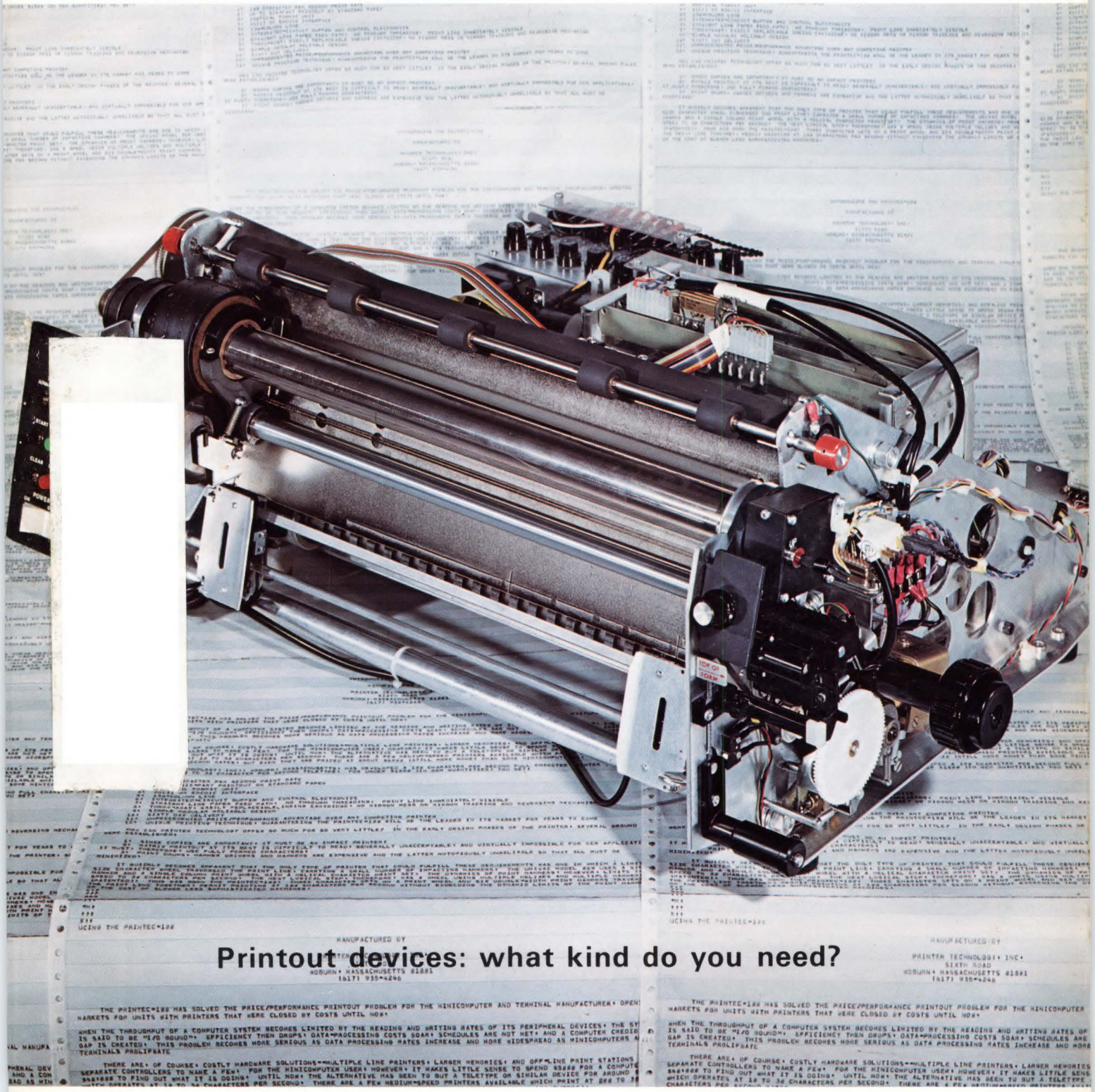
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

EDN

Two-color and ac LED lamps available in two-lead packages

Film resistor specs: all you wanted to know



Printout devices: what kind do you need?

A CAHNERS PUBLICATION

DECEMBER 1, 1972

power supplies for op-amps...$14

These 2.3 x 1.8 x 1-inch modules have tracking outputs of ±15V with regulation of ±0.1% and ripple of 1 mv. The Model D15-03 (25 ma outputs) costs $14.00 in 1000 lots and only $24.00 for one. The Model D15-05 (50 ma outputs) is $39.00. For ±12V, the model numbers are D12-03 and D12-05. Same prices. Three-day shipment guaranteed.

Acopian

Acopian Corp., Easton, Pa. 18042
Telephone: (215) 258-5441

CHECK NO. 1

If you think that one line of variable vacuum capacitors is just about the same as the next- you're right...

...except for three things.

1. *Amperex uses short duty cycle LONG LIFE BELLOWS—practically doubles the cycle-life of the capacitor.*
2. *Amperex SHOCK SUPPRESSING BRACE permits capacitor to withstand shock level of 150 G's at a pulse width of 11 milliseconds.*
3. *Amperex can supply EVERY CAPACITOR IN ITS LINE with a CERAMIC envelope, increasing the capacitor's temperature-handling range from 85°C to 125°C.*

Outside of longer cycle life, greater ability to withstand shock, and increased temperature-handling capacity, Amperex variable vacuum capacitors are probably no better and no worse than the competition's. They are competitively-priced and directly interchangeable with existing types, both electrically and physically. They are tested to exceed MIL standard 23183B specifications. And every capacitor shown in the Amperex catalog with a glass envelope is available on request in a ceramic version.

Application assistance on new or existing designs is available. For data, including complete replacement guide with prices, write: Amperex Electronic Corporation, Professional Tube Division, Hicksville, N.Y. 11802.

Amperex®

TOMORROW'S THINKING IN TODAY'S PRODUCTS

Sold through
North American Philips Electronic Component Corporation

CHECK NO. 4

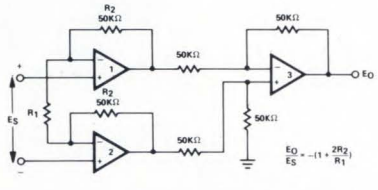
Here's a versatile new IC for
portable or battery-powered instrumentation

150 μWatts powers Triple Op Amp

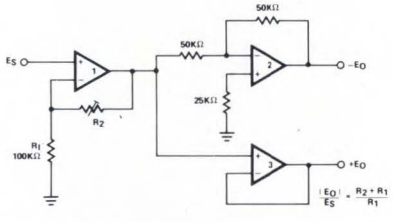
The Siliconix L144 is a *low-power* monolithic IC with three complete op amps and a common bias network on the same substrate. The circuit operates over a power supply range of ±1.5 to ±15 V, with a supply current set by an external bias resistor. With a ±1.5 V battery, only 50 μA is required for all three op amps!

Other features:

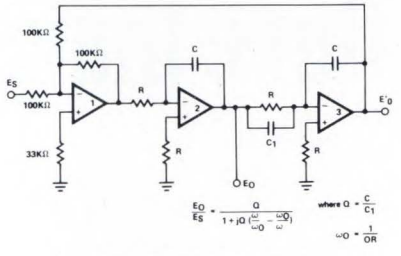
- Internal compensation provides stable operation for any feedback circuit—including capacitive loads >1000 pF
- 80 dB gain with 20KΩ load
- Typical slew rate 0.4 V/μsec
- Military or commercial versions available



Instrumentation amplifier for high input impedance with differential operation.



Precision phase splitter with good gain, high input impedance, low output impedance.



Active filter with high Q and excellent stability.

Applications? Above are three suggestions. There are more: Low-drift sample-and-hold, inverting amplifiers, voltage comparators, and so on. Call us if you have a specific design problem.

write for data

Applications Engineering: (408) 246-8905

Siliconix incorporated

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CHECK NO. 37

CHECK NO. 5 ▶

Cinch Dura-Con 0.050″ centers Small. Dependable. Available.

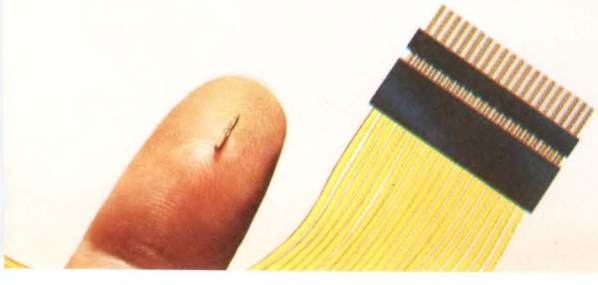
Now you have an effective source for your micro-miniature connector needs. Cinch can produce and deliver these rugged reliable connectors on a timely basis, with size 24 contacts on 0.050″ centers.

These connectors utilize the proven pin-socket contact system, where the pin, made from a precision spring cable, is the spring member. The seven cable strands are fused in a hemispherical weld, resulting in a strong flexible shock and vibration resistant contact with assured alignment and no discontinuities.

The Dura-Con pin is available in five sizes of Dura-Con D-configurations as well as single row strip configurations. It can also be supplied in custom insulators.

The size 24 contacts with 0.050″ centers are supplied factory terminated, with pigtail or wire leads. Size 22 contacts, on 0.075″ and 0.100″ centers, are crimp removable.

Cinch Dura-Con Micro-Miniature Connectors are described in Bulletin PBC-174, available free on request from Cinch Connectors, an Operation of TRW Inc. Electronic Components, 1501 Morse Avenue, Elk Grove Village, Illinois 60007. CM-7203



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CINCH CONNECTORS

14,000,000 CORDIP™ component networks can save you 12 olympic swimming pools, 8 tennis courts, and a polo field of board space.

Get out your slide rule and prove us right or wrong.

All you need to know is that CORDIP component networks are only one-quarter square inch each. And they can save you approximately 50% over discretes in size and space.

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Think about it.

For additional information on our Corning CORDIP component networks, check your EEM catalog. Or write the Electronic Products Division of Corning Glass Works, Corning, N.Y. 14830 for our technical brochure.

CORNING
ELECTRONICS

CHECK NO. 6

DECEMBER 1, 1972
VOLUME 17, NUMBER 23

EDN with EEE
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

The assortment of computer printout devices has increased rapidly in the last few years to match varying requirements. For a rundown on the types available, see special report starting on pg. 20. (Photo from Printer Technology)

DESIGN NEWS

DESIGN FEATURES

PROGRESS IN PRODUCTS

DESIGN PRODUCTS

DESIGN DEPARTMENTS

 EDN/EEE (formerly Electrical Design News) is published semi-monthly. Editorial, Advertising offices, 221 Columbus Ave., Boston, Mass. 02116 (617) 536-7780. Subscription offices, 270 St. Paul St., Denver, Colo. 80206 (303) 388-4511. Printed at 85 W. Harrison St., Chicago, Ill. 60605. Controlled circulation postage paid at Chicago, Ill. Send form 3579 to Subscription office. EDN/EEE is circulated to electronic design engineers and engineering managers in electronic OEM industries. Plants having more than twenty employees and manufacturing electronically operated or controlled equipment of their own design are considered part of this industry. Engineers in such plants responsible for specification of components, materials and test equipment for electronic application may receive EDN/EEE without charge. Completed qualification form and company letterhead required. Subscriptions to others in continental United States, $2 per copy. $20 per year. Send requests for qualification forms and changes of address to subscription office in Denver, Colo.

Everybody wants your components business.

But we're doing 6 things to earn it.

1 Extra reliability. We build extra reliability into our components to let you build extra reliability into your systems.

We offer documented reliability from ER through industrial, from precision through general purpose.

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3 Faster delivery. Our distributors can give you off-the-shelf delivery from an inventory of over 50,000,000 components. And our "ball parks" are firm, real and reliable. This lets you keep expediting and inventory levels to a minimum.

4 Production savings. Our unique product configurations greatly simplify both hand insertion and automatic insertion operations. This saves you money. And our QC is so stringent, many of our customers have totally eliminated their incoming QC testing of our parts. This saves them money.

