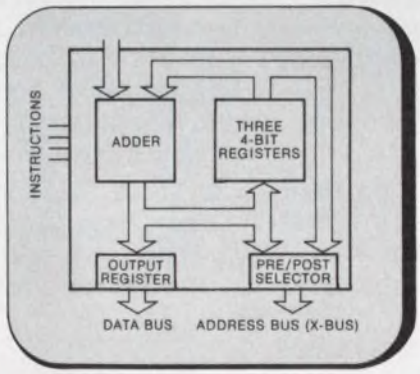

**The 9406 16-word by 4-bit "Push Down-Pop Up" Program Stack** stores program counter and return addresses for nested subroutines in programmable digital systems. It executes four instructions — Return, Branch, Call, and Fetch as specified by a 2-bit instruction. The 9406 may be expanded to any word length without additional logic and operates at a 10 MHz Microinstruction rate over 16 bits.




**The 9410 64-bit Read/Write Memory** is a register-oriented high-speed device organized as 16 words by four bits. An edge-triggered 4-bit output register allows new input data to be written while previous data is held. Three-state outputs are provided for maximum versatility. The 9410 operates at a 10 MHz Microinstruction rate.




**The 9405 Arithmetic Logic Register Stack** contains a 4-bit arithmetic logic unit (ALU), an 8-word by 4-bit RAM, an edge-triggered output register, and associated control logic. The ALU implements eight different arithmetic or logic functions where one of the two 4-bit operands is supplied from the input data bus and the other is supplied from one of the eight registers selected by the Address inputs. The result of the operation is loaded back into the same register and is also loaded into the edge-triggered output register and becomes available on the 3-state output data bus. The 9405 operates at a 10 MHz microinstruction rate over 16 bits.




**The 9407 Data Access Register (DAR)** performs memory address arithmetic for RAM resident stack applications. It contains three 4-bit registers — program counter, stack pointer and operand address — a 4-bit adder, a 3-state address output buffer and a separate output register with 3-state buffers. The DAR performs 16 instructions, and operates at a 10 MHz Microinstruction rate. Samples available August.

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INFORMATION RETRIEVAL NUMBER 14

JULY 19, 1975

# F-16: A multibillion bonanza for the makers of avionics

With only half the avionics of the ultra-sophisticated and super-expensive F-15, the new F-16 air combat fighter may be on its way to becoming the world's most popular military aircraft.

Eventual sales, the Air Force says, should reach $15-billion for 3000 planes. At least 20% of this total, or $3-billion, will go for electronic systems and components the Air Force estimates.

The Air Force has chosen the F-16 for its close-in, tactical fighter, as have four NATO countries —Belgium, Norway, the Netherlands and Denmark. The U.S. Air Force will buy 650 F-16s for a start, and the NATO countries, 306.

The whole concept of the F-16 differs markedly from that of its predecessor, the F-15.

"We designed the F-15 to be the ultimate," an Air Force spokesman says. "And it is. It has 'advanced' everything, and its cost $14.4-million a copy. The program cost $10-billion.

"The F-16, on the other hand, was designed as a simple, close-in fighter that could be easily maintained, that was highly maneuverable and would be cheap. And that's what it is." The total program cost for each fighter is $6.3-million.

The F-16 will complement the F-15, not replace it. The new fighter lacks the independence of the F-15. It needs to be in contact with ground radar or with Awacs, the airborne warning and control systems aircraft, whereas the F-15 can operate alone.

The technology used in the design of the F-16 avionics is sophisticated. "Perhaps more so than the F-15," the Air Force spokesman says. "We just didn't equip it with as much avionics or ask the avionics to do as much."

For example, the F-16 will carry

half the avionics the F-15 does—750 pounds, half of which will be a look-down radar system being developed competitively by Hughes Aircraft and Westinghouse.

The F-16 radar, which is the only new avionics system being developed specifically for the plane, is based on the design of the F-15 radar. But it will have only half its predecessor's range. It will be coherent pulse doppler, like the F-15 radar. But it will be considerably less complex—it won't have to guide missiles as the F-15 radar does. And it will be cheaper, lighter and twice as reliable, the Air Force says.

The F-16 radar will have a look-down detection range of at least 15 nautical miles, with 20 miles desired. A look-up range of 20 miles is required, with 25 miles desired. The radar will be able to detect targets five meters square at an azimuth of ±60 deg. And its automatic acquisition range will be five miles.

Borrowing from the Apollo spacecraft, the F-16 will use fly-by-wire aerodynamic controls built with quad-redundant sensors and power and triplex integrated servo-actuators. Also from Apollo, there will be a side-stick control for the pilot, making it easier for him to maneuver the stick when he is pulled back in his seat by high-G forces. And the aircraft's flight-control computer will automatically shift the aircraft's center of gravity according to the maneuver the aircraft makes.

To keep the F-16 lean, it won't carry the radar-guided Sparrow missile. It will be equipped only with the shorter-range, infrared-seeking Sidewinder. The F-16, therefore, won't need a radar-target data processor.

The aircraft will carry free-fall and electro-optically guided bombs and dispensers. There will be a multiple air-to-air target display for the radar and electro-optical weapons systems. And for the Maverick air-to-surface, TV-guided missile and the Hobo guided bomb, there will be a video display.

Besides the flight-control computer, the F-16 will have a central air-data computer, fire-control computer, an inertial navigation system, a stores management set to keep tabs on the weapons supply, the usual navigation aids, penetrations aids (ECM), a radar-data processor, a head-up display, a radar head-down display and an instrument landing system.

## U.S. metric conversion is called 'disjointed'

It's not a question anymore of whether the United States should convert totally to the metric system. The argument is rapidly shifting from whether to how and from why to when, according to Senator Daniel Inouye (D-HI).

Addressing a seminar on metrication in New York City, the

Senator noted that "events are leading us almost inevitably on an uncoordinated and disjointed conversion program which is fast leaving Congress behind."

Despite Congressional foot-dragging major American businesses have been converting their operations to the metric system. Senator Inouye—co-sponsor of the Administration's new Senate metric bill (S1882)—cited such diverse concerns as General Motors, Caterpillar Tractor, IBM, Exxon and Otis Elevator. He observed that the conversions were having ripple effects throughout the economy, because smaller concerns that supply the big companies that have converted must also convert, to ensure their share of market.

International trade is an important spur to metric conversion, Senator Inouye observed, particularly since the Eruopean Economic Community has indicated that by 1978 it will accept products only if they are marketed with metric measurements.

"Our exports to the European Economic Community amounted to more than $22-billion in 1974, and failure to adopt to these standards will have a vast impact on our trading community," the Hawaiian Senator noted.

The seminar was sponsored by Information Handling Services, Englewood, CO, which offers a "metric service" that supplies subscribers with microfilmed catalogs and data sheets on U.S. metric products and suppliers.

## GaAs cell produces 10 W from sunlight

Using gallium arsenide as the photoelectric conversion medium, researchers at Varian Associates in Palo Alto, CA, have produced a 1-cm-diam solar cell that can produce 10 W of electricity directly from the sun.

According to Joe Feinstein, vice president of research, other solar energy materials—such as silicon—require 1000 times as much surface area to produce the same amount of energy.

The dramatic increase in available power from solar cells, he notes, is primarily due to the fact that a concave reflector about 12 in. in diameter collects the sunlight and focuses it on the solar cell, concentrating the light by a factor of 1000. The thing that makes it possible to use such highly concentrated light with the Varian solar cell is gallium arsenide's ability to work at high temperatures and with high current densities. Silicon cannot.

**Gallium-arsenide solar cell** only 1 cm in diameter can produce up to 10 W of electrical power.

Gallium arsenide can operate effectively at temperatures as high as 300 C, Feinstein reports. Operation at such levels, however, does result in some degradation of performance. If the cell is operated at only 100 C, Feinstein continues, cooling can be easily accomplished by air convection.

Another factor that contributes to the high output power of the Varian device is its high efficiency. To date, experiments have shown that the cell can convert as much as 23% of light energy into electrical energy. But the future holds promise for even more efficient operation. Feinstein says that methods under investigation may make it possible to increase the efficiency to between 35 and 40%. This, however, is not expected for several years.

Plans are under way to build a rooftop array that will produce 1 kW of power. This is to be achieved by the use of 100 cells, each producing 1 V at 10 A. The array, Feinstein says, will be mounted on a rotating servo mechanism so it can follow the sun from sunrise to sunset and thereby use 40% more sunlight in a day than arrays that rely on incident sunlight.

A pilot production line could be set up within six months to produce devices for small rooftop units, Feinstein notes, with large-scale commercial applications requiring three to 5 years.

## Fiber-optic gyro called navigation-improvement

A low-cost, optical rate-sensing element—a fiber-optic ring interferometer—is the heart of a new kind of laser gyroscope.

Suitable for precision navigation systems, the fiber-optic ring provides the following advantages, according to one of its inventors, Dr. Richard Shorthill, director of the Geospace Sciences Laboratory at the University of Utah Research Institute, Salt Lake City.

- It theoretically can increase navigational accuracy by more than an order of magnitude over that of today's aircraft inertial navigation systems.
- Because of the ring element's simplicity, total system cost should be on the order of $25,000, about one-fifth the cost of the best system available today.
- Three-axis system size may be reduced ultimately "to the order of a shoebox."

The ring interferometer element—developed by Shorthill and Dr. Victor Vali, a physicist at the Geospace Laboratory—consists of several thousand turns of an optical fiber, a few kilometers long, wound on a frame about a foot wide.

In operation, light from a laser is piped into both ends of the fiber, and, as a result, it passes through the fiber coil in opposite directions. A small optical path difference is deliberately inserted ahead of one of the entering laser beams, and a phase difference between the opposite-going light is produced.

As a result, when the laser outputs are taken from the ends of the fibers and optically compared, a fringe pattern is produced, like that of a conventional interferometer.

As the fiber optics ring is rotated in space about its axis, the velocity of rotation adds to the speed of laser light traveling in one direction and subtracts from that going in the opposite direction. This effect is multiplied by the number of turns to produce a relatively large additional phase shift, thus causing a change in the fringe pattern. This change can be interpreted as a rate of rotation.

Shorthill sees a single-axis interferometer gyro useful in a low-cost system for ships.

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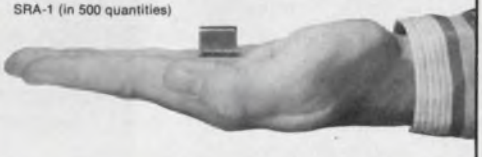

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News

REPORT ON HYBRIDS

# Better materials and equipment trim costs and raise reliability

Hybrids. They bridge the gap between tiny monolithic circuits on a chip and PC boards that use discrete components. They provide a technology that is most cost-effective at moderate volume —5000 to 100,000 units.

By comparison, hundreds of thousands of monolithics must be produced to justify the tooling costs, and above a few thousand units, PC boards don't provide much of a volume discount.

Formerly confined mostly to the military, hybrids are now used also in the data-handling and medical fields. And the automotive industry is considered a growth area in the next three to five years. New packaging materials and equipment are continually appearing to help solve tough design problems and to cut costs.

One area in which giant strides have been made is in thin-film technology. Thin films have the advantages of high stability, excellent as-deposited control and reproducibility and the ability to produce finer lines and smaller geometry components than thick films.[1]

Nevertheless the bulk of hybrid packaging is still done by thick-film methods; it is much less expensive and easier to set up a thick-film shop. And improvements in thick-film materials and equipment keep making it easier and cheaper to do a better job.

Advances in thick-film technology include the following:

- Improved thick-film printing machines and better screens. Routine production of 2 to 3-mil line definition is attainable, and even 1-mil is possible.
- An increased variety of inks —or pastes, really—to suit almost any need. Wider resistivity ranges, a wider selection of temperature coefficient, higher stability—especially after laser trimming—and better storage, handling and curing properties are evident. Also, as-fired resistor systems can now be held to closer tolerances.
- Improvements in component attachment materials, techniques and equipment. Epoxies have been improved for die attachment; both conductive and nonconductive materials are available.
- Higher power-handling capability. With substrates like beryllia, dissipation up to 50 W/in$^2$ can be obtained with proper heat-sinking.
- Functional trimming of hybrid circuits. Loose tolerances in hybrid circuit components can be accommodated by trimming strategic circuit components.

**Abrasive trimming** is frequently used to trim thick-film resistors at Raytheon's hybrid-facility, especially where stability is a prime concern.

The kind of equipment used in building hybrids and the materials employed are strongly influenced by the number of units in a manufacturer's average batch of circuits. The bulk of the hybrid business consists of custom designs, though some suppliers have standard catalog product lines, some on the market for years.

A quantity of 100,000 hybrid units is a huge production run. But this is only small change, when compared with catalogued monolithic circuits like TTL logic. On the other hand, less than 5000 custom hybrid units a year is considered uneconomically by a company like National Semiconductor, Santa Clara, CA. However, a small hybrid job shop might consider a quantity of 1000 a profitable run. And in special cases, as with high-frequency hybrids, only hundreds or even tens of units are often considered cost-effective.

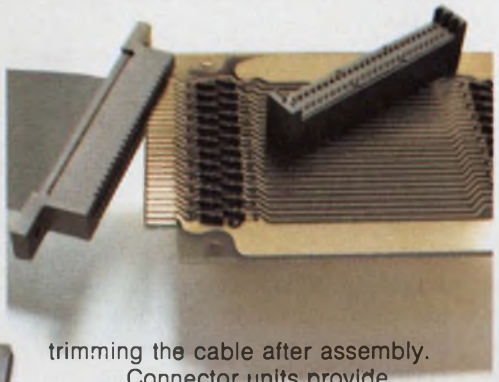
"In hybrids you don't often sell a circuit to more than one customer," explains Jerome Fischel, president of Circuit Technology, Farmingdale, NY. "Hybrid packaging is primarily a custom-design-oriented market, which generally commands only moderate quantities. This determines the character of the manufacturing methods and the equipment used by hybrid makers."

## Printer automation cuts costs

In spite of only moderate quantities, costs can be saved by automation, and some large hybrid producers—such as Beckman Instruments, Fullerton, CA—often design and build their own equipment. Beckman's screen and squeegee assembly prints resistors,

**Morris Grossman**
Associate Editor

# Design with the complete flat cable/connector system.



trimming the cable after assembly.

Connector units provide positive alignment with precisely spaced conductors in 3M's flat, flexible PVC cable. The connector contacts strip through the insulation, capture the conductor, and provide a gas-tight pressure connection.

Assembly-cost savings are built in when you design a package with "Scotchflex" flat cable and connectors. But more important, 3M Company offers you the full reliability of a one-source system: cable *plus* connectors *plus* the inexpensive assembly aids that crimp the connections quickly and securely (with no special operator training required).

The fast, simple "Scotchflex" assembly sequence makes as many as 50 simultaneous multiple connections in seconds, without stripping, soldering or

With cable, connectors and assembly tools from one design and manufacturing source, you have added assurance the connection will be made surely, with no shorts or "opens."

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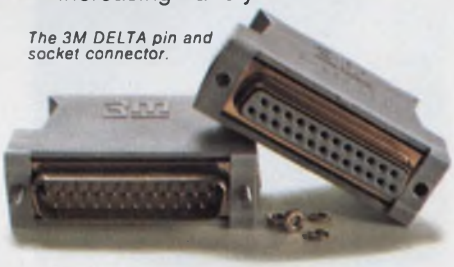
*The 3M DELTA pin and socket connector.*



100 connectors to interface with standard DIP sockets, wrap posts on standard grid patterns, printed circuit boards, or headers for de-pluggable applications. 3M's DELTA "D" type pin and socket connectors are now also available. For full information, write Dept. EAH-1, 3M Center, St. Paul, MN 55101.

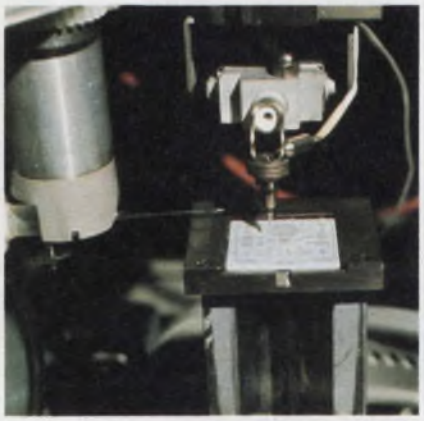
3M COMPANY


# 3M's "Scotchflex" line.

"Scotchflex" is a registered trademark of 3M Co.

INFORMATION RETRIEVAL NUMBER 16

**Probes are set up to test hybrid circuits** at various stages in Raytheon's manufacturing cycle to detect defects before final encapsulation.



**Wire bonding** to platinum-silver thick-film conductors is easy, reliable and now also economical, according to Electro-Science Laboratories.

capacitors and conductors at rates up to 4000 units an hour. This is up to 10 times more efficient than the usual hand-loaded machine used by small job shops, according to Gene Markley, a hybrid-product expert at Beckman.

"Experience shows," he says, "that typical commercial printers can handle only 1000 to 2000 parts an hour but our requirements need the higher speed to cut cost."

Dan Saslow, chief engineer of Aremco Products, Ossining, NY, describes his company's Model 3100 screen printer as an "old workhorse" capable of repetitive accuracy to 0.0003 in. and suitable for both production and lab work. A 1975 version has reduced vibration, increased speed and provides a squeegee pressure control option to allow light, 2-to-3-lb/in$^2$ pressure for special inks and out-of-chamber substrates. But the price is still $3250.

Saslow explains that the printer must be very rugged to provide this degree of reproducibility. "In addition," he says, "to close control of the deposited ink thickness and pattern definition, the printer should facilitate easy setup. Hybrid volume runs can be quite low and frequent changes may be required."

During the printing process, the squeegee blade deflects the screen down onto the substrate. The seal that forms between the screen and substrate "sucks" the ink through the screen openings onto the substrate, as the screen snaps back to its original distance from the substrate. The squeegee's speed, pressure and angle of attack must be kept constant to assure a reproducible rate of deposition.

Though older printing machines usually allowed the accurate positioning of the substrate holder and screen height, the squeegee pressure and speed were generally not controllable. And the pressure and speed were not known. Today's printers, however, are equipped with squeegee pressure and speed controls and accurate pressure gauges—a 0-to-12-in/s control covers the maximum usable speed range, and 0.15 to 4.2 lb/in. of squeegee length is a good adjustable pressure range. A vernier readout of the squeegee's angle-of attack setting is also desirable for good control.

To obtain controlled uniform ink deposits, in spite of variations in substrate height and multilayer work, the squeegee pressure must be kept constant. To help in this, some experts recommend large, soft squeegees that allow the wafer contour to be followed. But the mechanism used to maintain the squeegee pressure is probably most important, since it also influences the angle of attack on compliant squeegee blades. Manufacturers use various combinations of spring assemblies, dead weights and air cylinders to solve this problem.

The printing screen is one of the most critical items in thick-film technology. Screens are made of synthetic fibers like nylon or polyester and also of stainless steel. Affiliated Manufacturing, Inc., Whitehouse, NJ, a screen manufacturer, favors stainless steel because it can take the constant stretching that results from the squeegee motion.

Al Sweet, a microcircuit engineer with Mini-Systems, North Attleboro, MA, agrees saying: "Nylon doesn't seem to stand up, though it is more pliable and gets into recesses and handles multilayer work better than stainless steel."

However, Sweet adds, polyester screens are almost as pliant as nylon and wear better. Polyester has good properties for printing on irregular surfaces with crossovers and capacitors, he says. And polyester screens also permit the printing of heavier ink deposits than steel.

Microcircuit Engineering, Medford, NJ, supplies both synthetic-fiber and stainless-steel screens. It makes an improved 400-mesh stainless-steel screen with 0.0009-in.-diam wire. This allows very fine lines—to at least 2 mils—with its 41% open area. Also, 45° screen weaves are available, to eliminate the situation where a screen wire can run down the middle of a 3-mil printed line and block a good portion of it.

### To mask or to screen?

For really fine-line printing—perhaps to 1-mil definition—metal-etched masks are often used. An additional advantage is that the deposited ink conforms closely to the mask thickness. But masks have their drawbacks. They are three to six times more expensive than stainless-steel screens.

In addition masks lie directly in contact with the substrate; they don't have a screen's several mils of separation. Since a mask doesn't snap away from the substrate, as the screen does, the mask must be peeled off. In the process the mask retains some of the ink and the deposited lines have rounded sides. The screen's snap-off action is more desirable. This provides a sharp edge, which some experts feel results in better line control.

Further, a mask's lack of flexi-

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INFORMATION RETRIEVAL NUMBER 17

**Beckman-designed machine-controlled laser trimmer** can trim up to 20,000 resistors per hour. Laser trimmers are particularly effective in today's small geometry microcircuits.

bility prevents it from conforming to substrate surface variations and from use in multilayer work.

"In any event," says Aremco's Saslow, "many thick-film engineers believe that the ability to produce lines narrower than 2 or 3 mils is of little value, since the resistivity of the line becomes too high for many circuits and not many people ask for it."

### Ink is life blood of hybrids

A hybrid circuit can't be more reliable than the inks that the circuit's conductors, resistors and capacitors are made of. The ink is composed of powdered metals, metal oxides or semiconductors, often mixed with a glass-frit binder and all suspended in an organic vehicle. The type and quantity of metal, metal oxide or other material determines the ink's resistivity or dielectric constant. The frit helps bond the mixture to the substrate, and the organic vehicle determines the viscosity and how well the ink prints.

Metal powders are used for conductors, metal oxides for resistors and high dielectric glasses form capacitor dielectric layers. After the ink has been forced through the screen or mask onto the substrate, it is dried and then fired in a furnace at 750 to 950 C, where the organic vehicle burns off and the glass frit reflows and bonds to the substrate.

Separate patterns and screens or masks are needed for the conductor, crossover, dielectric, resistor and protective encapsulant materials. And careful sequencing is needed in the application and firing of the different materials. For example, a conductor ink that fires at 850 C can't be applied after resistors on the substrate have been fired at 750 C. Successive applications should be separated by firings that are at least 50 C lower than previous ones.

Bill Liederbach, a thick-film expert at Plessey EMD, Melville, NY, explains: "Essential to consistent performance of thick-film materials is the reproducible quality, quantity and mixing of the powders and vehicles. The powders must be very fine and properly suspended, or you're not going to get the correct properties, even if the right thickness of ink is deposited."

Plessey offers a complete line of ink materials. Conductor materials include gold, silver and various combinations with platinum or palladium. Resistor materials include rutherium and rutherium/silver, and nonmetalic materials include vitrious dielectrics, solder pastes and conductive epoxies.

Adrian Rose, a technical service engineer with Electro-Science Laboratories, Pennsauken, NJ, emphasizes that ink-material costs have become a major selection factor, because of the steep rise in the price of noble metals.

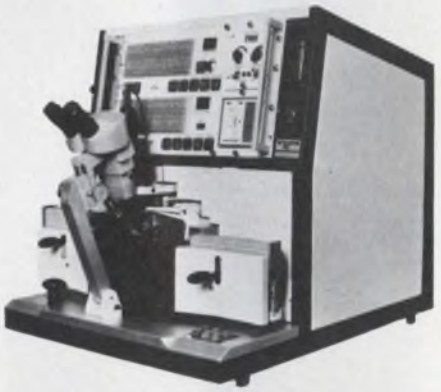
"For years, palladium/silver was the standard low-cost thick-film conductor," he notes. "But recent price increases have narrowed the gap between palladium and platinum. Since a small amount of platinum has the same effect as a large amount of palladium in a silver alloy; platinum/silver pastes, such as Electro-Science's 9500 series, have become competitive. Also, platinum/silver is more resistant to oxidation and thus has better bonding qualities and solderability, especially when fired at temperatures that cause palladium to oxidize.

"But the next few years should see the development of completely base-metal systems for conductors and resistors that are fully compatible with each other and also possess most of the desirable qualities of noble-metal mixtures."

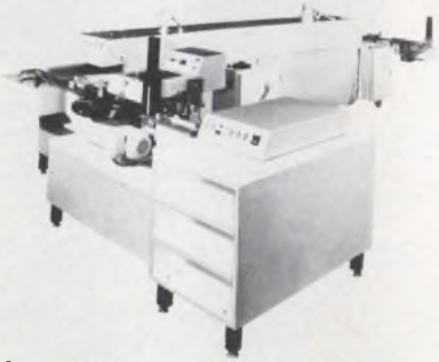
At least two dozen companies supply thick-film inks. If the number of announcements of new materials is any measure, Thick Film Systems of Santa Barbara, CA, the Sel-Rex Co. of Nutley, NJ, and

**This screen and squeegee assembly** of a Beckman-built high speed printer can handle up to 4000 units per hour versus up to 2000 per hour for commercial printers.

**Motorized ultrasonic ball bonders,** such as this Model 9700 unit offered by West Bond Equipment, provide the capability of presetting tool motions for repetitive action.



**Teledyne's high-speed wire bonder** can attach wires at 0.5 s/wire. Off-line programming is easily changed and repeatability is up to 0.0002 in.



**An automatic screen printer,** such as Wells Electronics' Model 44-PS, handles 2100 substrates per hour.

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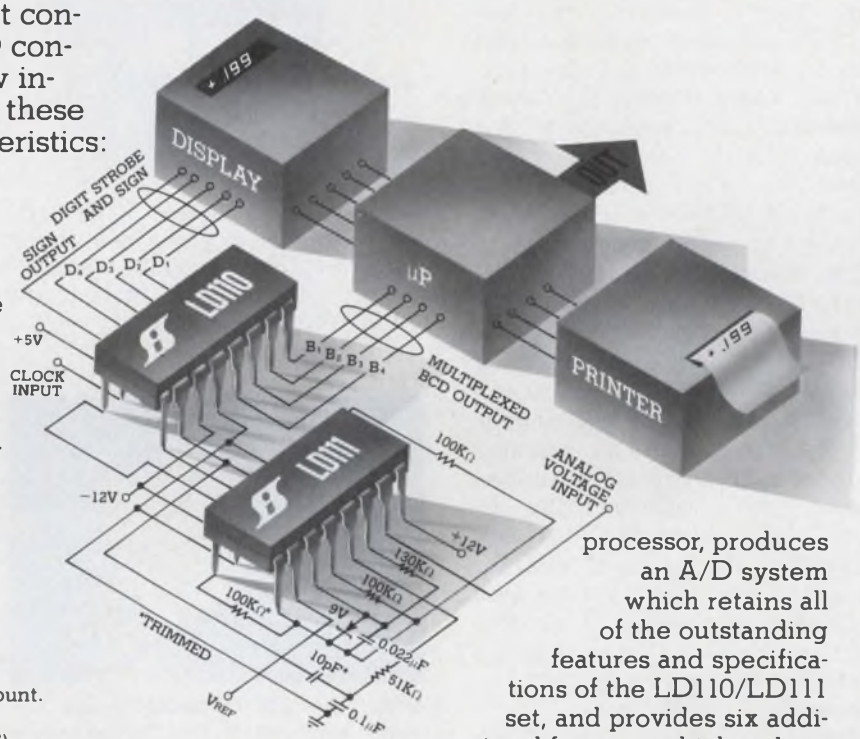


**Specifications**

- Accuracy of 0.05% of reading, ± 1 count.
- $Z_{IN}$>1000 MΩ.
- 4 pA typical input bias current (25°C).
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- 40 dB NMRR @ 60 Hz.

**Features**

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- TTL-compatible outputs.
- $19.60 per set (100-unit price).

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**LD111/LD114 Features**

- External latch inhibit control ("Hold" feature).
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- Active high or active low digit strobe outputs.
- Active high or active low data bit outputs.
- Sequential or interlaced digit scan.
- ÷512 output available for phase locked loop clock.
- $25.85 per set (100-unit price).

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INFORMATION RETRIEVAL NUMBER 18

Transene Co., Rowley, MA, are in the forefront in developing improved materials.

## Connecting the components

After inked components are fired, the hybrid's substrate is ready to receive additional chip components and then be connected to the outside world. Discrete chip capacitors, special resistors, multilead IC chips and other parts that can't be fabricated by the printing process are added during this stage. Microcircuit engineers agree that lead attachment gives rise to most failures in hybrid packaging. But they agree on little else when discussing component bonding.

The methods of attachment are many, the opinions expressed by the experts contradictory and the solutions offered apparently not ideal. At the 1975 Electronic Components Conference in Washington, DC, Jerome J. Mazenko, manager of the Hughes Aircraft Microelectronics Dept., Fullerton, CA, reported: "The promise of increased reliability and decreased cost for beam-lead attachment has not been realized in our tests of over 4000 beam-lead ICs for more than 2.5 million device hours of tests."[2]

According to Mazenko:

"The improved reliability claims for beam leads are based upon assumptions, such as beam leads allow the use of metallurgy that is less prone to migration problems; silicon-nitride sealed junctions are impervious to sodium-ion contamination, and the integral beam-lead configuration eliminates failure-prone wire bonds. Claims for reduced cost are based upon statements such as: beam-lead attachment is faster than chip-and-wire bonding; beam leads simplify functional testing of the chip before assembly in the hybrid, and beam leads eliminate the need for hermetic packaging—a simple polymer coating is sufficient protection."

However, beam-lead bonding is a complex operation and hence more expensive, Mazenko goes on. And it introduces failure modes that didn't exist before, he says, concluding: "Thus in solving one set of problems, new ones take over to produce a net negative result."

Beam-lead bonding was, however, staunchly defended by representatives of Bell Laboratories and Western Electric during a question and answer period at the Components Conference. Bell Laboratories is credited with the development of the beam-lead technique.

In another report at the conference ("A Second Look at Beam Leads—Are They Cost-Effective?"), Thomas B. Gillis of Raytheon Co., Quincy, MA, agreed with one of Mazenko's conclusions: that beam leads are expensive. He estimated them to be three to six times more costly than wire bonding. In Gillis' evaluation, however, beam-lead assemblies provided higher yields than equivalent wire-and-chip assemblies, which is contrary to Mazenko's findings.

Though many hybrid-packing experts predict that the use of beam-lead devices will eventually increase, chip-and-wire bonding is still the favored method. Wire bonding is an entrenched technology, and the inertia to change is considerable, the experts say.

Strengthening this entrenchment is the fact that significant advances have been made in wire-bonding technology. High-speed wire bonders, such as the new Tacmatic-1000 by Teledyne TAC, Woburn, MA, is said to need only about 0.5 sec per wire, where older manual machines needed 3 to 10 sec. The Tacmatic can compensate for a high degree of die-placement errors during operator alignment. Other features include off-line preparation of program panels, which can be quickly changed; positioning accuracy repeatable to 0.002 in.; variable ball size, and adjustable wedge and ball band pressure.

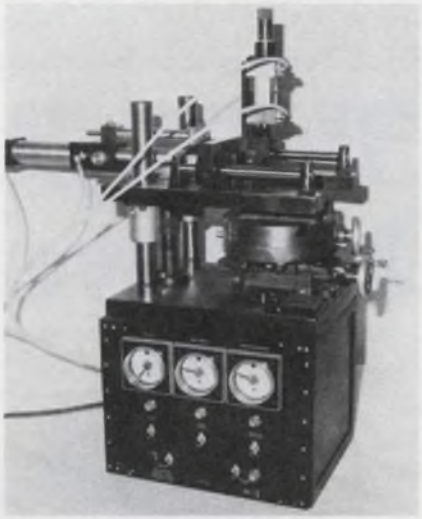
When combined with commercially available wire bonders, the L101 control system by General Automation, Anaheim, CA, is said to bond more than 2500 wires an hour at a cost of only 0.7 to 0.8 cents a wire. The cost with typical manual systems is put at 1 to 1.3 cents. The control can compensate for die-placement inaccuracies in the X and Y axis of up to ±1 in. and rotational errors up to ±89 degrees.

"Once programmed, the L101 allows less-skilled personnel to achieve expert results, since the system automatically corrects for inaccuracies and prevents table movement while a bond is being made," explains Allen G. Fiegehen, director of General Automation's Advanced Systems.

## Bonding the components

Many IC chips and some chip components are temperature-sensitive, but many new epoxies can be cured at low or even room temperatures. The conventional gold-silicon eutectic bond requires temperatures close to 400 C, which can damage some ICs. Thus epoxy bonding, with either insulating or conductive compounds, is being used increasingly.

In addition to low curing temperatures, some of the newer epoxies can be heated to at least 350 C for short periods after curing and still retain most of their strength on cooling. Earlier materials seriously degraded in bond strength



**Aremco's 1975 version of its 3100 screen printer** provides new squeegee pressure controls, settable timers, vibration-free motion and 0.0003-in. repeatability.

**Some discrete components are still hand soldered** to the hybrid's substrate, especially in small quantity and prototype designs.

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after only a 200-C rise. On the other hand, to be repairable, a die adhesive should weaken between 200 and 250 C, to permit chip removal without substrate damage.

In operation, a small dispensing needle is used, whose diameter corresponds to the smallest die on the circuit. For large dice, several small dots of epoxy are dispensed. After all dots have been placed, the dice are aligned and placed upon the resin. Automatic and semi-automatic equipment is available.

For example, Tridak, Inc., of Danbury, CT, offers its Model 2805 metering/dispense system, which is said to "accurately dispense any flowable material in any shot size without any after-drip." A micrometer adjustment in the head allows selection of a shot size as small as 0.005-in. diam, or any larger size up to the entire contents of its reservoir.

Many other companies, such as West Bend, Inc., Orange, CA, and Kasper Instruments, Mountain View, CA, make metering and dispensing equipment for epoxy die-bonding. And dozens of resin manufacturers can supply the epoxy material to go into these bonding machines.

Epoxy Technology, Watertown, MA, offers the Epo-Tek H61, a medium-to-heavy flowable paste that is also screen-printable, easy to handle and will not dry out, because it is a solventless formulation. Its curing time is 60 min at 120 C or 30 min at 150 C, and it has a shelf life of six months at room temperature.

Other epoxy manufacturers include Sigma Plastronics, Dearborn, MI; Emerson & Cumings, Canton, MA, and Formulated Resins, Inc., Greenville, RI. Plessey EMD of Melville, NY, supplies a line of conductive epoxies with silver, gold and base-metal fillers. Curing temperatures range from 150 to 380 C, and the materials store well at room temperatures.

## Alumina substrate has rivals

Most hybrid substrates for thick films are made of 96% alumina. One problem with this material is its hardness, which makes it difficult to cut and drill. However, there are companies like Comco, Inc., of Sun Valley, CA, that can produce

**Bonders come in many sizes and forms.** This bonder performs ultrasonic aluminum-wire bonding.

96% or 99.5% alumina substrates with special shapes and hole locations, and even do it in small prototype quantities delivered in three weeks. The 99.5% alumina has an as-fired surface finish of less than 4 microinches; the 96% surface is less than 15 microinches.

But for high thermal conductivity, beryllia is the ceramic to choose, says Ceredyne, Inc., Chatsworth, CA. It produces a complete series of precision ground beryllium-oxide substrates with accuracies to better than 0.001 in. And National Beryllia Corp., Haskell, NJ, makes a substrate material called Berlox-Strates, which it says has 14 times the head conductivity of alumina. It is even 15% better than aluminum metal, the company says, and it has a thermal conductivity of 150 BTU/hft-°F/ft at 25 C. Berlox-Strates is made from 99.2% beryllia and has a surface finish of 15 microinches. Stock sizes come in 1 × 1 to 2 × 2 in., all 0.025-in. thick.

Mica Corp., Culver City, CA, however, departs from the traditional ceramic substrate and offers its Micaply Ohmega system.

The key features:

- An epoxy-glass substrate that is much less expensive than ceramic.
- A more easily machined and fabricated material.
- A material that can be more readily multilayered than ceramic.

Among the drawbacks: Thermal-compression bonding can't be used, because the high temperature can damage the epoxy glass. And the surface is still too rough for microwave use, but Mica engineers are working on this.