5 Product innovations. Like our new CORDIP™ Component Networks. With up to 23 discrete resistors/capacitors/diodes in a miniature, pre-tested, plug-in package to save you time, money, and a whole lot of board space.

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We too want your business. But we're doing 6 extra things to earn it.

Give us a chance to prove it. Write: Corning Glass Works, Electronic Products Division, Corning, New York 14830. Or call: (607) 962-4444, Extension 8381.

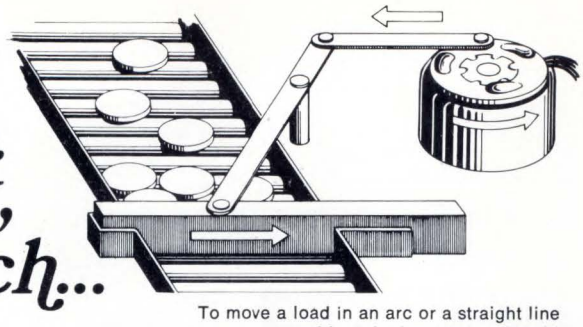
CORNING
ELECTRONICS

Resistors & Capacitors

for guys who can't stand failures

CHECK NO. 7

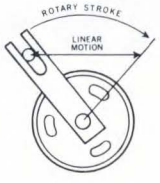
snap, lock, index, punch...

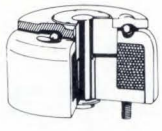


To move a load in an arc or a straight line
. . . consider a Ledex rotary solenoid

A Ledex rotary solenoid gives you a down-hill solution to an up-hill problem.

The force of an electromagnet is inversely proportional to the square of the distance between the pole faces. Most solenoids live with this problem, which means less force in the beginning, where you need it, and wasted energy at the end, where you don't need it.





The Ledex rotary solenoid starts off working where the force is really at, about .030" between the pole faces. Then the armature rides a helical ramp, to distribute the force over the stroke you need. It gives you efficient, direct rotary action and uniform linear movement.

The Ledex rotary solenoid delivers a lot of power for its size. That's because it works in the tiny area where magnetic attraction is highest. It's efficient because it spreads this high concentration of energy over a longer useful stroke.

For rotary or linear positioning it's hard to beat its simplicity and high output. Choose from a family of eight models, with strokes from 20° to 95° and torque to 117 pound-inches. For a quick prototype, there are over 250 shelf models. Then, for a custom snap / lock / index / punch solution, you just talk to our positioning technology people.

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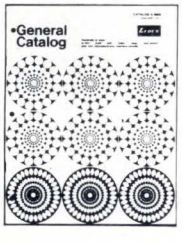
POSITIONING · SWITCHING · MICROELECTRONICS



Over 400 ways to turn . . . push . . . pull . . . index . . . step . . . and switch, plus new microelectronic interface circuits. All from the shelf.
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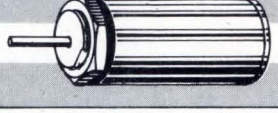
new things keep happening at Ledex

. . . push solenoids

Push action quick, with three new Ledex shelf model solenoids.

PUSH

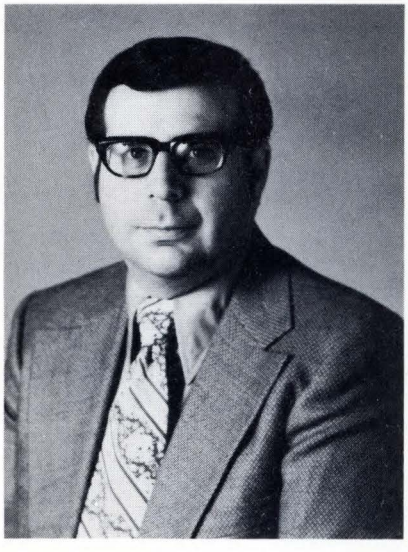


	1/2" dia x 1"	3/4" dia x 1 1/2"	1" dia x 2"
force, .050" stroke	15 ounces	3 pounds	7 pounds
force, .750" stroke	———	0.6 pounds	2 pounds
weight	24 grams	3 ounces	6 ounces

Standard features:

1—Electroless nickel plated plungers, for smooth performance
2—Built-in impact cushions, for pole face protection
3—Flatted bushings, for positive alignment and ease of assembly

CHECK NO. 8



What is the future for EEs?

The field of electronics is beginning to boom again.

Company profits are up. Spending is increasing, both for R&D activities and modernization. Electronics is expanding into new and previously untapped fields that have potential beyond belief. The demand for engineers has increased by more than 50% this year and is at its highest level in three years. Predictions of future shortages of engineers are once more being heard. Both political parties acknowledged the plight of large numbers of engineers and pledged support in their platforms. The IEEE has started to act more like a true professional organization than just a large publishing house and convention organizer.

Things couldn't be better. Right? Wrong!

If we're not careful, we will still operate just like an underdamped circuit, with all the oscillations we know so well. It's not a simple case of supply and demand.

When the glamor of electronics began to fade just prior to this recent depression, undergraduate enrollment started to drop. As jobs faded, this drop in enrollment accelerated and graduate enrollment decreased. Now engineering schools are beginning to close their doors. This may cut down on the competition for jobs for a while, but it also cuts out a lot of basic research and a source for education. How many EEs who received their Bachelor's degrees 15 years ago knew anything about transistors when they started working? Not too many. They learned through on-the-job training, trade publications such as EDN and graduate courses. What about ICs and computers?

We know what to do to keep an amplifier from oscillation. What about our own profession? What's to prevent a recurrence of the recessions of 1969-72, 1966, 1962, 1957-58, etc? What's to prevent us from becoming obsolete? Are unions the answer? A stronger IEEE with lobbying clout and control over the education of EEs à la the American Medical Association? What do you think is the answer? And more important, are you willing to do something about it?

Steven A. Erenburg

Steven A. Erenburg
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CHECK NO. 40 ▸

This is no time for popcorn noise...

In fact, no time is acceptable for Popcorn (burst) noise, if you're designing a system to handle extremely small signals.

So RCA is announcing a new micropower, low noise operational amplifier. It's a designer's dream.

Our unique process gives you a monolithic silicon op amp that not only exhibits low burst noise but operates from a single 1.5-volt cell with a power consumption of 1.5 microwatts.

How low is the noise? Every CA6078AT op amp that leaves RCA must operate with equivalent input burst noise less than 20uV (peak) at $R_S = 200{,}000$ ohms.

That's not all, the CA6078AT features output short-circuit protection through built-in output resistors, input voltage range ($\pm$ 15V max. for $\pm$ 15V supply) wide dif-mode range ($\pm$ 6V), and low offset-voltage nulling capability.

So go ahead! Design the CA6078AT into your system...and relax. Because you can be certain that with the new RCA micropower op amp, no time is acceptable for popcorn (burst) noise.

Want more data on the CA6078AT or CA3078AT (the low cost version of the CA6078AT for less critical applications) or the CA6741T, RCA's low-burst-noise 741? See your RCA Representative or Distributor and ask for Technical Bulletins, File No. 530 and 592 and Application Note ICAN-6732. Or write RCA Solid State, Box 3200, Somerville, N.J. 08876. Phone (201) 722-3200.

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CHECK NO. 40

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. . . the people with the drive to solve your fhp problems

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BODINE MOTORS/GEARMOTORS
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CHECK NO. 10

CHECK NO. 11

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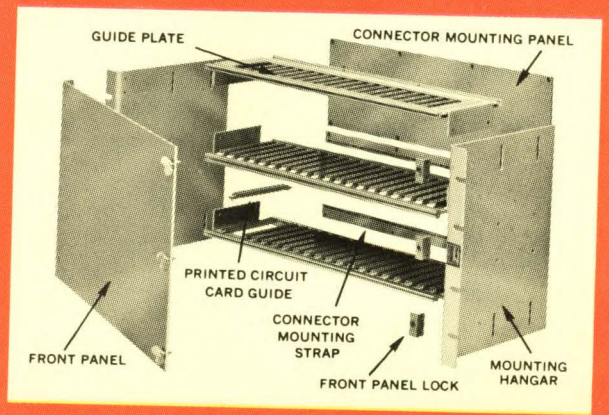
Low cost. Easily assembled.

Varipak® II. The modular printed circuit card enclosure system. Elco's trick to help you beat problems caused by high density card packaging. Like space limitations. Component overheating. And overall systems design.

Use Varipak II to pack up to 82 cards and connectors in a row. Even with cards this tight, we've made sure you'll get plenty of air flow between them. To keep components cooler, working longer. For convenience, we mount connectors on the back panel. Makes it easy to cross wire and check out. And Varipak's modular construction lets you design around your needs. Not the limitations of your enclosure. So even special packaging adaptations require little or no tooling costs.

The Varipak II system is available in 32 standard models. In an almost infinite variety of configurations. You'll find it useful in large logic storage cabinets, as pull-out computer drawers, and even as the framework for small instrument panels. Construction is rugged aluminum. And the system will take all the hard knocks you can give it. While protecting delicate components inside. Where can you get it? From any authorized Elco distributor. He'll put it together for you. To put you ahead of the system. And keep you there. Another service in keeping with CONNECTRONICS, Elco's Total Connector Capability.



For full details on the Varipak II system from Elco, contact your local Elco representative or distributor, or:

Elco, Willow Grove Division
Willow Grove, Pa. 19090
(215) 659-7000

Elco, Pacific Division
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United States factories are trailing Japan and Germany in applying minis

U.S. manufacturers are already one year late in parlaying the steadily falling minicomputer prices into increased U.S. productivity according to top executive at mini-maker General Automation, Inc., of Anaheim, CA. There is some part of every factory in the U.S. with 25 or more workers that could benefit from a minicomputer system, the views by G. A. President Lawrence Goshorn indicate, yet U.S. manufacturers are not moving as fast as Japan or Germany.

The Japanese government has decreed that 19 of the major industries be automated, and West Germany is giving subsidies to encourage its factory owners to automate, G. A. Executive Vice President Raymond Noorda said.

Noorda presented the G. A. views in a paper at Quantum Science Corp.'s recent seminar on factory automation, and Goshorn elaborated on these in a telephone conversation with EDN.

Right now is the time for any country that hopes to remain competitive in the world market to automate, Goshorn said. Minicomputers will become so cheap that by 1978-1982 we will have a $1000 worth of basic mini hardware in a $4000 mini system. Then using industry's own rules of 1% investment per annual throughput and 2-year payback of investment, it will be feasible to tackle portions of a factory line with throughputs as small as a half-million dollars a year. At this grass-roots level we will be able to make realistic progress, Goshorn said.

Goshorn's own $25-million-a-year company is an example of how minicomputers can raise the productivity per employee. We do about $40-$45k per year per employee, Goshorn said. We think the reason we are so much higher than the actual 20k or so rate is that we use 50 of our own minicomputers. We expect that in the next couple of years we'll design in even more of our computers and raise our productivity per employee to $60-$80k.

He backed up his reasoning with the chart shown here that he whimsically calls "The Gross National Momentum." The chart recaps what has happened in the minicomputer technology over the past 11 years and predicts what will happen in the next 9. It shows how faster logic and memories have increased computing throughput while the batch processing techniques of integrated circuits and PC boards have lowered costs. Goshorn says that the only revisions he'd make in this chart would be to favor MOS memories over bipolar memories in the 74-78 time frame and to include details on a whole new set of low performance all — MOS minicomputers.

The resulting increase in performance/price index shown at the bottom of the chart is quite striking. In the past 11 years minicomputers have improved 100 fold. It predicts that the improvement will be 20,000 fold in the next 9 years.

G. A. predicts in this chart that by 1982 minicomputers will be sold as a maintenance-free system. The customer's mini will actually consist of three redundant minis that self-check each other and use majority logic to adap-

GROSS NATIONAL MOMENTUM

Year	1958	1966	1970	1974	1978	1982
LOGIC	15 COMPONENTS/GATE DISCRETE COMPONENTS RTL DTL 2 MHz	8 GATES/INTEGRATED CIRCUIT COMPONENT INTEGRATED CIRCUITS DTL TTL 5 MHz	25 GATES/INTEGRATED CIRCUIT COMPONENT TTL 20 MHz	100 GATES/INTEGRATED CIRCUIT COMPONENT SCHOTTKY-TTL-(ECL?) 80 MHz	400 GATES/INTEGRATED CIRCUIT COMPONENT ? 200 MHz	
MEMORIES	50 – 100 MIL CORE 10μS R/W	4 WIRE 3D 25 MIL CORE 2μS R/W	3 WIRE 2½D 18 MIL CORE 1μS R/W	SOLID-STATE BI-POLAR (MOS) 300 NANO-SEC. R/W	SOLID-STATE 50-100 NANO-SEC. R/W	
PACKAGING	10 GATES/PCB WIRE WRAP INTERCONNECT SINGLE SIDE ETCH	20IC/PCB WIRE WRAP INTERCONNECT DOUBLE SIDE ETCH MECHANICAL FEED THROUGH	50-100IC/PCB MOTHER BOARD ETCHED INTERCONNECT DOUBLE SIDE ETCH PLATED THROUGH HOLES	50IC/PCB 2 BOARD SYSTEM MULTILAYER BOARDS DISTRIBUTED INTERNAL POWER 2 SIDED SIGNALS	30IC/PCB 1 BOARD SYSTEM MULTILAYER SIGNALS DISTRIBUTED INTERNAL POWER	
MTBF-HRS RELIABILITY – MAINTAINABILITY	600 MAN TROUBLESHOOTS TO GATE ∿ FIX OR REPLACE BOARD ∿ 400 BOARD COMPUTER	5,000 MAN TROUBLESHOOTS TO BOARD LEVEL ∿ REPLACE BOARD ∿ 50 BOARD COMPUTER	15,000 COMPUTER TROUBLESHOOTS MAN REPLACES BOARD 10-BOARD SYSTEM	45,000 SELF CHECKING COMPUTER SWITCHES TO A REDUNDANT SYSTEM ∿ MAN REPLACES SYSTEM	100,000 SELF CHECKING COMPUTER SWITCHES TO REDUNDANT SYSTEM ∿ NEVER REPLACE SYSTEM ∿ 3 SYSTEMS IN PARALLEL	
SYSTEM ARCHITECTURE	SMALL CORE, SMALL BULK, FEW PERIPHERALS FOR PROGRAM GENRATION	LARGE CORE, LARGE BULK ROTATING MEMORY, LARGER PERIPHERALS FOR PROGRAM GENERATION	LARGE CORE, MASSIVE ROTATING STORAGE FOR ADDITIONAL DATA, PROGRAM GENERATION ELSEWHERE	ALL SOLID STATE MEMORY; CASSETTE, DISC, DRUM, BACKUP ∿ COMMUNICATIONS WITH HIGHER LEVEL MACHINES ∿	ALL SOLID-STATE (NO PERIPHERALS) COMMUNICATIONS TO NEXT HIGHER LEVEL FOR LARGER AMOUNTS OF DATA ∿	
COMPUTER ARCHITECTURE	SINGLE OR TWO REGISTER WITH APPROX. 30 INSTRUCTIONS	MULTI-ACCUMULATOR (2), MULTI-INDEX REGISTER (2), APPROXIMATELY 300 INSTRUCTIONS	MULTI-ACCUMULATOR (4) & MULTI-REGISTER 94) MACHINES ∿ MULTIPLE SETS OF REGISTERS ∿ FAIL-SAFE DETECTION & AUTO-RESTART CAPABILITY BUILT-IN ∿	SAME, PLUS COMPLETE SUB-ROUTINES FOR DOING WORK IN HARDWARE	SAME, PLUS HARDWARE WHICH EXECUTES HIGHER LEVEL LANGUAGES DIRECTLY	
CAPABILITY VS. COST	80 UNITS/SEC $80,000	400 UNITS/SEC $25,000	1,000 UNITS/SEC $10,000	3,500 UNITS/SEC $3,000	20,000 UNITS/SEC $1,000	
PERFORMANCE PRICE INDEX UNITS/SECOND/$1,000	1	16	100	1,200	20,000	

tively self-heal itself by switching around any failed components.

These 1982 minis will not have any electro-mechanical peripherals to be weak links. They will be all solid state and will communicate to higher levels (central computers or files) whenever they need mass memory beyond the capabilities of their solid state memories. They will be designed to execute higher-order languages directly. This will enable the worker to control and program them in his own trade language.

These predicted technology trends will have their effect upon the relative apportionment of the costs in the system, as shown in a second chart—"Dedicated Computer System Cost Distribution." The cost of the hardware for the computer itself will decrease to just 25% of the total. The peripherals will decrease to a mere 5% of the total (because all the failure-prone electro-mechanical elements will either be replaced by solid state or removed to some central location where they will be time-shared among a number of these dedicated systems). The portion of the system that will grow most will be the interfaces that match the minisystem to the factory machinery and communicate with the worker. These will become much more important in factory automation applications for the mini itself and represent a new market for designer talents. The cost of the application and installation engineering will remain the same 30% as at present, according to General Automation. — *BC* □

New method tests CATV coax cable shield effectiveness quickly and accurately

A comparative testing technique that permits accurate measurements to be made of the shielding effectiveness of CATV service drop coaxial cables has been developed by the Technical Research Center of Belden Corp.

Called SEED for Shielding Effectiveness Evaluation Device, the technique is said to be convenient, fast, and offers high repeatability of test results — an essential characteristic in making valid cable shielding comparisons which has been lacking in previous evaluation methods.

It is expected that the new test technique will be a significant aid to CATV systems operators in selecting optimum cable configurations on a cost/effectiveness basis and will further the development of improved cable designs.

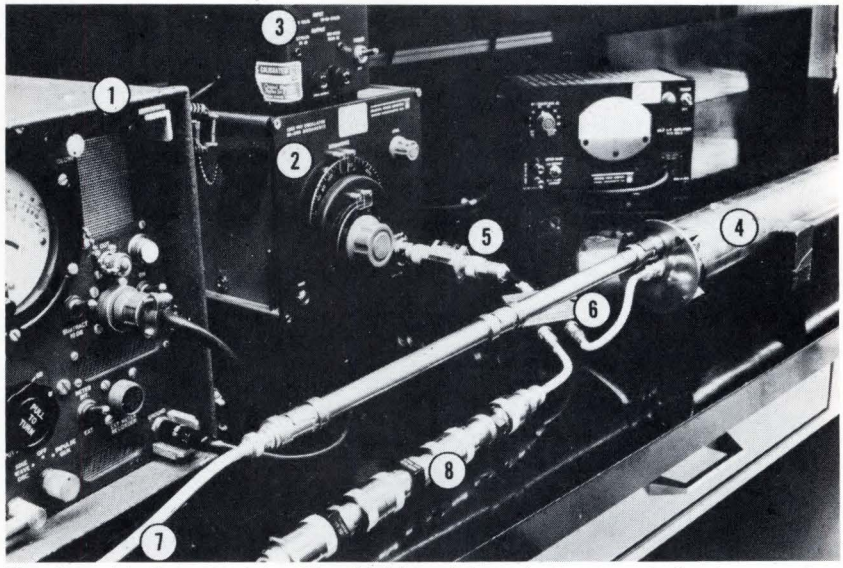

Fig. 1 — Testing coaxial cable shield effectiveness quickly, conveniently and to a high-degree of repeatability is made possible by SEED, a new testing technique that makes comparative cable measurements. The technique makes use of the test apparatus shown above consisting of: **1.** a tuned rf voltmeter, **2.** a vhf oscillator, **3.** oscillator power supply, **4.** the test fixture which is the heart of the new technique, **5.** a 50-to-75Ω balun, **6.** a splitter, **7.** coaxial cable under test and **8.** fixed attenuator pads.

Shielding on CATV drop cables is necessary to contain the transmitted signal — and thereby prevent radiation that might interfere with other signals in nearby cables or system components — as well as to protect the signal from degradation due to external interference.

Test data obtained with the new technique are stated in terms of the difference between signal levels impressed on and radiated by a sample cable length. Limited pilot tests confirm that measurements are repeatable within 1 to 2 dB from test to test and from like cable to like cable over the entire 5- to 270-MHz spectrum of interest in the CATV industry.

Test results with all previous methods commonly varied as much as 20 dB. Further, results are repeatable in normal ambients, as well as under controlled laboratory conditions.

According to Belden, previous tests commonly required long, cumbersome cable samples that were significantly influenced by ambient electronic noise, location of measuring equipment, installation of connectors, sample position and other factors. Wide swings in data from test to test and from sample to sample were simply unavoidable.

How it works

Heart of the method is a 5 ft. long fixture, consisting of two concentric solid copper tubes which actually form a length of rigid coaxial cable (see **Fig. 1**). The sizes of the copper tubes, 1 in. in dia. for the inner conductor and 2½ in. for the outer conductor, were chosen to produce a characteristic impedance of 50Ω in order to match Belden's laboratory equipment. One end of the fixture is terminated in 50Ω, and both ends are capped to deal out ambient noise.

The test fixture serves as a pick-up device for radiation emanating from a 3 ft. long length of sample cable that is centered within the inner tube and powered with a reference test signal. The advantage of such a fixture is that the entire signal radiated by the sample cable is absorbed by the fixture.

As a result, the method is much more sensitive than older techniques. With the earlier methods, most of the radiated signal was lost because the sample being tested, and the pick-up, were generally oriented parallel to one another rather than concentrically. Further, the fact that the fixture is itself a coaxial cable helps to block out the ambient noise.

Because the signal radiated from the sample cable and picked up by the fixture is relatively strong and clear, minor variations in cable placement, length, connections, fixture materials and other factors have no significant effect on test repeatability.

How a test is made

A 3 ft. length of cable is carefully measured with a rule, cut, and fitted with connectors at both ends. Crimp-type BNC connectors are used to provide the highest termination consistency from sample to sample.

One end of the cable is then terminated in its characteristic impedance, and the other end connected to a lead from a signal generator. The sample is inserted into a split plastic tube slightly larger than the cable's dia., and the assembly is in turn inserted into the inner copper tube conductor of the test fixture. The plastic tube which prevents the cable sample from sagging is centered in the copper tube by means of plastic disc spacers.

Both the cable sample and signal-strength measuring instrument are simultaneously powered by a signal generator through a hybrid splitter, and signal strength is noted to establish a reference level. The measuring instrument is then disconnected from the signal generator and connected to the test fixture to measure the strength of the signal radiated by the sample cable within.

The difference between the reference and fixture readings, expressed in dB of signal strength, indicates the effectiveness of the cable shield under test. This difference will typically range from about 40 to over 100 dB for RG59/U type drop cables, depending upon shield configuration. The higher the dB value, the more effective the shield.

Shield curve

The simplest way to make a shield effectiveness evaluation is to use a conventional oscillator for the signal generator and a tuned rf voltmeter or field-strength meter for the measuring instrument. With this equipment, a series of tests are performed at selected frequency intervals and a plot made of differential dB vs frequency.

Typically, about 25 separate tests, taking about two hours, are required to plot a valid curve from 5- to 270-MHz for one cable sample. Using a spectrum analyzer, however, the entire evaluation can be reduced to a few minutes, with the output being an oscilloscope trace of the curve. At present, the new SEED technique provides comparative data between similar cable types.

Upgrades selection

Currently, most CATV operators determine drop cable shielding requirements empirically — if a shield configuration proves inadequate in a particular locale, cables of progressively superior effectiveness are substituted until the problem appears to be corrected. This is time-consuming and expensive.

The new test technique is claimed to provide operators with far more exact and reliable rankings of relative drop cable shielding effectiveness than have been available previously. It also is expected to help develop more sophisticated methods of analyzing the entire problem of undesirable signal pickup and radiation in CATV systems. As a result, it will be possible to match cable shielding more closely with CATV system requirements at the planning stages.

Belden expects that the SEED method will ultimately become a reference standard for specifying coaxial cable shield configurations which will be particularly important for 2-way systems.