## Functional trimming cuts costs

Thick-film resistors are typically within ±50%, as fired. To attain closer tolerances, they are trimmed to reduce cross-sectional area, thereby increasing their resistance. Trimming methods include laser, air-abrasing, oxidizing and etching with chemicals.[3]

But trimming is a major cost consideration, especially when the components are handled individually. Many hybrid circuits are designed so that only one or two key components need be trimmed to attain circuit operation within desired tolerances. This is called functional trimming.

This operation can compensate for wide tolerances in active components, set trigger levels, adjust time constants, vary biases, etc.

More than half of Beckman Instruments circuits are functionally trimmed, according to Gene Markley, hybrid product manager. "Although we prefer laser trimming, because it's fast and subsequent cleaning processes are unnecessary, we do rely on air-abrasive trimming for very critical applications where resistor stability is imperative," Markley says. "However, in the tight layouts of the newer geometries—with up to 1/10 the former spacing—lasers are better and can handle 10,000 to 20,000 resistors per hour on a component basis and about 35,000 circuits a day of functional trimming."

With thick-film resistors, pretrimming to 0.5% is often first done abrasively. Then, for functional trimming, a fine cut is performed with a laser, perhaps to as close as 50 parts per million. ■■


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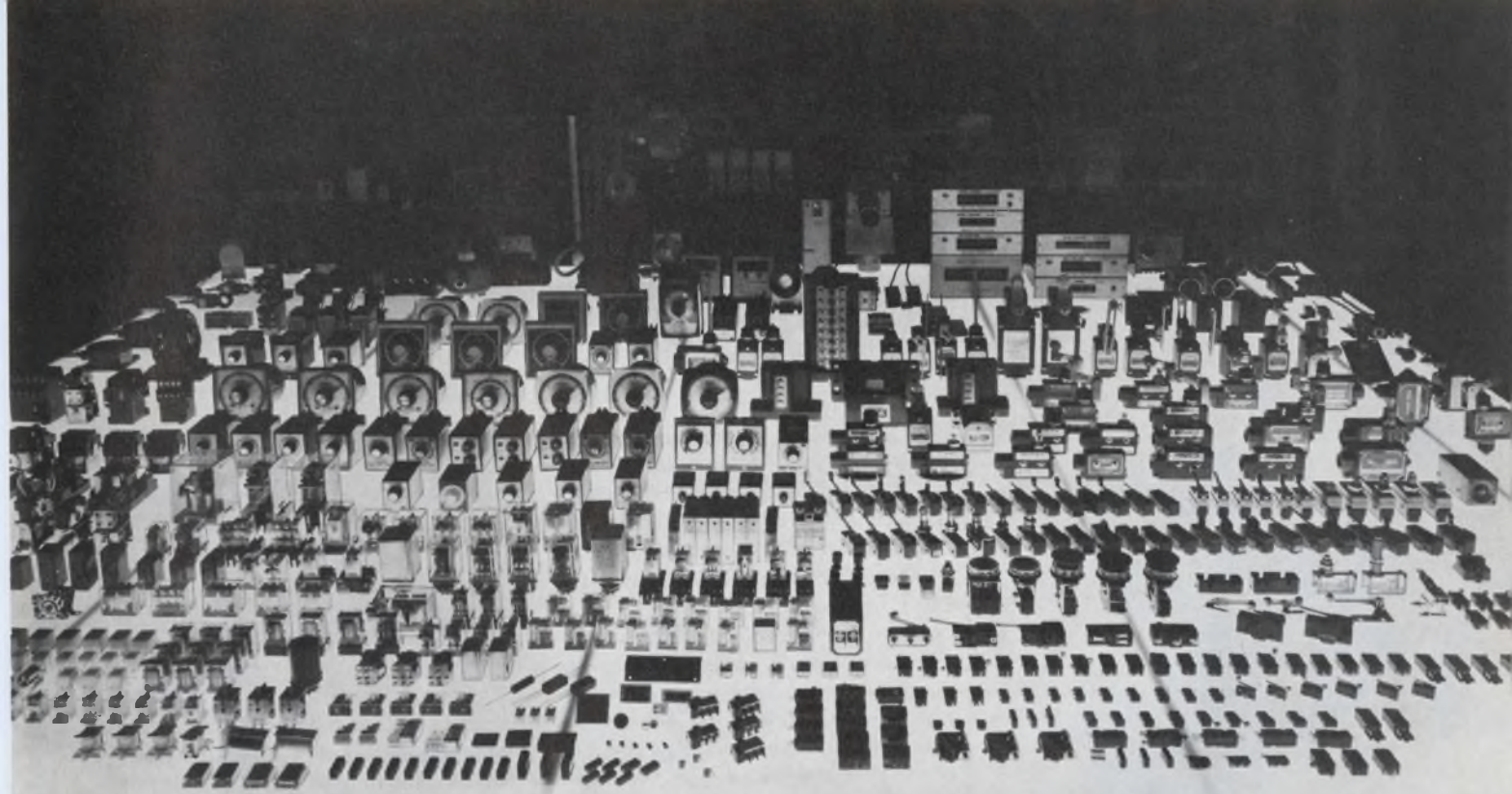

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*Limit, one guess per entrant.
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# Micro-optic devices show advantages over optical ICs

A new class of micro-optic devices under development in the laboratory shows promise of having advantages over the optical IC technologies now being explored.

The micro-optic devices use the interference and reinforcement of coherent light in an interferometer-like waveguide arrangement to function as modulators and switches. The optical integrated circuits use the resonant coupling of two parallel waveguides for the same purpose.

Dr. William E. Martin, inventor of the microscopic elements at the Naval Electronics Laboratory Center in San Diego, says the micro-optics are easier to fabricate than optical ICs. And their dimensional tolerances are substantially broader than those of equivalent ICs, he adds.

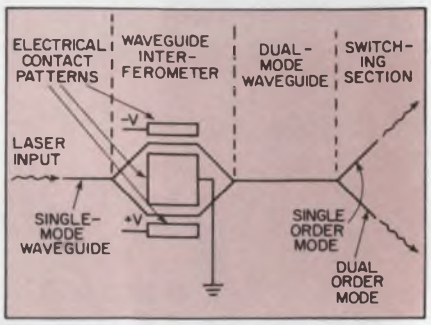
The basic micro-optic building block is a single-mode waveguide interferometer patterned after the Mach-Zender interferometer (see figure).

The single-mode channel waveguides that form the active structure are roughly 2 by 2 $\mu$m square, Martin reports. The waveguides are diffused into the surface of a zinc-selenide or lithium-niobate substrate. The device length is about 5 mm, and the substrate width about 20 $\mu$m.

In operation, coherent laser light is piped into the lefthand end of the structure, where it splits into the two waveguide arms of the interferometer and then goes back into one at the output.

Electrodes on the substrate can be connected to provide an electrical field across both of the channel waveguides. This field changes the optical path length in each leg of the interferometer. With zero voltage across the device, the light from the two interferometer legs joins at the output and is reinforced at this junction.

Application of a differential voltage across the structure increases the propagation constant in one leg and decreases it in the other.




**Modulating and switching device,** which uses micro-optics, is said to be easier to fabricate than an equivalent optical IC.

If a differential electric field is applied to the interferometer and it is high enough to cause a phase shift of 180° between the light passing through both arms, the recombination at the output results in light distribution that is zero at the center of the exit waveguide —the second-order mode. Thus modulation can be produced.

The propagation constant of the dual-mode waveguide between the interferometer element and output Y causes the light to follow and exit at the two end branches for the first-order mode. This occurs when no voltage is applied to the interferometer.

Application of a field to the interferometer changes the lowest-order mode to the second order, which has a different propagation constant—one designed to channel the light up the other branch of the Y. Thus an optical switch is obtained.

The first generation of zinc-selenide devices required 25 V for operation, Martin reports. With this substrate, a single-pole, double-throw optical waveguide switch was made that had an on-off ratio of 7:1. With use of lithium niobate and only 5 V, extinction ratios of better than 12 to 1 have been

achieved, Martin points out.

The upper frequency of operation—at present about 1 GHz—is limited only by the drive electronics, Martin points out. The device presents a capacitive load of about 1 pF. Depending upon the substrate material, from 5 to 20 V is required for its operation.

For increased input-output isolation, cascading of the devices is needed at the present state of the art, Martin notes. However, these micro-optic elements have among the highest on-off ratios of any of the optical IC switching devices so far proposed.

A present limitation of the micro-optic elements is high-level cross talk, Martin says. But he is confident of reducing these levels with improved understanding of the device and its fabrication. ■■

## The 2-in-1 watch


**Combination digital timepiece and split-second stop watch** contains a liquid-crystal display for the time and a LED for the chronograph. A button activates a lamp for reading the LCD at night. The digital watch sells for about $400 and will be available from Heuer-Leonidas of Springfield, NJ, later this year. Integrated Display Systems of Montgomeryville, PA, supplies the electronics.

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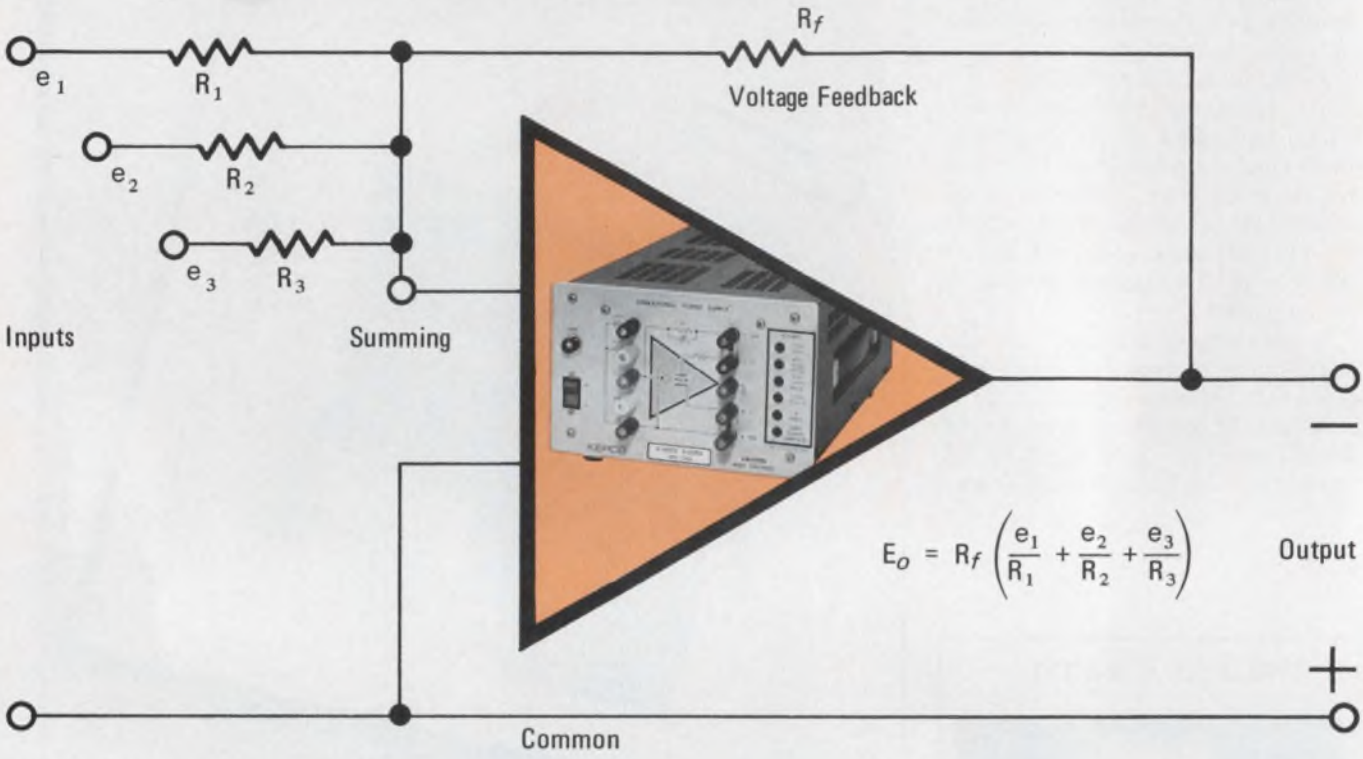


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INFORMATION RETRIEVAL NUMBER 23

# Washington Report

## A Federal R&D corporation asked

High-risk, high-technology research and development programs—the kind that most private companies can't afford to gamble on—would be financed by a national technology development corporation under a bill proposed by Rep. Thomas J. Downey (D-NY).

The corporation would be funded initially with $1-billion, with which it would make investments and guarantee long-term loans. Patterned on the Depression days' Reconstruction Finance Corporation and the existing Export-Import Bank, the corporation would share in the profits of any development that might come from funded research.

Emphasis would be on energy, pollution, resource conservation, environmental problems and basic research. A scientific advisory panel would approve any loans or guarantees.

## Polymer studied as copper substitute

In this age of substitution, with fiber optics already bidding to replace copper in some communications areas, the National Science Foundation has announced another candidate—thin layers of electrically conducting polymeric sulphur nitride.

Working under a joint NSF and Advanced Research Projects Agency program, University of Pennsylvania scientists say they have demonstrated that the thin layers can be synthesized so the chains of molecules are aligned parallel to one another on the plastic surfaces. The fibers that make up the crystals and films are aligned parallel to one another, because electricity flows more easily along them than across them.

Researchers, who call the discovery "metallic polymer," say the new synthetic metals may one day replace ordinary metals. The polymer, first discovered in 1910, wasn't given serious consideration until 1973. With copper deemed exhaustive, the new synthetic may be a strong candidate in the future, since its basic ingredients, sulphur, chlorine and ammonia, are readily available and inexpensive.

## A reorganized FCC proposed

The Federal Communications Commission would be restructured if legislation recently introduced in the House by Rep. Torbet H. MacDonald (D-MA) becomes law. In it are 15 recommended changes that would scrap some procedures, allow the agency to be more independent of the White House and generally raise the veil of secrecy under which the FCC sometimes operates.

A major change would be to reduce the present number of commissioners from seven to five and to increase their terms from seven years to 10.

More staff help would be authorized for the commissioners. This is designed to give each a better grasp of problems, according to Rep. MacDonald, who is chairman of the House Subcommittee on Communications.

To give Congress greater oversight of operations, the bill would grant committees immediate access to FCC documents.

## New radio propagation studies under way

More studies on radio propagation activity at higher frequencies—10 GHz to 300 GHz—will be carried out by the Dept. of Commerce's Office of Telecommunications, according to Assistant Secretary of Commerce for Science and Technology Betsy Ancker-Johnson.

Among the programs is an investigation of the use of high-powered microwaves to "heat" a section of the ionosphere, which then reacts as a large reflector. Using the Department's transmitter near Platteville, CO, ionospheric irregularities 100-km in diameter have been created at F-region heights. Such a phenomenon is capable of bouncing communications signals for very long distances.

Besides research on propagation, the Telecommunications Office will also increase its search for new telecommunications applications.

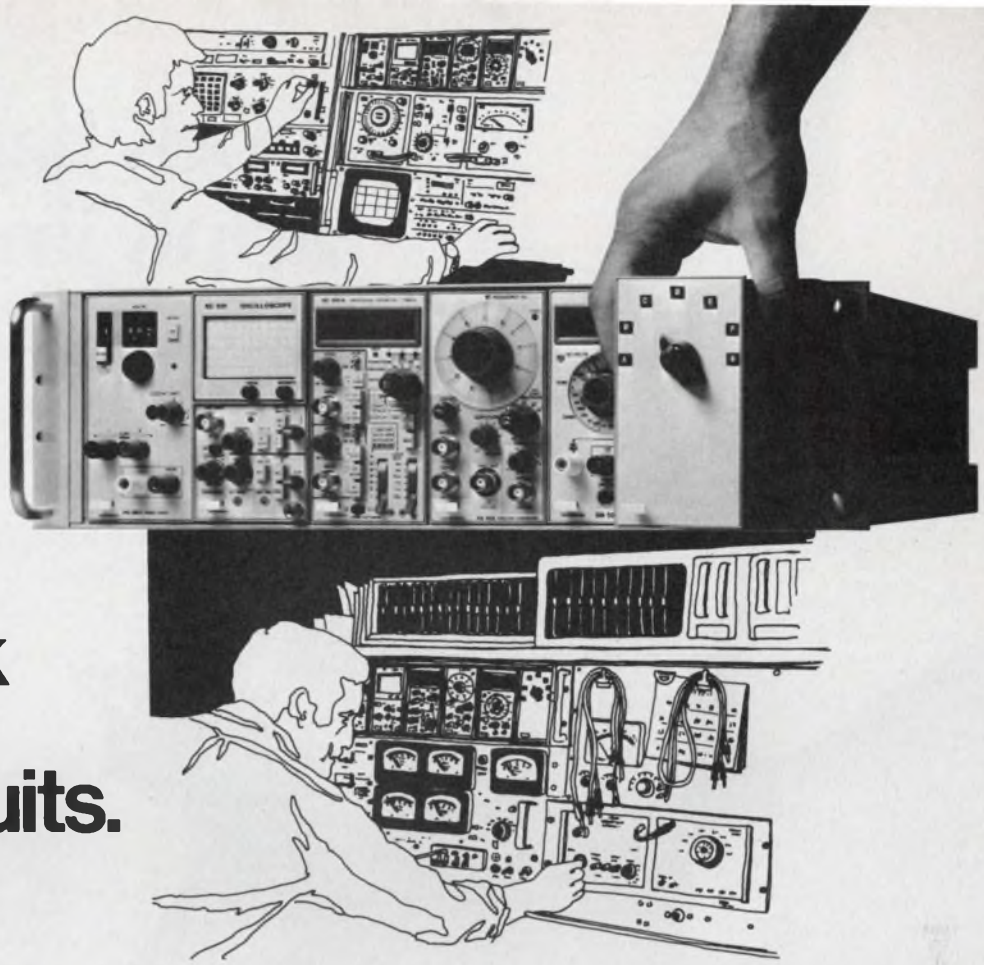
## Capital Capsules:

The Electronic Industries Association has a **seven-point export control program that it is pushing vigorously on Capitol Hill and in the State Dept. and Dept. of Commerce. The goal is to make U.S. manufacturers more competitive with those overseas.** Problems that have to be solved include those arising from uneven application of export controls and excessive time to process licenses. . . . Apollo Soyuz astronauts are going to try to produce superior optical fibers in a small electric furnace. **Lithium fluoride fibers made under weightless conditions are expected to have better continuity, regularity and orientation.** . . . The Energy Research and Development Administration is **drawing up a blueprint of work to be done by a Solar Energy Research Institute.** Its creation is required by the Solar Energy Research and Development Act of 1974. The National Research Council of the National Academy of Sciences and the National Academy of Engineering favor a single center, which would be a contract-operated lab. The contractor would be a consortium of universities or a single university. . . . Sources are being sought by the Air Force for **an exploratory development program to establish the feasibility of nonvolatile semiconductor memory chips.** The USAF Avionics Laboratory says the element will be an MNOS transistor. The contractor must trade off the various technologies, such as aluminum vs silicon-gate. . . . **A study of the chemical and structural influences of doped aluminum conductors on ICs is about to be launched by the Air Force.** The effort will include building aluminum thin-film conductors doped with silicon. To be investigated through accelerated stress tests will be their chemical stability, resistance to electro-migration and interaction with other device features, such as deposited dielectric layers and silicon contacts. . . . **The Office of Management and Budget is out to stop Federal agencies from awarding grants to an organization or company instead of a contract.** A grant makes sure the agency assigns the work to the outfit it wants but it bypasses the competitive system. The office's proposed solution? To redefine the "vague" definitions of "contract, grant and cooperative agreement" to strengthen pending legislation.

# Tektronix TM 500

## a line of 29 test instruments

## that go six-in-a-rack including custom circuits.



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- **a blank plug-in for your own circuitry**
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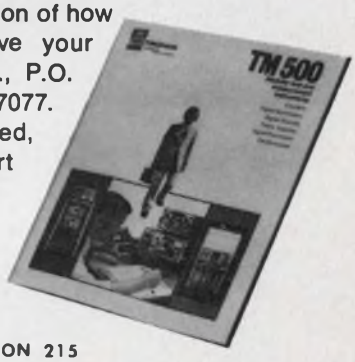
TEKTRONIX modular instrumentation offers your QC, production test, or built-in test equipment a highly compact, extensive line of test instruments . . . TM 500. They are designed to work totally independently or as a system with each other. Blank plug-in kits make it easier for you to build in your own testing circuits compatible with TM 500. The RTM 506 rackmounting power module/mainframe (only 5¼" high) provides six compartments to accommodate TM 500 plug-in modular instruments and the plug-in kits. It is available for benchtop or portable use (TM 506), as well as for rackmounting (RTM 506).

A common interface circuit board within the mainframe permits the intercommunication of inputs, output, and various parameters among the plug-ins. Tektronix will supply you with data on voltages, currents, and pin connection diagrams, so you can determine the feasibility of assembling your special circuits in blank TM 500 plug-in kits.

The TM 500 family of instruments is designed to fulfill your test and system needs in such widely divergent areas as high-speed logic; dc, power line frequency, audio, and rf to 550 MHz; oscilloscope and other instrumentation calibration; and even medical instrumentation calibration. They represent Tektronix standards of quality in design, performance, and ease of operation. Included are pulse generators with features such as independent pulse top and bottom controls and repetition rate to 250 MHz. And the DC 505A Universal Counter/Timer features direct counting to 225 MHz and time interval averaging with resolution to 100 ps.

Here is a growing, compatible family of 29 plug-in modular instruments, accessories, and one, three, four, and six-compartment mainframes providing the common power supply. All mainframe/power modules may be hand-carried, all go on the bench, and there are SCOPE-MOBILE® configurations as well. Some instruments are general purpose, such as DMMs, some are highly specialized, such as those for oscilloscope calibration. They comprise test and measurment systems that are difficult to duplicate with monolithic instruments.

Send for the 56-page TM 500 catalog A-3072 with full specifications and suggested selections of instruments for typical applications. Or contact your local Tektronix Field Engineer for a demonstration of how TM 500 instruments can solve your needs. Write to Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077. In Europe write Tektronix Limited, P.O. Box 36, St. Peter Port Guernsey, Channel Islands.

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FOR DEMONSTRATION 215

# Nobody has an easier to apply line of no-strip, no-solder, round-conductor flat-cable connectors than AMP.


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AMP Latch connectors terminate 10 through 60 leads on multi-conductor flat cable. Simultaneously. They mate with two rows of .025 posts on .100-inch centers. Our 14- and 16-position AMP Latch connectors mate with standard DIP sockets. There's also a family of edge connectors in the line.

**Fail-safe.** Dual camming and latching ears on the unique AMP Latch folding contacts provide a four-point electrical contact and mechanical grip for each conductor—not just two points—to provide true redundancy. You can inspect the termination itself before the cover is applied. After termination, inspection ports in the connector cover allow visual checkout of each fork-type contact for proper locking and latching. The latching of individual contacts prevents bowing or parting of the covers. The connectors can also be probed under electrical load via the inspection ports. To insure integrity, the cover also locks to both ends of the connector housing with auxiliary latches.

**Connects three ways.** With AMP Latch, you can interconnect to pc board spring sockets, directly to the board itself, or to DIP sockets—anywhere you want to interface on high-density, .100-inch patterns.

Ask your AMP representative for an in-plant demonstration. Or write for AMP Latch connector literature. AMP Incorporated, Harrisburg, Pa. 17105.



**AMP**
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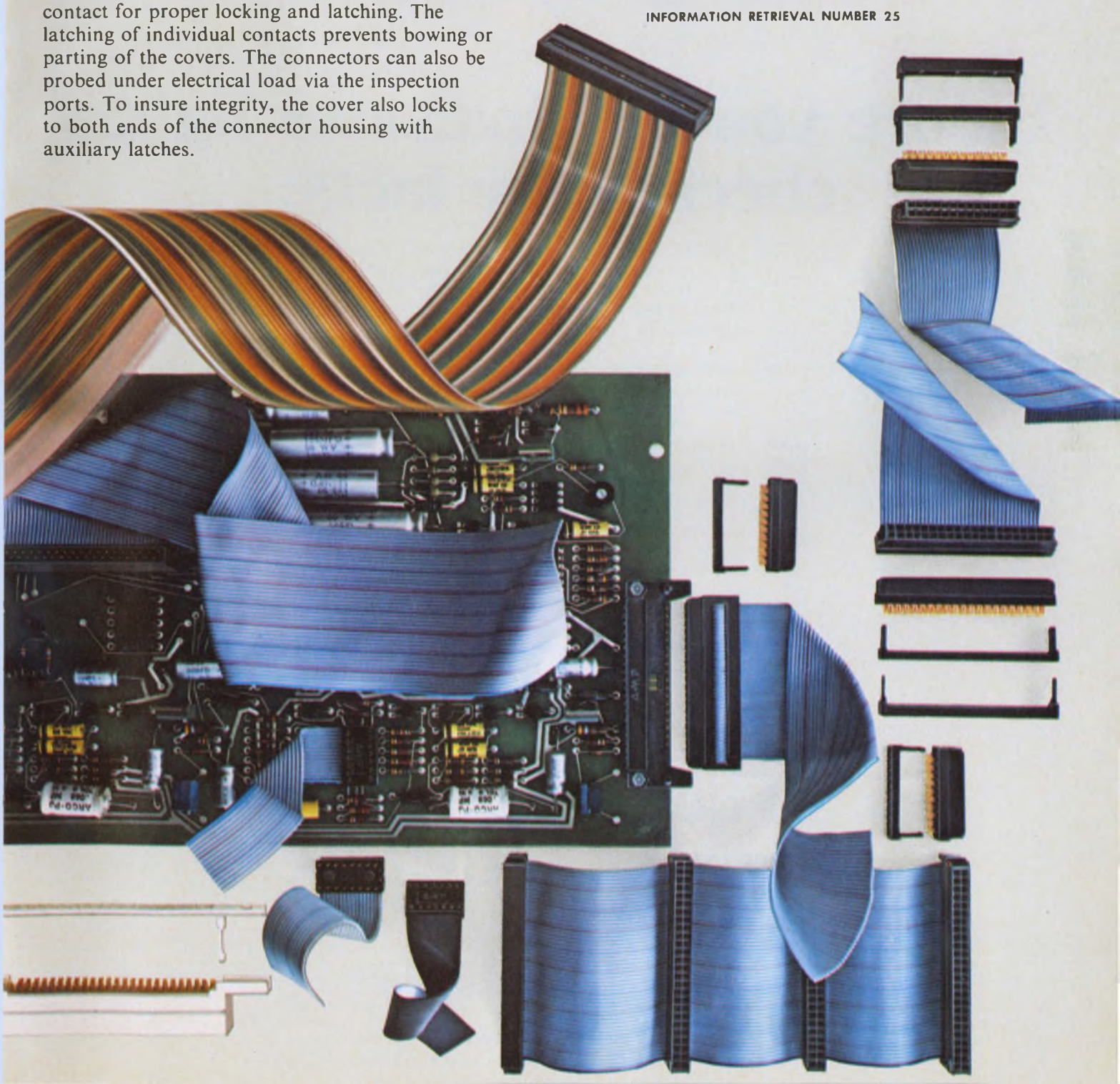

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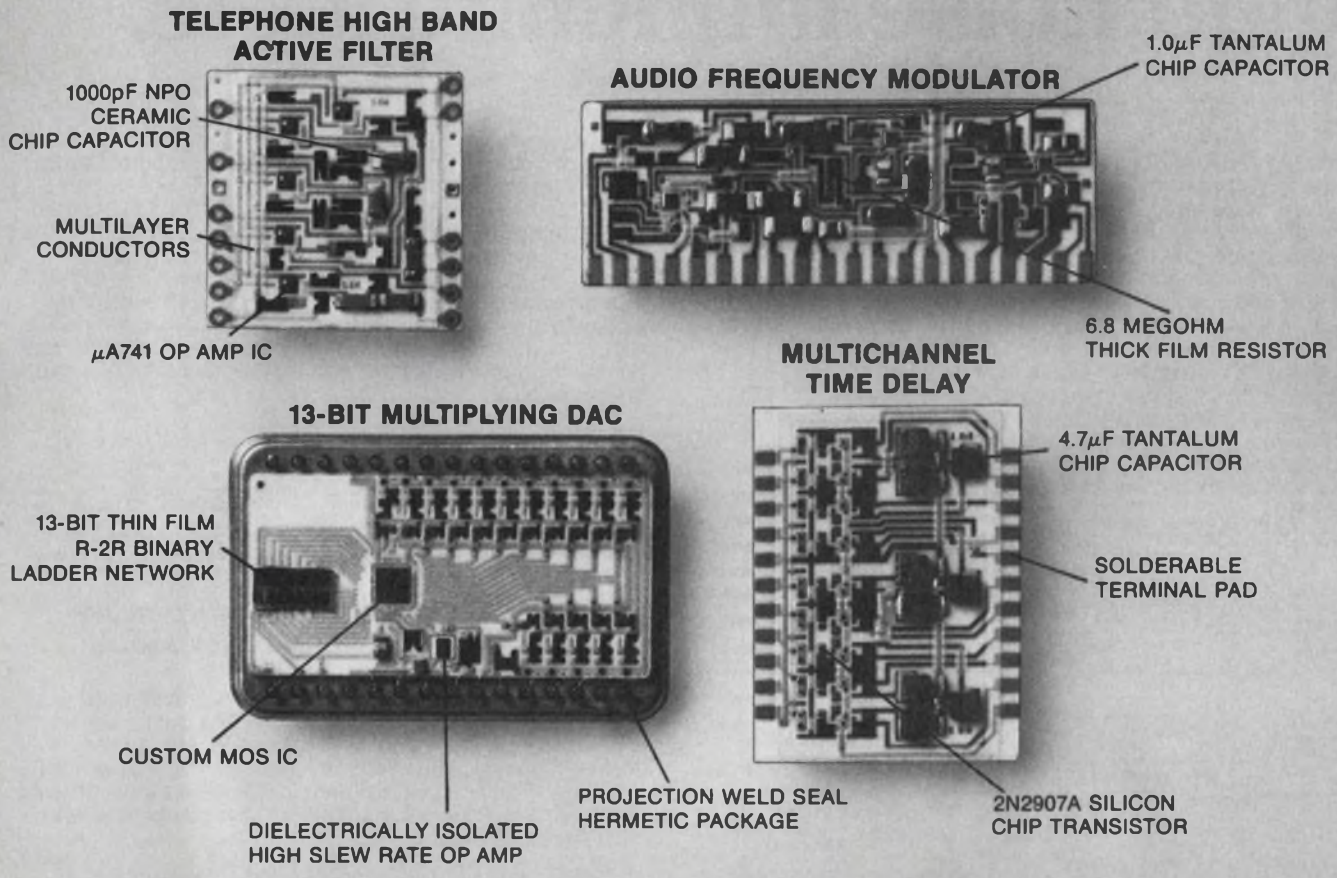


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INFORMATION RETRIEVAL NUMBER 27

## HiNIL Interface

# Keeping the bugs out of microprocessor systems with high noise immunity logic.

An MOS microprocessor system can be troubled by disastrous bugs unless it is protected against noise transients generated by switches, electromechanical peripherals and other nearby noise sources, such as lamps and machinery. But filters and shielding, the traditional cures, are often difficult to add to a microprocessor because of size and cost constraints.

These problems can be avoided by substituting HiNIL interface devices for conventional I/O logic. HiNIL—Teledyne's bipolar High Noise Immunity Logic—has a guaranteed DC noise immunity about 10 times that of TTL, for example (3.5 vs. 0.4V). Also, HiNIL blocks AC transients large enough to cause TTL malfunctions. Two additional advantages are superior output drive and, in low power systems, protection of CMOS memory and random logic inputs.

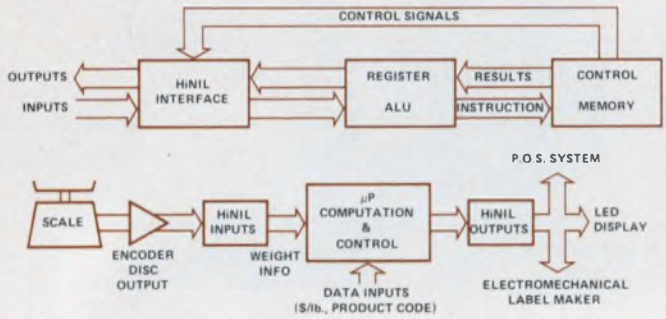


**Figure 1. Use of HiNIL interfaces in POS systems with electronic scale. Top diagram shows basic microprocessor configuration.**

One manufacturer of microprocessor-controlled electronic scales decided to use the configuration in Figure 1 because he was concerned about the consequences of incorrect weights and prices. The probability of errors resulting from noise transients was high because the scale would be used in a supermarket POS system, where the environment includes refrigerators, fluorescent lamps, meat grinders and electromechanical label makers.

In the system, the microprocessor receives weight codes from an encoder disc in the scale and operates a cash register interface, LED display, and relays of a receipt printer or label maker. The system designers put HiNIL interface logic on the microprocessor board to handle the I/O functions, suppress noise transients picked up along the transmission lines, and drive the peripheral devices. HiNIL output interfaces can drive long lines, relays, displays and lamps without additional components since they sink up to 65 mA and source up to 12 mA. (The new 390 buffer series will sink up to 250 mA.)

Manufacturers of systems requiring random logic are finding that HiNIL and CMOS are an ideal combination. They maximize system noise immunity and assure an excellent system function/power product. HiNIL and 54C/74C CMOS interface directly at $V_{CC}$ voltages from 10 to 16 volts, the power supply range of HiNIL. Moreover, HiNIL protects CMOS inputs from destruction by static electricity and from harmful DC input levels that can exist before CMOS circuits are powered up.

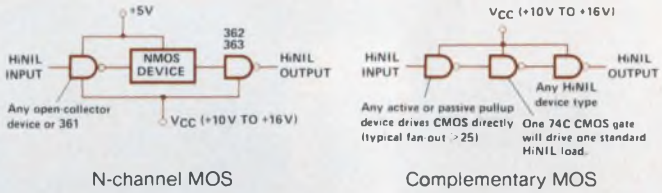


**Figure 2. Typical HiNIL/MOS and HiNIL/CMOS interfaces**

The rules for using HiNIL with MOS or with CMOS operating at lower voltages are simple. The pullup resistor of an open collector HiNIL device is connected to the desired high logic level voltage (see Figure 2). To use HiNIL with other bipolar logic, just plug in a Teledyne dual or quad interface circuit (see table). HiNIL is also compatible with most analog devices.

**Examples of HiNIL Interface Devices**

| | |
|---|---|
| 301 Dual 5-Input Power Gate<br>302 Quad Power NAND Gate (OC) | 65mA relay or lamp driver |
| 323 Quad NAND Gate (OC)<br>332 Hex Inverter (OC)<br>334 Strobed Hex Inverter (OC) | Input noise protection plus open-collector pullup to other logic levels |
| 350 8-Bit Multiplexer<br>351 Dual 4-Bit Multiplexer | Drive longer lines than TTL with 10X noise immunity ($I_{OH}$=12mA) |
| 361 Dual Input Interface<br>362 Dual Output Interface<br>363 Quad Output Interface | 361 directly connects HiNIL to DTL/RTL/TTL<br>362 and 363 connect DTL/RTL/TTL to HiNIL |
| 367 Quad Schmitt Trigger<br>368 Quad Schmitt Trigger (OC) | Suppress 100V/1μs spikes, protect CMOS, decode switches, etc. |
| 380 BCD to Decade Decoder<br>381 BCD to Decade Decoder (OC)<br>382 BCD to Decade Decoder<br>383 BCD to 7-Segment Decoder | Provide decode/drive for lamps, LEDs, gas discharge displays, etc. |
| 390 Interface Buffer Series | 250mA HiNIL driver series will be available soon |

If you need a simple, inexpensive solution to a difficult noise problem, write or call Teledyne Semiconductor for a copy of application notes and specifications on Teledyne's High Noise Immunity Logic family.