One reason is that in dual cable systems, the downstream and upstream cables will be close in proximity to one another, increasing the possibility of cross-talk. Another is that 2-way systems will most likely utilize the 5- to 35-MHz range, a spectrum that contains several HAM frequency bands that are potential sources of interference. — *RA* □

Neither rain nor fog stops this CO_2 laser: at a 10.6 micron wavelength, it reaches 5 miles

Laser communications systems are gaining tremendous importance due to their long-range capabilities, high energy densities and their ability to carry large bands of information on a single beam. However, they have one limitation which has been difficult to solve — laser beams cannot operate effectively over long distances through rain or fog.

Now comes a laser communications system from Hughes Aircraft Co., operating at a 10.6-micron wave-length, that can provide a wideband communications channel over a 5-mile path, even in the presence of moderate rain or fog.

The experimental system consists of a transmitting and a receiving station. The transmitter uses a sealed-off air cooled CO_2 laser, with frequency modulation provided by an intracavity crystal of cadmium telluride. The receiver uses optical heterodyne detection with a mercury cadmium telluride detector cooled with liquid nitrogen contained in a dewar.

Disclosure of the new laser system was made in a paper given recently at the International Telemetry Conference in Los Angeles by Frank E. Goodwin, who is in charge of optical communications research at Hughes Research Laboratories, Malibu, CA.

Although designed primarily for terrestrial communications, the system also offers potential application in space, Goodwin said. The high power and efficiency of the CO_2 laser and the sensitivity of optical heterodyne detection are the key factors in providing its operating capability, he noted.

According to Goodwin, 10.6-micron radiation penetrates fog and haze better than visible light, so this system will operate in all but the most severe weather conditions. For example, a rainfall of greater than 20 millimeters/hour over the entire 5-mile path would be required to block the transmission.

Power output of the laser is 1W, and the system provides a single communication channel using a 5-Mbit/sec frequency shift keying digital format. Goodwin said that a data rate of greater than 300 Mbits is possible with design modifications, and that the system has the potential of easily handling 10 TV channels.

Use of cadmium telluride, instead of the previously-used gallium arsenide, in the modulator portion of the transmitter has reportedly raised transmitter oscillator efficiency to nearly 10%. Other factors affecting the performance of the system are the increased reliability of the CO_2 laser which now has a 5000-hour life, and the use of a liquid-nitrogen dewar capable of 3-day unattended operation.

The high efficiency and relative ease of aiming the transmitter, as well as the feasibility of using a radiation cooler in place of the dewar for refrigerating the detector, is said to give the system a high potential for use in satellite-to-satellite communications.

RA □

Multi-color CRT phosphor is applied in single coat

A multi-color phosphor which can be applied to cathode ray tubes in a single coat has been announced by General Electric's Cleveland-based Chemical Products Section.

The new phosphor operates in beam penetration CRTs used for high resolution color display. Using a single coating of phosphor, as in monochrome CRTs, eliminates the costly coating operations required in multi-layer construction and provides greater resolution and brightness.

The new GE phosphor responds in red at a low voltage of 5 kV ranges through orange and yellow as voltage is increased, and peaks in green in 10 kV. The phosphor is made so that the green will not be visible at the lower voltage but will become visible gradually as voltage increases.

By modulating the anode voltage CRTs coated with the new phosphor can provide a variety of different signals. The colors can be programmed to differentiate inputs, flag the approach of critical limits, mark relative position, or identify change in conditions.

The single coating provides a uniform coverage from the edges across the face of the tube, eliminating fringe areas. Information can be displayed at high resolution on a maximum screen area. The new phosphor has a medium short decay.

Applications for CRTs with multicolor phosphors include stock market quotation units, medical monitoring units, teaching machines, high resolution computer readouts, and tracking displays such as those used to control air traffic. An example of the latter would be programming the CRT to display all scheduled aircraft in yellow, all unscheduled aircraft in orange, changes which bring two aircraft into the same altitude in red, and background data in green. — *BF* □

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Dielectric Materials & Systems Division 3M COMPANY

Easy to apply, Scotch Brand Shielding Tapes end the need for plating, painting or other expensive shielding methods. Can be applied in the factory or in the field and permit easy on-the-spot shielding repairs.

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CHECK NO. 12

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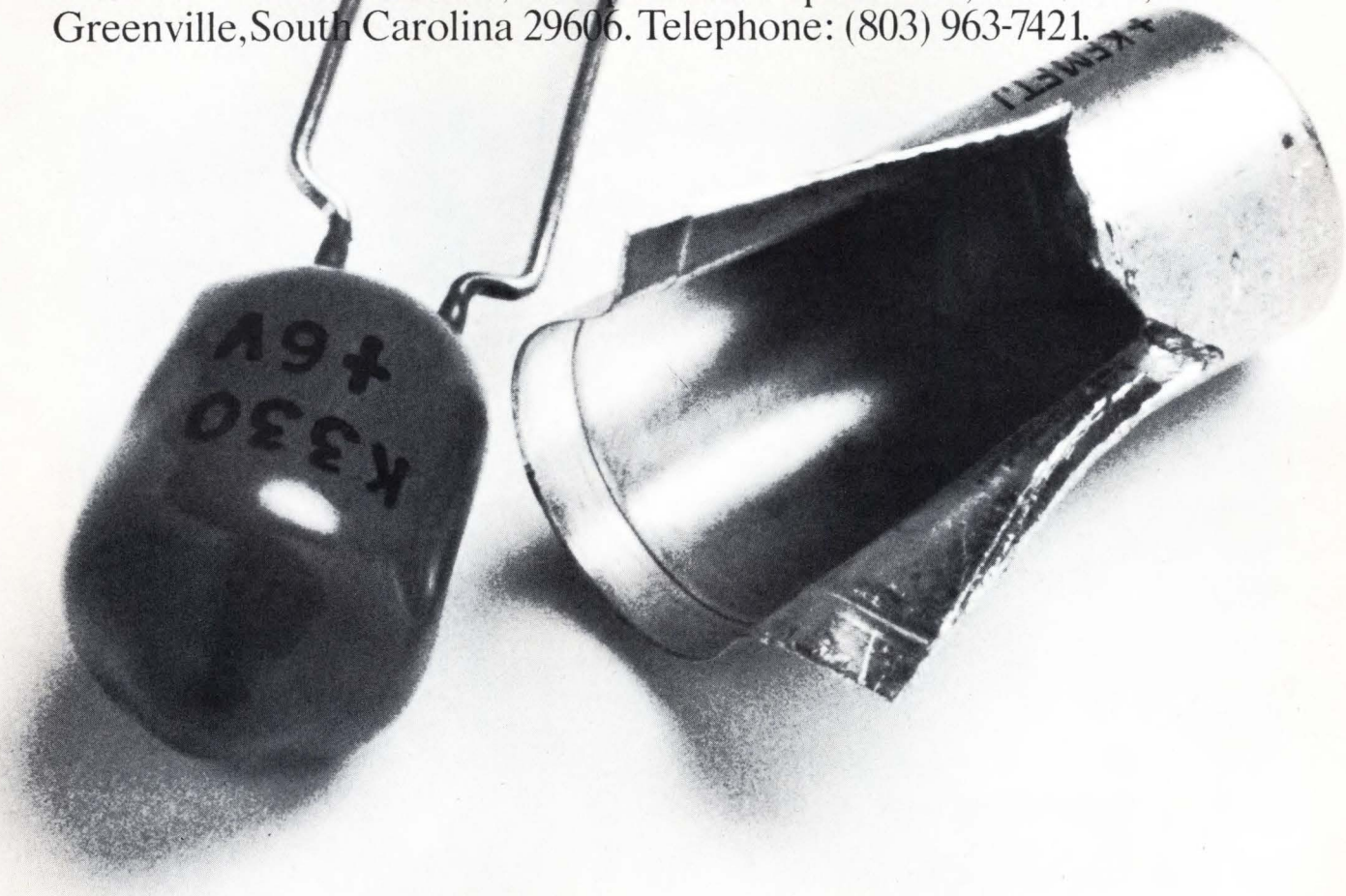


CHECK NO. 13

UNION CARBIDE COMPONENTS DEPARTMENT

Printout devices — The computer's eyes and ears

High speed or low cost, impact or non-impact, line or serial, dot matrix or full character? All the ingredients are there, but what do you need?

Roy W. Forsberg, Senior Editor

Up until the most recent past, users of printout devices had only two clear-cut choices; either low-speed, low-cost devices or high-speed, high-cost ones. Until the advent of the minicomputer, this situation created few problems. However, once the mini became a commonplace piece of equipment, the situation became intolerable. If the minicomputer user chose a printer with a cost that fit in with the computer's cost, its printing speed was ponderously slow, about 10-15 characters per second (cps). If, on the other hand, he chose a printer to match the mini's speed, it's cost could easily outstrip the mini's by two to five times.

It wasn't long before some enterprising marketeers spotted this gap in the marketplace, and soon a number of medium-speed (30-165 cps) machines started to show their heads. Today, a user of printout devices can virtually match his needs precisely with one of the devices available on the market. This of course depends upon his knowing just what's available and how to evaluate one device against another. Does he need a full-impact or dot-matrix printer? How about noise? Will thermal, ink-jet, electrostatic or electrographic suit his application? Does he need graphic plotting ability, multiple copies, optical character recognition (OCR) ability?

The more one looks into printers, the more one can get confused and misled. What we will do in this article is look at each of the above-mentioned questions in more detail, so that potential users of printout devices can evaluate their applications in a more knowledgeable and objective light.

Medium and high-speed impact line printers use both chains and drums. (Mohawk Data Sciences)

What are the different kinds of printers?

There are two major categories of printers; impact and non-impact. Within these categories many subclasses exist; however, most comparison tables will give separate analyses for each of the former since they are completely different technologies and industries. Rare is the case when a given manufacturer will make both impact and non-impact devices.

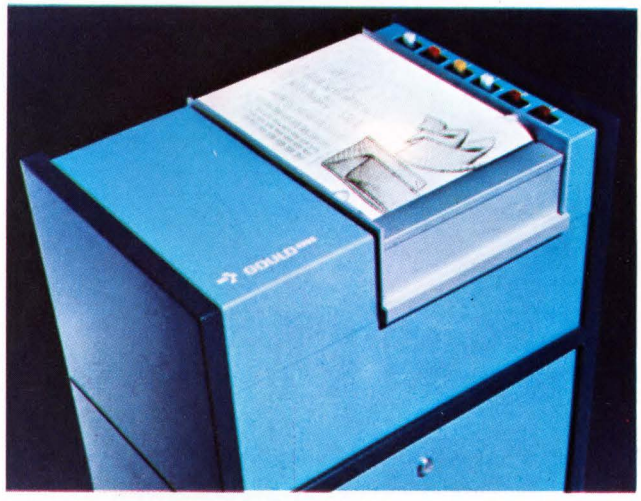
Basically, in the impact class, some form of mechanical mechanism drives either the character-making device into contact with the paper and inking means, or drives the paper into contact with the character. This is a matter of designer's choice and not usually of great interest to the user. What's more important is whether you get a full-character or a dot-matrix one. A full-character has the entire character already formed on a steel drum, wheel, or slug (although one plastic character wheel is available). Most medium to high-speed printers have coined drums which give sharp, clear characters over a long period of time.

A dot-matrix character is formed by impacting a series of wires onto the paper to form a character. The usual device has a 5 × 7 dot matrix; however, 7 × 9 and 7 × 10 matrices are available to give better resolution. A given dot-matrix printer will usually be quieter and faster, but it requires more driving electronics, more moving parts, and will present an incomplete character if one pin fails to fire.

Within the full-character impact class, various means are used to move the character into printing position. Some use a rotating drum with one or more character sets on its periphery; others use a moving chain or train with four or more character sets moving horizontally across the paper. A chain has the character slugs connected together on a continuous chain, while a train has the slugs moving in a continuous track. Still others use small, flat rotating wheels, spheres, moving bars or type boxes.

Non-impact printers can also be full-character or dot-matrix types. They are generally characterized by being faster, quieter, and in many cases, more reliable. The full-character types mostly use an electrostatic process similar to xerography, and have their characters stored on a film. Dot-matrix types can imprint characters by applying heat to heat-sensitive paper (thermal), spray ink or dry toner with individual jets, or they can attract it to spots energized by pins similar to dot-matrix impact pins (electrostatic), or expose patterns on photoconductive paper using a CRT and fiber optics (electrographic). The matrices are usually 5 × 7, but are available as 5 × 9, 7 × 9, 7 × 10, 7 × 11 and 10 × 14. The larger matrices are more legible, can produce complex symbols and both upper and lower-case characters.

Printers are also classified as serial and line. A serial printer prints a character-at-a-time by moving the character set across the paper. These are almost always full-character impact types (a few are dot-matrix) and have speeds ranging from 10 cps to 120 cps for full-impact, and 165 cps for dot-matrix. They are also the least expensive full-line (132 characters/line) printers, and the faster ones perform well for minicomputer printouts.



Rasterscan matrix printer/plotter can print and plot simultaneously. It plots up to 75 square inches/sec and prints up to 3000 lines/min. (Gould)

A line printer will print an entire line at a time and can be either an impact or non-impact type. Impact types use a rotating character cylinder with a character set and hammer mechanism at each print position (a shuttle printer is a modification of this and has a character set in every other print position, half as many hammers and moves the paper over one position to print every other character), dot-matrix with a matrix at each print position, or a chain with print hammers at each character position.

Non-impact printers use the methods described earlier to print each entire line at a time, or use a raster-scan technique. The latter is quite versatile in that it is fully electronically controlled and can print any type of complex characters, as well as plot graphics.

Typically, both line and serial printers have 132 characters per line (some have 80) and come with a full 64 ASCII character set.

Two other classes of printers are lister and strip types. A lister printer is usually a line printer with up to 32 characters per line and has either numeric or sometimes limited alphanumeric character sets. These are commonly used for data logging, miniterminals, instrumentation recording and for electronic calculator printouts. A strip printer has a narrow (about 1 in.) strip of paper that moves horizontally across the print head. It prints only a single continuous line.

How do you judge speed?

Don't get fooled by the printing rate given in a spec or touted by your local friendly salesman until you determine just what is meant. For example, a

Full-character serial-impact chain printer in foreground prints up to 120 characters/sec. (General Electric)

line impact printer may be rated at 300 lines per minute, and under certain conditions it will do it. However, it may only print at this rate when only 48 characters of the set are used. If both upper and lower case are to be printed, you can lose up to 50% of rated print speed. Also, the above printer may be rated at this speed for an 80-column form. If you go to 132 columns, it will take more than 30% longer to print a line.

Some line printers will use shared electronics; that is, the electronics provided will print a line in segments, say 20 columns at a time. It is essential that you know if your prospective printer falls in this category, and at what column widths the advertised print rate is using.

Most line printers have four major variables that affect print rate; the actual time to print a line, line width, the time to move the paper, and size of the character set. Be aware of what changes in any of these variable will do to your throughput. Some machines are affected more than others. Generally, manufacturers will provide tables which cover these variables.

Non-impact line printers are not usually affected by any of these variables except for perhaps line feed, so their advertised rates should be right about on the money.

Serial impact printers are a horse of a different color. They are invariably rated in characters per second, which is only one factor (and sometimes a small one) of its actual throughput. Although the following analysis for throughput is aimed primarily at serial impact printers, it could also be used with a line printer by adding in some obvious and simple mathematics.

Although the terms "lines per minute" and "characters per second" are frequently used to describe the operational speed of printers—a much more meaningful measure is "throughput". Expressed in characters per second, throughput is the actual number of characters disposed of by a printer within a given time frame.

Actual throughput is determined from several parameters: average number of characters per line, carriage return (CR) and line feed (LF), printing characters per second, and time to print one line.

$$\frac{\text{Av \# Char/line}}{\text{Printing char/sec}} + \text{CR and LF} = \text{Sec/line}$$

$$\frac{\text{Char/line}}{\text{Sec/line}} = \text{Actual throughput in cps}$$

A printer that prints an average of 40 characters per line at a rate of 30 cps with a carriage return and line feed of 0.3 seconds would have an actual throughput of:

$$\frac{40 \text{ char/line}}{30 \text{ char/sec}} + 0.3 = 1.6 \text{ sec/line;}$$

$$\frac{40 \text{ char/line}}{1.6 \text{ sec/line}} = 25 \text{ cps throughput.}$$

Every printer has a maximum throughput level which can be determined by making the above computations. The data transfer process, however, can be limited by either the input rate or the printer.

When a printer is **data limited**, it disposes of data faster than it is being sent. In this case, its actual throughput is equal to the data transfer rate. A 200 cps printer, for example, receiving data at a rate of 300 bps is data limited. That is, receiving data at 30 characters per second it can have a throughput not greater than 30 characters per second, regardless of its maximum rated speed.

When **printer limited**, the data source can send data faster than the printer can dispose of it. To equalize the source transfer rate and printer disposal rate, the data source either includes a timeout, or utilizes a control signal from the printer to hold up transmission temporarily.

As mentioned earlier, serial impact printers print at a rate ranging from 10-165 cps. Full line printers of the impact variety will print as fast as 1800 lines per minute, while full line non-impact printers can go as fast as 9200 lines per minute. Lister impact printers can get up to 40 lines per second, while non-impact types get up to about 60-75 lps. Strip printers range from 10-65 characters per second.

Options give versatility

Make sure you know what you are getting for your money. In other words, what's standard, and what's optional? Many manufacturers will supply you with a print mechanism only, a mechanism including frame, cabinet and power supply but no electronics or buffers, or a completely buffered printer. Even within these groups, there's lots of standards and options. Most spec sheets will give a list of both—check it and make sure.

Do you get buffers, interfaces or vertical formatting? For communications applications, is the machine receive only, does it come with a keyboard,

Non-impact dot-matrix line printer uses an electrostatic writing technique. It prints at 500 lines/min. (132 char/line). (Versatec)

how does it receive data? These questions will be discussed later. Just be sure what you will be paying extra for.

Some machines come with a static eliminator. This is especially useful in high-volume work in a dry environment, otherwise static can cause paper to seek the nearest metal object and thus prevent the paper from stacking properly.

Another useful option that can be standard on some machines is a test generator card, which can be plugged into a slot to determine whether a fault is in the printer or in the computer.

It is important to have the ability to accommodate various fonts if the machine has to perform varying job requirements. You will usually find the 64-character ASCII font (upper case only) as standard on most printers. Some will provide a 96-character ASCII font (upper/lower case), and others up to 128 characters. Other fonts are foreign language like Kata-Kana or have special symbols for German and French. A very important consideration is a font acceptable for optical character readers (OCR).

Ease of changing from one font to another should be investigated. Chain printers usually have chains in the form of a cartridge, which can easily be changed in minutes. Because drums rotate on bearings, they can easily take over an hour to change. Discs and balls are easy to change. Non-impact printers including matrix (both impact and non-impact) require a change in electronics (a ROM), usually a simple case of replacing a pc card. Xerographic printers have an operator-changeable film mask.

Most manufacturers will offer any font already built. If artwork has not been previously done, they will have a set-up charge and you can expect up to 12 weeks for delivery of full impact fonts, perhaps shorter for fonts in ROM.

Don't be fooled by reliability data!

Be prepared to really get a run-around when you start talking reliability, especially when you try to pin things down to mean-time-before-failure (MTBF) and mean-time-to-repair (MTTR). The biggest problem with getting figures stated publicly depends on the nerve of the marketing manager in many cases.

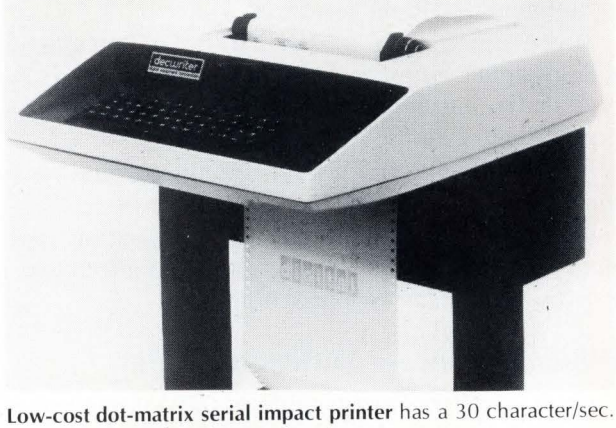
If you do get MTBF figures, find out the conditions under which they were obtained. Was it by calculations, independent studies, actual service data, or testing? If the latter, what was the duty cycle? Some manufacturers will give figures for both 20% and 100% duty cycles. A good one to consider is 50%. And what documentation is available to you to back up the numbers stated? However, if you will only run your printer a few hours per week, you don't use it enough to be overly worried about MTBF.

Keep in mind that MTBF is often only an empirical thing, calculated from a handbook. The only true number would be obtained if a manufacturer kept detailed records for every unit he sold and on all maintenance performed. Then he would have access to a good data base. The more units he builds, the better they should become because early failures and weak components are weeded out.

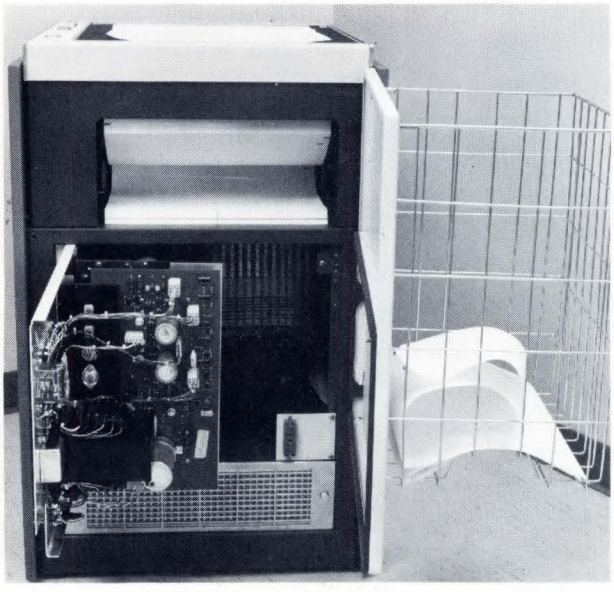
Remember, impact printers must be built on a very rugged base or they will tear themselves apart by shock of vibration. Further, hammers generate lots of heat through friction, which must be dissipated through heavy baseplates acting as heatsinks. So don't hesitate to look into mechanical construction.

MTBF figures that are pretty valid run from 150 to 1000 (sometimes 2000) hours for impact printers, depending on duty cycle. Non-impact printers can run up to 3000-5000 hours, but be wary of numbers at the upper end. If you get numbers outside these ranges, be very careful and see what guarantees and back-up the manufacturer or salesman will give you (in writing).

With regard to MTTR, this deals with serviceability



Low-cost dot-matrix serial impact printer has a 30 character/sec. print rate. (Digital Equipment Corp.)



Serviceability is enhanced by having all electronics and paper-loading readily accessible. (Varian)

of the machine. Look for modular construction so that failed parts, both mechanical and electronic, can be easily removed and replaced.

For impact printers, find out how easy it is to adjust the hammers. Some require one adjustment, some as many as three. If no adjustments are claimed, make that manufacturer prove it to your complete satisfaction.

Look to see how accessable the machine's innards are. Front access means that you can load paper, get at electronics and power supply, adjust hammers, change ribbon and fuses.

Take a look at the technical manual provided. One that is well detailed will be indicative of a good MTTR. A good number for MTTR should be 1-2 hours. Numbers significantly higher will surely lead to high maintenance costs.

Some machines send as well as receive

Printers meant to be tied to computers are mostly receive-only (RO), while those involved with data communications can be keyboard-send-receive (KSR) or automatic-send-receive (ASR).

If you expect to be involved with data communications applications, make sure that your printer can operate in that environment without excessive and costly modifications.

The keyboard is not always a standard item, so if you require a KSR capability, whether it be in communications or direct computer input-output, find out if one is provided. If not, can a standard commercially-available keyboard be used?