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Editorial

# The hard driver

Larry can't get good engineers. He's willing to pay top dollar if the right people come along, he says, but nobody wants to work anymore. He admits that he drives his people pretty hard, but if he didn't do that, they would simply loaf. Everybody knows that people are lazy.

At least he's honest. Larry really tells his engineers what he thinks. He shows them that he knows what's going on. "You have to watch them like a hawk," he says, "or they'll try to get away with murder." In fact, it's amazing how many small mistakes he's caught, and how many times he's caught his engineers making judgments that differed from his.

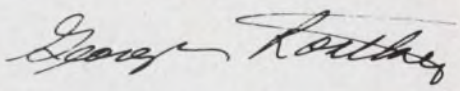
Well, if constant criticism is nourishment for dedication and creativity, Larry should have the most dedicated, most creative engineers in the world. The fact that he doesn't is proof again that you can't find good people. Or, at least, Larry can't.

Strangely, one of his competitors, Steve, doesn't have that problem. It's not that Steve isn't tough on his engineers; he demands more than Larry does. He's always pushing them to do a better job—to cut power consumption, to improve stability, to broaden bandwidth, to cut costs—and they do. And everytime they do, he's all over them with honest praise and with other forms of appreciation—like money.

But Steve's a fool. If you don't believe it, ask Larry. Larry can tell you how many of his no-good engineers have gone to work for Steve. It seems that Larry loses bad engineers while Steve gains good ones, though they're the same people.

Larry gets bad engineers by tearing them down, discouraging them and letting them know how bad they are. He thinks he's whipping them into shape; he can't see that they're simply whipped. Steve gets good engineers by building them up, encouraging them and letting them know how good they are.

Larry poisons his engineers with disapproval. Steve nourishes his people with the ambrosia of encouragement and recognition. Larry creates losers. Steve breeds winners.



GEORGE ROSTKY
Editor-in-Chief

Technology

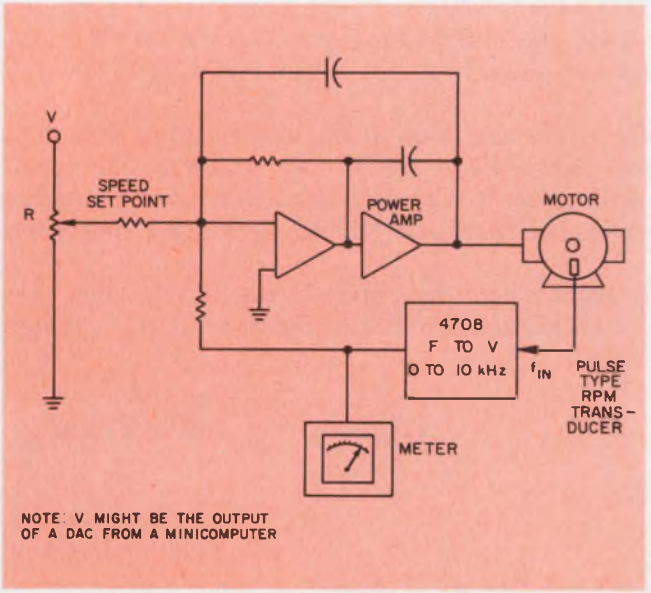
# Solve your measurement problems with v/f and f/v converters. These versatile circuits offer simple ways to send and receive data over two-wire links.

Use v/f and f/v converters to help solve tough data-acquisition problems. These versatile subsystems can transmit data from analog sensors over simple two-wire links. Thus you can minimize the effects of electrical noise and transients on the transmitted signal.

By mating a voltage-to-frequency converter with a counting circuit, you can generate computer-compatible digital signals. By doing the reverse and feeding pulses to a frequency-to-voltage converter, you generate analog signals that can, in turn, control a process or instrument.

Modular v/f converters are available in versions to handle signals from millivolts to well over 100 V. And both v/f and f/v converters are available with various frequency ranges—from 1 kHz to well over 5 MHz, full scale (see table). Furthermore, these ranges can be modified—with external circuitry—to match specific applications.

**Frank Goodenough**, Product Marketing Engineer, Teledyne Philbrick, Allied Drive at Route 128, Dedham, MA 02026




1. **An f/v converter and a magnetic pickup** are paired in a closed-loop control system to monitor and regulate the speed of a motor.

When you must monitor, say, the speed of a motor, you have a choice of many types of sensors. The transducer outputs are very often pulse trains whose frequencies are proportional to the speed at which the motor shaft rotates. In this form, the signals usually aren't too useful. Often you will need an analog output to drive a chart recorder, analog controller or panel meter to indicate the rotational speed.

### Measure rotational speed

Most transducers for rotation measurement fall into one of these categories:

- Mechanical: cam-driven switches and reed switches closed by magnets.
- Magnetic (no moving contacts): Frequency-sensitive (in which the output voltage is a function of rpm), variable-reluctance and variable-magnetic-field. Nonfrequency-sensitive: Hall-effect sensor and flux-gate pickup (saturated core).
- Capacitive.

## Typical v/f and f/v converter models

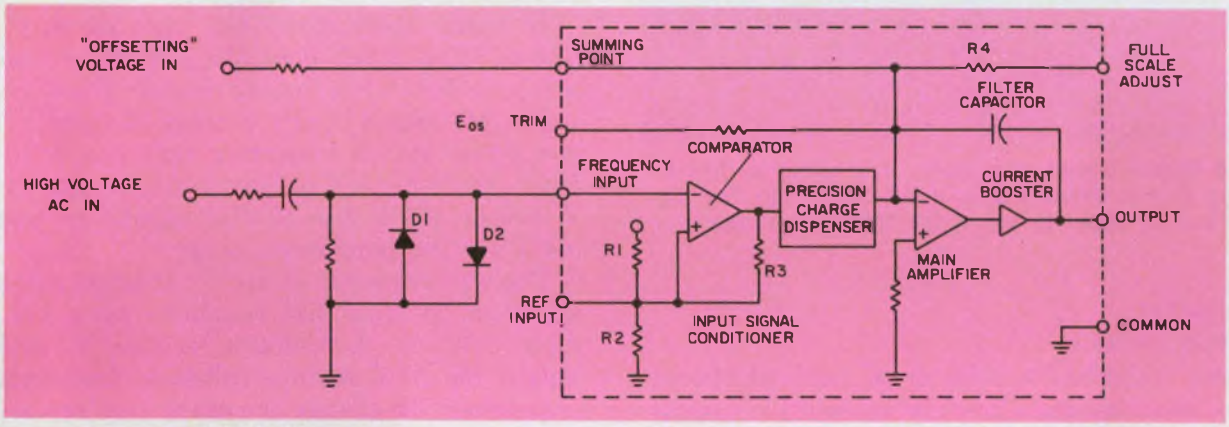
| FUNCTION | Full scale frequency | MODEL Teledyne Philbrick | Non-Linearity % Full Scale | Non-Linearity % Sig. | Dynamic range (decades) | Full-scale tempco ppm/°C | COST 1 to 9 pcs. |
|---|---|---|---|---|---|---|---|
| V TO F | 10 kHz | 4701 | 0.05 | ... | 3-1/2 | 100 | $ 53.50 |
| | | 4721 | 0.2 (0.05 typ) | ... | 3-1/2 | 300 | $ 19.50 (1000 pcs) |
| | 100 kHz | 4709 | 0.005 | 0.02 | 6 | 44 | $ 79 |
| | | 470903 | 0.005 | 0.02 | 6 | 6 | $114 |
| | 1 MHz | 4705 | 0.001 | 0.05 | 6 | 200 | $ 99 |
| | | 470501 | 0.0005 (0.0002 typ.) | 0.02 (0.01 typ) | 6 | 200 44 (typ.) | $153 |
| | 5 MHz | 470702 | 0.01 0.004 (typ.) | 0.05 0.02 (typ.) | 5 | 40 | $195 |
| F TO V | 10 kHz | 4714 | 0.1 (0.03 typ) | ... | 4 | 150 (100 typ.) | $ 39.50 |
| | | 470803 | 0.005 | 0.01 | 4 | 6 | $114 |
| | 100 kHz | 4704 | 0.05 | ... | 4-1/2 | 150 | $ 69 |
| | | 4710 | 0.007 | 0.013 | 5 | 44 | $ 79 |
| | 1 MHz | 4706 | 0.008 | 0.02 | 6 | 150 | $125 |

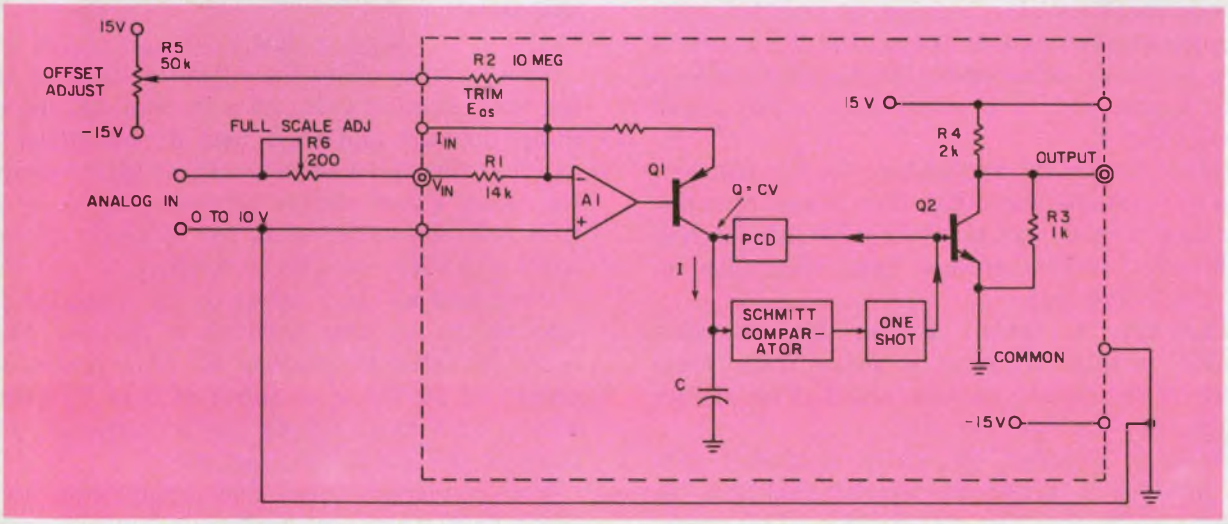
(All specifications guaranteed unless marked typ.)

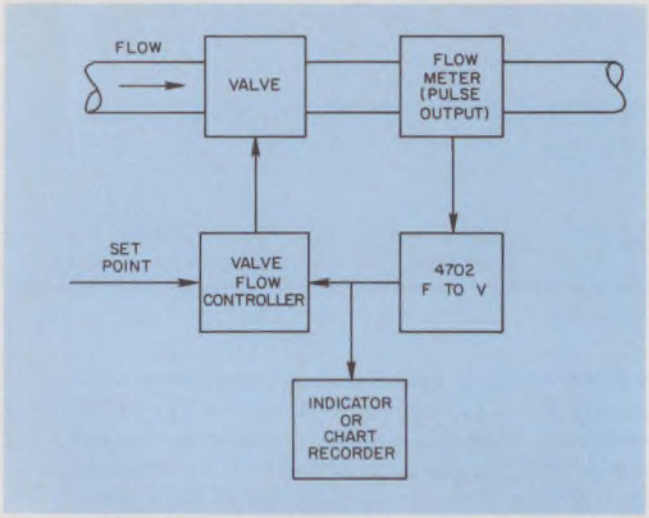
## The f/v and v/f converter

A typical f/v converter module (top) accepts many different waveforms. It conditions them with an op-amp type comparator, then converts the comparator pulses into voltage levels by use of a precision charge dispensing circuit. Two internal resistors and an external reference voltage set the comparator trip point. The comparator controlled charge dispensing network feeds constant amounts of charge into an integrator. The faster the charge feeds in, the higher the voltage out. The amplifier-integrator also forms a low-pass filter that smoothes any abrupt changes in voltage levels and then boosts the current to a usable level for analog indication or control circuitry.

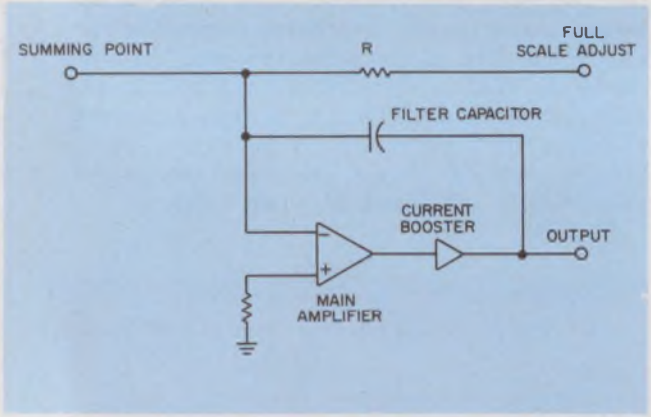
V/f converter modules (bottom) handle varying voltage inputs. After the converter-conditioning circuitry modifies the analog input voltage, it feeds the signal to transistor $Q_1$ which, combined with $A_1$, forms a precision current pump which charges capacitor C. The precision current is a direct linear function of the current that flows into the summing point of $A_1$. Thus C charges at a constant linear rate. When the charge reaches a precise, pre-set level, the Schmitt trigger/comparator trips and starts the one-shot multivibrator. The one-shot, in turn, controls $Q_2$ and the charge dispensing circuit. Each time the one-shot triggers, the precision charge dispensing circuit resets C to the same initial voltage. Thus C is always charged to exactly the same voltage by the current pump but the rate of charge and thus the output pulse rate is a function of pump current.






2. **Different types of flow meters** can be connected to f/v converters in liquid or gas-flow control systems.




3. **The output circuit of a typical f/v converter** has an op amp that is connected as a low-pass filter. The amplifier can be offset to adjust the frequency range.

- Optical.
- Piezoelectric.

These transducers, with or without additional signal conditioning, provide compatible inputs for f/v converters. Whether the transducer output waveshape is sine, square, triangular, narrow-pulse or even random-noise, the f/v converter can be easily adapted to the requirements. A simple application is a closed-loop motor speed control (Fig. 1).

Another important application for f/v converters is in systems for fluid flow measurements. Many flow transducers provide pulse information as a linear function of flow rate. Examples include the following:

- Turbine, in which a variable-reluctance magnetic pickup produces a pulse train from moving vanes on the turbine shaft. This device is much like the rpm sensor.
- Acoustic doppler, in which electronic circuits produce a difference signal that can be handled easily by f/v converters. This technique often measures very low or very high flow rates without obstructing the flow path.
- Fluidic, which produces a frequency that is a function of mass flow and is said to be as accurate as differential pressure transducers.
- Vortex shedding, which produces a frequency output caused by a turbulent vortex that forms around a taut wire or other obstruction in the flow path. The signal created is usually sensed by a piezoelectric microphone transducer.

Many of the applications for sensing flow are process-control oriented and part of feedback systems. The circuit of Fig. 2 shows an f/v converter connected in such a closed-loop control system.

## Customize converters for applications

Because of the many measurements possible with f/v converters, the odds are that the range you need isn't available in an off-the-shelf design. In your application, the input to the converter may be a full-scale frequency of only 5000 or 100 pulses per second instead of the 10,000 (full-scale) specified on the data sheet of a moderate-precision f/v. You can, though, take full advantage of the full 0-to-10 V (or ±10 V) converter output by offsetting or expanding the scale.

In many applications the rpm or flow only varies by a small percentage from a nominal value. A flow meter might produce 6000 to 8000 pulses per second over the range of interest. You can offset an f/v converter that has a 10-kHz input and 0-to-10-V output to produce a 0-to-10-V output for a 5-to-10-kHz input—or possibly ±5 V for the same input range.

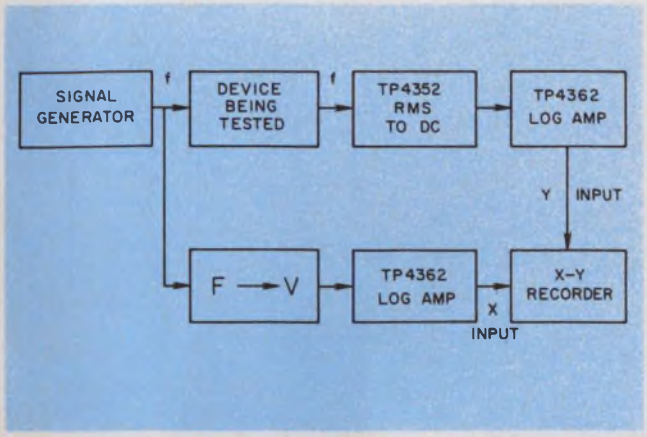
The output circuit of an f/v consists essentially of an op amp that functions as a low-pass filter (Fig. 3). A feedback resistor, R, sets the output for 10 V when a full-scale frequency, K, is inputted. To change the scale, just replace the resistor with a value that can be calculated from this equation:

$$R_{(new)} = KR_{(old)}/f_{(new)}.$$

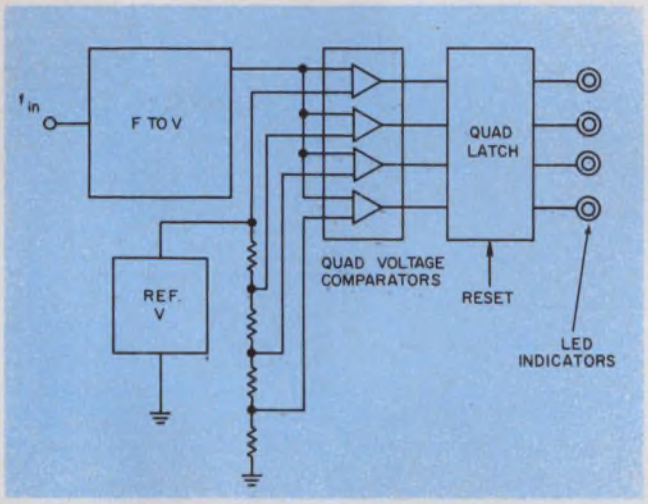
You can also offset the output voltage by treating the summing point as a normal op-amp summing junction and then feed an offsetting voltage to it through a series resistor. If, for example, the input signal varies between 5 and 10 kHz, first find the value of R for a 5-kHz full-scale input (10 kHz − 5 kHz = 5 kHz).

Next feed a −10 V offset to the summing junction of the op amp through a resistor that is equal in value to resistor R. This produces an output of 10 V for an input of 5 to 10 kHz. To obtain ±5 V as an output, use an offset of −15 V through the summing junction.

F/v converters also find application in the audio field. They can produce a semi-log plot of




4. **A simple test set can be built** from an f/v converter and several log amps. Plots of output frequency vs voltage can be obtained.




5. **Building a multifrequency alarm system** is simple when you use an f/v converter and a quad comparator. The comparator outputs can control indicators.

frequency vs amplitude for an amplifier or speaker (Fig. 4). An f/v and a log amp can be used over any frequency range from near dc to the converter's maximum. The same basic system of Fig. 4 can be used in vibrational analysis if a shaker stand and vibration pickup are used instead of a signal generator.

Wow and flutter measurements for high-quality magnetic tape recorders and turntables are also possible with the f/v. The converter can detect the change in frequency from a known, precise crystal source when the recording is played back. The converter output can be offset so that the recorded frequency provides a zero output and the maximum deviation expected becomes the full-scale output.

F/v converters also double as precision FM demodulators. They can be set to produce a zero output at the center frequency and to deliver a 10-V signal at the maximum deviation. A very similar application uses the f/v as a broadband analog frequency meter or frequency monitor and alarm. The alarm could consist of several preset voltage comparators that drive logic circuits or indicators (Fig. 5).

### Use v/f's to reverse the process

The v/f converter is just as versatile as its cousin the f/v. The simplest application is as a variable frequency pulse generator. All you need is the converter, a ±15-V power supply and a frequency-adjustment potentiometer (Fig. 6a).

The useful frequency range of this type of pulse generator depends upon the converter's characteristics and the resolution of the pot. Of course, you can use more precise converters and higher-frequency units to get more accurate outputs and wider dynamic range. By replacing the simple pot with a linear multiturn digital pot, and by adding a unity gain voltage follower between the pot and v/f, you can get three-decade settability, since many v/f's are more linear than the pots that control them.

Fig. 6b shows the full circuit with a precision voltage source and a vernier frequency adjustment that provides an extra two decades of frequency range. The vernier input, controlled by resistors $R_1$ and $R_5$, feeds the current input of the v/f. The buffer amplifiers ensure that $R_2$ and $R_4$ are not loaded and thus don't degrade linearity.

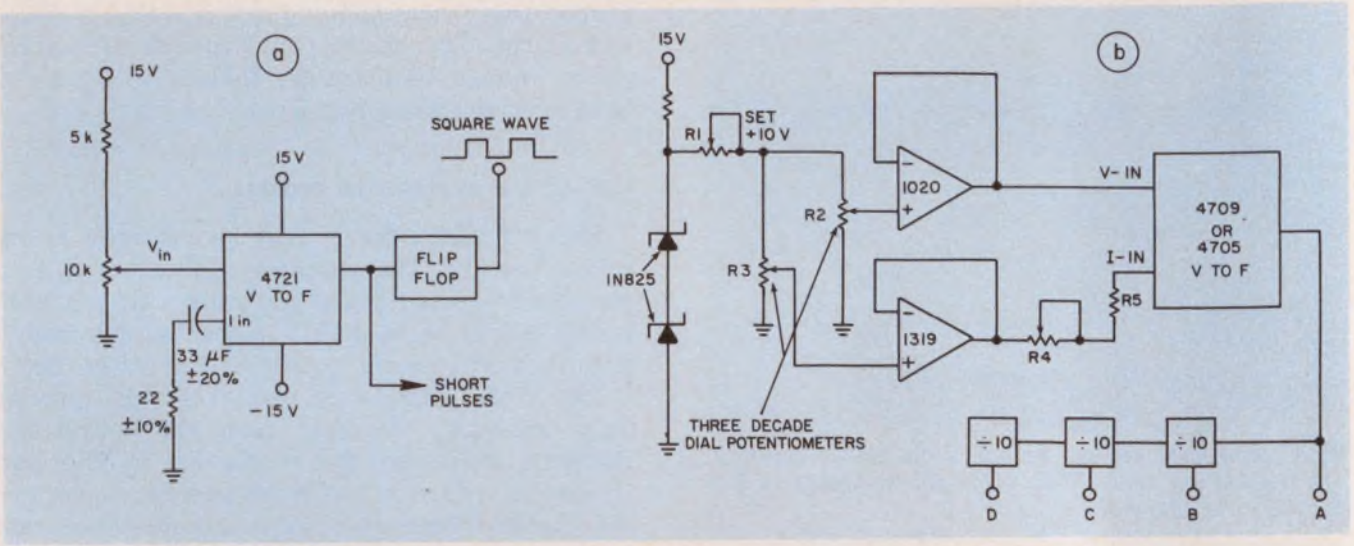
Resistors $R_1$ and $R_5$ should be set to approximately 1000 times the value of the input resistance to the v/f. Trim $R_1$ so that the same frequency appears at the output when the decade dials read 000 999 and 001 000 (for $R_2$ and $R_3$, respectively). An extra three-decade divide-by-10 circuit enhances low-frequency resolution.

You can feed a ramp or sawtooth waveform into a v/f converter to get a swept-frequency signal generator. The input voltage waveform can easily be generated by analog or digital techniques.

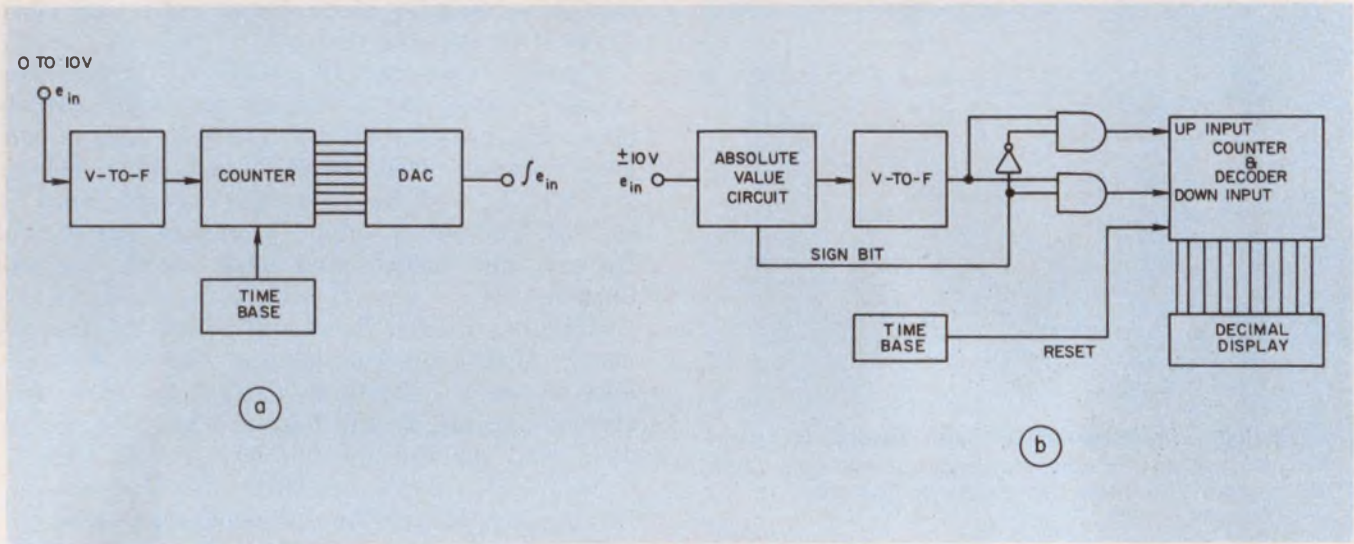
For computer control of the v/f, just feed the digital signals into a digital-to-analog converter. The d/a, in turn, feeds its analog output into the v/f.

Long-time-constant integrators can be built if the output of the v/f is connected to a counter and the counter output is fed into a d/a converter (Fig. 7a). The resulting output is the integral of the input. This method is simple compared with the problems of designing and building a 1000 or 10,000-second integrator. To build such a circuit with linear op amps requires precision devices with ultra-low bias currents, ultra-low-leakage, low-soakage capacitors and very-high precision resistors. And all of these must have low temperature coefficients.

An outstanding feature of the digital inte-




6. **Build a simple variable-frequency pulse generator** (a) that uses a v/f converter. By modifying the circuit and using decade potentiometers, you can increase the resolution to six decades (b).




7. **A v/f converter** combined with a counter, time base and d/a converter makes a simple integrator (a). By eliminating the d/a and using an up/down counter, you can build a simple integrating digital voltmeter (b).

grator method is its infinite-hold capability, which has no losses. Once the counter is stopped, the count remains stored until a reset pulse is sent. Linear circuits always have leakage paths that let the output vary with time.

Bipolar digital voltmeters can be built with a v/f converter, a time base and some counting logic (Fig. 7b). An absolute-value circuit can be placed in front of the v/f input to condition negative input signals and tell the counters whether to count up or down (up if the input is positive, down if negative).

This combination of v/f and counter forms an integrating digital voltmeter, especially if you use a binary-coded decimal display and BCD counters. This analog-to-digital conversion method can separate the counter and signal source over long distances, and it uses simple two conductor wiring instead of 8, 10, 12 or higher conductor cable. Also, you can use optocouplers to provide high levels of circuit isolation and eliminate any ground potential problems between the converter and the processing circuit.

The simple cabling and the low cost of moderate-precision v/f converters (about $20 in large quantities) make it economical to use a converter for each channel in a data acquisition system.

V/f converters have a unique overrange capability, which can range from 10 to 100%. With a chain of counters, any converter overrange causes the counters to overflow and to lose the most-significant bit. But all other bits remain accurate. Thus you can have a digital voltmeter with up to 100% overrange capability at no extra cost. ■■

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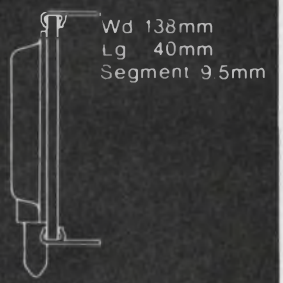


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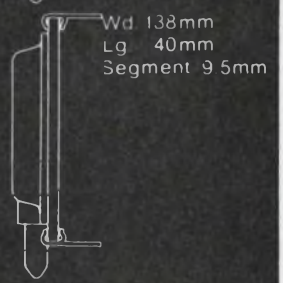


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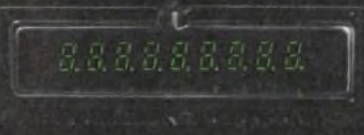

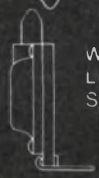


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# Are buffered CMOS gates right for you?

## They are when you can trade off the dynamic performance of unbuffered CMOS for improved transfer characteristics.

The best way to determine the relative advantage of newer buffered CMOS gates vs "traditional" unbuffered types is to compare ICs that use the same process and layout techniques. You'll then be able to judge the merits of each approach without being misled by supposed advantages that actually are due to differences in technology rather than circuit configuration.

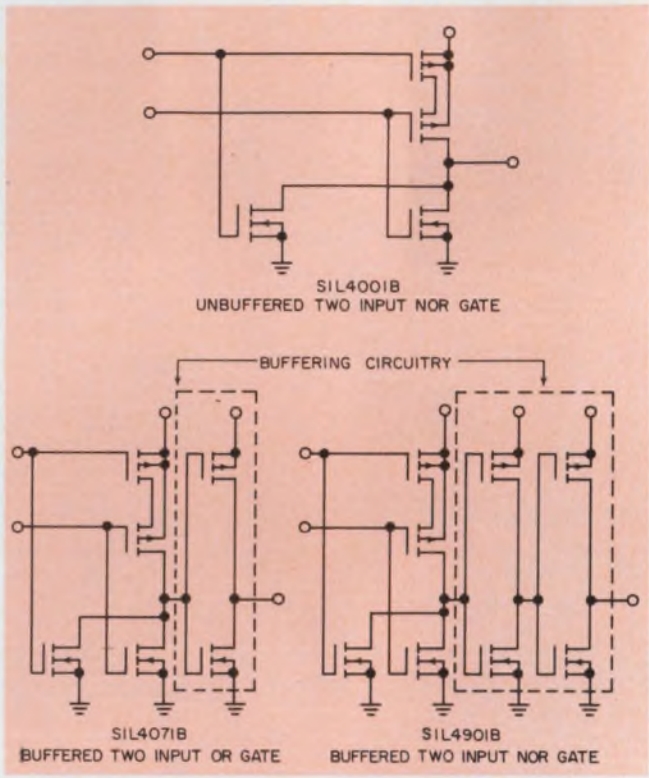
This kind of comparison reveals that buffered gates are the preferred choice in applications requiring enhanced noise immunity, pulse-shaping and tolerance for slow input transitions. The costs for both circuit types are about the same, so either can be used for general-purpose CMOS logic. However unbuffered gates provide better over-all dynamic performance. Low-fanout propagation delays, for example, of less than 20 ns, can be obtained with a 10-V supply.

### Unbuffered gates use fewer devices

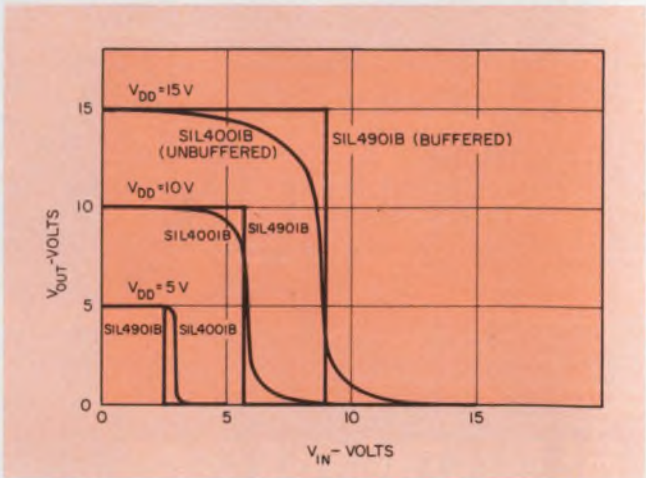
In the unbuffered CMOS approach, a minimum number of p and n-channel devices implement the logic function (Fig. 1). The size of individual transistors is increased to obtain the required output-current drive capability.

In the buffered method, recently adopted by several semiconductor manufacturers, a pair of inverters follow the basic gate structure and provide isolation between inputs and outputs. Only the output inverter sources and sinks output current.

The unbuffered gate circuit selected for comparison—the SIL4001BE quad two-input NOR gate—represents one of the basic circuits available from Siltek and other manufacturers of the widely available 4000-series CMOS family, which was originally introduced by RCA. The selected buffered gate is the SIL4901BE, a pin-compatible alternative for the SIL4001BE that uses a buffered, triple-inversion circuit. Although only one gate function is compared, the over-all results apply equally well to both NOR and NAND two,




1. **Buffered CMOS gates contain a pair of inverters** that follow the basic circuit. The inverters isolate the input from the output and provide output drive.




2. **Nearly ideal transfer characteristics** are offered by buffered gates. Hence they provide higher noise immunity than unbuffered circuits.

**Roger T. Griffin,** CMOS Applications Manager, Siltek International Ltd., Airport Industrial Park, Bromont, Quebec, Canada JOE 1LO.

three and four-input logic functions in the series.

The buffered circuit has a 7% smaller chip size, than the unbuffered unit. This small size difference results in minimal cost difference between packaged circuits. Material and labor costs associated with assembly and packaging are much larger than the cost of the chip itself—at least when the IC employs standard aluminum-gate diffused technology. Hence cost isn't a selection factor.

The static characteristics of the two circuit types also exhibit relatively little difference. Both specify the same leakage current of 5 $\mu$A maximum with a supply of 10 V for commercial-grade units. And both circuits can source and sink the same output currents by suitable choice of channel-width-to-length ratio in each case.

### Noise immunity—a major difference

Only input-voltage noise immunity differs significantly. For a specified 3-V noise voltage at the inputs (with 10-V supply), the buffered-gate output has a guaranteed level of less than 1 V (logic ZERO) compared with 2.9 V for the unbuffered gate.

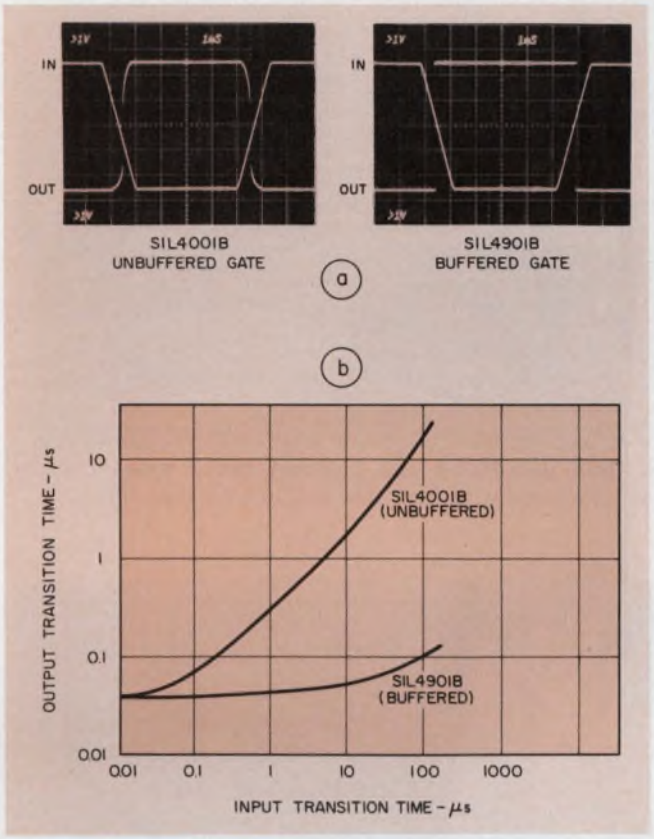
The buffered structure offers almost ideal transfer characteristics when compared with those for the unbuffered gate (Fig. 2). With increasing input voltage, the buffered-gate output remains at $V_{DD}$ all the way to the switching threshold. Then the output switches rapidly to $V_{SS}$. Also, a buffered-gate structure inherently has a very high voltage gain.

The high gain improves output transition time when slow-transition signals are applied to the input (Fig. 3). For an input transition time of 10 $\mu$s, the output transition of the buffered circuit exceeds that of the unbuffered gate by a factor of 30.

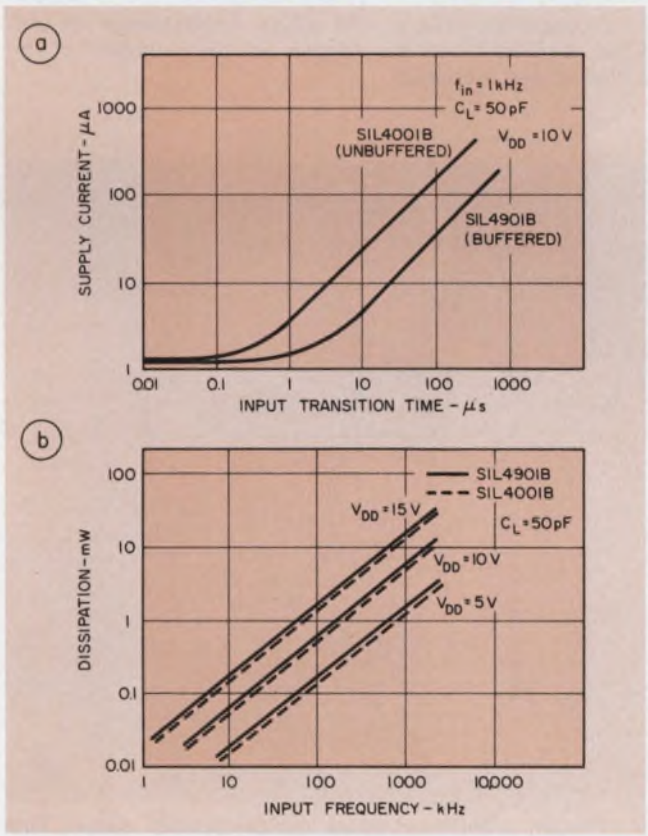
Moreover the buffered gate uses less power when input signals have slow transition times. The smaller input transistors of the buffered circuit permit less current to flow from $V_{DD}$ to $V_{SS}$ during the part of the input transition when both n and p-channel devices are conducting (Fig. 4). With input transistions of greater than 5 $\mu$s, dissipation reduces by a factor of 5. With transitions of less than 100 ns, however, power dissipation remains essentially the same in both circuits.

### Delay—a minus for buffered gates

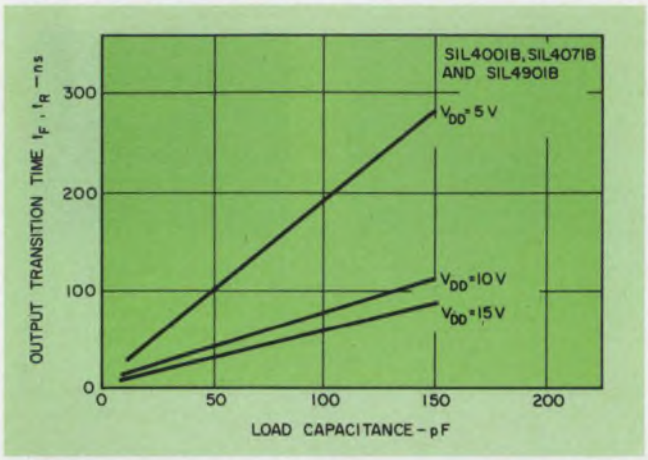
The extra stages in buffered gates increase propagation delay—the major disadvantage of these circuits. However, since the circuits are designed to meet a standard output-drive specification, output transition times are the same for both circuit types (Fig. 5).



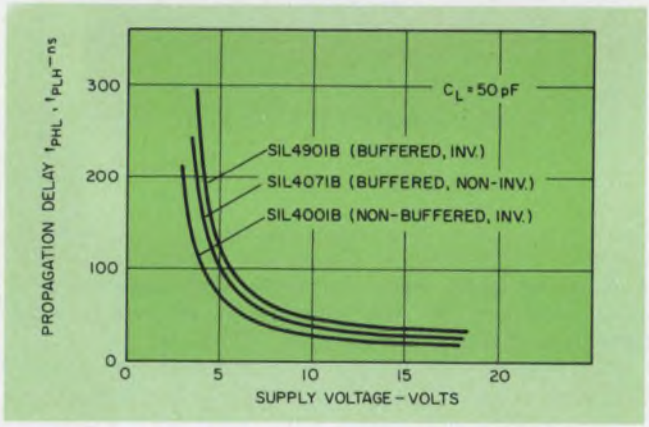

3. **Buffered gates have the higher tolerance** to slow input transitions (a). The improvement extends to input transitions that are shorter than 100 ns (b).



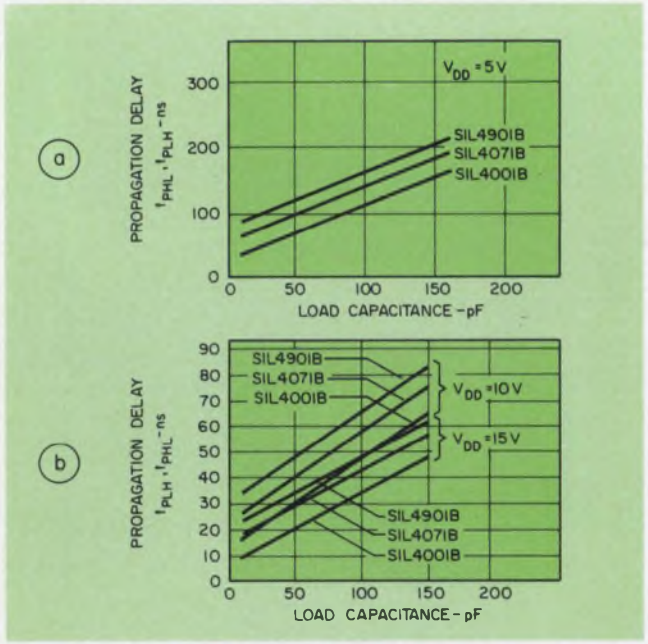

4. **Power drain is less** with buffered gates for a wide range of input transition times (a). However power dissipation with fast input edges is essentially the same (b).




5. **Both unbuffered and buffered circuit types** can be manufactured with the same output transition times.




6. **Propagation delays—the major disadvantage** of buffered circuits—become longer as the number of inverter stages increases.




7. **Though unbuffered gates exhibit smaller delays** than buffered circuits do, the difference depends on supply voltage. At 5 V (a) the difference is much higher than at 10 and 15 V (b).

But propagation delay strongly depends on the number of inversions between input and output (Fig. 6). Propagation delay falls from about 120 ns for the triple-inversion SIL4901BE to 100 ns for the double-inversion SIL4071BE, and to 70 ns for the SIL4001BE at 5-V supply and with a 50-pF load. However, the delay difference at higher supply voltages is considerably less: 48, 40 and 30 ns, respectively, at 10 V; and 34, 28 and 20 ns, respectively, at 15 V. Similarly Fig. 7 illustrates the variation in propagation delay with load capacitance.

### Applying buffered gates

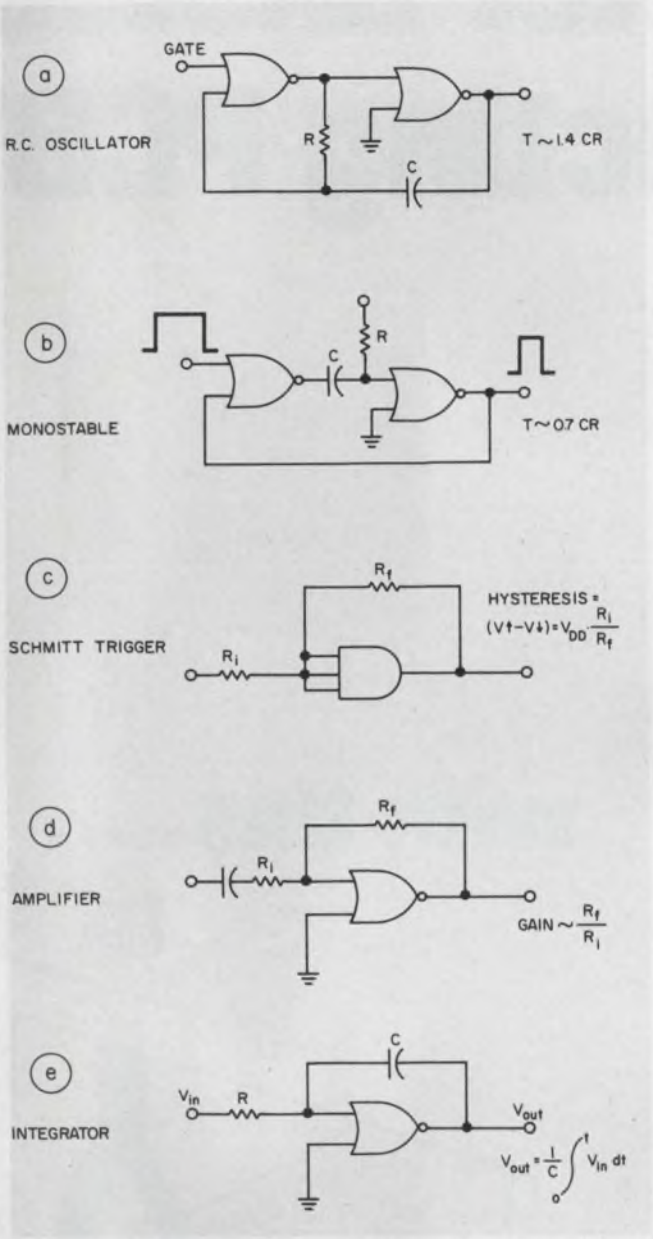
Like unbuffered CMOS gates, buffered types are offered in inverting and noninverting forms for a host of applications (Fig. 8).

An astable circuit, for example, depends for its operation on the fact that the capacitor charges via the resistor up to the threshold of the first gate (Fig. 8). Then the output switches to logic ONE. Thus the voltage at the resistor-capacitor junction increases rapidly until it is clamped by the input diode of the first gate. Subsequently the resistor-capacitor junction discharges until it again reaches the threshold of the first gate, so the output switches to ZERO.

Use of a buffered gate results in very fast transitions at the output, even if large values of resistance and capacitance produce very long input transition times. Hence the output can be used directly without need for additional gates to "square up" the output waveform. Power dissipation is also reduced considerably, especially when the circuit is designed to operate at low frequencies.

The monostable circuit functions on a similar principle (Fig. 8b). The negative edge of the output of the first gate causes the resistor-capacitor junction to swing below the threshold of the second gate. The output pulse width depends on the time it takes the capacitor to charge back to the threshold. Again, use of a buffered gate results in an output pulse with sharp transitions, so that no further pulse shaping is necessary and power dissipation is reduced.

Use of a noninverting gate yields a method of obtaining hysteresis in the transfer characteristic (Fig. 8c). This type of circuit depends on the fact that the input-resistor junction lags the input waveform until the threshold of the gate is reached. At that time the output changes state. Positive feedback via resistor $R_f$ then causes the input-resistor junction to lead the input waveform. Since only one noninverting gate is necessary, this technique provides an economical method of increasing noise immunity and of interfacing to a slowly varying and noisy input waveform.




8. **Buffered gates can be applied** in most cases where unbuffered ICs are now used. In many applications, the use of buffered gates leads to lower power dissipations.

A simple voltage-amplifier circuit uses a buffered gate to obtain very high open-loop gain (Fig. 8d). The closed-loop gain then essentially equals the ratio of the resistors, so that the circuit can be used for such applications as a dc amplifier, summing amplifier or unity-gain buffer.

Care must be exercised to prevent oscillation caused by phase shift through the amplifier. Usually a stable circuit can be obtained by the addition of a capacitor between output and ground.

The integrating circuit (Fig. 8e) resembles that of the voltage amplifier. But it uses capacitive feedback to obtain an integrating function. Again, an external stabilizing capacitor is needed when a buffered gate is used. ■■

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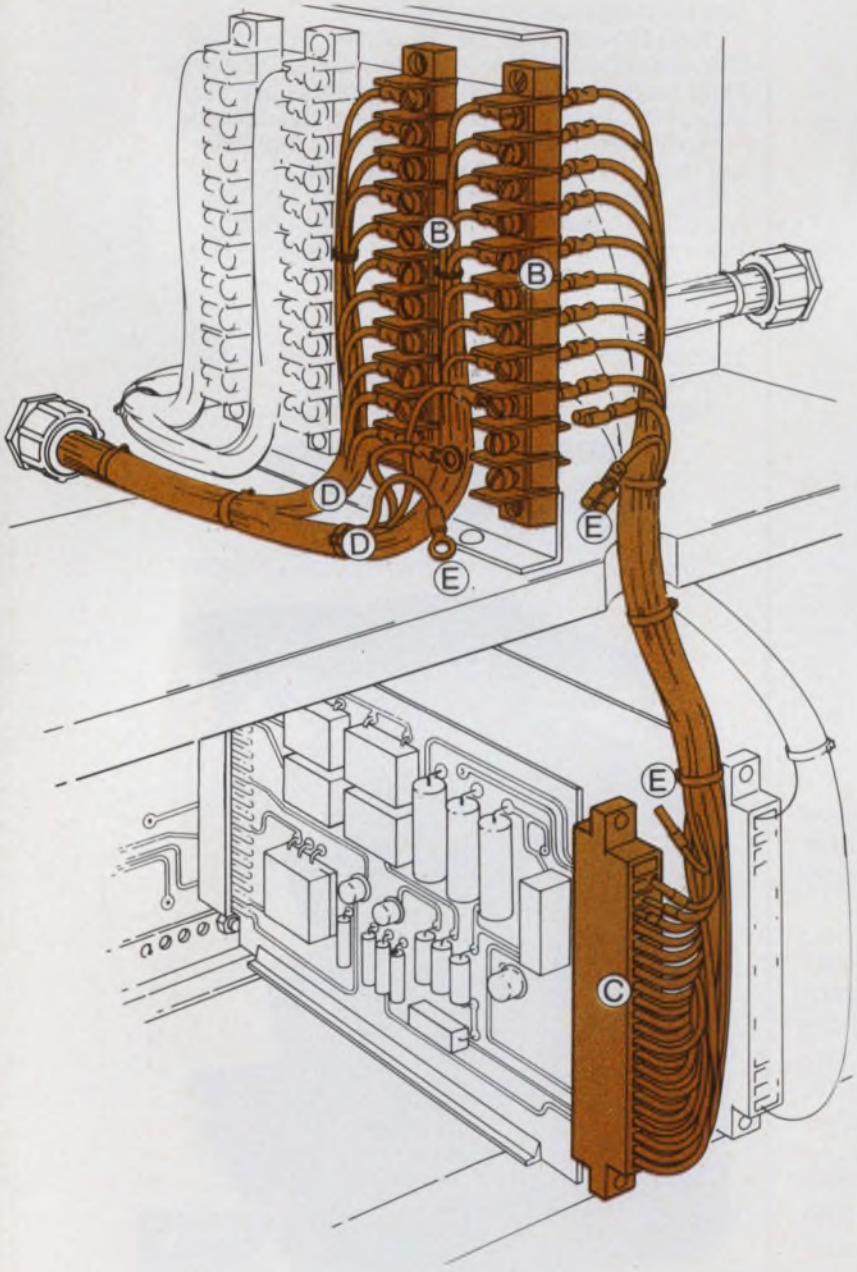


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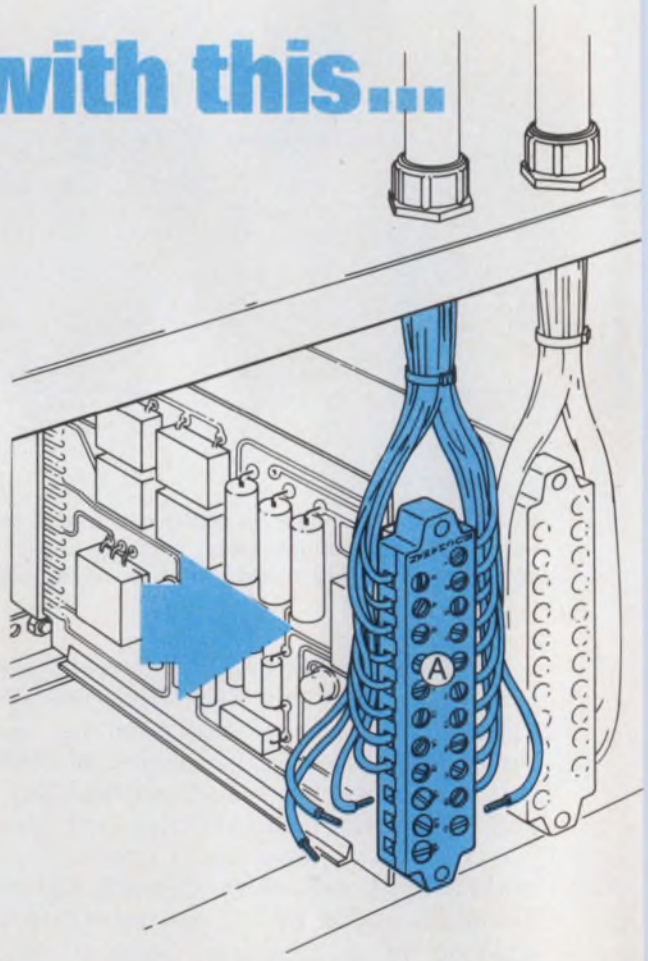


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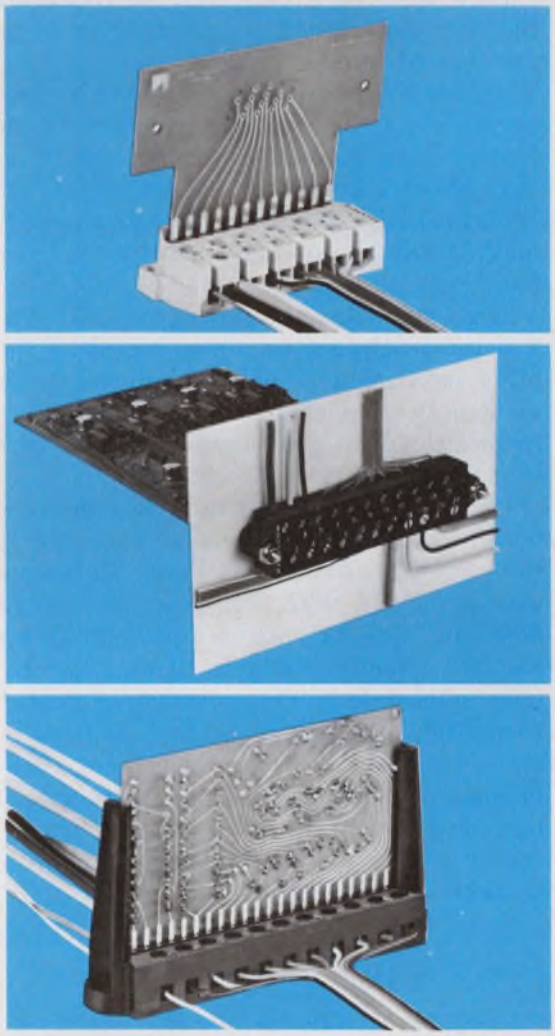

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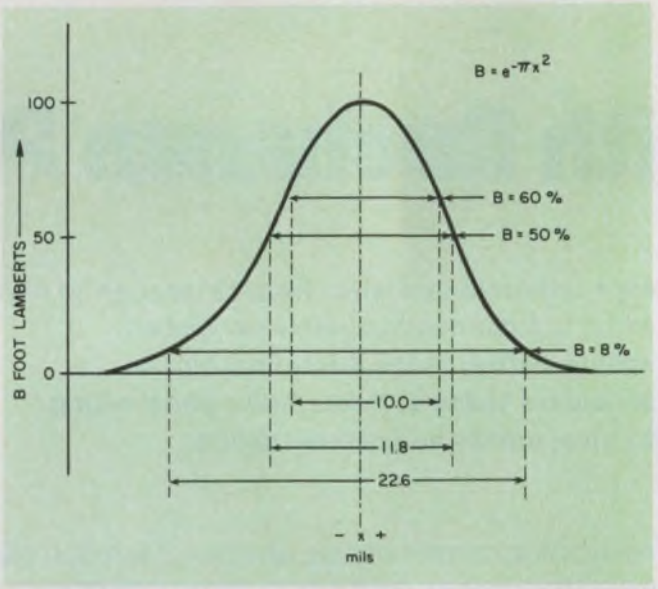
# **Measure CRT spot size** to pack more information into high-speed graphic displays. You can do it accurately with the vernier line method.

Engineers who design systems using high-speed graphic displays need new, more accurate techniques to determine the information capacity of the displays. One such technique is the vernier-line method, which offers repeatability of 1.5%, compared with up to 30% for other methods. And most laboratories already have all of the required equipment. However, since vernier accuracy depends greatly on the concentration of the test engineer, the repeatability is gained at the cost of human fatigue.

Another thing a designer wants is the sharpest possible contrast for each character to minimize fuzzy edges. Ambient lighting, reflection shielding, the phosphor, trace sharpness—all affect contrast and make it tough to measure. So better methods are needed to measure this parameter, too.

High-speed graphic displays position a spot to a point on the screen, then "paint" a line to another point. The amount of information that can be legibly displayed in a given area is directly proportional to the observed width of the line that makes up each stroke.

Classical methods for measurement of spot size or line width do not perceive phosphor illumination as the human eye does. Historically spot size is defined with spot-scanning techniques at 50% of the brightness amplitude, and with shrinking-raster methods, at 60% of the brightness amplitude.[1,2] This gives an indication of information display capability, but it does not measure what the eye really sees—8% of the brightness amplitude. Thus a 100-foot-lambert line actually appears two times wider to the observer than the width given by spot-scanning or shrinking-raster methods.




1. **Brightness distribution across the width of a CRT spot or line:** If the distribution is gaussian, the width at the 50% brightness point will be 1.9 times less than the apparent, or perceived, width.

### Flaws in classical methods

Classical techniques are also based on a gaussian distribution of the brightness of a spot, line, or raster. However, because of CRT lens aberrations, the brightness distribution only approximates a gaussian function. The major flaw in the gaussian assumption occurs at the edges of a spot.

For a true gaussian distribution, the ratio of the width at the 50% point to the width at the base (or 8% point) must be constant. However, the aberrations in electrostatic lenses distort the distribution primarily at the skirts of the curve. The extension of these skirts has a minimal effect on spot-size measurements with shrinking-raster, spot-scanning, spatial-frequency, or modulation-transfer function techniques. But the eye will see the skirts of individual traces or of characters. Therefore, aberrations increase the observed spot size.

Since graphic-display users look at relatively widely spaced traces and characters, the display should be measured and designed around the observed spot size. Then, spot size must be determined at approximately 8%-of-the-brightness amplitude, not at the 50% specified with other techniques.

If the brightness distribution equals a gaussian

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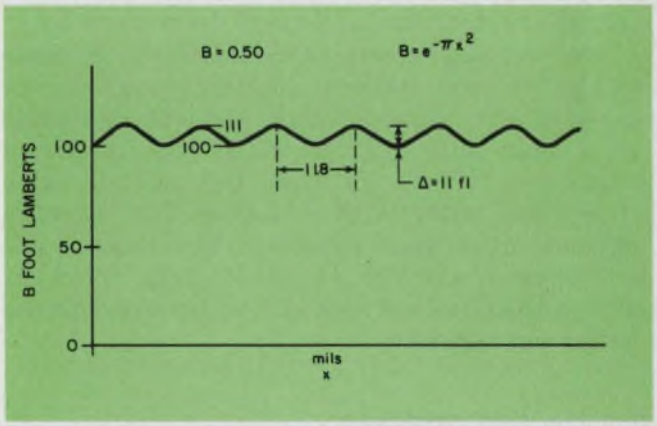
function (Fig. 1) and has a peak brightness of 100 foot-lamberts (fL), the human eye will perceive a spot size 1.9 times greater than that measured at the 50% point, and 2.3 times greater than that measured with the shrinking-raster method (60% point). Measurement of the spot size at the 50% point gives an indication of information capability but does not measure what the eye really sees.

For example, with the spot size measured at the 50% amplitude point and the characters spaced accordingly, the viewer will see the lines run together. Brightness variations for lines positioned on the basis of the 50% point are illustrated in Fig. 2 and lines positioned by the 60% point are shown in Fig. 3.

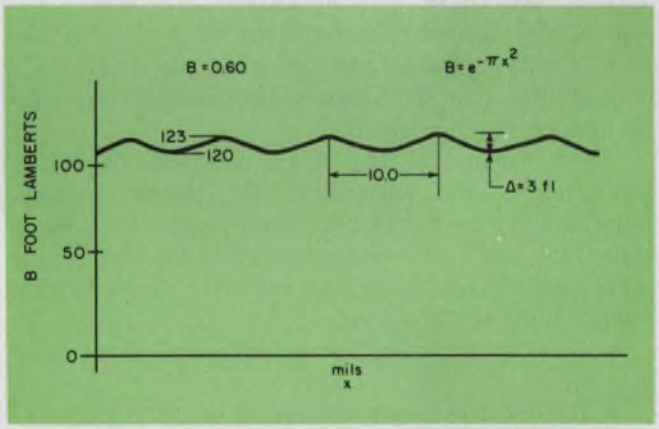
Displays that use scanned TV rasters brighten or intensify certain areas in the formation of pictures. Each of the 525 picture elements per line and 525 line per frame overlaps into the adjacent element or line, resulting in the obscuration by the background illumination of brightness levels below the 50% point.

If a TV raster is merged with standard shrinking-raster techniques, the measured line width will be at 60% of the peak brightness if the brightness distribution is gaussian and the peak light output of an individual line is 100 fL. This can be traced to the ability of the human eye to resolve a difference in brightness of 3% at 100 fL.[3]

If the distribution becomes nongaussian, two points of mergence occur: one at the 60% point and another in the 80 to 85% region. The second mergence (80% point) will become more notice-




2. **If characters, or lines, are spaced** according to the width at the 50%-brightness point, the lines will appear to the eye to run together, or merge. Brightness variations for such spacing are shown as a function of width.




3. **Brightness varies as shown** when the 60% brightness points are used to define spot width.

## Other ways to measure CRT spot size

Existing methods to measure spot size include the traveling-microscope, the shrinking-raster and the modulation transfer-function techniques. These are in addition to the vernier-line technique.

The first technique maps the complete brightness distribution and the typical spot size is specified at the 50% point. To perform the test, position a fiber optic bundle at the focal point of a microscope and draw the bundle across the CRT screen. Light from the screen is amplified by a photomultiplier tube, amplified again, and then applied to a recording instrument.

The microscope technique is usually performed in the lab since shifts in ac line power, movements on the measuring table and other variables can cause large errors—±20% is not uncommon. Also, typical equipment costs are on the order of $5000 to $10,000.

In the shrinking-raster method, a raster of horizontal lines (50, 100, 250, etc.) is displayed on the CRT. With the desired number of lines displayed, adjust the vertical gain until individual lines can no longer be discerned. This mergence should occur at about the 60% amplitude point on the brightness distribution. If the brightness is nongaussian, a second mergence can occur at about the 85% amplitude point.

With the shrinking raster, it is not always clear which is the correct mergence, and errors on the order of 30 to 40% are likely if the 85% point is picked. The technique, though satisfying TV-raster display requirements, does not allow measurements of severe beam aberrations on the skirts of the brightness distribution.

The third method—the modulation transfer function—is generally used in photographic work to measure lens aberrations. When used with a CRT display, this technique specifies the number of lines per inch at 50% of the brightness amplitude. To determine the 50% point, however, the raster generator or photometric technique is required.

able as the distribution departs from gaussian.

Spot size measurements should always be made under the same ambient lighting conditions as expected in the field. While ambient light acts as a bias and thereby offsets the measured brightness, it does not affect the absolute value of emitted light. With a darker than average ambient (100 foot candles), the human eye will observe a lower threshold light. This increases the observed spot size with respect to the darker environment.

### Simulate field conditions

In the vernier-line technique, the visual acuity of the human eye determines the width of a line painted on a CRT in its operating environment: under actual ambient lighting, with noise on input voltages, contrast filters, in place, phosphor effects, etc.[4] Spot size measured this way gives the actual information content of a display device. Fuzzy trace edges, for example, indicate a larger spot size. This means that characters must be spaced further apart.

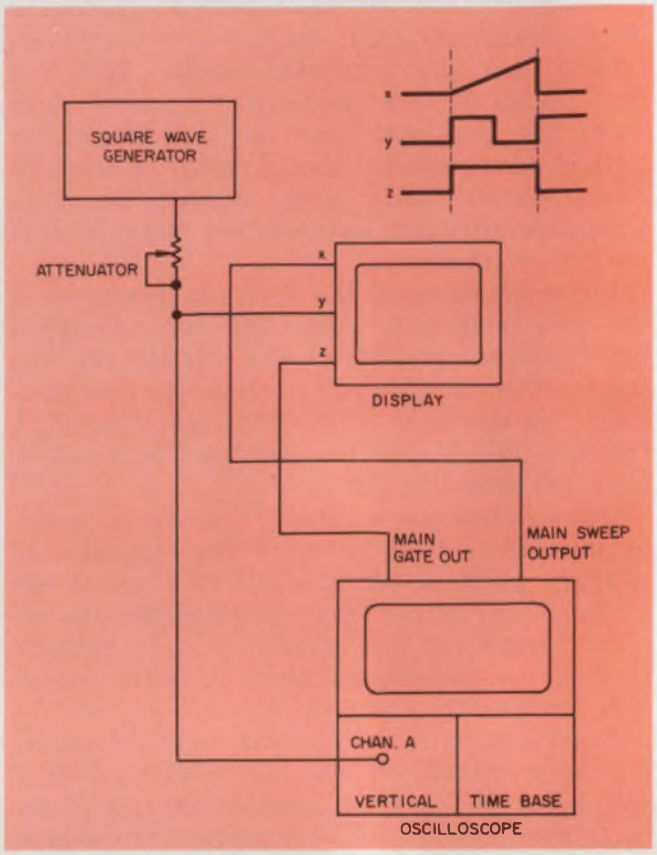
To perform the test, you'll need the following equipment: dc voltmeter, dc power supply, square-wave generator, an oscilloscope with main gate and main sweep outputs, and an attenuator (Fig. 4). First, measure the display deflection factor with these steps:

- Display and position a horizontal trace near the top of the CRT.
- Record the input voltage.
- Position the trace near the bottom of the CRT and measure the distance the trace has moved.
- Record the input voltage.
- Determine the difference between the two input voltages and divide this voltage by the distance the trace moved. This gives the deflection factor in volts/cm or volts/inch.

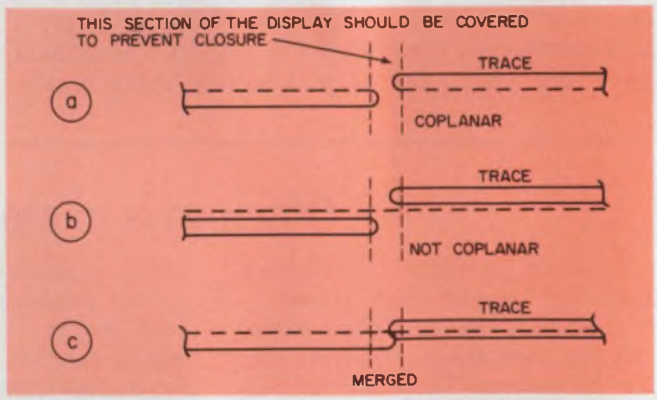
Next, measure spot size:

- Apply a square wave to the Y-axis of the display and oscilloscope. The rise time should be about 1% of the horizontal sweep time.
- Adjust the horizontal gain of the display to position the square wave near center screen.
- Attenuate the pulse to position the top edge of the lower line and the bottom edge of the upper line as shown in Fig. 5. It may be necessary to cover the center of the display screen as shown in the figure, as the background brightness from one trace may blank out the skirt of the other.
- Measure the pulse amplitude with the oscilloscope.
- Divide the measured pulse amplitude in volts by the measured deflection factor of the display (V/in. or V/cm) to obtain the observed spot size.

Repeat this test a few times until the readings can be repeated. A magnifying glass will improve the ability to resolve between proper and improper readings as shown in Fig. 5. ■■




4. **The vernier-line technique** first measures the display deflection factor, then the pulse amplitude needed to bring two displayed lines colinear. Spot size is the ratio of amplitude to deflection factor.




5. **Traces must be properly aligned** for accurate measurement. Correct position is shown in "a," while "b" and "c" show incorrect gapped and merged alignments.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3. "IES Lighting Handbook," Fifth Edition 1972, Illuminating Engineering Society, New York.
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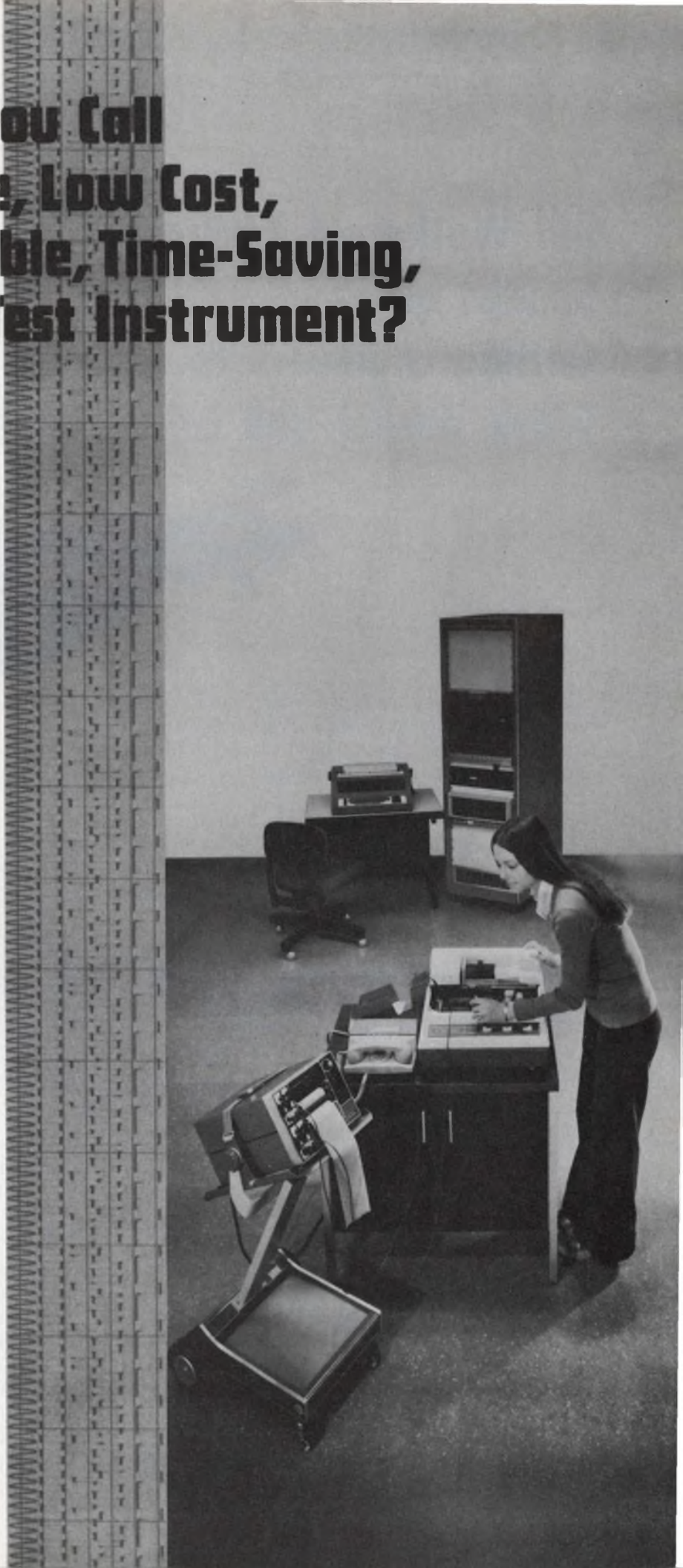

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INFORMATION RETRIEVAL NUMBER 32

# Bill Walker of Tektronix Speaks on Getting Engineers to Work Harder and Enjoy it More

What makes engineers work harder or do better work? No monetary incentive, no bonus system, no profit-sharing plan, no stock option plan is effective in itself in getting people to work harder and do better engineering.