When are storage buffers needed?

Storage buffers are desirable in most printers and for most applications. In some cases, lack of an adequate buffer will decrease printer throughput and could even cause a loss of data.

The most common buffer is a single-line buffer, capable, as the name implies, of storing a single line of data. These are quite common as standard items. Other buffers are double or dual-line buffers, partial-line buffers and floating buffers.

Single and partial-line buffers accumulate data while paper is being stepped to the next line. A dual-line buffer commonly uses one to queue up data, while a second is printing data. It is used as a storage buffer when data is coming in continuously. Floating buffers operate on a first-in, first-out basis and operate similar to a dual-line buffer. A last type of buffer is a page buffer used on extremely fast non-impact line printers, which interleaves new data while printing previously received data. It enables printing at rated speeds. Some machines use magnetic or punched tape for a buffer, but this is a special case and not covered here.

Some type of buffer is needed in applications when data is coming in at a steady rate, but its form requires the printing of short lines. In such a situation, throughput is altered drastically since printed lines are finished faster than normal. Thus, in a given framework of time, the paper must be advanced 2-3 times normal, and the mechanism cannot keep up with the data.

Another case when buffers are necessary is when data rates are much faster than machine print rates.

Make sure you know which buffers, if any, are standard, and which are available as options. Watch the costs! Some are very inexpensive, while others add a large chunk to your printer's price tag.

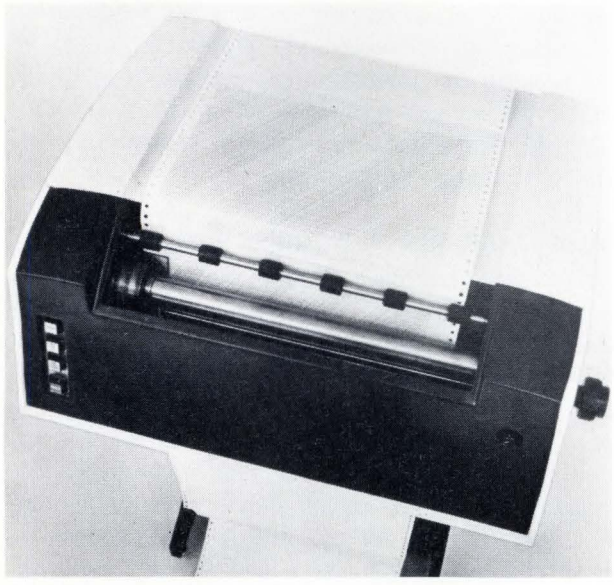
It doesn't work without an interface

Whether you will be tied into a computer or hooked onto a communications line, you will need an interface. Some machines in the latter category not only come with an interface as standard, but also include a modem.

When the printer is involved with data communications, it should have a bit-serial, character-serial interface. It should meet RS-232 standards, as should the connector. Watch the connector, because even though it may meet RS-232 standards, some manufacturers use different pins for different command structures. For example, the return channel or busy signal might be a voltage level in one machine and a pulse in another.

While many machines are capable of using either a serial or parallel interface, depending on the connector used, most line printers are hooked to computers and are provided with a word or character-serial, bit-parallel interfaces.

A big question to ask is how adaptable is the printer to interfaces for various popular computer manufacturers. You may even get lucky and have the in-



Full-character serial impact printer uses a rotating print drum (shown at left-front) and prints at 100 characters/sec. (Printer Technology)

terface provided by the computer manufacturer for certain printers.

Another good thing to watch for is whether line terminators come with the printer, especially when TTL interface circuits are used and the line will be greater than 10 feet long.

Do you need vertical formatting?

On every printer but lister and strip printers, some form of vertical format unit (VFU) is normally available. VFU allows the printer to skip different numbers of lines on a form. Without such a unit, the printer would have to step through every line, even though nothing has to be printed on many of them, thus seriously decreasing throughput. Some machines have a high-speed slew for these line skips.

The VFU is usually a punched tape (either mylar or paper; mylar is preferred because of longer life) put on a carrier moving in synchronism with the paper. For programming convenience, it is usually provided with multiple channels—eight and twelve are common. Associated with each line of print is a forms control character, which defines what channel on the VFU tape to look at next. Thus VFU gives greater throughput allowing a form to step through the printer at a faster rate.

Some machines without VFU will have a forms feed. What this does is advance the paper to the beginning of a form only.

A few high-speed printers have electronic forms control, which allows a complete page format to be programmed via computer.

Raster scan machines can have any format programmable, horizontal or vertical. Forms can be printed on the paper simultaneously with the type at no decrease in throughput.

You should also know whether the tractors are adjustable. This becomes an advantage in a 120-160 column machine since you can set the tractor to print on the right half only or left half only, or, with dual tractors, a different form on each half.

Determine to which sizes the tractors are adjustable, and how easy it is to make the adjustment. Tractors will be adjustable from 3 to 20 in., but not all machines go as small or as large as these figures.

Expect the number of columns (character print positions per line) to range from a low of 20 up to 160. Again, not all printers can reach these extremes. Most fall in the 80 to 132 column range.

Lister and strip printers have no need for VFU. The former can have as many as 40 columns.

Paper feeds are straightforward

There are two basic types of paper feed and two basic feed mechanisms. With the former, you can either push or pull the paper through the printer. Nearly all printers are of the pull-type thus reducing the chances of the paper becoming fouled and bunched up.

The basic feed mechanisms are pin-feed tractors or pinch rollers. Most higher-speed printers use the former because of exacting registration requirements, and low-speed machines typically use a pinch roller. High-speed non-impact printers will also use pinch rollers to a large degree.

One method used to maintain high reliability in the latter type is the combination of stepper motors and a differential friction drive. The differential design prevents paper skew and mistracking, thus allowing conventional paper to be used.

Another approach used to minimize the possibility of paper jam and allow fast line feeds is to tension paper between pinch rollers and a pair of pin-feed tractors. The pinch rollers take up slack when the tractor is advancing.

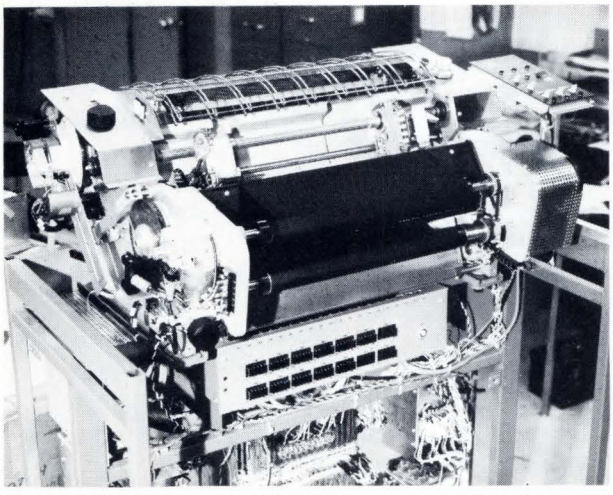
Be sure to look at these and other similar approaches and you will eliminate a good amount of printer down time. Some manufacturers will offer you the choice of either mechanism.

Inking means should be replaceable quickly

Some form of ribbon is the usual inking means in almost all impact printers. Different types of ribbon can be changed back and forth after you buy your machine; however, it helps to know what each type does for you.

Most ribbons come in some form of a cartridge that requires a certain amount of threading to install. Look for ease of threading. It shouldn't take longer than 3-5 minutes to change it. The ribbons should also be available from a number of sources.

Silk and nylon are the common ribbon materials. Silk gives a better character transfer and has good smear characteristics—a must for OCR applica-



Full-character impact line printer has a rotating character drum and shuttle tractor. Shuttle reduces the number of hammers by 50%, printing odd characters on one print cycle and even ones on a second cycle. Note full-width ribbon in center. Print rate is 300 lines/min. (Mohawk Data Sciences)

tions—but it doesn't have the life that nylon does.

Some nylon ribbons have an aluminum coating to stabilize ink flow characteristics. It is more costly, but it releases the ink at a more constant rate, giving a more uniform print over the life of the ribbon.

One manufacturer eliminates all ribbon changes completely by inking the print wheel directly with a disposable ink soaked porous elastomer roller. Another manufacturer uses an inking roller with an ink transfer ribbon.

Ribbons for line printers are as wide as the print drum and you should be careful to prevent skew or tearing.

Electrostatic printers use either a liquid or dry toner. Liquid toner requires no heat-fixing. Other non-impact printers use a variety of treated papers.

Some impact printers give a choice of using ribbons or pressure-sensitive papers without ribbon. The latter eliminates ribbon changing and removal of carbons in multi-part forms, but is more costly.

Not all machines make multiple copies

In many applications, it is not only advantageous but also necessary to make multiple copies of printouts. Impact printers, both full-character and dot-matrix, can make multiple copies simultaneously using special forms with interleaved carbon, or using pressure-sensitive paper. The most common numbers quoted are an original and five copies. However, the quality of the last copy depends on paper weight and carbon, and the adjustment of print hammers. Look for operator-adjustable penetration controls via lever or other means. This allows different settings for different thicknesses of paper. It is generally not advisable to have paper-thicknesses greater than 0.018 inches.

Non-impact printers have yet to develop a capability to make simultaneous multiple copies. Some very high-speed printers overcome this shortcoming by making up to 99 copies via sequential printing. At the present, this method is more costly than multi-part forms because of higher-cost paper. As volumes increase, it is possible for future manufacturing advances to narrow this cost gap.

OCR capability is available too

The ability to have printed matter readable by automatic methods is becoming more and more important in industry. If special care is taken, most full-character impact printers can be machine-readable. To date, dot-matrix, both impact and non-impact, and all other non-impact printers are not machine-readable. It is rumored that Siemens has developed a dot-matrix printer that is machine-readable, but so far it is not available outside Siemens.

Special OCR fonts are available for many full-character printers; however, this is only part of the solution. The type ribbon (inked or Mylar) and ink is one variable. Another is the paper. Special image-control papers should be considered. Drum and paper speeds are critical, as well as hammer dwell time. Make sure you define your requirements very strictly with your printer salesman.

Few printers can plot graphics

In some applications, it is desirable to be able to plot graphics as well as print characters and symbols. Very few machines have this capability. A few serial impact printers can be modified to present simple curves and graphs. This requires that the tractor and print wheel move and print in both directions. Resolution is fair with this method.

If you have a need for high-quality graphics along with your printing, there is a class of machines called printer/plotters. These are non-impact, raster-scan machines, and can both print and plot (at the same time) quite fast. For example, one machine can print and plot 14 inch wide paper at 2.2 inches per sec. Thus an 11 × 14 inch plot can be made in 5 seconds, about 20 times the speed of a conventional pen plotter.

Can your commands be recognized?

Within the printer industry, there is no common set of commands that all machines will recognize, respond to, or output. The closest thing to common commands are ANSI and EIA standards for communications applications. Find out if the printer you are considering will recognize your commands. If you buy a full buffered console, it should have a complete command set including remote turn-off and status send back.

One command worth considering is a hammer-fire command (somewhat like a parity signal) that tells that a hammer has truly fired when ordered to. Another is an end of line command that

will start a new line printing as soon as the previous line, if not a full one, has been received and printed.

How quiet is quiet?

Some printers, like non-impact types, are inherently quiet, the only sound being the paper feed; while others need special added-cost soundproofing enclosures. Don't be afraid to ask your salesman for dB sound levels, and have them compared to well-known sound-makers like teletypwriters or Selectrics. Keep in mind that a given printer can have different sound levels at different print rates. For example, if your printer will be printing short lines, the greater number of carriage returns and/or line feeds can add substantially to noise levels.

The paper itself is a good sounding board, thus if the paper is fully enclosed along with the printing mechanism, sound levels will be reduced.

If absolute quiet is your prime requirement, then one of the various non-impact printers will beat all impact types hands down.