But if there is sufficient creative challenge if engineers realize that they're carrying a vital load and can make a significant achievement for the company; then they'll show amazing performance. And they'll enjoy it.

**What motivates engineers to work hard is operating in a team context that sets difficult, but meaningful challenges.**

For engineers to realize their greatest potential, they must have goals that are meaningful and real in today's market, yet truly challenging to their creative and intellectual capacities.

Engineers tend to be conservative. When an engineer expresses certainty, you can pretty well rely on it, but you must also know when to ask for more. There are times when someone needs to say, "We can do a lot better than that," or "Here's what I think we can do." The motivation begins there. But you need to know what you're doing and where you're going. One of the problems we have is that the electronics business is not a place for the "professional" manager. The engineering manager has to be competent technically. He doesn't have to be more skilled in every facet than any person he manages. But he must be skillful enough to lead with imagination, as opposed simply to keeping the house in order.

The manager supplies that leadership when he talks with an engineer about his hopes for higher performance. It is he who must supply the belief that far-out objectives can really be achieved. If the manager does not have insight into what might be achieved, he has no basis from which to ask for extra achievement on the part of the engineer.

**This whole business is the challenge of making engineering exciting. That's the real motivation.**

Excitement will cause engineers to produce more by a factor of two or three than they would otherwise. The manager must help them with the idea—and the reality—that they are doing something vitally important.

I remember our 500-MHz oscilloscope, the 7904. One of our competitors was at WESCON in 1969 with a 250-MHz scope. That was 100 MHz faster than anything we had at the time. Well, we felt a little disconcerted about that. We had been busy with our 7000 Series. We were all

tied up working on the four-hole plug-in concept, on new ICs that had to be developed and on a new CRT.

When we got back from WESCON, we sat down with some of our senior engineers. The essence of what was said was, "OK, our competition has us beat in bandwidth. What can we do? We could go up to 250 MHz and match them, or we could move a bit ahead to, say, 275 MHz. But we need to do a lot better than that. Can we do it?" We talked for many long hours.

We finally convinced ourselves that we should shoot for a 600-MHz scope in the 7000 Series. We decided that 600 MHz should be our target—with no holds barred. We knew our IC group was just getting off the ground and had never done anything with $f_T$s of this order. We didn't have the kind of traveling-wave CRT structure that would be needed. And at that time, we didn't have people with that kind of high-speed experience.

But we had the basic resources. And we sure had the engineers who knew abo t the prob ems you can run into with oscilloscopes as you approach that kind of speed. Oliver Dalton (presently manager of Laboratory Oscilloscopes Engineering), who always seems to get things right, warned that it would not come out that high, but we ought to shoot for 600 MHz anyway.

So we put together a high speed team that was absolutely first class. We had Val Garuts, who came out of our low speed, 500-kHz scope line. And we had Thor Hallen, who did an impressive job on the vertical, though he was a relative newcomer at the time, just out of college. Wim Velsink, who is now vice-president in charge of Tek Labs, took a major interest in the CRT design. The CRT group developed the smoothest helical deflection structure I've seen.

Dalton, who had plenty of experience, put the team together and made sure there were no major holes in the program as we went along. In a year and a half, at the 1971 IEEE Show, we announced the 7904, a 500-MHz bandwidth, 10-mV/div scope with 1-GHz direct access. That's not a bad compromise with the 600 MHz we originally shot for.

**The key here was inspiration. The engineers felt the need and challenge of new vistas; they wanted to achieve something beyond what had ever been done.**

We couldn't have done the job without such a turned-on crew. I know that Thor Hallen spent long periods at a time never leaving this place. He'd go three or four days with almost no rest. He's very intense about his work, anyway, but that's real dedication.

## Who is Bill Walker?

"I was destined to work for Tektronix," says Bill Walker. It started in the Air Force one day, when a dozen newly arrived Tektronix 511s generated a great deal of excitement. Walker found the staff people taking the sides off the scopes and admiring the workmanship.

"Boy, wouldn't it be something to work for a company like that," he said. It was after his wife's folks moved to Oregon that he learned that Tektronix was located there, so he needed no further confirmation that Tektronix was, indeed, his destiny.

He tried, but failed, to get summer work at Tektronix during his junior and senior years at the University of Missouri at Rolla, where he took his BSEE. He tried again after graduation, and didn't make it. So he took a job at Boeing in Seattle which, he felt, was pretty close to Portland. Within five months, in November, 1958, he got a job as an engineer with Tektronix. He's been there ever since, moving up the engineering ladder till, in 1969, he was appointed Vice-President, Engineering.

Walker has two main hobbies—tennis and flying. He owns a Cessna 172 and has been a Sunday flier for about eight years.

His son, Scott, is graduating from high school this year, and his daughter, Janice, is married and "back home" in Missouri. He's too young to have grandchildren, he says, though his wife, Lula Fay, points out that they're from the Ozarks, where folks marry when they're 13.

All the fellows, in fact, were determined that we weren't going to give up our leadership. They knew that if they didn't do the job, it would probably never get done, and that if they missed with this effort, or if they did it badly, our leadership could well be lost, and, with it, a significant piece of our marketplace. They took it as a personal mission.

From a management viewpoint, it then became a matter of making sure that the engineers had the necessary resources. We had to make sure, for example, that the integrated-circuits people understood the size of the bet we were making and would uphold their piece of it. They did and were a key factor in the success of the project. We had to be certain that other development people knew that this was a top-priority thing and that they were involved, too.

I helped select the people who were needed and talked with them about the importance of the project to us. How do you find them? Engineers tend to build reputations for themselves. We have more than 700 engineers, but word gets around about who the really hot ones are. I get to know the strong individuals. That's part of my job. All managers need to watch for the bright young engineers and not let them go unnoticed.

Our managers spend a lot of time talking to each other, too. We kick around what can be done by one manager who has the people another manager needs. You do run into problems where a manager doesn't want to give up his strong people for someone else's project. Everybody wants to build a strong team.

But we've evolved a culture in which managers talk about these things. We really encourage them to talk about their good people.

**Another problem you face when you try to inspire people to higher levels of performance is that you still have to maintain interest in your bread-and-butter lines. Unfortunately, they're usually not nearly as sexy as the more advanced technological products are.**

Bread-and-butter products keep you in business; they provide the money so you can work on the dramatic products for the future. So you need to maintain enthusiasm among the people working on them.

It helps sometimes to bring in new people to revitalize an old line. Let me give you an example. Back around 1965, we had an older series of low-frequency scopes, the 503/504 Series. A competitor brought out a nice, solid-state series. It wasn't a huge business—a few million dollars—but we didn't want to give it up.

Well, we had brought out the 5030 Series in 1968 and though these scopes were excellent, they were not cost competitive. Howard Vollum (Tektronix' founder and Chairman of the Board) agreed. He saw the need for a new low-cost line and visualized what it could be.

Rather than give the project to an existing group, we decided to put together a new group to achieve what we wanted. After much conversation between Jerry Shannon, Howard Vollum and me, we put together a plan and Jerry said, "A year from now we'll introduce the series." Shannon gathered several engineers and started working with the manufacturing people. The concept of the 5000 Series began to emerge. They developed a complete line of instruments that included plug-in versatility at nonplug-in prices. Within nine months it was obvious that Shannon and his group were going to make the goal.

I was talking to Howard about this later, and he commented that it was a miracle. In just over a year, Jerry introduced four mainframes and 13 plug-ins. I think that's kind of neat. Shannon's success came from one of the most inspired groups I've seen. Everyone from the people wiring and assembling the hardware to the design engineers felt they were part of an important team making a major contribution to the company. And they were.

**The ultimate question here is how to keep engineering people excited. We have to realize that an engineering project can extend from many months to several years—a long time to maintain any kind of effective motivation.**

You can't keep people going on the pep talk you might use with a football team that has to play for a few hours. The key is that you have to have something real.

It used to be a great game when the engineers working on the low-cost 5000 Series would go over to their counterparts on the 7000 Series, pick up some good ideas, then put them together in cheaper form. They'd joke with the 7000-Series people and show them how much less expensive the new 5000 Series time base was going to be, for example. So the competitiveness is part of the fun and part of the inspiration, too.

In every way, that spirit has to be kept going. Keep the competitiveness and the fun and the excitement alive and make the projects worthwhile to the people involved.

**Far more is accomplished when people are enjoying themselves than when management is leaning on them.**

Managers get together for a beer or coffee and rib each other about their projects. They talk about new achievements—how sharp a trace they have, or how little noise there is in this vertical amplifier compared with another. They needle each other all the time. We like that pride and *esprit de corps.*

You need to keep reminding your engineers that they are the best in the world. I keep putting it to our people that we are the ones who set the mark on the wall for our industry. Performance, price, appearance, weight, ease of use. These are the challenges that I like to keep in front of everyone. If we can't provide this leadership, someone else will. And if no one else will, then the whole world will slow down a little bit. So our role is very important and all the engineers are aware of it.

There's another thing we have to watch constantly. The environment won't sit still so I can't keep my organization stable. We continually have programs spilling over into another market area or another technology area. So I have to be willing to abandon an organizational structure. We must create environments in which we can change without a lot of insecurity.

An engineer does get concerned about status or position, and when you start switching organizations around, he will be nervous. He gets concerned about losing some prerogatives. When he gets a good team of people working for him, he hates to see some of them move off into someone else's group.

A certain amount of insecurity always goes with organizational change. You have to nurture an environment that decreases people's insecurity about this kind of thing. Managers need to know that they'll be recognized not just for their own achievements, but for having developed strong engineers who move on to other areas.

You have to reward people not just for their own accomplishments, but for the potential they develop in others. You also have to remember who was responsible for which part of a project's development. Inevitably, when a product moves from one group to another, the second group begins to get the spotlight. Its people may take the product to its final form; then it's easy to forget who made the original contribution and who deserves additional recognition.

You have to make sure that people understand that you remember these things. There's still another aspect to this reorganizing aside from an engineer being deprived of due recognition. People tend to fall in love with a project. If you're doing everything else right, the engineer is really convinced that it's a very important project. If a project is taken away after a person has worked on it a couple of years, it's like separating a mother from her baby. The engineer needs to be told the overriding reasons and his manager must put forth the next new challenge.

Don't forget: engineers get emotionally involved in what they do, like you and me and everybody. Giving direction to these emotions and providing the challenge to existing aspirations are the keys to better management and more creative engineering. ■■

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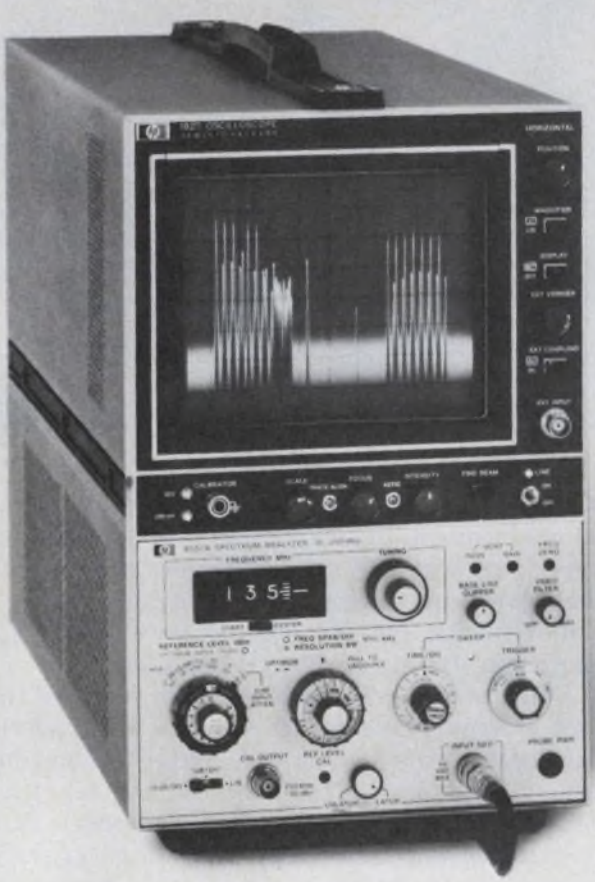

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INFORMATION RETRIEVAL NUMBER 33

# Straight talk about IC sockets.

Integrated-circuit sockets are becoming such a household item, people are starting to forget something.

They're not all alike. And the differences can have a major impact on the performance and profitability of the products they're used in.

That's why we've decided to go over a few socket basics.

## THE REASONS... AND THE RISKS.

All sockets serve basically the same purpose: they allow you to replace ICs without damaging either the IC or the PC board. In so doing, they make both design changes and field service economically feasible for you and your customer.

There's only one problem. When a socket fails, troubleshooting can be a nightmare—to a point where you'd have been better off without sockets in the first place. So it pays to be sure that the sockets you buy are right for your application.

## CHOOSING THE RIGHT SOCKET.

Buying the right socket is much more than a matter of profile and price. It's matching the right one to the demands of your application.

For low-cost, high-volume products where the risk and consequences of socket failure are minimal—and where repeated IC insertion and high retention aren't required—buy the cheapest sockets that will do the job properly.

But for high-shock and vibration environments, or other situations where performance is critical, by all means get the best sockets money can buy.

At Augat, we understand these differences. That's why we make sockets for both needs, in the widest range of sizes and specifications in the industry—from 6 to 40 contacts, on .300", .400", and .600" centers. These include low-profile, LED, and test sockets, socket carrier assemblies, and more—with PC, wire-wrapping, and solder pocket terminations.

And thanks to high-volume, automated production economies, these sockets are priced competitively despite many features you can't get elsewhere.

## SMALL POINTS MAKE A BIG DIFFERENCE.

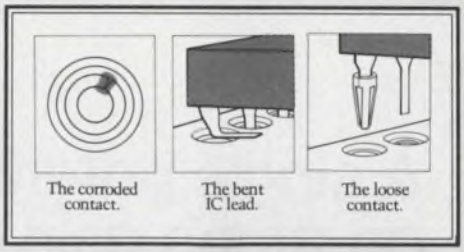
It's amazing how the finer points of socket construction can affect reliability.

Take the material the contacts are made of. For repeated IC insertion and good retention no other material can match the beryllium copper used in all Augat PC sockets. Cost alone leads other producers to use other materials.

The Augat method since 1965.

Designs vary, too. Among low-priced sockets, Augat's new low-profile series grip the IC lead along *both* flat sides, rather than by the edge, for best contact. And they'll take the full range of lead sizes, too.

Among premium sockets, Augat's Series 500 and 700 are the only ones in the world to include the two-piece machined contact assembly designed and perfected by Augat. While stamped "equivalents" abound, their looser tolerances have given rise to a series of pitfalls avoided by the Augat design:



The corroded contact. The bent IC lead. The loose contact.

In the important matter of flow soldering, both series again provide a decisive edge. The closed-end construction completely eliminates the possibility of flux or solder wicking.

These distinctions may seem small. But taken together, they're a good indication of how well the sockets you buy will stand up under long-term use. And in a market flooded with lookalikes, they're something to shop for.

## A SUPPLIER YOU CAN COUNT ON.

As the pioneer and leader in the IC interconnection industry, Augat has always been the world's prime supplier of IC sockets.

Now, after completing a multi-million dollar program of vertical integration, we're better equipped than ever to maintain that position—by providing the best sockets, the best service, and the finest distributor network in the world.

For all the facts, send today for our new brochure. We're convinced that the more you know, the more you'll come to Augat for all your IC interconnection needs.

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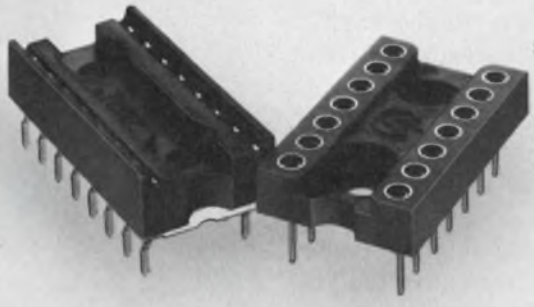

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# A single potentiometer adjusts op-amp's gain over bipolar range

An op-amp's gain level must often be adjusted over its full inverting and noninverting gain range. The simple circuit shown can provide bipolar gain control, and it uses only a single potentiometer. And the gain adjustment is linear —as linear as the pot used.

Pot $R_3$ varies the signal applied to both the inverting and noninverting amplifier inputs. When the wiper position (denoted by x) equals zero, the noninverting amplifier input is grounded. This also holds the voltage across $R_2$ at zero, so $R_2$ has no effect on operation. Now only $R_1$ and R carry feedback current, and the amplifier operates at a gain of $-n$.

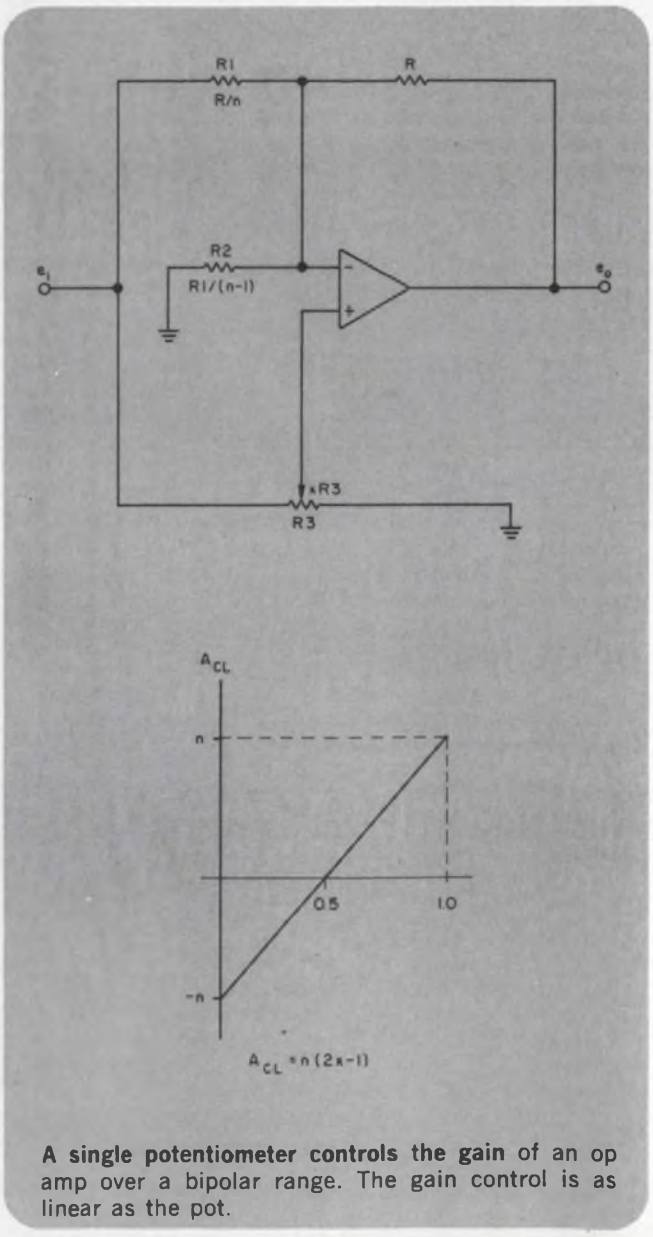
At the other pot extreme, where $x = 1$, the input signal is connected directly to the noninverting input. Since feedback maintains a near-zero voltage between the amplifier inputs, the amplifier's inverting input will also be near the input signal level. Thus little voltage is across $R_1$. Also now the gain is $+n$.

However, the amplifier input resistance varies with the pot setting, as does the feedback current drawn by $R_1$. This variation can produce a source loading error that looks like a nonlinear gain function. The amplifier should be driven from a low-impedance source to minimize this effect.

Trouble can also come from input offset voltages, since the inverting and noninverting amplifier inputs both boost any offset to double that of the conventionally connected amplifier. Thus the circuit should be used with low-offset op-amps.

*Jerald Graeme, Manager of Monolithic Engineering, Burr-Brown, International Airport Industrial Park, Tucson, AZ 85734.*

CIRCLE NO. 311




**A single potentiometer controls the gain** of an op amp over a bipolar range. The gain control is as linear as the pot.

# A new 310-Type 3. Made to take a fall.

**The rugged new "drop-resistant," hand size Triplett Model 310, Type 3 is priced at just $49.**

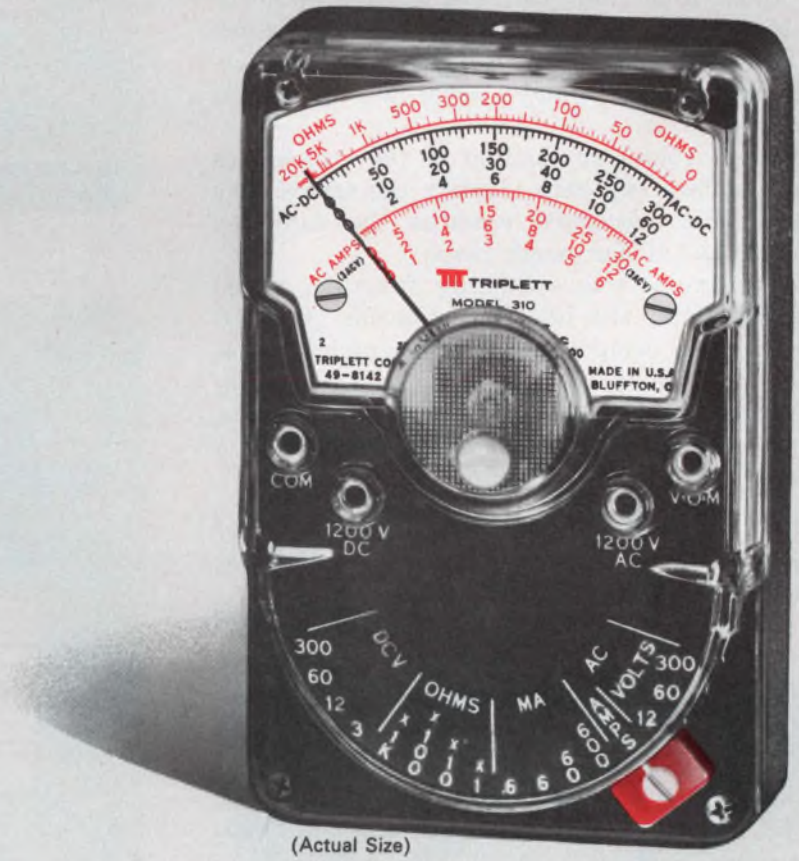
The latest addition to the rugged Triplett 310, general purpose, multi-range V-O-M family—the Model 310, Type 3—has impressive new features. Its case and clear front are made of high impact-resistant plastic.

The low Ohms range Rx1 has been fused to protect against damaging overloads. These two improvements should eliminate over half of all repair requirements resulting from field use damage.

But that's not all. The case of the new Triplett 310, Type 3 sports an elegant new non-slip "finger-tread" surface finish. The meter movement brackets and pointer feature a new rugged design as well as newly designed lead jacks and Model 10 jack. Added to this, the front range and tester dial markings are changed to read easier when used with Triplett's Model 10 Clamp-on-Ammeter.

**Outstanding features:**

1. **Drop-resistant, hand size V-O-M with high impact thermoplastic case.**
2. **20,000 Ohms per Volt DC and 5,000 Ohms per Volt AC; diode overload protection with fused Rx1 Ohms range.**



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3. **Single range switch; direct reading AC Amp range to facilitate clamp-on AC Ammeter usage.**

The durable new 310, Type 3, self-shielded for checking in strong magnetic fields is an extra-rugged, high-torque, bar-ring instrument with spring back jewels. Interchangeable test prod fits into the top of the tester, making it a common probe and freeing one hand. All this for only **$49.**

See for yourself. Try the new Model 310, type 3 V-O-M. Have your Triplett distributor or sales representative give you a free demonstration of this new tester. You'll be glad you did. So, do it today. Triplett Corporation, Bluffton, Ohio 45817.

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INFORMATION RETRIEVAL NUMBER 35

# Combine multichart Karnaugh maps into single, easy-to-handle versions

Traditionally two separate Karnaugh maps are employed to minimize a five-variable switching function, VWXYZ (Fig. 1a). To provide a simpler and less error-prone approach, the two maps can be combined into a single map (Fig. 1b). Place corresponding values of WXYZ into sub-cells created by the diagonal division of the square cells.

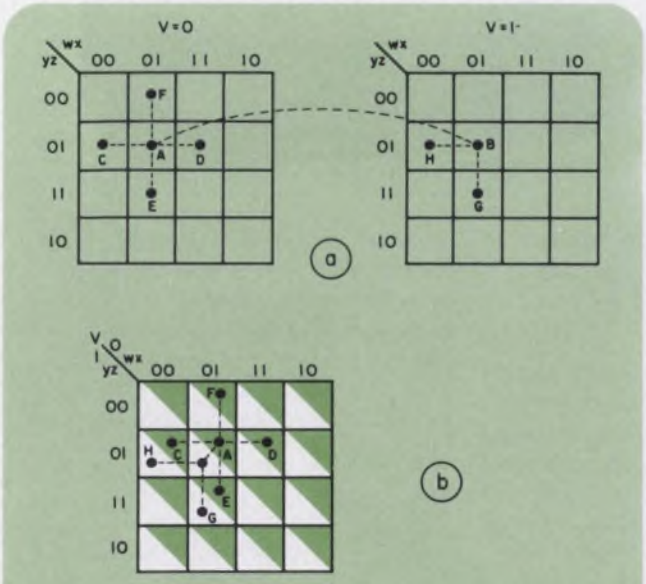
In this so-called embedded Karnaugh map, the upper half of each square corresponds to the false value of the fifth variable, V, and the lower half to the true value. Logically adjacent terms are now also physically adjacent in the corresponding upper and lower-half sub-cells (Fig. 2).

Different colors or shading of the two halves of each square can help identify the terms. The minimization procedure remains the same as with traditional Karnaugh maps.

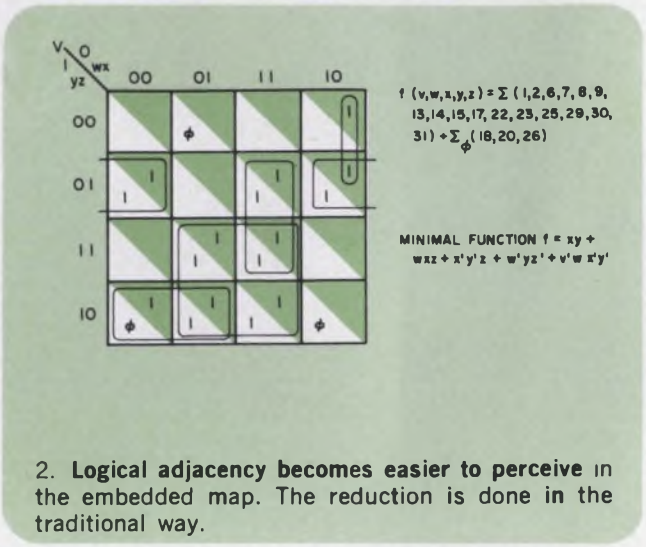
For a six-variable switching function, a cell is divided diagonally into four sub-cells (Fig. 3). Otherwise you would need four Karnaugh maps, which are difficult to work with. Logically adjacent terms, formerly scattered among four maps, are now located in neighboring sub-cells within a single square of the new map.

*Om Vikas, Senior Research Assistant, Dept. of Electrical Engineering, Indian Institute of Technology Kanpur, Kanpur-208016, India.*

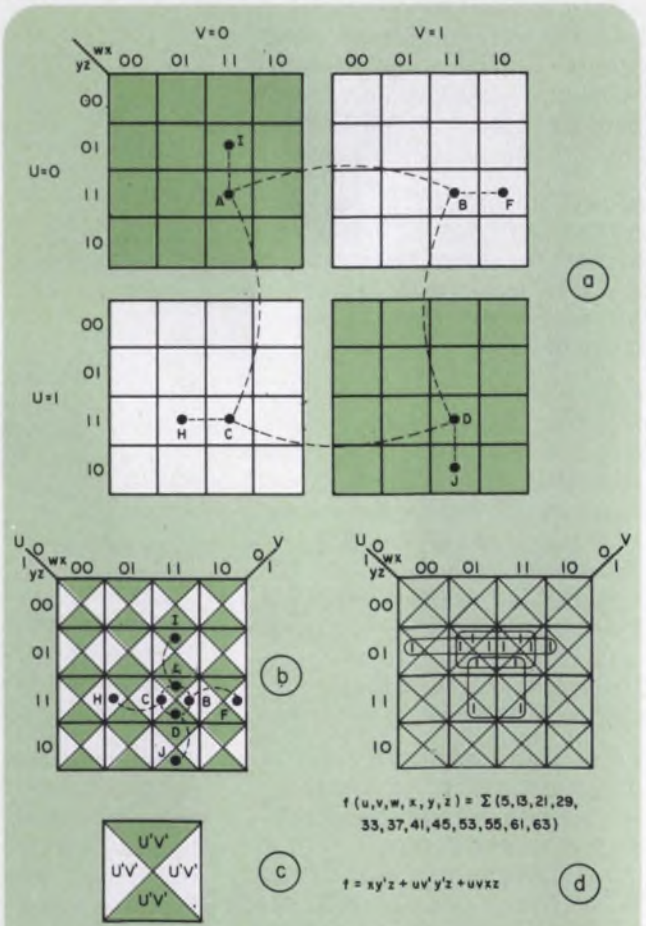
CIRCLE NO. 312




1. **Two Karnaugh maps for a five-variable switching function** (a) are combined into a single embedded map (b).




2. **Logical adjacency becomes easier to perceive** in the embedded map. The reduction is done in the traditional way.




3. **Six variables need four traditional Karnaugh maps** (a). Embedded versions (b) use a single map, with each square divided into four parts (c). Function reduction of a six-variable embedded map (d) also is done in the usual way.

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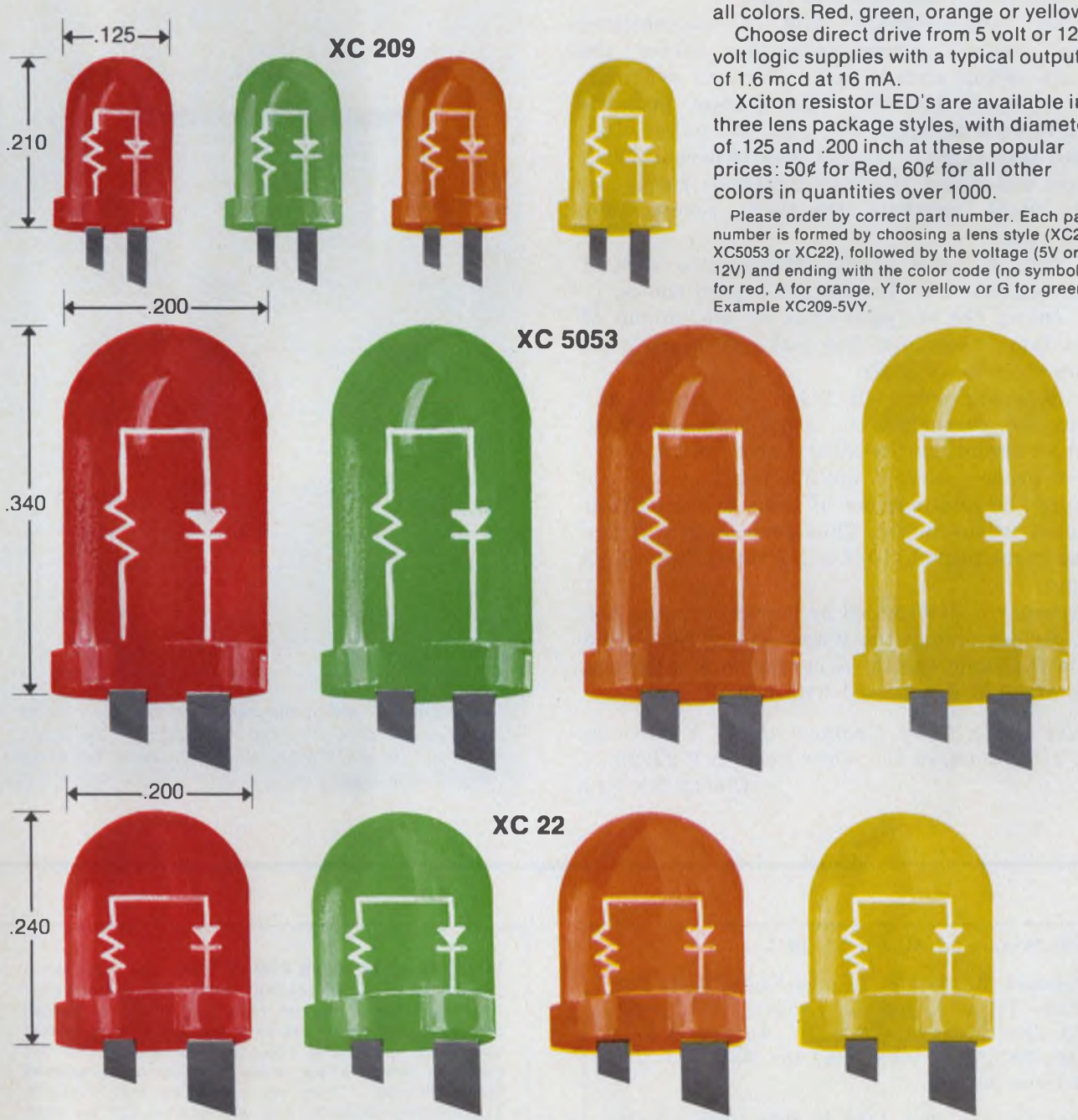
Xciton resistor LED's are available in three lens package styles, with diameters of .125 and .200 inch at these popular prices: 50¢ for Red, 60¢ for all other colors in quantities over 1000.

Please order by correct part number. Each part number is formed by choosing a lens style (XC209, XC5053 or XC22), followed by the voltage (5V or 12V) and ending with the color code (no symbol for red, A for orange, Y for yellow or G for green). Example XC209-5VY.

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Cramer: See adjacent list for the Cramer location nearest you.
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INFORMATION RETRIEVAL NUMBER 36

# Increase current-probe range up to 10 times for 15¢ with wire-and-lug assembly

A simple way to increase a current probe's range can be assembled in five minutes from a few lengths of wire and two lugs.

Pulse measurements with a conventional scope's current probe sometimes exceed the probe's rating and provide erroneous readings. For example, the HP 1110A current probe is rated at 50-A max, peak to peak, but pulses often exceed this value. A circuit may generate 500-A pulses, which are 10 times the probe rating.

To handle currents like these, follow these three steps:

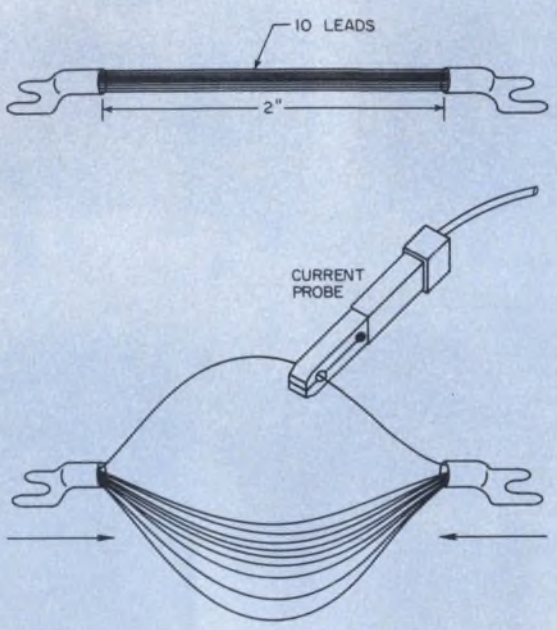
1. Cut 10 pieces of No. 22 insulated wire of equal lengths—2-in. lengths are a good choice.
2. Insert the stripped ends of the bundle of leads into spade lugs and make good electrical connections to all leads.
3. Separate one lead from the bundle and clamp the current probe around this lead, to yield a current-multiplication factor of 10.

The probe's current multiplying factor is the ratio of the total number of leads to the number enclosed in the probe. Thus four leads clamped in the probe provide $10/4 = 2.5$ times the probe's rating.

Accuracy is determined by how equally the current divides among the wires. The wires should all be the same length. Accuracy to 5% is common, and 1% is achieved with a little care.

*Mike Coyle, Chief Engineer. MCG Electronics Inc., 279 Skidmore Rd., Deer Park, NY 11729.*

CIRCLE NO. 313




**Current-probe multiplier accuracy to 1%** can be achieved, if care is taken to make all leads the same length and if good electrical connections are made to the lugs.

**IFD Winner of March 15, 1975**

**Marshall K. Kessie,** Bechtel Corp., P.O. Box 60860, Term. Annex, Los Angeles, CA 90060. His idea "Flat, Flexible TV Antenna Offers High Gain" has been voted the Most Valuable of Issue Award.

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INFORMATION RETRIEVAL NUMBER 37

# Large meteorology net to be installed in Zaire

A nationwide meteorological network will be installed in Zaire to provide information for agriculture and aviation in the African republic. There will be seven regional weather-data stations, according to Omera-Segiel of Paris, the builder, with outlying observation stations that employ SSB or CW hf radio links transmitting information to the regional terminals.

The main station, near Kinshasa/Binza, will be connected to the regional centers by hf radio. This center will also receive data from other stations in Africa via facsimile and Teletype. And the center will also be equipped with an automatic picture-transmission receiver to obtain meteorological data from outside Africa via satellite.

Equipment to be supplied to the main Zairan Meteorological Office will monitor the following weather parameters:

- Precipitation within a 400 km radius from each station.
- Weather at various altitudes. Radiosonde balloons will measure air pressure, temperature and humidity. The balloons will be tracked by radar to determine the wind speeds at various altitudes.
- Visibility near the threshold of the longest runway at the country's main airport.
- The altitude of the cloud base at the airport.

## 10-W gain reported for a GaAs FET

The highest known rf power gain for a gallium-arsenide FET—10 W at 18 GHz—has been reported by the Institut fur Halbleitertechnik in Aachen, West Germany. By minimizing parasitic series resistances, the institute has fabricated a GaAs FET with a 1-$\mu$m gate length.

A new fabrication process combining dc sputter etch and chemical etch was developed. The process improves control of the spacing of the thin layer between the gate stripe and the ohmic contacts, which limits the series resistance to a low value. To minimize the resistance of the gate stripe—which with its capacity, causes an input delay—silver was used for gate metallization.

To maximize the transconductance and saturation characteristics, which depend on the carrier concentration, doping and mobility profile, and the presence of trapping centers, an undoped buffer layer or qualified substrates were used. These elements retain their semi-insulating character near the surface when the epitaxial layer is grown on top of it.

The gallium-arsenide device developed is a single-gate FET with 1.0-$\mu$m gate length, a 200-$\mu$m gate width and 3.0 $\mu$m source-to-drain contact spacing. A pinchoff voltage of 1.3 V was obtained. This value includes the built-in voltage of the gate diode. The diode was fabricated on a 0.4-$\mu$m-thick layer, with doping near the surface on $n \simeq 1 \times 10^{17}$ cm$^{-3}$.

## Surface-wave oscillator can be programmed

An acoustic surface-wave oscillator that can be programmed to operate at 10 frequencies between 121 and 130 MHz has been produced by Thomson-CSF in Domaine de Corbeville, Orsay, France.

The oscillator, which is expected to find application in telecommunication systems, consists of a filter bank, an amplifier and diode output switches. The bank of 10 channels is etched on a 50-mm-long and 10-mm-wide quartz substrate to obtain maximum frequency stability.

The device has a single input transducer that operates in a beam-steering mode. This transducer has 200 point sources, and the direction in which the beam is launched is a function of frequency. The output transducers are positioned to intercept the 10 beams, each beam corresponding to one of the spot frequencies.

The angle between the X axis of the substrate and the line joining the input transducer sources is 41°58′, and the 10 output transducers lie at angles that vary with respect to the X axis from −2°8′ to 2°23′. The output elements with the largest off-axis angles are deposited closest to the input array to reduce any anisotropy effect.

The frequency response of the individual channels is a sin X/X curve, while the 3-dB bandwidth of the filters is about 0.8 MHz. The frequency of the oscillator is controlled by a number of diode switches, two of which are used for each output.

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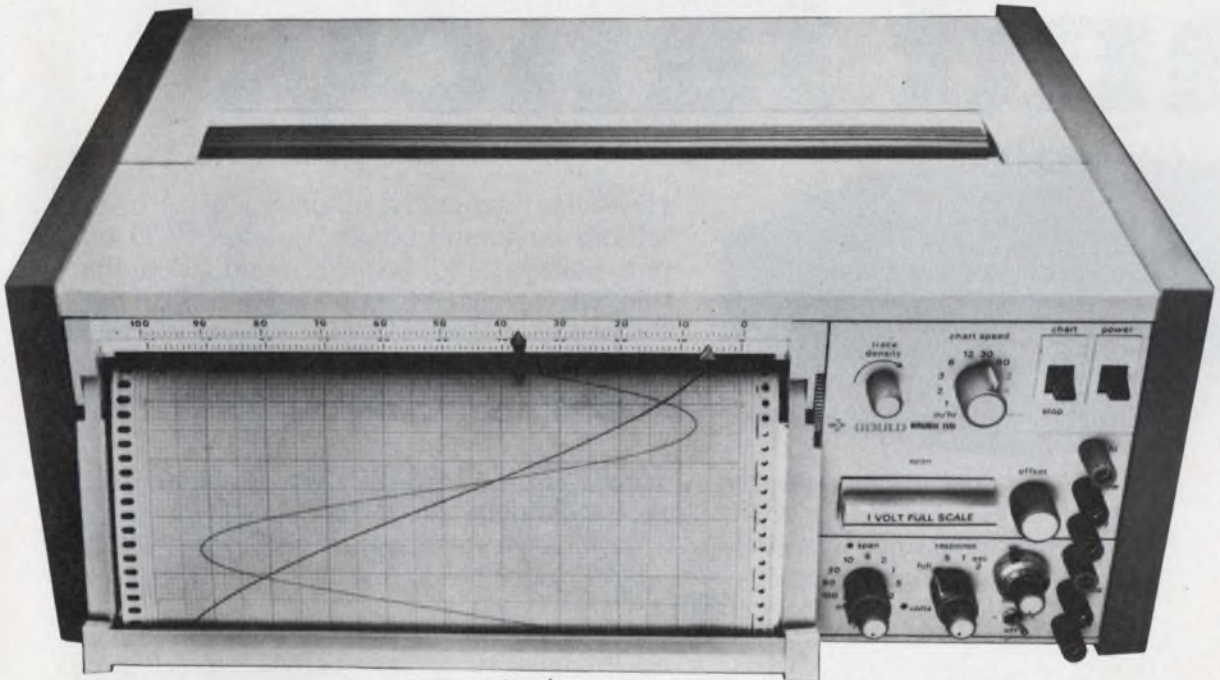


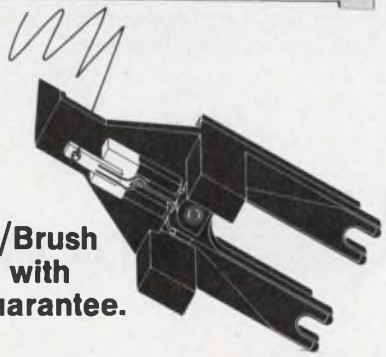

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INFORMATION RETRIEVAL NUMBER 38

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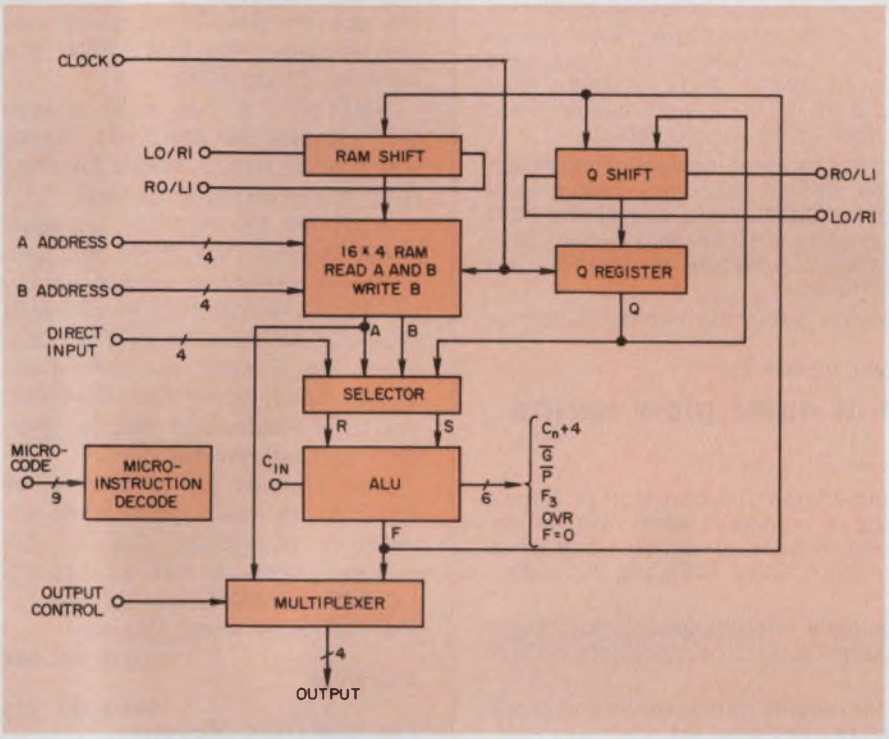
INFORMATION RETRIEVAL NUMBER 39

# New Products

# 4-bit bipolar/LSI processor slice cuts microcycle time to 100 ns




*Advanced Micro Devices, 901 Thompson Pl., Sunnyvale, CA 94086. (408) 732-2400. Under $50 (100 up); August.*

The latest bipolar/LSI microprocessor slice—Advanced Micro Devices' Am2901—offers the fastest speed from available controller chips. The 4-bit Schottky-TTL circuit has a micro-instruction cycle time of only 100 ns, or one-half the cycle of presently competing units.

However, the AMD processor will face a higher-speed competitor when the MC10800 becomes available from Motorola Semiconductor (P.O. Box 20912, 5005 E. McDowell Rd., Phoenix, AZ 85036). Due for 1976 introduction, the Motorola 4-bit slice processor will use emitter-coupled logic to achieve a microcycle time of 55 ns (see "Motorola Processor to Have 55-ns Micro-Instruction Time," ED No. 12, June 7, 1975, p. 25).

Bipolar microprocessors that have preceded the AMD unit include these: the 3001, a 2-bit slice from Intel (3065 Bowers Ave., Santa Clara, CA 95051); the 6701, a 4-bit slice from Monolithic Memories (1165 E. Arques Ave., Sunnyvale, CA 94086); and the SBP0400, a 4-bit slice from Texas Instruments (P.O. Box 5012, MS/84, Dallas, TX 75222).

Like the AMD circuit, the Intel and MMI versions use Schottky-TTL, but their cycle times are around 200 ns. A slower speed is offered by the TI version, which employs integrated-injection logic to decrease power dissipation. All present and expected bipolar/LSI processors require microprogramming techniques for application.

The architecture of the new AMD chip (see diagram) most resembles that of Monolithic Memories' 6701. Compared with the 6701, the Am2901 achieves the lower cycle time primarily by enhancing the speed of its internal RAM and by its method for decoding micro-instructions.

The Am2901 contains three separate logic blocks that control the arithmetic-logic unit's source operand, function and destination register. Micro-instructions, which are 9 bits long, consist of three 3-bit segments that correspond to the three logic blocks. This breakup reduces delays and permits parallel decoding of different segments of the same micro-instruction.

Also, the three-part segmentation leads to a higher number of possible micro-instructions. With the MMI 6701, that number is 256, but with the Am2901, it's 512. However, not all 512 represent useful instructions.

Both processor slices can be cascaded in multiples of 4 bits with full look-ahead carry. They have three-state outputs, and they permit shift-left, shift-right and no-shift entries from the ALU into RAM. However, the 2901's RAM permits external access through an A port and the multiplexer block. The MMI version furnishes this access with both an A and B port.

Both versions provide three status bits, or flags: carry-out, overflow and zero detect. In addition the Am2901 includes a sign bit for negative values.

The eight possible destinations in the 2901 are indicated directly in the micro-instruction. As a result, external decoding blocks can

*(continued on page 78)*

### INTEGRATED CIRCUITS

*(continued from page 77)*

be avoided when the chip is used with external multiplexers in multiplication and division routines.

And one destination control function permits operations that don't require any writing into the RAM or the Q register (a scratch pad or accumulator extension). Hence operations, like Compares, can be performed without loss of register contents.

Like the MMI 6701, the AMD circuit operates from a single 5-V supply. The 2901 has the lower current requirement (185 mA vs 215 mA for the 6701), and it dissipates about 900 mW. Both ICs come in 40-pin DIPs.

AMD plans a wide range of support circuits for the 2901. These will provide circuit blocks for complete microcomputer systems.

A 16-bit system, for example, would employ four 2901s and two 2909 microprogram sequencers to address up to 256 ROM words, each typically 32 bits long. The four 2901s would need one 2902 look-ahead carry generator. External registers would hold source operands and microwords.

Also planned are a number of I/O circuits (with either open-collector or three-state outputs) for bussed systems, as well as supporting ROMs, PROMs and RAMs.

For Advanced Micro Devices

CIRCLE NO. 302

For Intel

CIRCLE NO. 303

For Monolithic Memories

CIRCLE NO. 304

For Motorola

CIRCLE NO. 305

For Texas Instruments

CIRCLE NO. 306

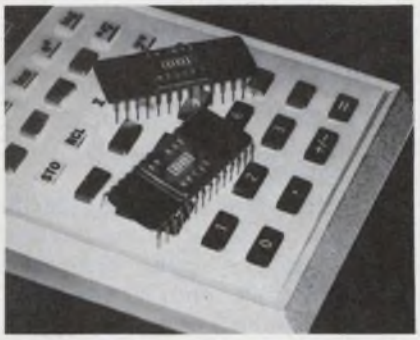
## 5-V/μs dual op amp has 35-nA bias

*Harris Semiconductor, P.O. Box 883, Melbourne, FL 32901. (305) 724-7407. $3.40 (100 up); stock.*

The HA-2650 internally compensated dual op amp features a slew rate of 5 V/μs and a bandwidth of 8 MHz. Even at ±2 V, the slew rate is still 4.0 V/μs. The dc characteristics include a bias current of only 35 nA with 75-mW power consumption, and an average offset voltage drift of 8 μV/°C. Pinouts are identical to Motorola's 1558 model.

CIRCLE NO. 307

## CMOS multiplexers route analog data



*Burr-Bown, International Airport Industrial Park, Tucson, AZ 85734. (602) 294-1431. $29.00 to $29.80 (100 up); stock to 2 wks.*

Two monolithic analog multiplexers, the MPC16S and the MPC8D, respectively, provide 16-channel single-ended operation and dual eight-channel operation for differential inputs. Both are constructed with failure-protected CMOS devices. And both are DTL/TTL/CMOS compatible and feature self-contained binary-channel address decoding. Power consumption is 15 mW when operating at 100 kHz, and 7.5 mW on standby. Transfer accuracies of better than 0.01% can be achieved at sampling rates up to 200 kHz from signal sources of up to ±10-V amplitude. Digital and analog inputs are protected against either overvoltages that exceed the power supplies or from loss of power.

CIRCLE NO. 308

## 18-lead DIP holds 4-k RAM

*National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000.*

The MM5270, a 4-k read/write memory in an 18-lead package, employs a single lead to serve three functions: read/write, logical chip select and $V_{CC}$. The new memory also has Tri-State, common I/Os. With only 18 leads, the MM5270 reportedly achieves a PC-card memory density nearly twice as great as that possible with standard 22-lead 4k RAMs. The MM5270 features TTL-compatible inputs (except for chip enable) and on-chip registers for address and chip select. Access time is 200 ns, and cycle time is 400 ns.

CIRCLE NO. 309

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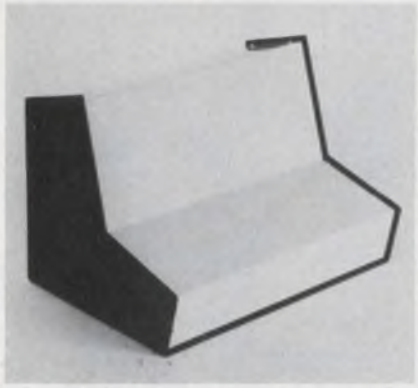

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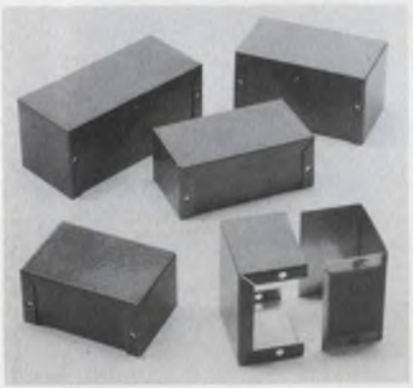

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INTEGRATED CIRCUITS

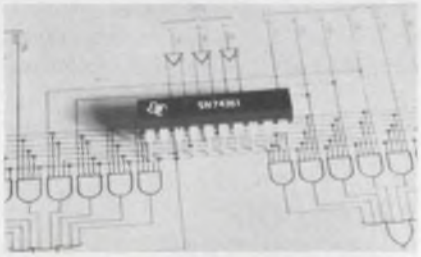
## CMOS multiplexers avoid latchup

*Intersil Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. $28 to $55 (100 up).*

A pair of nonlatching CMOS multiplexers consist of the IH5060—a 16-channel plug-in replacement for the DG506 and HI-506—and the IH5070—an 8 dual-channel differential multiplexer replacement for the DG507 and HI-507. The new circuits come in 28-pin DIPs for both MIL and commercial temperature ranges. Maximum negative and positive supply current drain for the MIL model is 300 $\mu$A total; for the commercial model, it's 2 mA total. Intersil uses its floating-body process to stop latchup caused by analog signals when the power supplies are off or interrupted. Maximum $R_{ON}$ is 400 $\Omega$ for the military model and 450 $\Omega$ for the commercial. Total output capacitance is 40 pF.

**CIRCLE NO. 320**

## 20-pin package holds dual multiplexer

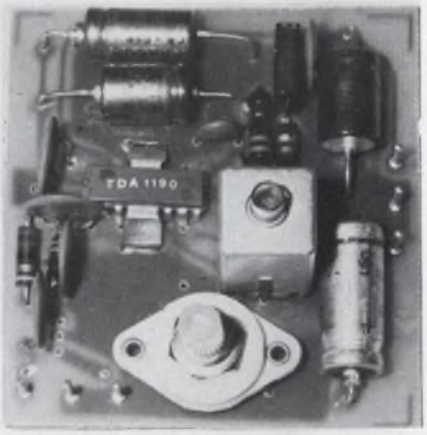


*Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, TX 75222. (214) 238-3741. $2.16 (100); stock.*

A dual multiplexer—the SN74351—combines the equivalent of two SN74151s in a single 20-pin package. The TTL multiplexer features three-state bus-connectable outputs from each of the eight-line data-input logic sections. Each eight-line section shares four common data lines to allow a simultaneous dual eight-line conversion. Organized as three independent four-line input sections, the multiplexer can handle either four-line binary or BCD digits. Through the use of the output enable, the SN74351 can be expanded to handle n-bits or n-digits.

**CIRCLE NO. 321**

## Chip holds TV sound channel

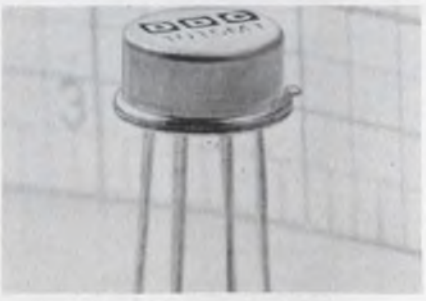


*SGS-ATES Semiconductor Corp., 435 Newtonville Ave., Newtonville, MA 02160. (617) 969-1610. $2.80 (100-999); stock.*

The TDA1190 combines the functions of a TV sound channel—from i-f amplifier/limiter and low-pass active filter to dc volume control and FM detector—on a single chip. The new IC has a dc volume control range of 90 dB typical, output power capability of 4.2 W at 24 V and 16 $\Omega$, and limiting voltage of 30 $\mu$V, typical. The chip avoids thermal feedback and irradiated frequencies.

**CIRCLE NO. 322**

## FET amp specs 100-MHz gain-BW



*ILC Data Device Corp., Airport International Plaza, Bohemia, NY 11716. (516) 567-5600. $14 to $21; stock to 6 wks.*

The Model 1015 FET op amp specifies 100-MHz gain-bandwidth product at gains of five and above, and 600 kHz for full output. The unit comes in a TO-99 package. It has an input impedance of $10^{12}$ $\Omega$ and a bias current of 1 pA. The amp provides an external connection for frequency shaping or compensation of closed-loop gains of less than five.

**CIRCLE NO. 323**

# International Rectifier.

## New 10 Amp device makes one-stop shopping easy for fast-switching power transistors.

Now, IR is your source for a wide variety of 3, 5 and 10 Amp JEDEC fast-switching power transistors, to simplify your buying. These hard-glass passivated devices are the ones to use for better reliability and lower costs in line operated power supplies, whether you're chopping line voltages at 20 KHz or inverting and stepping down at high frequency.

**Fast Switching Speed—Cooler Operation** . . . the oscillographs show typical fall times in the one-microsecond and lower range. Gives extremely low switching losses for cooler operation and higher reliability.

**Lower Leakage — High Temperature Stability** . . . with ICEO in the microamp range, IR devices are about one-tenth the accepted leakage rates of others. Provides the higher stability important for high performance at elevated temperatures.

New International Rectifier Fast Switching Power Transistors

| IR Part No | $V_{CEO(sus)}$ (Max V) | $I_C$ Peak (A) | $h_{FE}$ (min/max) | @ $I_C$(A) | $V_{CE(sat)}$ (Max V) | @ $I_C$(A) | $P_d$ (W) | $t_r/t_f$ (μs) |
|---|---|---|---|---|---|---|---|---|
| 2N6306 | 250 | 16 | 15/75 | 3.0 | 0.8 | 3.0 | 125 | .6/.4 |
| 2N6307 | 300 | 16 | 15/75 | 3.0 | 1.0 | 3.0 | 125 | .6/.4 |
| 2N6308 | 350 | 16 | 12/60 | 3.0 | 1.5 | 3.0 | 125 | .6/.4 |
| 2N6542 | 300 | 10 | 7/35 | 3.0 | 1.0 | 3.0 | 100 | .7/.8 |
| 2N6543 | 400 | 10 | 7/35 | 3.0 | 1.0 | 3.0 | 100 | .7/.8 |
| 2N6544 | 300 | 16 | 7/35 | 5.0 | 1.5 | 5.0 | 125 | 1/1 |
| 2N6545 | 400 | 16 | 7/35 | 5.0 | 1.5 | 5.0 | 125 | 1/1 |
| 2N6249 | 200 | 30 | 10/50 | 10.0 | 1.5 | 10.0 | 175 | 2/1 |
| 2N6250 | 275 | 30 | 8/50 | 10.0 | 1.5 | 10.0 | 175 | 2/1 |
| 2N6251 | 350 | 30 | 6/50 | 10.0 | 1.5 | 10.0 | 175 | 2/1 |

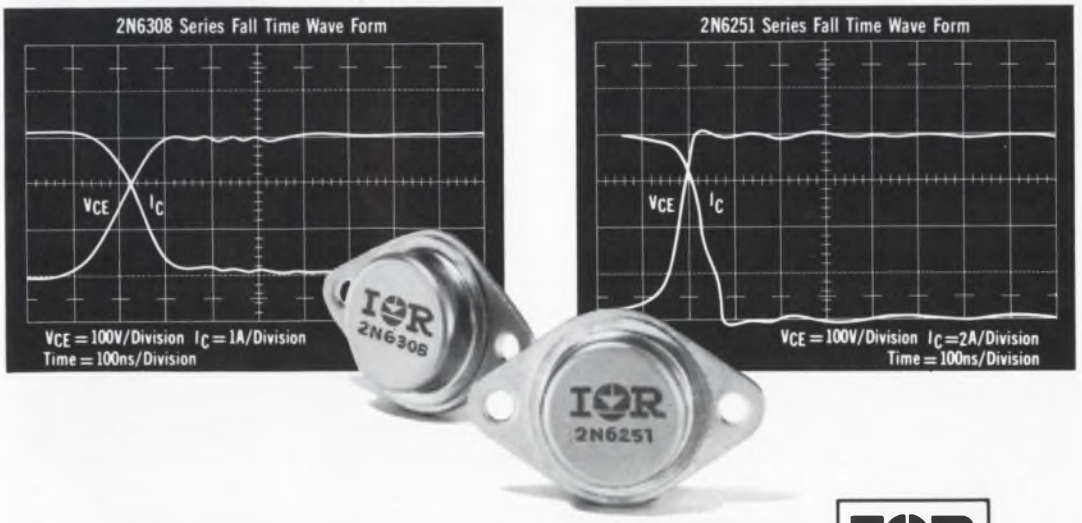
**High Second Breakdown — High Reliability** . . . high second breakdown helps provide a broad safe-operating area for an extra margin of safety.

**Glass Passivation — Long Term Reliability** . . . high reliability and long term stability is achieved by hard glass passivation. Also, if you're using chips to make your own circuits, IR's glass passivation gives you the most stable, easy to assemble chips you can start with, making your yields higher.

If you are paralleling devices, the tight gain, switching time and saturation voltage control of these transistors make the job easier. And through 100% testing of key parameters we can provide even closer matching if necessary.

JEDEC types listed are immediately available, so contact your local IR salesman, rep or distributor today.

International Rectifier, 233 Kansas Street, El Segundo, California 90245. (213) 678-8261.




INTERNATIONAL RECTIFIER IOR
the innovative power people

SEMICONDUCTOR DIVISION, 233 KANSAS STREET, EL SEGUNDO, CALIFORNIA 90245, PHONE (213) 678-6281

INFORMATION RETRIEVAL NUMBER 151

## ICs generate rhythms for instruments


*SGS-ATES Semiconductor Corp., 435 Newtonville Ave., Newtonville, MA 02160. (617) 969-1610. $10 to $13 (100-999); stock.*

Monolithic rhythm generators—the M252 and 253—are designed for organs and other electronic instruments. The M252 provides 3840 bits of ROM arranged to generate 15 rhythm patterns for eight instrument outputs. The M253 provides a ROM capacity of 3072 bits to generate 12 rhythm patterns, also for eight instruments. Other features include mask programmable reset after 24 or 32 counts, down-beat output and external reset. The PMOS ICs operate from +5 and −12-V supplies.

CIRCLE NO. 374

## A/d converter set has multiple options

*Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054. (408) 246-8000. $34.85 (100); stock.*

The company's latest 3-1/2-digit a/d converter chip set—the LD-111/LD114—features multiple option outputs that are brought out to the pins of the digital IC. Options include either multiplexed serial or parallel BCD outputs and active high or active low logic outputs. Addition of a display, reference voltage and clock comprises a full analog-to-digital system. The two-chip pair consists of the LD111 analog processor in a 16-pin DIP and the LD114 digital processor in a 28-pin DIP. The LD111/LD114 system features include overrange and underrange signals; $2^n$ divisible output for phase-locked-loop clocks; 0.005% accuracy of reading, ±1 count; sampling rates to 12 samples per sec, and auto-polarity.

CIRCLE NO. 375

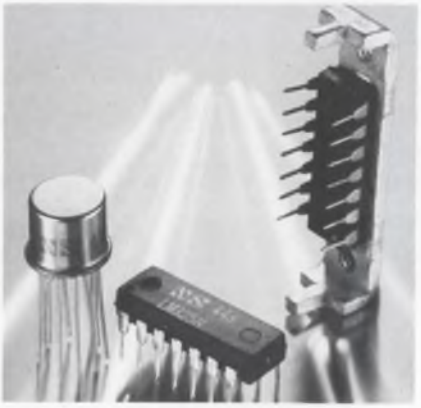
## 4-k bit RAM boosts speed

*Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. (408) 246-7501. $21.10 to $28.90 (100-999); stock.*

A high-speed version of the company's 4096-bit NMOS RAM—the 2107B—has a worst-case access time of 200 ns and a guaranteed minimum cycle time of 400 ns over the operating temperature range of 0 to 70 C. A lower cost version, the 2107B-4, has a worst-case access time of 250 ns and minimum cycle time of 450 ns. The 2107B operates from standard MOS supply voltages of ±5 and +12 V. It is a single-clock, fully decoded RAM with a TTL-compatible, three-state output and TTL-level inputs. Clock margins are ±1 V.

CIRCLE NO. 376

## Dual regulators output up to 100 mA

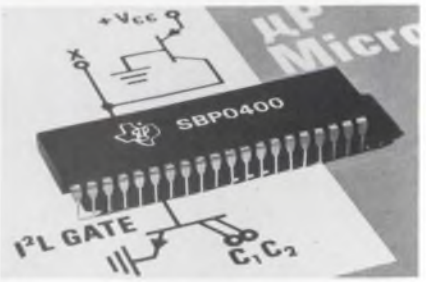


*National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. LM325: $2.60 (100); stock.*

Three dual-tracking voltage regulators—the LM125, LM126 and LM127—provide balanced positive and negative output voltages at currents up to 100 mA. Input voltage can be as high as ±30 V, and the ICs have a provision for external adjustable current limiting. The LM125 provides tracking outputs of ±15 V, and it features output voltages balanced to within 1% and line and load regulation of 0.06%. The LM126 provides ±12-V outputs balanced to within 1% and features line and load regulation of 0.08%, while the LM127 has +5 and −12 V outputs.

CIRCLE NO. 377

## $I^2L$ microprocessor uses 4-bit slices




*Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, TX 75222. (214) 238-3741. $90 (1-24).*

The first integrated-injection-logic ($I^2L$) microprocessor—the SBP400—is a 4-bit slice microprogrammable parallel-binary unit that comes in a 40-pin package. Featured in the circuit's architecture are a 16-function ALU having full carry-look-ahead capability, an eight-word general-register file including program counter with incrementor and two 4-bit working registers for both single and double-length operations. Internal control transformation is generated by a factory programmable logic array (PLA) containing a standard repertoire of 512 one-clock-length operations. In addition, special architectural features including a 20-bit operation register and a 2-bit relative position control give the capability of simultaneously fetching an instruction while executing complex operations. Use of $I^2L$ makes possible typical operation propagation times of 110 to 530 ns at a 128-mW nominal power. Any dc power source capable of providing +0.85 V minimum at the desired supply current can be used.

CIRCLE NO. 378

## CMOS IC contains phase-locked loop

*Motorola Semiconductor Products, P.O. Box 20924, Phoenix, AZ 85036. (602) 244-3466. $1.90 to $2.85 (100-999).*

The MC14046 CMOS phase-locked loop contains two phase comparators, a voltage-controlled oscillator (VCO) and a zener diode to assist in supply-voltage regulation. It operates at a VCO frequency up to 1.4 MHz ($V_{DD}$ = 10 V dc). Power dissipation is in the microwatts for typical applications.

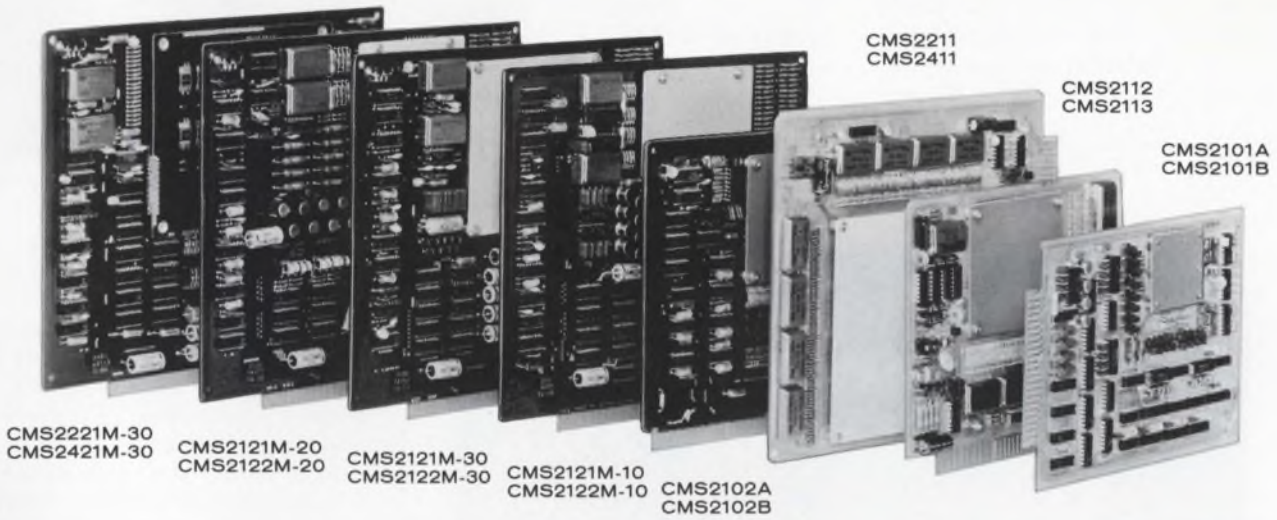
CIRCLE NO. 379

# FUJI MEMORIES

**4BITS·9BITS SERIES**
**SMALL CAPACITY MEMORY SYSTEMS**

# MIXED MEMORY RAM·PROM

## for one-chip CPU micro-processors




# NON-VOLATILE, LOW·COST but HIGH·RELIABILITY

Microprocessors combined with one-chip CPU are making tremendous advances in the peripheral **terminals** of computer networks, **control devices, electronic cash registers, banking systems** and **POS systems.** Semiconductor memories have generally been applied to the micro-processor, but which is involving such problems as the volatility of the stored data, reliability, and the influence against on noise.