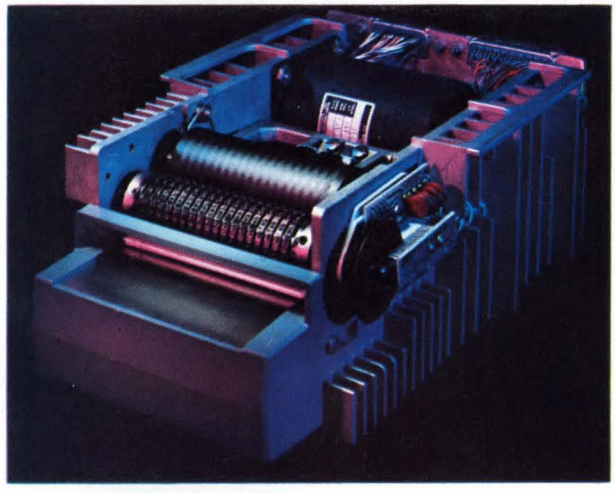
Another form of noise to consider is electrical noise. Make sure that the printer of your choice will not interfere with other equipment in the room.

Who should service the printer?

If you are buying a large number of printers, most manufacturers offer service training programs for your field service personnel. You will find that many manufacturers would prefer to service their printers themselves and offer a variety of service contracts, from on-call types to full preventive-maintenance contracts. Each should be negotiated separately, depending on the application.

Small users of printers would be best off with some form of a service contract.

If you buy printer mechanisms only, you will probably find the manufacturer reluctant to service them for you. In this case, they would prefer that you do it. Or you could always go to a third party service house.



Rugged construction and heat sinks in lister printer reduce failures from impact vibration and heat. 18-column print drum shown has a character set for each column. (Hewlett-Packard)

What should you expect to pay?

There is no way to give a definitive answer here because it depends on quantities, options and type printer. Even amongst manufacturers of the same type of machine, price spreads can be in the thousands of dollars. In general, you can get a lister printer for as low as $300, a low-speed serial impact printer as low as $1200, a medium-speed serial impact printer as low as $2300, a medium to high-speed impact line printer as low as $5200, a medium to high-speed non-impact printer as low as $7000, and a non-impact printer/plotter as low as $6000. You can also pay as much as $60,000 for a high-speed line printer. The spreads are wide, so shop carefully. ▭

EDN would like to thank the following companies who responded to our questionnaire, and who helped make this article possible.

Clary Corp.,
320 W. Clary Ave.,
San Gabriel, CA 91776

Datadyne Corp.,
37A Valley Forge Ctr.,
King of Prussia, PA 19406

Datalog Div., Litton Systems, Inc.,
1770 Walt Whitman Rd.,
Melville, NY 11746

Data Products Corp.,
4219 De Soto Ave.,
Woodland Hills, CA 91364

Digital Equipment Corp.,
146 Main St.,
Maynard, MA 01754

Dytro Corp.,
63 Tec St.,
Hicksville, NY 11801

Elec-Trol, Inc.,
26477 N. Golden Valley Rd.,
Saugus, CA 91350

Facit-Odhner, Inc.,
501 Windsor Dr.,
Secaucus, N J 07094

General Electric Co.,
Mountain View Rd.,
Lynchburg, VA 24502

Gould Inc., Data Systems Div.,
20 Ossipee Rd.,
Newton, MA 02164

Hewlett-Packard Co.,
5301 Stevens Creek Blvd.,
Santa Clara, CA 95050

Honeywell Information Systems,
40 Walnut St.,
Wellesley Hills, MA 02181

International Teleprinter Corp.,
493 Washington Ave.,
Carlstadt, N J 07072

Keltron Corp.,
225 Crescent St.,
Waltham, MA 02154

Litton ABS,
600 Washington Ave.,
Carlstadt, N J 07072

Macro Products Corp.,
14403 Crenshaw Blvd.,
Gardena, CA 90249

Mohawk Data Sciences Corp.,
Palisade St.,
Herkimer, NY 13350

Path-Uppster Corp.,
73 Southfield Ave.,
Stanford, CT 06902

Printer Technology Inc.,
Sixth Rd.,
Woburn, MA 01801

Shinshu Saiki Co., Ltd.
C. Itoh & Co.,
555 S. Flower St.,
Los Angeles, CA 90071

Syner-Data, Inc.,
133 Brimbal Ave.,
Beverly, MA 01915

Tally Corp.,
8301 S. 180th St.,
Kent, WA 98031

Teletype Corp.,
5555 Touhy Ave.,
Skokie, IL 60076

Transcom, Inc.,
12 Tobey Rd.,
Bloomfield, CT 06002

Tycom Systems Corp.,
750 Hamburg Tpke.,
Pompton Lakes, N J 07442

Varian Data Machines,
611 Hansen Way,
Palo Alto, CA 94303

Versatec,
10100 Bubb Rd.,
Cupertino, CA 95014

Remember the commitment we made to "883" in this '69 ad?

MACH IV

Let TI's special HI-REL Task Force take you through the turbulent sometimes uncharted universe of MIL-STD-883.

We'll keep you on course.

Scout's honor.

Others have called 883 a lot of confusion, a mixed bag, and even "unprintable words."

But we have tried to keep our mouth shut, our shoulder to the centrifuge, and our nose to the stress levels.

While our best minds solved the problems.

Quietly, TI has committed itself to 883. Money, manpower and facilities.

And we're ready to deliver "in accordance to MIL-STD-883."

In fact, we've been delivering 100% tested IC's for years. Millions of them for Minuteman, Sprint, Poseidon, F-111 and other programs.

And some of these had even tighter requirements than 883!

From this experience, TI has organized special HI-REL Task Forces to help you meet 883. A special Task Force has been created for DTL, another for linear, and the one pictured here for TTL/Os.

Its members are some of TI's top managers in the areas of reliability engineering, process engineering, product sales, military marketing, product planning, product engineering, quality control engineering, manufacturing and HI-REL assembly.

They're specialists in Series 54 and 54H TTL ICs, now available from TI in both flat pack and ceramic dual-in-line packages, standardized for 883 Classes A, B and C.

The Task Force's assignment starts with your problem: determining the specific test procedures and levels you'll need to satisfy 883 requirements.

Once the most practicable test plan has been devised, the Task Force sees it through. Thousands of TI personnel in many departments may be involved in your program, but the Task Force is responsible for its success.

Task Force members can cross departmental boundaries, step on toes and crack bottle necks, if need be, to keep your program on t

In addition, you have the industry's best test facilities going for you at TI... from more than 50,000 burn-in sockets to environmental shake, rattle and roll labs, to IR scanners, microprobes, Radiflo and variable data loggers.

One thing more.

TI has prepared a comprehensive 40-page procurement specification incorporating MIL-STD-883 — supplemented by 100 pages of detailed product specifications. From your first source for TTL ICs.

Use it to plot your course, and TI's H-REL Task Force will keep you on it. Scout's honor.

Write for "MACH IV High Reliability Procurement Specification MIL-STD-883." Texas Instruments Incorporated, PO Box 5012, MS 308, Dallas, Texas 75222. No confusion. No mixed bag. No unprintable words.

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Now it's JAN ICs.

Series 54 TTL, developed by TI, has been chosen as the standard. And the same HI-REL Task Force that helped you stay on course through 883 and 38510 (with the MACH IV program) can do it again with JAN.

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Now comes JAN-M-38510 with its new challenges and uncertainties. And the same Task Force is still on the job. This same group of managers who worked for you in '69 are still working for you today, along with some new members. Together, they bring more than 120 man-years of HI-REL experience to the task—in the areas of reliability and process engineering, product planning, product engineering, marketing, quality control, manufacturing and HI-REL assembly. The Task Force is fully committed to making JAN IC availability a reality—and TI has committed the money, facilities and manpower to support the team.

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Already you have a broad choice of JAN ICs from TI, and the list is growing rapidly under an aggressive qualification program. Our objective is to lead the industry.

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High-volume production facilities

We've been delivering MACH IV ICs, in volume, for nearly three years—and high reliability military ICs for more than a decade. So squarely behind our new JAN effort are TI's unmatched 54/74 HI-REL domestic production facilities in Houston and Dallas. From 150,000-plus burn-in sockets to environmental shake, rattle and roll labs, to scanning electron microscopes, IR scanners, microprobes, Radiflo and computer data acquisition.

You'll find our JAN ICs already on distributors' shelves. You can count on TI's production strength to maintain excellent JAN IC availability.

Send for procurement aids

We've prepared a booklet answering common questions about JAN ICs, as well as a handy pocket card which lists existing JAN IC specs, the corresponding standard TI type numbers, and explains the JAN numbering system. They're both yours by circling 242 on the Service Card. Or write Texas Instruments Incorporated, P.O. Box 5012, M/S 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
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EDN Design Course

CMOS — Part II

The basic building blocks in the 4000 Series have made CMOS a full fledged logic family.

Bill Furlow, Associate Editor

An immense family of standard functions and enough competition among suppliers to drive the prices down brought success to the 54/74 TTL logic series. If those same factors are still valid, then the CMOS 4000A Series will attain the same level of acceptance. Today nine semiconductor manufacturers produce at least the basic devices of the 4000A Series, and two more large semiconductor makers seem to be on the verge of entering the market. In addition, most makers of 4000A CMOS are busily designing proprietary parts that they feel will be of particular value to their customers, and most of these new devices will be second sourced by the competition. The 4000A family is expanding at such a rapid clip that a designer must be on the mailing list of each company in order to stay up to date. If you are up against a logic function that is awkward in standard CMOS functions, it is well worth your time to call a few of the applications people at various CMOS houses; they may have a standard building block that will be available in time for you to use, even though it hasn't been announced yet. In any case, the series is already large enough to be extremely versatile.

The CMOS family tree

Borrowing once again from the RCA COS/MOS seminars, **Fig. 1** represents a very good way to divide up the 4000A Series for a closer look. We will cover only the basic family because the total number of devices available is much too large to present here. **Fig. 2** lists the simple gate functions that are available. Both NAND and NOR gates in 2-, 3- and 4-input versions are available in multiple-gate packages.

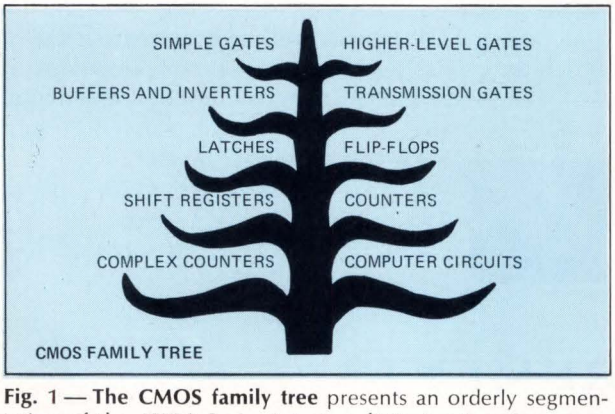

Fig. 1 — The CMOS family tree presents an orderly segmentation of the 4000A Series into ten distinct categories.

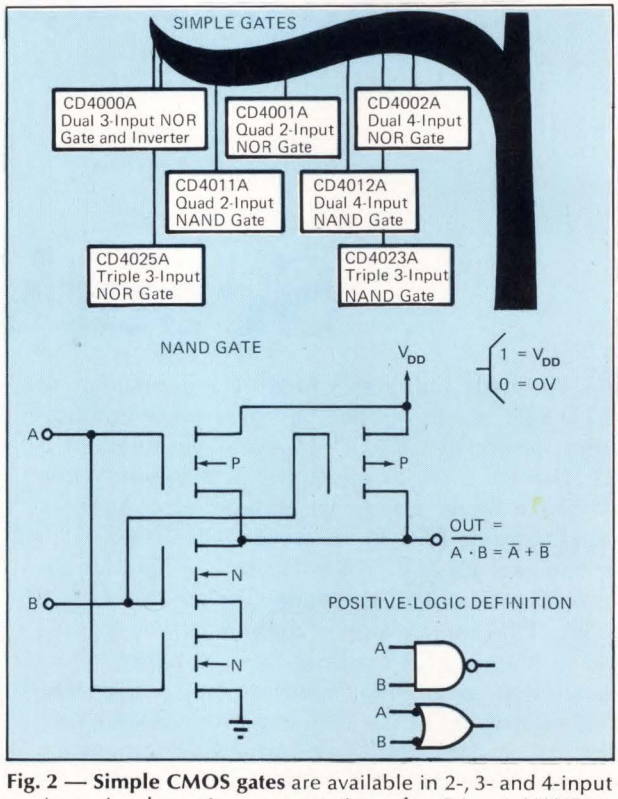

Fig. 2 — Simple CMOS gates are available in 2-, 3- and 4-input versions. A schematic representation of a 2-input NAND is shown below.