Therefore, in the case of the small capacity memories, it has come to be considered more desirable to apply Core Memory system specially featured by it's **non-volatility, high-reliability** and **low-cost.**

In particular, Core Memory which can not only be used as **RAM,** but also as **PROM** in small scale systems not equipped with a program data loading device is extremely versatile for various applications and is highly praised for its greater dynamic design. For instance, a newly developed **MIXED MEMORY** can adopt a part (example, 1K, 2K or 3K) of 4K words memory systems as RAM, and the residual of them as PROM by employing the address protection mode of operation. Moreover, since a floating charge battery system is provided as an auxiliary back up power supply in order to cover the volatility of the semi-conductor memory, Core Memory is not only more economical, but also more reliable than IC memory system. Since the FUJI small capacity Core Memory system employs **hybrid IC** as its peripheral circuitry, it has been designed to be sufficiently compact and economical.

Each module has also been designed as a complete series, considering expandability, and major models have been designed for use with **only +5V** as the power supply.

Standard models are available in 1 bit, 4 bits and 9 bits length series, and various modules from 128 words to 16K words are immediately available from stock. In adition to our standard models, special design for OEM use can also be performed quickly upon request.

| | Model | Capacity | Access time | Power supply | Dimensions: Card size | Dimensions: Card pitch |
|---|---|---|---|---|---|---|
| 9 BIT SYSTEM | CMS2121M-10 | 512W-9BITS | 0.3 μs | +5V ONLY | 10"×8"×0.7" | |
| | CMS2122M-10 | 1024W-9BITS | | | | |
| | CMS2121M-20 | 512W-9BITS | | +5V +9V | | |
| | CMS2122M-20 | 1024W-9BITS | | | | |
| | CMS2221M-20 | 2048W-9BITS | | | | |
| | CMS2421M-20 | 4096W-9BITS | | | | |
| | CMS2821M-20 | 8192W-9BITS | | +5V, +12V | 10"×8"×1" | |
| | CMS2121M-30 | 512W-9BITS | 1.0 μs | +5V ONLY | 10"×8"×0.7" | |
| | CMS2122M-30 | 1024W-9BITS | | | | |
| | CMS2221M-30 | 2048W-9BITS | | | | |
| | CMS2421M-30 | 4096W-9BITS | | | | |
| | CMS2821M-30 | 8192W-9BITS | | | 10"×8"×1" | |

| | | Model | Capacity | Access time | Power supply | Dimensions: Card size | Dimensions: Card pitch |
|---|---|---|---|---|---|---|---|
| 4 BIT SYSTEM | Discrete models | CMS2101A | 128W-4BITS | 1.0 μs | +5V | 8.7"×5.8"×0.6" | |
| | | CMS2101B | 256W-4BITS | | | 9"×7"×0.6" | |
| | | CMS2102A | 512W-4BITS | | | | |
| | | CMS2102B | 1024W-4BITS | | | | |
| | Hybrid models | CMS2112 | 512W-4BITS | | +5V ONLY | 8"×6"×0.6" | |
| | | CMS2113 | 1024W-4BITS | | | | |
| | | CMS2211 | 2048W-4BITS | | | 8"×10"×0.6" | |
| | | CMS2411 | 4096W-4BITS | | | | |
| | | CMS2811 | 8192W-4BITS | | | | |
| 1 BIT to 8 BITS variable system | | CMS6115M-10 | 4KBITS | EMM micromemory 9000 plug compatible | | | |
| | | CMS6115M-20 | 8KBITS | | | | |
| | | CMS6115M-30 | 16KBITS | | | | |

## FUJI ELECTROCHEMICAL CO.,LTD.

Head Office: No.36-11, 5-chome, Shinbashi, Minato-ku, Tokyo, Japan TEL: 03-434-1271

New York Office: TEL. 212-532-5630 Los Angeles: TEL. 213-626-1123 Düsseldorf Office: TEL. 211-89031 Hong Kong Office: TEL. 3-691382

INFORMATION RETRIEVAL NUMBER 152

INTEGRATED CIRCUITS

## Byte-organized CMOS RAM holds 256 bits

*Motorola, P. O. Box 20924, Phoenix, AZ 85036. (602) 244-3466. $20 to $40 (100-999).*

With three chip-enable inputs and a format of 64 bytes of 4-bits, the MCM14552 static CMOS RAM can be expanded into a 2048-bit (512 bytes of 4-bits) system without any additional address decoding. Three-state output control permits bus-organized operation; also on-chip output data latches can be used to hold data during the write mode. Operating statically without the need for a clock signal, the 256-bit MCM14552 can be controlled by dc levels—there are no maximum pulse-width restrictions. Quiescent power dissipation is typically 10 $\mu$W/package at $V_{DD} = 10$ V, $T_A = 25$ C. Access time is typically 700 ns at $V_{DD} = 10$ V, $T_A = 25$ C.

CIRCLE NO. 380



## Oscillator generates variety of waveforms

*ILC Data Device Corp., Airport International Plaza, Bohemia, NY 11716. (516) 567-5600. $5.25 to $27.00; stock to 6 wks.*

The Series 1453 generator/voltage-controlled oscillator can produce simultaneous outputs of sine, square, triangular, sawtooth and pulse waveforms. Selection of operating frequency or repetition rate is made externally and covers a range of from less than 0.001 Hz to greater than 1 MHz. Frequency stability is 50 ppm/°C maximum over a wide range of temperatures and supply voltages. Other features include distortion of 1%, linearity of 0.1% and a duty cycle that is variable from 2% to 98%.

CIRCLE NO. 381

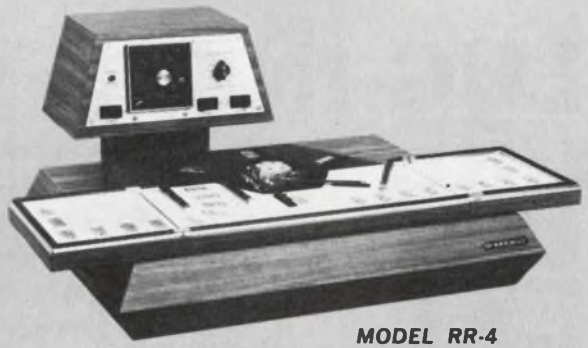
## 256-bit PROMs come pre-tested

*Advanced Micro Devices, Inc., 901 Thompson Pl., Sunnyvale, CA 94086. (408) 732-2400. $8.10 to $16.00 (100 up).*

Factory pre-tested 256-bit field-programmable ROMs come with an extra bit on each word and two extra words to provide optimum programming yields. The Am27S08 and Am27S09 (open-collector and three-state output versions, respectively) are high-speed, Schottky-TTL circuits designed to replace functionally similar devices offered by Signetics, Intersil and other manufacturers. These units are organized as 32 words by 8 bits and offer guaranteed address access speeds of 55 ns over the commercial temperature range, and 75 ns over the full military temperature range. The additional bits and words are used by AMD engineers to ensure field programmability.

CIRCLE NO. 382

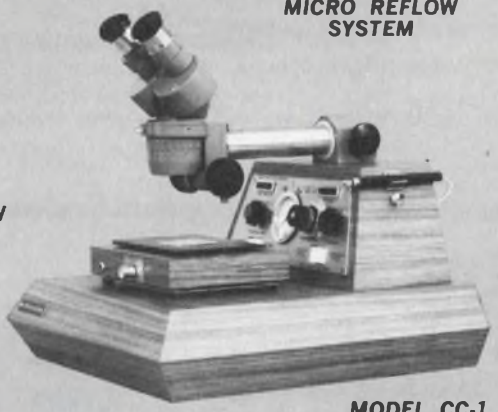
# YOUR HYBRID CIRCUITS DESERVE THE BEST SOLDERING INSTRUMENTS AVAILABLE...



MODEL RR-4
ROTARY REFLOW
SYSTEM

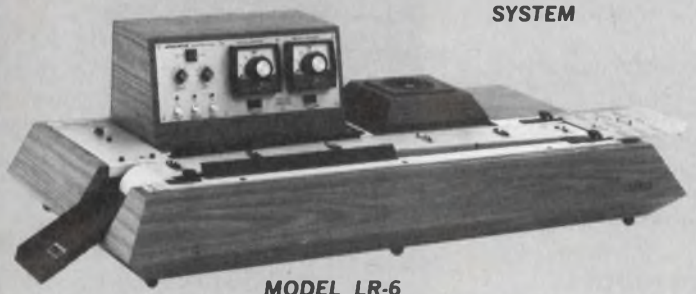
MODEL CM-2
MICRO REFLOW
SYSTEM

MODEL AR-7
AUTOMATED REFLOW
SYSTEM



MODEL CC-1
SPOT REFLOW
SYSTEM

MODEL SR-3
SONIC REFLOW
SYSTEM



MODEL LR-6
LINEAR REFLOW
SYSTEM

. . . . INTRODUCING A COMPLETE LINE OF REVOLUTIONARY HIGH SPEED LABORATORY AND PRODUCTION SOLDERING SYSTEMS . . .

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PHONE (805) 963-0371

INFORMATION RETRIEVAL NUMBER 42

INTEGRATED CIRCUITS

## Latest 1103 lists access of 90 ns

*Synertek, 3050 Coronada Dr., Santa Clara, CA 95051. (408) 241-4300. $12.50 (100-999).*

A high-speed version of the company's 1024-bit MOS RAM provides a maximum delay, from chip enable to output, of 90 ns. Called the SY1103A-X, the company's latest version of the popular 1103 employs ion-implanted silicon-gate techniques. As a result chip-enable capacitance is 18 pF, which reduces clock power dissipation by a third and cuts the number of clock drivers needed at the system level. Also, a precharge clock isn't required.

CIRCLE NO. 324

## 4-k NMOS RAM chooses 22-pin DIP

*Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. (408) 739-7700. $19 (100-999); stock.*

The latest 4096-bit, n-channel MOS dynamic RAM—the Model 2604—comes in a 22-pin package and has a maximum access time of less than 300 ns with a minimum cycle time of 470 ns. Standard power supplies are +12 and ±5 V, but selected ICs operate from −3 V instead of −5 V. Outputs are three state, and refresh is needed every 2 ms.

CIRCLE NO. 325

## 1-k bit CMOS RAM has 250-ns access

*Intersil Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. (408) 257-5450. $28 to $70 (100 up).*

When connected to a 5-V supply, a 1024-bit static CMOS RAM (the IM6508) has a 250-ns access time over the full temperature range. With a 10-V supply, access decreases to less than 100 ns at 10 V. Total power requirements are 5 μW in standby and 10 mW at 1 MHz. Two versions of the IM6508 cover MIL and commercial temperature ranges. Both have TTL-compatible inputs and outputs, and both can operate from a supply as low as 3 V.

CIRCLE NO. 326



INFORMATION RETRIEVAL NUMBER 45 ►

# WESTON® Promises:

## With the Model 1242 you'll see the difference but you won't feel it!

No, you can't see the difference in any photograph, or even by looking at the real thing. But you will see the difference the instant you start working with it.

The big change is in the readout...It's improved, and at no extra cost to you. Just look...

When the Weston Model 1242 was first introduced, it was a winner. Priced right—very competitively. That was about 1½ years ago.

Model 1242 is a 4½ digit (19999) DMM with 25 ranges of operation, a resolution of 10 uV on the 100 mV range, and with the Weston patented Dual Slope integration* for automatic rejection of ac noise on dc input signals and greater accuracy. Circuitry fully protected from overload by resistor/diodes or fuses (made removable from the front without additional tools) or both.

We found a way to improve this already versatile DMM...a new improved readout. The numerals are brighter, easier to read, and since the digits are now coplanar, the angle of readability is made wider. This new readout is also made to last longer with greater reliability.

Such improvements usually carry with them a price mark-up, but not at Weston. We continue to sell this improved new version Model 1242—for the same price...no extra cost to you. Now you'll be able to see the difference, but you won't feel it.

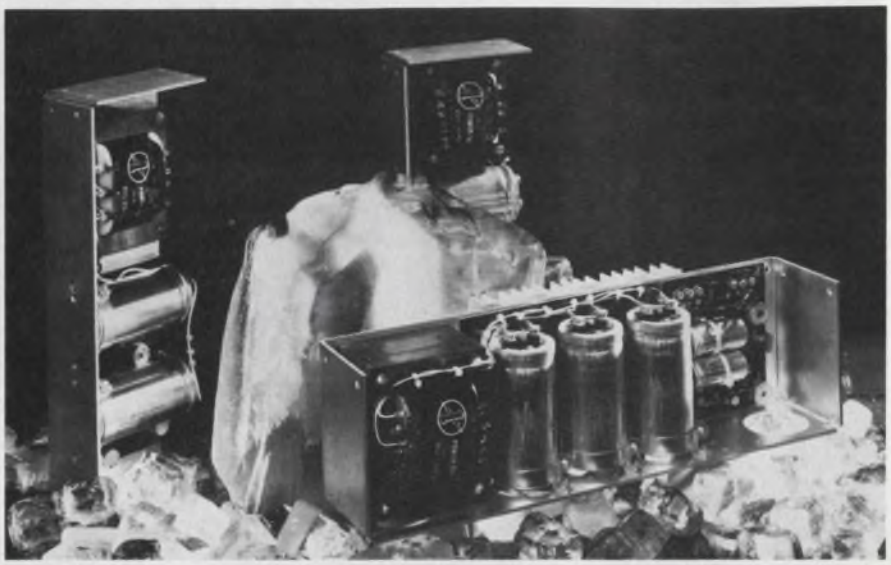
If you would like to see the difference on the improved Weston DMM Model 1242—at no extra cost—start by calling your local distributor or by writing directly to: Weston Instruments, Inc., 614 Frelinghuysen Ave., Newark, N.J. 07114.

*U.S. Pat. #3051939


WESTON

WESTON Schlumberger

# Series-regulated supplies hurdle efficiency barrier



| dc output current | | | ac input tap | ac input / efficiency | | |
|---|---|---|---|---|---|---|
| Model RD5-15 | Model RE5-23 | Model RG5-40 | | Low eff. | Nominal eff. | High eff. |
| 9 A | 14 A | 25 A | A | 105 V 70% | 115 V 65% | 125 V 60% |
| 9 A | 14 A | 25 A | B* | 98 V 71% | 111 V 63% | 125 V 55% |
| 12 A | 18 A | 32 A | B | 105 V 67% | 115 V 61% | 125 V 56% |
| 9 A | 14 A | 25 A | C* | 91 V 71% | 108 V 60% | 125 V 50% |
| 12 A | 18 A | 32 A | C* | 98 V 65% | 111 V 57% | 125 V 49% |
| 15 A | 23 A | 40 A | C | 105 V 63% | 115 V 58% | 125 V 53% |

*Wide input range for extended low-line "brown-out" capability.

*Power-One, Inc., 531 Dawson Dr., Camarillo, CA 93010. (805) 484-2806. See text.*

For the highest efficiency, coolest operation and highest power-density package in 5-V power supplies, you may think you've got but one choice: the switching-regulated supply. But not quite. Power-One's R Series gives you another option: linear, series-regulated sources with efficiencies up to 65% and output power densities to 0.54 W/in.$^3$.

By sticking with the linear design, you may avoid some of the problems possible with switchers—including EMI, poor reliability and relatively slow response to transients. Of course, these aren't necessarily found in all switching supplies. The better designed ones take care of these worries—but at a price.

The R Series probably won't head off the progress that switchers are making both in design and in market acceptance—especially above about 300 W—but it's nice to know that alternatives exist when it comes to selecting a supply.

Three models comprise the present R Series. The RD5-15 delivers 15 A to 50 C, while the RE5-23 and RG5-40 provide 23 A and 40 A respectively, also up to 50 C. All three supplies can be used to 70 C with linear derating to 40% output.

Important specs common to all models include line regulation of

±0.01% for a 10% change in input, load regulation of ±0.02% for a 50% load change (not no load to full load, as is commonly specified), and a maximum output ripple of 1.5 mV, pk-pk (0.4 mV rms). Tempco is listed as a maximum of ±0.01%/°C for all units.

Power-One has designed the R Series with a number of input taps so you can optimize the efficiency for the required output current level (see table). Or you can use the taps to stretch the input-voltage range for low-line (brownout) capability.

For example, with the 40-A unit, use tap "A" to get 40 A over an input range of 105 to 125 V ac. If you can live with less current, put the input line on tap "C," and 25 A will be delivered while the line varies from 91 to 125 V ac.

The size of Power-One open-frame supplies ranges from 9 × 4.87 × 3.2-in. for the 15-A unit, which weighs 7.5 lb., to 16.75 × 4.87 × 4.87 and 19 lb for the 40-A supply. Thus power densities average around 0.52 W/in.$^3$ and 10 W/lb.

At $79.95, the RD5-15 prices out at $1.07 per watt, while the $104 RE5-23 and the $176 RG5-40 come in at 90 cents and 88 cents a watt, respectively. Note that the prices are for quantities of 100.

High efficiency isn't all the R-Series offers. Output voltage is adjustable over a ±5% span. And three forms of protection are standard. Short-circuits and overloads are handled with automatic current limiting (foldback), and overvoltage protection is built in, with the trip point set at 6.2 V dc ±0.4 V. Finally, the output and pass elements are protected against reversed voltages.

Other key specs demonstrate that the company traded little of the linear design's advantages for efficiency. Transient response is 30 μs for a 50% change in load. Stability is specified at ±0.05% for 24 h after warmup. And remote sensing is standard.

All units are 100% tested for regulation, ripple protection and isolation resistance. The supplies are then burned in for 2 h and retested. Power-One's warranty runs two years for parts and labor. Delivery is four weeks.

CIRCLE NO. 301

POWER SOURCES

## Triple-output units deliver common levels

*ACDC Electronics, 401 Jones Rd., Oceanside, CA 92054. (714) 757-1880. $105 (10-24); stock.*

Triple-output power supplies intended for OEM computer peripheral applications provide a single voltage output for driving IC logic and a dual voltage output for driving op amps and a/d converters. These new supplies are available with voltage output of 5 V at 3 A/±12 V at 0.75 A and 5 V at 3 A/±15 V at 0.64 A. Overvoltage protection is built into the single output and is optional on the dual output. Regulation is 0.1%.

CIRCLE NO. 327

## Potted dc/dc converters deliver 6 W


*Intronics, 57 Chapel St., Newton, MA 02158. (617) 332-7350. $89; stock-2 wks.*

This series of dc/dc converters offers 200-mA output current at either ±12 or ±15 V in a compact 2 × 2 × 0.88 in. encapsulated module. Designed for powering various analog circuitry, the units have a line and load regulation of 0.01%. Added features include electrostatic shielding noise of only 1 mV rms, high efficiency, and typical input/output isolation of 1000 V dc. All models may be used with plug-in sockets or soldered directly onto PC boads. Input voltage options are 5, 12 and 28 V.

CIRCLE NO. 328

# New Old Faithful

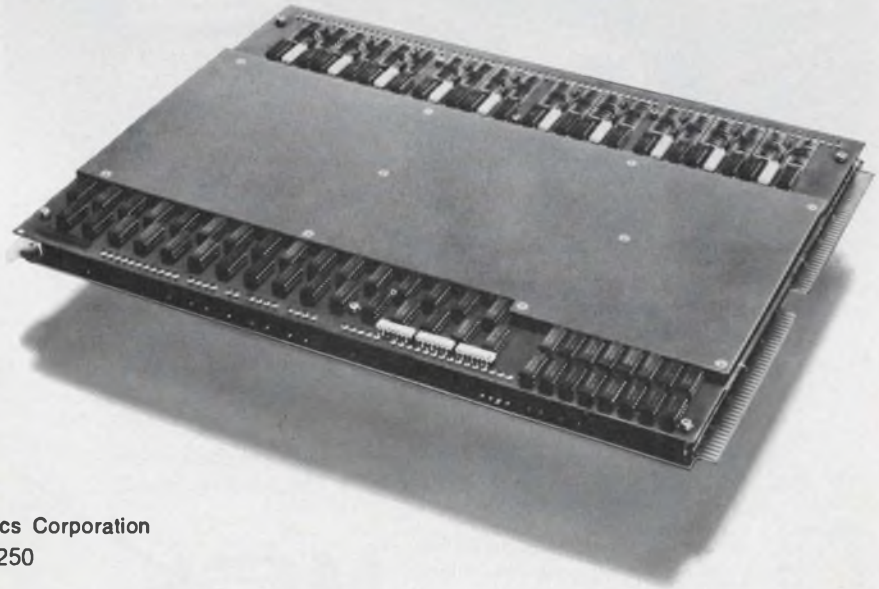
## MICROMEMORY 3000QD...32K x 20

Old Faithful. That's what you've been calling the whole MICRO-MEMORY 3000 family. Fast. Trouble-free. Dependable. Flexible — easy to build on or design around. Either core or NMOS.

Now we have a new Old Faithful to add to the line . . . the MICRO-MEMORY 3000QD. 32K x 16, 18, or 20 (alterable to 64K x 8, 9, or 10). A 3-wire, 3D core system with the same fast 300 nanosecond access. Same single card convenience. Same building block flexibility. Same day-in, day-out dependability. And it's form, fit, and functionally compatible with all core or NMOS MICRO-MEMORY 3000 systems.

Now more than ever MICRO-MEMORY 3000 makes an ideal transition between core and NMOS systems. You can design for all core, mix core and NMOS in the same chassis, or go completely NMOS — whatever suits your needs — without costly equipment modifications. You can build from an 8K single card memory up to high density mass storage (up to 512K in a single standard chassis).

Let us show you how MICRO-MEMORY 3000 can meet your memory needs whatever they are. Call or write your local EMM office today.



**EMM ELECTRONIC MEMORIES**
***COMMERCIAL MEMORY PRODUCTS***
A Division of Electronic Memories & Magnetics Corporation
12621 Chadron Ave., Hawthorne, Calif. 90250

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REPRESENTATIVES: Gentry Associates; Orlando (305) 894-4401, Huntsville (205) 534-9771, Burlington, N.C. (919) 227-3639. In Canada: Megatronix, Ltd.: Toronto (416) 742-8015, Montreal (514) 488-0404, Ottawa (613) 729-4004, Burnaby (604) 526-3312.

INFORMATION RETRIEVAL NUMBER 50

## Polyfunction operator handles positive inputs

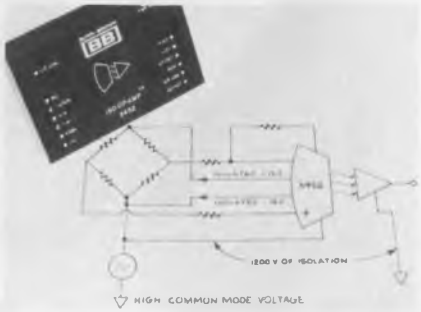
*Bell & Howell, 706 Bostwick Ave., Bridgeport, CT 06605. (203) 368-6751. $49 (100-up); stock to 4 wk.*

The Model 435 polyfunction analog operator performs first quadrant multiplication, division, exponentation, squaring and square root. When used with an external op amp it will generate the trig functions of sine, cosine and arc tangent. In the divider mode the denominator can span a 100:1 range and still meet the 0.25% accuracy spec. Output rating is 0 to 10 V at 0 to 5 mA. Supply voltages can range from ±12 to ±18 V dc at ±10-mA quiescent current. The 435 is designed to operate over the 0-to-70-C temp range and is housed in a hermetic 14-pin DIP.

CIRCLE NO. 329



## High isolation amplifier also supplies ±15 V




*Burr-Brown, International Airport Industrial Park, Tucson, AZ 85706. (602) 294-1431. $135; stock.*

The 3452 Iso op amp has an isolation voltage capability of ±1200 V dc and is tested at ±4800 V dc for 1 s. And, the 3452 has an isolated ±15 V dc, ±10 mA power source available at the input. The 3452 can be operated in the noninverting, inverting, or difference amplifier configuration. Designed for use with high-level voltage sources or low-level current sources, the amplifier has a FET input which provides a $10^{11}$ Ω input impedance, and a low bias current of −20 pA, max. Common-mode rejection is 90 dB at ±10 V, while isolation mode rejection is 160 dB, min. Input voltage drift is a respectable ±5 μV/°C, max., and gain nonlinearity is guaranteed at ±0.05%.

CIRCLE NO. 330

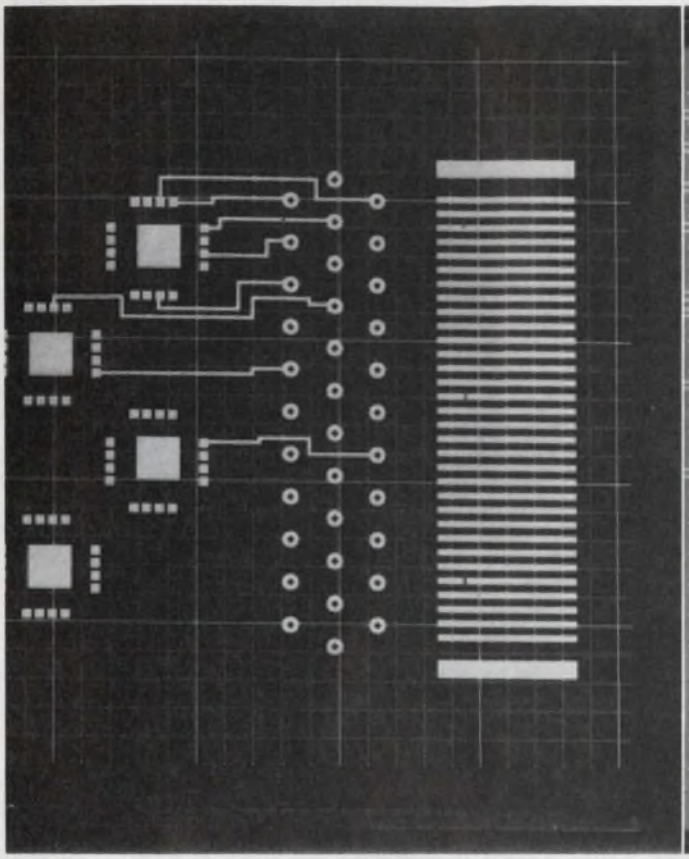
## Hybrid op amp boasts 100-MHz bandwidth


*M.S. Kennedy Corp., Packard Dr., Syracuse, NY 13211. (315) 455-7077. $38 (100-up); stock.*

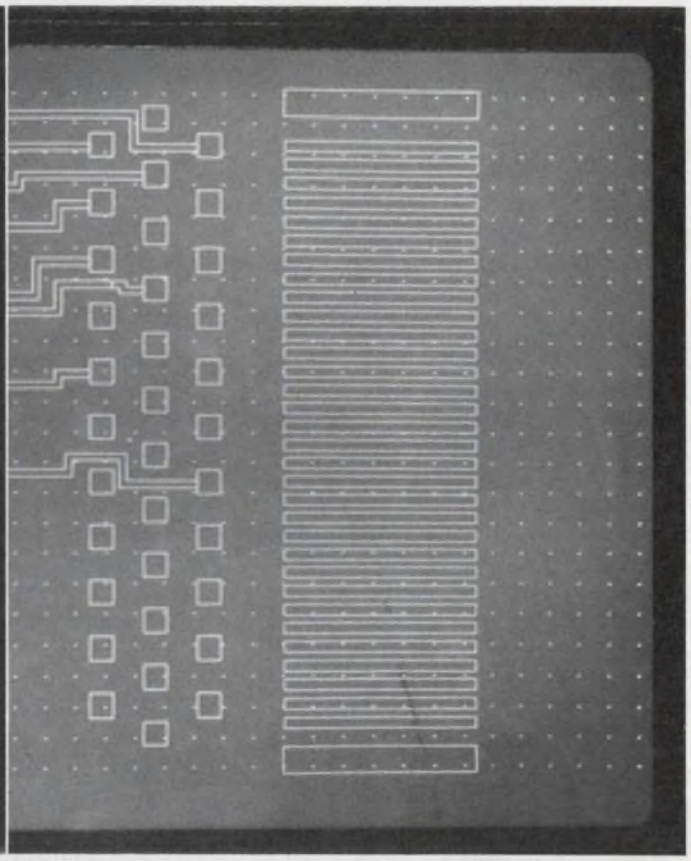
The Series 720 hybrid operational amplifiers have a 100-MHz unity gain bandwidth. Some of the amplifier's specs include: 10-MHz full power output when operated at ±10 V and 30 mA; 50-ns settling time to 1%, and 100 ns to 0.1%; 1000 V/μs slew rate; and a voltage gain of 10,000.

CIRCLE NO. 331

# Digivue®- a better way to look at it.



Unretouched time exposure of data displayed on a Digivue unit
Note high contrast picture, precise graphics.



Unretouched time exposure of same data displayed on a CRT.
Note lack of contrast in CRT image

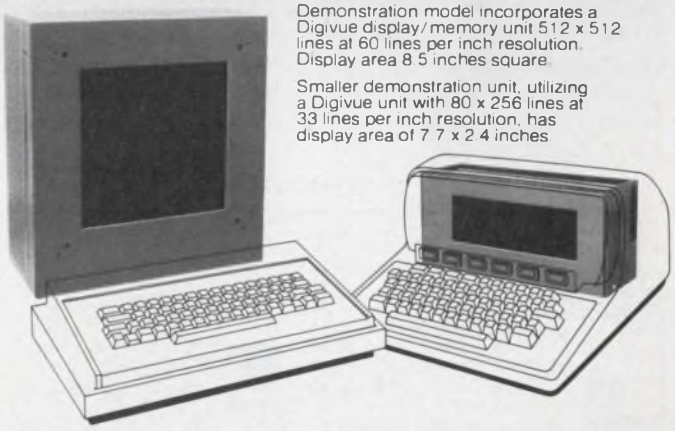
When your customers spend a lot of time looking at data displays and computer terminals, the advantages of Digivue plasma display units over CRT's become clear.

Very simply, Digivue display/memory units are better to look at. Digivue units present a flicker-free high contrast display for more precise readings and reduced chance of eye fatigue.

And Digivue units make it easier to use what's on the screen. Inherent memory is a feature of every unit. Digivue images appear on a thin, flat panel – which allows you to design compact components. The 512-60 models offer hard copy and rear projection capabilities, too. All of which gives *you* a product with more features to sell.

Sure, Digivue display/memory units currently cost more than CRT's. But they're worth a lot more to your customer, because they do a lot more.

For an informative booklet about Digivue display/memory units call (419) 242-6543, Ext. 66-415, or write Electro/Optical Display Business Operations, Owens-Illinois, Inc., P.O.Box 1035, Toledo, Ohio 43666



Demonstration model incorporates a Digivue display/memory unit 512 x 512 lines at 60 lines per inch resolution. Display area 8.5 inches square.

Smaller demonstration unit, utilizing a Digivue unit with 80 x 256 lines at 33 lines per inch resolution, has display area of 7.7 x 2.4 inches.

OWENS-ILLINOIS
Toledo, Ohio

INFORMATION RETRIEVAL NUMBER 52

## D/a converter system made from CRT displays

*Dynamic Measurements, 6 Lowell Ave., Winchester, MA 01890. (617) 729-7870. $375. (8 bits) to $495 (13 bits); 2 wks.*

A card-mounted, complete deglitched DAC system, the Digisweep, can draw 1600 full-scale vectors per second. It can do this with 12-bit resolution (under 0.005 in. steps on a 20-in. screen) with almost unnoticeable curvature or variations in intensity and line width. On the same size screen Digisweep can draw over 20,000, 0.25 in. high characters per second, or mix characters and vectors without tilt or displacement. Units are supplied with 8, 10, 12 and 13-bit resolution, and settling times to 0.01% of 150 ns or 350 ns. Individual temperature coefficients are specified for scale factor (±17 ppm), offset (±10 ppm), linearity (±3 ppm) and differential linearity (±3 ppm). Spikes or glitches coincident with changing the digital input word are both small (under 10 mV) and consistent, regardless of major carries or changes in polarity. The output is selectable up to ±10 V, and capable of driving 6 ft or RG58V cable. An optional line driver mounts on the card and can drive over 150 ft of cable. The standard Digisweep PC card, containing all necessary power filtering and adjustments as well as the system modules, measures 4.5 × 7.625 in.

CIRCLE NO. 332

## Waveform generator delivers 3 outputs


*Interdesign, 1255 Reamwood Ave., Sunnyvale, CA 94086. (408) 734-8666. $39 (unit qty.); stock.*

The 1511 waveform generator has a sine-wave distortion of only 0.3% maximum. The distortion remains low over an extreme sweep or programming range. The module has three independently buffered outputs for sine wave, triangle wave, and square wave. It can be operated from a single 15-V supply and draws less than 30 mA. The square-wave output is TTL, MOS and CMOS-compatible, and the unit operates over a −25 to +75 C range. The user only needs a single resistor to set or vary the frequency between 45 Hz and 45 kHz. The addition of a capacitor extends the frequency range to over eight decades, from 0.001 Hz to 200 kHz. No trimming of any kind is necessary. The frequency has a guaranteed temperature stability of 100 ppm/°C maximum and a supply voltage dependence of less than 0.1%/V. A sweep and FM input allows a change in frequency of greater than 1000:1 with a linearity of 0.2%. The module is housed in a 1.5 × 1.5 × 0.4 in. epoxy package with gold-plated pins on 200-mil centers.

CIRCLE NO. 333

## Instrumentation amp has zero suppression

*Incor, 144 Lamor St., West Babylon, NY 11703. (516) 643-7070. $295; stock.*

Model 300, dc instrumentation amplifier, has zero suppression, a high input impedance and a short circuit proof output with low impedance. Plus and minus stepped and variable input suppression allows input signals of up to 50 V to be bucked-out. Small signal excursions may be observed and amplified without overloading. Stepped and variable gains from 0 to 100 and an output of ±10 V at 100 mA are provided. Each amplifier contains a fused, regulated power supply. Up to 10 amplifiers may be mounted in a 3.5 in. high Model 103 rack adapter.

CIRCLE NO. 334

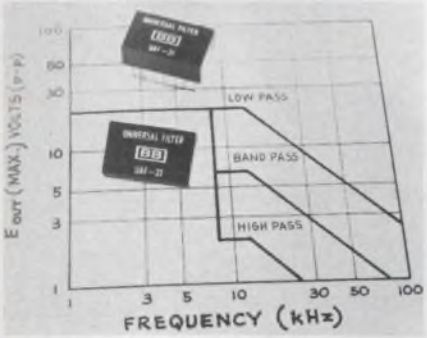
## DIP crystal oscillators available to 65 MHz

*MF Electronics, 118 E. 25 St., New York, NY 10010. (212) 674-5360. From $9 (large qty.).*

The 5406 series of DIP crystal oscillators is available with output frequencies from 4 to 65 MHz. The units are powered by +5 V and their outputs are Schottky TTL compatible with a fanout of 10. Rise and fall times are typically 2.5 ns while the symmetry is typically 52/48. These epoxy units will withstand humidity, temperature cycling and aging at 125 C for 168 hours. Unit height is 0.3 in. Guaranteed frequency accuracy is 0.005% from 0 to 65 C, or 0.0075% from −55 to +125 C.

CIRCLE NO. 335

## 2-pole filter spans 0.001 Hz to 25 kHz




*Burr-Brown, International Airport Industrial Park, Tucson, AZ 85734. (602) 294-1431. $13 (100-up); stock.*

The UAF31, a hybrid, universal active filter, has a resonant frequency range of 0.001 Hz to 25 kHz. Each UAF31 is a 2-pole active filter element. Only three, or at most four, external resistors are required to make a complete low pass, high pass, bandpass, or band reject active filter. The external resistors let the user easily control resonant frequency, Q-factor and gain. The resonant frequency temperature coefficient is a low ±35 ppm/°C and the resonant frequency accuracy is ±1%. The UAF31 is housed in a 14-pin single wide epoxy DIP that measures only 0.8 × 0.5 × 0.25 in. The Q range is 0.5 to 500 with Q stabilities from ±0.01%/°C to ±0.025%/°C, and the operating temperature range is −25 C to +85 C.

CIRCLE NO. 336

## Binary multiplier does 16 × 16 bit math

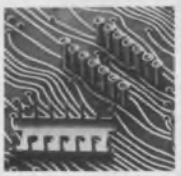
*Interface Engineering, 386 Lindelof Ave., Stoughton, MA 02072. (617) 344-7383. $270; stock to 45 day.*

The DD123 high performance 16 × 16 bit binary multiplier was developed for control system applications. The DD123 can relieve computers of time-consuming iterations such as scaling to and from engineering units, coordinate conversion, coordinate translation, etc. The multiplier has a 10 μs execution time, an 18-bit product output and is housed in a 3 × 4 × 0.4 in. module. You can also use it for division and square-rooting when the DD137 accessory unit is added.

CIRCLE NO. 337

# NEW FROM AUGAT.

**Lead socket carrier assembly.** Now it's easier than ever to put Augat machined-contact reliability into your PC board. Disposable carrier provides 6-40 pin IC patterns for fast, easy insertion into boards. Permits maximum density, visibility for soldering and inspection, and increased air circulation. Available now from your Augat distributor.



**AUGAT**®

Augat Inc., 33 Perry Avenue, P.O. Box 779, Attleboro, Massachusetts 02703

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Title

Company

Address

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INFORMATION RETRIEVAL NUMBER 56

# No down-time in rotary switches

**Unique 5-second wafer replacement obsoletes other switches. Simply lift out old wafer, slip in new wafer. No unsoldering . . . no disassembling . . . no wire removing.**

CDI patented switches with dust covers are available in sizes 2" x 2", 3" x 3", and 4" x 4" with lengths to accommodate up to 36 wafers. Switches can be customized to your specifications.

Operation may be manual, motor or solenoid for use in any rotary selector switch application. Now supplied for numerous military and commercial applications.

Mfd. under Tabet U. S. Patents 2,841,660, 2,971,066, 3,015,000, 2,956,131, 2,988,607.

**CHICAGO DYNAMIC INDUSTRIES, INC.**

C·D·I PRECISION PRODUCTS DIVISION

1725 Diversey Blvd., Chicago, Ill. 60614. Phone 312, WE 5-4600

INFORMATION RETRIEVAL NUMBER 58

# Reliable DC transient protection you don't have to design and build.

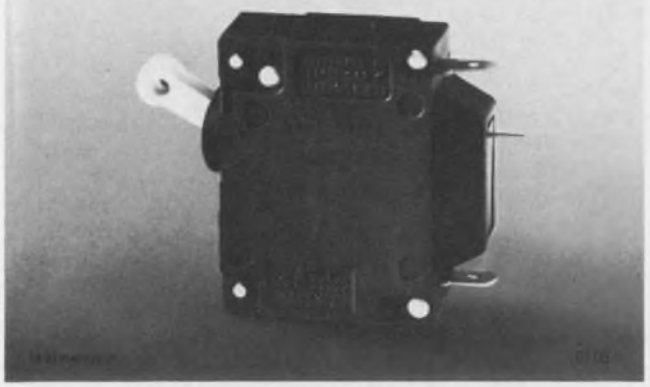
**Protect your power supplies and other semiconductor equipment from sudden death with an economical Heinemann JA/Q® combination voltage-transient/overcurrent protector.**

**The JA/Q gives you nanosecond response to voltage transients that could destroy a transistor or an entire IC chip. Lower-level sustained overvoltages are simply absorbed by our suppressor network, while the bigger spikes are diverted before they ever reach the protected circuits.**

**Write for Bulletin 3372, which tells you not only about the JA/Q but about our wide range of DC and AC overvoltage and brownout protectors. Heinemann Electric Company, Trenton, NJ 08602.**

**HEINEMANN**

We keep you out of trouble.



INFORMATION RETRIEVAL NUMBER 57

WASTING **STOP** MONEY

ON WIRE BONDING OR MINIATURE COMPONENTS

## USE FLIP CHIPS

FLIP CHIPS ARE AVAILABLE
FLIP CHIPS ARE ECONOMICAL
FLIP CHIPS CONNECT THEMSELVES

FOR YOUR SEMICONDUCTOR NEEDS CONTACT:

MICRO COMPONENTS CORPORATION
99 BALD HILL ROAD
CRANSTON, RHODE ISLAND 02920
TEL 401-463-6000
TWX 710-381-1757

INFORMATION RETRIEVAL NUMBER 59

## Storage scope weighs only 10.5 lb

*Tektronix, P.O. Box 500, Beaverton, OR 97005. (503) 644-0161. $1995 with probes; stock.*

At 10.5 lbs., the new 314 portable storage oscilloscope is said to weigh less than any available dual-channel storage scope with a 10-MHz bandwidth. Bistable storage with 4-h viewing time, dual channels, and 10 MHz bw with 1 mV/div sensitivity are all combined in this instrument, designed for rugged environments. The CRT of the 314 is a direct-view bistable device with an internal graticule and an 8 × 10-div display area (0.25 in/div). An auto erase capability allows the user to view changes in the slow-moving phenomena. Erase cycle time can be varied from 1 to 5 s. An enhanced writing rate allows the capture of fast transients. Low-rep-rate signals are intensified by integration.

CIRCLE NO. 338

## Dual-limit comparator fits standard panel size

*Newport Labs, 630 E. Young St., Santa Ana, CA 92705. (714) 540-4686. $175; stock-2 wks.*

Series 870 single and dual-limit digital data comparators are panel-mounted instruments that provide instantaneous warning or feedback signals whenever high or low preset limits are exceeded. Both single and dual-limit devices are housed in a high-impact Lexan case, which fits the standard 42.7 × 99.6 mm panel cutout. The units can be used with any DPM or other device having IC-compatible outputs in a parallel BCD or binary (octal) format. A front-panel LED indicator and a logic-level output announce within 500 ns of when the preset limits are exceeded.

CIRCLE NO. 339

## Counter/timer features remote programming

*Fluke, P.O. Box 1094, Station D, Buffalo, NY 14210. (716) 842-0311. $845.*

Model 1953A is a universal counter/timer with provision for full remote programming. The instrument, designed for both bench and systems applications, measures frequency, ratio, period(s), time interval and gated totals, with a frequency range of dc to 125 MHz at sensitivities to 30 mV. The 1953A has a 9-digit LED display with full leading-zero suppression, automatic annunciation and overflow. Preset and variable trigger level controls with status indicators, and slope, coupling and attenuation switches are provided for each of two direct-coupled input channels.

CIRCLE NO. 340

## 520-MHz sig gen locks to 0.2 ppm/h

*Wavetek Indiana, 66 N. 1st Ave., Beech Grove, IN 46107. (317) 783-3221. $1975; 60 days.*

Model 3000 phase-locked 1-to-520-MHz signal generator offers built-in AM/FM capability. The frequency of the single-range instrument can be digitally set to an over-all accuracy of ±0.001% with a resolution of 1 kHz. In addition, it has a phase-lock stability of 0.2 ppm/h. Output power is monitored on a front-panel meter calibrated in both dBm and volts rms. A 15-position 10-dB step attenuator used in conjunction with an 11-dB vernier provides the user with a range of ±13 to −137 dBm. The calibrated output is leveled to within ±0.75 dB across the complete frequency range.

CIRCLE NO. 341

DISCRETE SEMICONDUCTORS

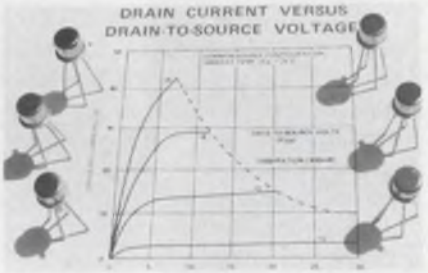
## Power Darlington units have gain of 1000

*RCA, Route 202, Somerville, NJ 08876. (201) 722-3200. From $1.50 (100-up); stock.*

Three 10-A pnp Darlington transistors, the RCA 8203, RCA 8203A, and RCA 8203B, are monolithic silicon pnp complements of the JEDEC 2N6386, 2N6387 and 2N6388. They have $V_{CBO}$ ratings from −40 to −80 V, power dissipations of 60 W and a gain of 1000 at 5 A. The transistors are designed for low and medium-frequency power applications and are supplied in the JEDEC TO-220AB, straight lead version of the Versawatt plastic package.

CIRCLE NO. 342

## D-MOS FETs designed for communications gear




*Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. (408) 739-7700. $0.70 (100-up).*

Two dual-gate D-MOS FET transistors, the SD306 and SD305, are intended for vhf front-end applications. The SD306 has typical power gain of 20 dB at 200 MHz and a noise figure of 2.8 dB. The 1% cross-modulation distortion performance is superior to bipolar or conventional dual-gate MOSFET devices since 480 mV of interfering signal can be applied at gate 1 before 1% distortion is observed. The SD305 was designed specifically for mixer applications and conversion gain is typically 17 dB at 200 MHz. When the rf signal and oscillator signal are fed into separate gate terminals, but with both gates biased to the same dc potential, there is 20 dB of isolation between gate 2 and gate 1 at 200 MHz. Both the SD305 and SD306 have a wide AGC range—about 50 dB at 200 MHz.

CIRCLE NO. 343

# shigoto cables and cord sets

. . . we go to any lengths.
. . . we go to any ends.

That's why Shigoto can help make your ends meet. From hundreds of standard combinations to unusual characteristics that meet your own requirements. Even U.L. and C.S.A. approved. Our volume production for O.E.M.'s in electronics, communications, automotive, appliances, and practically every other industry, takes all the variables out of price-performance differences. Shigoto's ability to consistently produce top quality assemblies, when combined with large quantities, always brings in the prices you need. Unmatched quality has become our standard, our reliability and delivery schedules will become yours. Call, write, or wire your specs. At Shigoto, you'll find we'll go to any ends, to any lengths, to satisfy you.

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INFORMATION RETRIEVAL NUMBER 62

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INFORMATION RETRIEVAL NUMBER 63

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INFORMATION RETRIEVAL NUMBER 64

## Introducing the Revolutionary

# PowerDIP™ AC & DC SOLID-STATE RELAYS*


- **OPERATES FROM TTL, DTL... EVEN CMOS**
- **SWITCHES UP TO 4 AMPS WITHOUT HEAT SINKS**
- **"LOCKOUT" FEATURE PREVENTS FALSE TRIGGERING BY TRANSIENT PULSES**
- **OCCUPIES ONLY ¼ CUBIC INCH**

At Theta-J, we decided it was about time someone started designing useful relays at a price you could afford. So we put together a group with considerable know-how in power semiconductors, circuit design and volume production methods.

Result? Pretty startling, especially for those who thought solid-state would never compete with mechanical. Or even come close.

Here's a quick idea of what we mean:

**STANDARD MODELS (partial listing)**
7 mA maximum control current*

| Model | Control Voltage | Output Voltage | Output Current |
|---|---|---|---|
| MA-1201 | 4 - 8 VDC | 90 - 140 VAC | .75 A |
| MB-1201 | 9 - 15 VDC | 90 - 140 VAC | .75 A |
| MD-1201 | 90 - 140 VAC | 90 - 140 VAC | .75 A |
| MA-1202 | 4 - 8 VDC | 90 - 140 VAC | 2.0 A |
| MA-0602 | 4 - 8 VDC | 60 VDC | 2.0 A |
| MB-0602 | 9 - 15 VDC | 60 VDC | 2.0 A |
| MA-0604 | 4 - 8 VDC | 60 VDC | 4.0 A |

* Add "S" suffix to Model Number for 500 microampere Control Sensitivity

If you have a difficult switching problem, please tell us about it... we can probably help. For complete information call or write us today: Theta-J Relays, Inc., 2 Linden Street, Reading, Massachusetts 01867 (617) 942-0390.

* Patent applied for

**THETA-J RELAYS, INC.**

INFORMATION RETRIEVAL NUMBER 65

## Interface makes timing generator programmable

*Interface Technology, 627 Fremont Ave., South Pasadena, CA 91030. (213) 682-3705. $2495; 3 wks.*

The Computer Interface Option (CIO) enables the RS-648 Timing Simulator/Word Generator to be programmed and controlled by an external, local or remote device. The CIO is designed for interfacing with any computer in general use today. It allows full remote, hands-off programming of the RS-648. Data transmission is one way signal; levels are TTL with one unit load. Among the interface lines are 16 data, eight address and four function.

CIRCLE NO. 344

## Serial 165 char/s printers use LSI

*Centronics Data Computer Corp., 1 Wall St., Hudson, NH 03051. (603) 883-0111. 301: $2275; 501: $3315.*

Models 301 and 501 are serial LSI impact printers that operate at 165 char/s. The 301 prints an 80-column line at 70 line/min; the 501 prints a 132-column line at 50 line/min. A 5 × 7 or 9 × 7 dot-matrix character pattern is used, and the printers produce five clear copies. Serial interface is optional; a parallel interface is standard.

CIRCLE NO. 345

## Mount neatly stacks flat cable

*Panduit Corp., 17301 Ridgeland Ave., Tinley Park, IL 60477. (312) 532-1800.*

New flat-cable mounts can secure stacked cables, folds and break-outs and still retain the inherently uniform transmission characteristics of flat cable. Pan-Ty intermediate cross-section cable ties are used. They can accommodate cable stacks to 5-1/4-in. high. The mount is all nylon and the base can be screw-mounted or affixed with commercial adhesive. Three sizes are available in widths to 3-in. maximum.

CIRCLE NO. 346

## Prepackaged insulators speed assembly

*Thermalloy, Inc., P.O. Box 34829, 2021 W. Valley View Lane, Dallas, TX 75234. (214) 243-4321.*

Insul-Cote is a combination of insulators and Thermalcote grease for clean, convenient use on assembly lines. Thermalfilm or other insulator material, uniformly coated with Thermalcote, is heat-sealed between two strips of paper tape. The operator peels back the tape, lifts the precoated insulator with tweezers and puts the insulator in place. Prepackaged insulators are available for TO-3, TO-5, TO-18, TO-66 cans or plastic packages, as well as for stud-mounted rectifier applications.

CIRCLE NO. 347

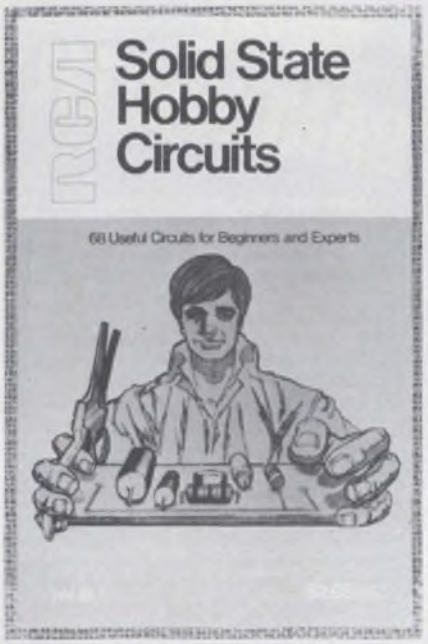
## Tool cuts and flattens component wire ends

*Micro Electronic Systems Inc., 8 Kevin Dr., Danbury, CT 06810. (203) 746-2525. $23.50 (unit qty); 30 days.*

A new Belzer hand tool, Model 2658TQ, cuts component leads and flattens them at the same time to prevent the component from falling out of a PC board if turned over. The tool measures 5-in. in length and weighs only 90 g. It can cut copper wire 1.5-mm in diameter and piano wire 1-mm in diameter.

CIRCLE NO. 348

# New Literature




## Hobby circuits manual

An updated 400-page edition of the Solid State Hobby Circuits Manual presents 68 practical and useful solid-state circuits plus substantial operation and construction information. Copies may be ordered for $2.95 each from RCA Solid State Div., Box 3200, Somerville, NJ 08876

INQUIRE DIRECT

## Magnetometers

The theory of operation of vibrating sample magnetometers and primary advantages of using magnetometers for magnetic characterization studies in diverse environmental conditions are covered in an eight-page catalog. Princeton Applied Research, Princeton, NJ

CIRCLE NO. 349

## Microprocessor manual

A 714-page manual describes the operation and applications of Motorola's M6800 family of microcomputer building blocks. The manual covers topics from system organization to system design and development. The manual costs $25. Motorola, Semiconductor Products Div., P.O. Box 20924, Phoenix, AZ 85036

INQUIRE DIRECT

## Power supplies, regulators

Two volumes—power supplies and voltage regulators—cover the company's products. Vol. 1 is a 136-page book subdivided into three major areas: standard and custom power supplies and power instruments. Vol. 2 is a 48-page book that details voltage regulators. Lambda Electronics, Melville, NY

CIRCLE NO. 350

## Atomic frequency standards

Miniaturized atomic frequency standards, LF/VLF receiver and digital clock are combined for a precise time and frequency system. Principles of operation and performance data are described in a brochure. Efratom California, Costa Mesa, CA

CIRCLE NO. 351

## I/O connectors

Several series of precision-engineered wrap/crimp or DIP solder/crimp I/O connectors and IC socket contacts are covered in a 12-page guide. U.S. Components, Bronx, NY

CIRCLE NO. 352

## Rotating components

Ten classes of electrical rotating components are detailed in a 136-page catalog. Performance data and characteristic curves are given, as well as dimensional and circuit diagrams. Eastern Air Devices, Electro Audio Dynamics, Dover, NH

CIRCLE NO. 353

## Electronic hardware

Solder terminals, chassis hardware, contact pins and sockets and handles are featured in a 42-page handbook. Positronic Industries, Electronic Hardware Div., Springfield, MO

CIRCLE NO. 354

## Calculators

A calculator catalog provides details on the company's Models 21 and 31 programmable calculators, plus the interfaces and peripherals available. Tektronix, Beaverton, OR

CIRCLE NO. 355

## Amps and generators

TWT amplifiers, rf signal generators and frequency synthesizers are featured in a four-page catalog. LogiMetrics, Plainview, NY

CIRCLE NO. 356

## Brass, bronze, copper

An 80-page "Brass, Bronze, Copper" catalog is indexed according to metal form. A special data section gives information on how to calculate weights of forms, gauge numbers and millimeter equivalents and more. T. E. Conklin Brass & Copper, New York, NY

CIRCLE NO. 357

## Metals, alloys, ceramics

128 pages describe over 1000 materials for R&D and thin-film production. Applications, conversion charts and methods of deposition are included. Materials Research, Orangeburg, NY

CIRCLE NO. 358

## Glass fabrics and tapes

A six-page foldout guide describes Teflon-coated glass fabric and tape properties, capabilities and specifications. Chemical Fabrics, Bennington, VT

CIRCLE NO. 359

## Packaging system

An "erector set" packaging system for the Standard Electronic Module Program (SEM) is illustrated in a 17-page pamphlet. IERC, Burbank, CA

CIRCLE NO. 360

## Switches

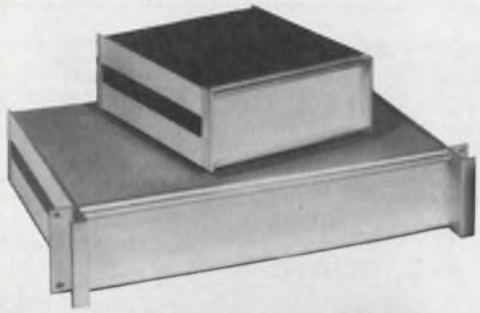
Subminiature and microminiature switches are featured in a 24-page catalog. C&K Components, Watertown, MA

CIRCLE NO. 361

## Cabinets and enclosures

Separate, detailed sections on electronic cabinets and enclosures, engineering drawings and prices are given in a six-page brochure. Zero Manufacturing, Burbank, CA

CIRCLE NO. 362



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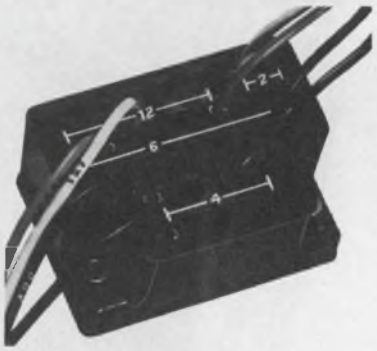

There's an Underwriters Terminal Block for virtually any design requirement you have or can conceive.

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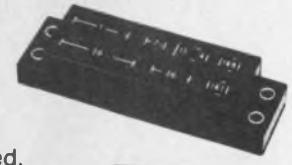


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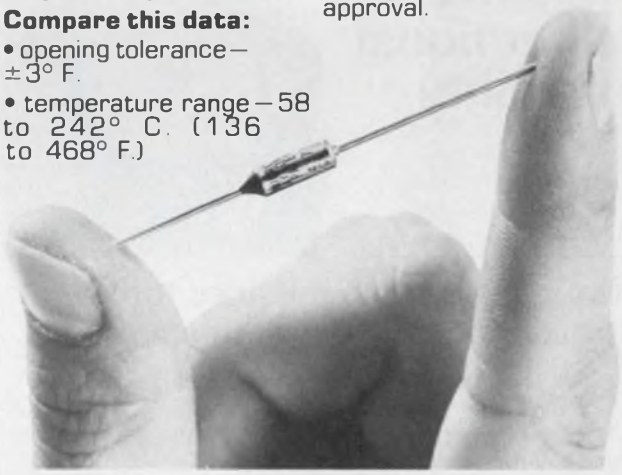

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## MICRO DEVICES CORP.

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INFORMATION RETRIEVAL NUMBER 72

# Application Notes


## Liquid-crystal displays

Fundamentals of liquid-crystal displays, what they are, how they work and types available (dynamic scattering and field effect) are covered in an application note. Hamlin, Lake Mills, WI

CIRCLE NO. 363

## Spectroscopy

A report on coherent anti-stokes Raman spectroscopy (CARS) discusses the process and shows several practical results obtained with this technique. Molectron, Sunnyvale, CA

CIRCLE NO. 364

## EMI shielding

How to make the correct choice and apply conductive coatings to effectively protect against electromagnetic interference are covered in a six-page publication. Acheson Colloids, Port Huron, MI

CIRCLE NO. 365

## Impatt diodes

Four factors that contribute to failures in operation of silicon double-drift Impatt diodes are discussed in a bulletin. The four-page bulletin describes problems caused by fabrication defects, excessive junction temperature, bias circuit related burnout and tuning induced burnout. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 366

# Bulletin Board

**Applied Materials** has increased prices on the **IN-SOURCE 1500 vacuum evaporation system** and on all of its options. The base price for the system will be $9000, compared with the present $7800.

CIRCLE NO. 367

**Phone-Mate** has been licensed by AT&T to manufacture the Bell System's **"Authorized Protective Connecting Module"** for connection of Phone-Mate automatic telephone answerers to the Bell System telephone network.

CIRCLE NO. 368

**Litronix** has announced an improvement in the current transfer ratio of the **IL-12 phototransistor opto-isolator.** The guaranteed minimum CTR has been increased from 2 to 10% and typical CTR is 20%. The price has been reduced from $0.89 to $0.69 (1000).

CIRCLE NO. 369

**Hybrid Systems** has introduced the **Model ADC-12QZ,** a pin-for-pin, plug-in replacement for existing versions of the popular 12-bit Analog Devices Model ADC-12QZ a/d converter.

CIRCLE NO. 370

**Sensitron Semiconductor Div.** has added the JAN and JAN TX 1N3643 through and including JAN and JAN TX 1N3647 **silicon rectifiers** to its qualified products.

CIRCLE NO. 371

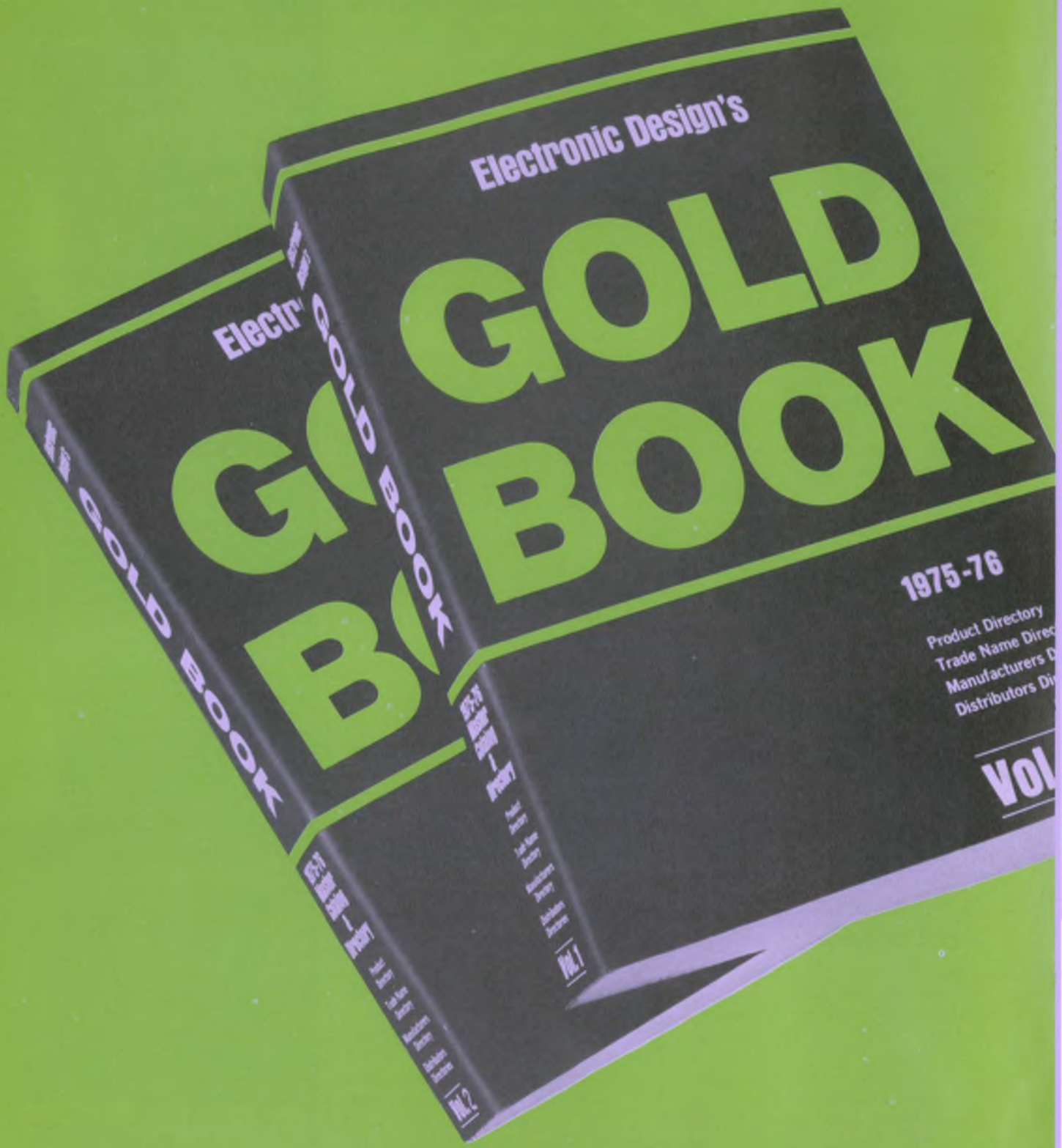
Twenty general-purpose completely self-contained **digital-to-analog converter modules** have been announced by **Phoenix Data.**

CIRCLE NO. 372

**Harris Corp. Computer Systems Div.** has announced price increases on its **computer systems product line.** A typical 48 kbyte system will increase by 8%, a 192 kbyte system by 6% and a 288 kbyte system by 4%.

CIRCLE NO. 373

# NOW OFF THE PRESS!

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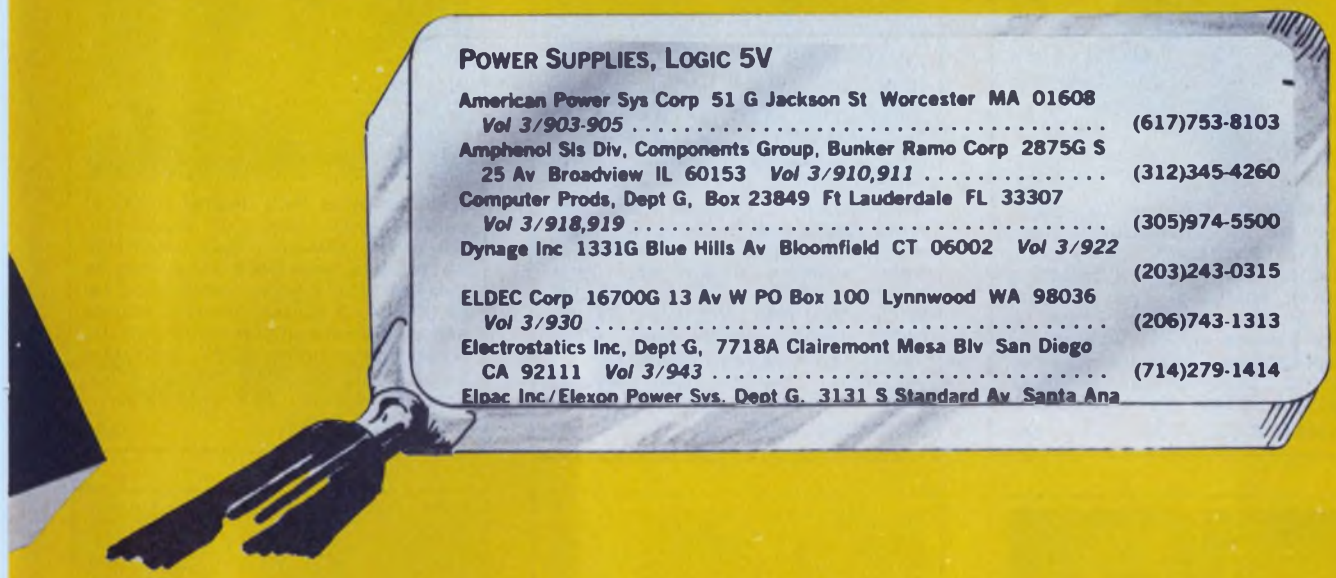


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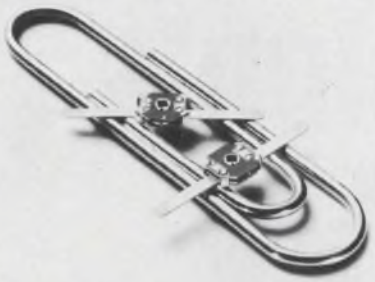
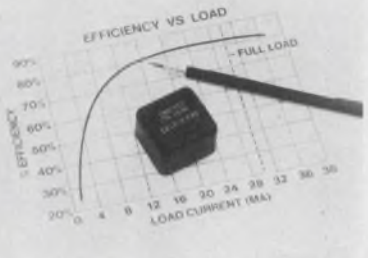


**Thin-Trim variable capacitors** provide a reliable means of adjusting capacitance without abrasive trimming or interchange of fixed capacitors. Series 9401 has high Q's and a range of capacitance values from 0.2-0.6 pf to 3.0-12.0 pf and 250 WVDC working voltage. Johanson Manufacturing Corporation, Boonton, New Jersey (201) 334-2676.

THIN-TRIM CAPACITORS **601**

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Computer Conversions Corp., East Northport, N.Y. 11731 (516) 261-3300."

SYNCHRO TO DIGITAL **607**

**New Transistor Catalog:** Crystalonic's new 40 pg catalog offers junction FETs, Fotofets™, and bipolar transistors, with low level switching integrated choppers. The semiconductor pioneer details 52 high reliability devices with a wide range of applications. Teledyne Crystalonics, Inc., 147 Sherman St., Cambridge, MA 02140. (617) 491-1670.

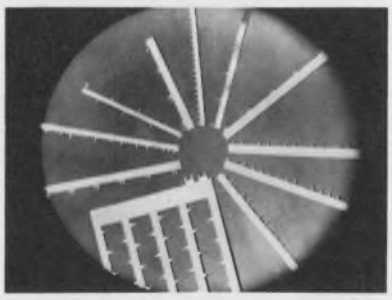
TRANSISTOR CALATOG **602**

**Introduction To Defense Radar Systems Engineering.** Excellent introduction and practical reference to radar systems design and applications. #9194, 260 pp., $22.95. Circle the Info Retrieval No. to order 15-day exam copy. When billed, remit or return book with no obligation. Hayden Book Co. 50 Essex St. Rochelle Park, N.J. 07662

RADAR SYSTEMS **605**

**Logic analyzer with display** works in parallel synchronous or asynchronous mode; pattern trigger selectable up to 8 bits' generated trigger can be delayed after pattern recognition up to 999 clock pulses; input is stored and displayed coincidentally with delayed trigger pulse. $265. Computel Engrg & Mfg Co. 2848 Charter, #207 Troy, MI 48084 (313) 524-2284.

LOGIC ANALYZER **608**



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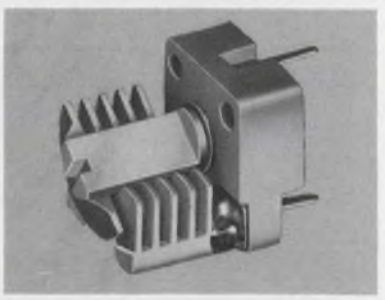
MINI BUS **603**



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POWER SUPPLY **609**

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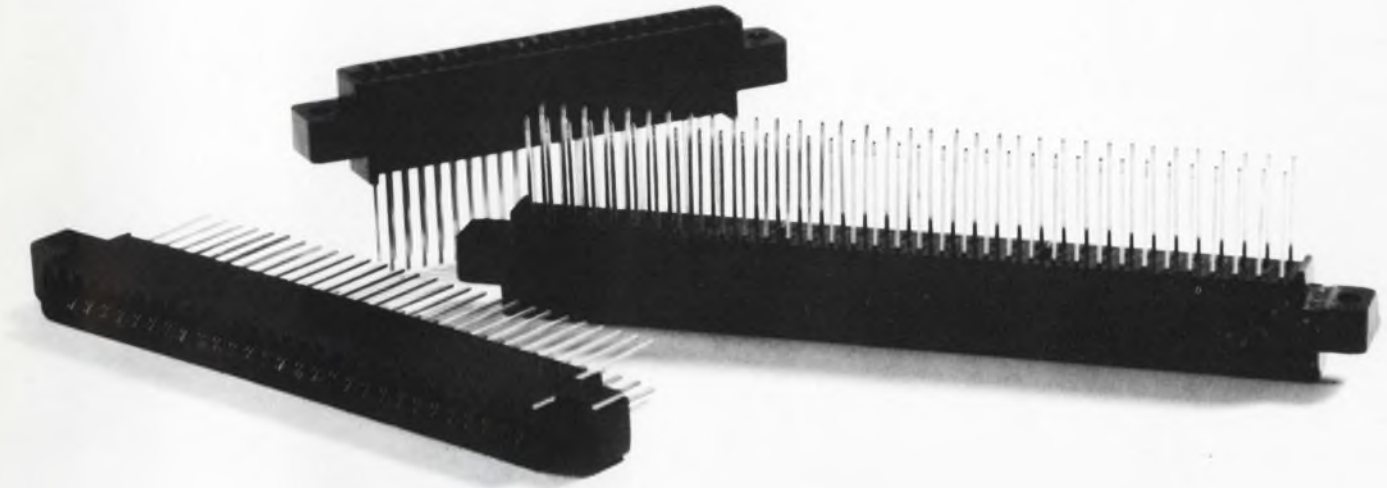

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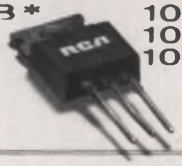



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