Unlike TTL, AND and OR gates are not yet available in CMOS, but the requirements for these functions are very easy to work around or to implement with inverters, where required. The same basic inverters discussed in Part I of this series (EDN, Vol. 17, No. 21, Nov. 1, 1972) are used in various combinations to build the various gate functions listed here. As you can see from the 2-input NAND gate shown in the lower section of **Fig. 2,** the series-parallel arrangement of the inverter pairs is

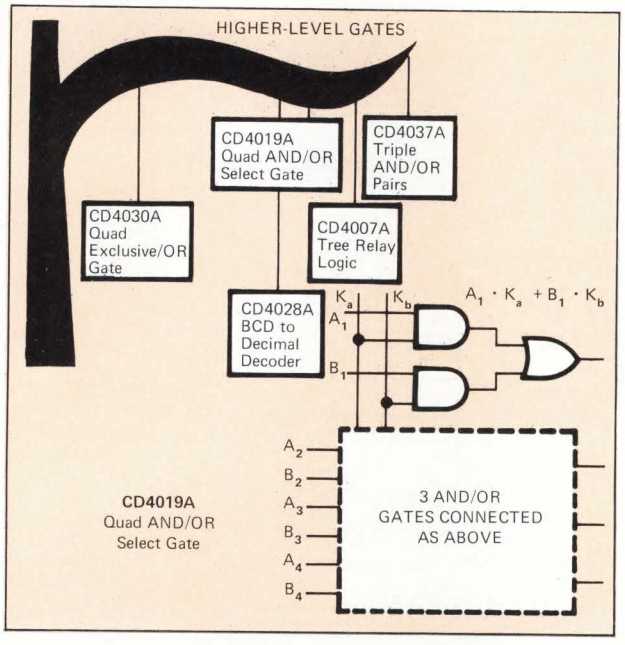

Fig. 3 — Higher-level CMOS gates offer a designer increased flexibility. The 4019 allows selection of one 4-bit word (A or B) with only one IC package.

merely the reverse of the NOR gate shown in **Fig. 11,** Part 1.

Higher-level CMOS gates are listed in **Fig. 3.** The 4019 Quad AND-OR select gate shown in the lower portion of **Fig. 3** allows the selection between two 4-bit words (A and B) onto the output lines. The 4007 Triple inverter, listed in several places, appears here because it has separately accessible p- and n-type transistors that allow the implementation of tree-relay logic, an extremely efficient way of performing certain logic functions.

The schematic of the 4007, shown in **Fig. 4,** will give some idea of why it is so versatile. The device is actually a "dual-complementary pair plus inverter." While it is usually found externally wired as a triple inverter, the separate access to two of the n- and p-channel devices allows you to tie it in with many other devices to implement whatever random logic may be required by your system.

The 4007 is also considered the basic CMOS device, and most of the curves and operating parameters quoted for CMOS gates are derived from it.

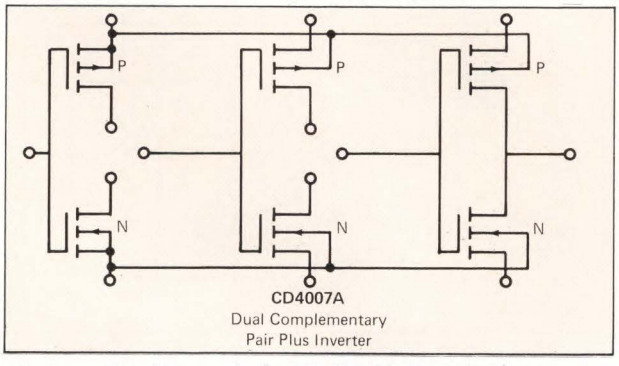

Fig. 4 — The 4007, a dual complementary pair plus inverter has individually accessible p- and n-channel devices, making it a workhorse of the CMOS family.

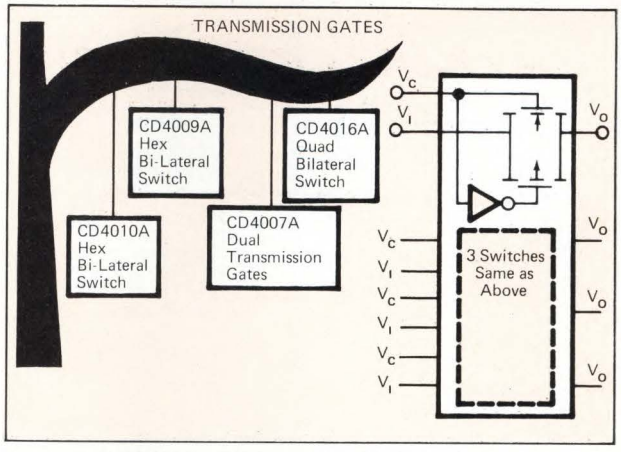

Fig. 5 — CMOS transmission gates are gaining popularity as both digital and analog switches, even in non-CMOS systems.

Transmission gates gain wide acceptance

Transmission gates, like those listed in **Fig. 5** probably represent the area of CMOS which is receiving the most scrutiny. Devices like the 4016 shown in the lower half of that diagram are not only useful as data multiplexers but also can be used for analog signal switching as well. A CMOS device used as an analog switch exhibits a much smaller change in R_{on} with respect to signal voltage than any of the single FET switches that are popular for signal switching. They can also be used in conjunction with the other CMOS digital devices to affect a 3-state output logic system.

You'll notice that the 4007 is listed again in this category since it can be wired as a "dual transmission gate plus inverter." The ON impedance for CMOS transmission gates is about 250Ω, and bear in mind the fact that there is no defined input or output; they are completely bidirectional with regard to the signal path. New devices that are presently being developed in this area are an 8-line to 1-line multiplexer/demultiplexer and a bilateral switch that will permit the switched signal to go below zero. The diode protection circuits of the 4000A Series, which will be discussed later, clamp the signal on a 4016 at about −0.5V.

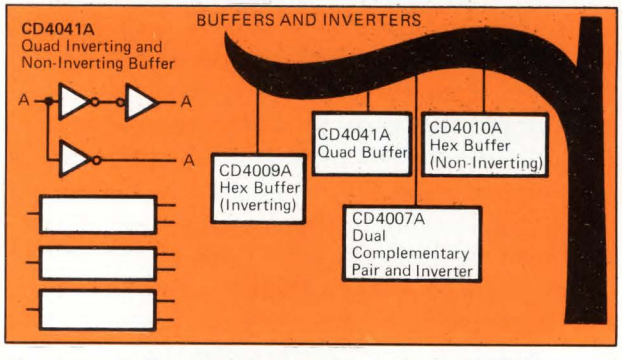

Fig. 6 — Buffers and inverters provide level shifting and current-interfacing capability between CMOS and other devices.

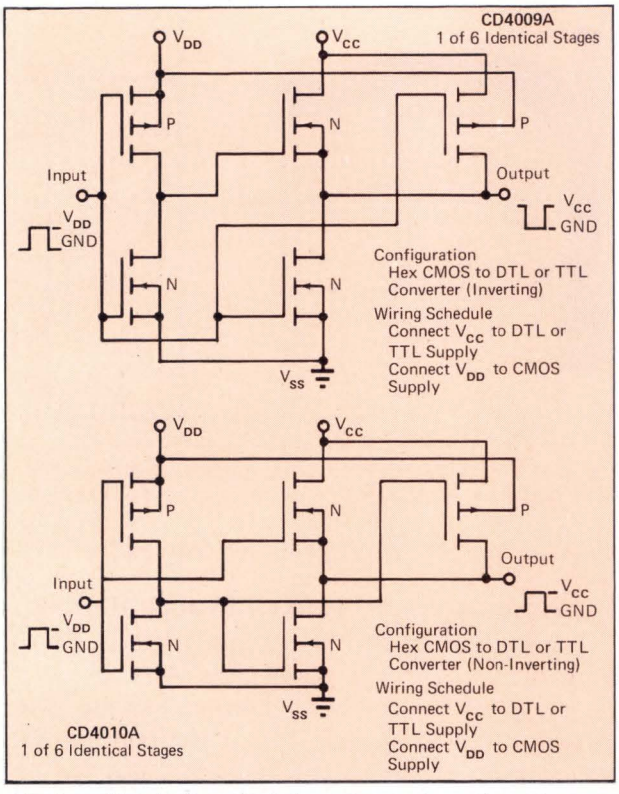

Fig. 7 — Hex buffers, both inverting and non-inverting can operate from dual-voltage supplies (V_{DD} and V_{cc}) to provide CMOS/TTL interface.

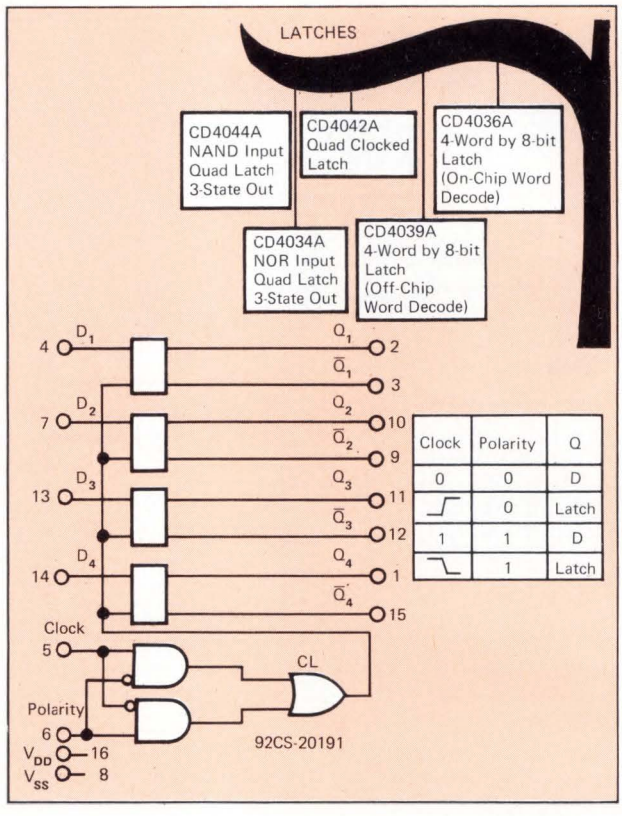

Fig. 8 — Latches and registers in the 4000A family include the 4042, which can be programmed to latch during either the "high" or "low" portion of the clock cycle.

Buffers ease CMOS/TTL interface

The buffers and inverters listed in **Fig. 6** allow CMOS at any logic supply level from +3 to +15V to be interfaced to TTL at +5V. These devices will drive 2 TTL inputs. The 4041 provides both inverting and non-inverting outputs, while the 4009 and 4010, shown in **Fig. 7,** provide only an inverting (4009) or non-inverting (4010) output.

The schematics in **Fig. 7** are given to illustrate the dual supply feature of these buffers. In cases where only buffering is required (but not level shifting), V_{DD} and V_{cc} are simply tied together externally. Once again, the "Universal" 4007 is listed because it can be wired as a buffer.

Latches and flip-flops are basic

The CMOS latches shown in **Fig. 8** range from the 4042 quad clocked D latch to the 4036 and 4039 which are quad 8-bit storage registers. The 4042, shown in the lower portion of **Fig. 8,** contains four latch circuits, each strobed by a common clock, and each providing complementary outputs. Information present at the D lines is transferred to the Q and $\overline{Q}$ outputs during the clock level selected by the "polarity" input signal, as shown in the truth table. This allows you to transfer data on either a **High** or **Low** clock cycle. The 4043 and 4044 are NOR- and NAND-input R-S type latches with 3-state output circuits.

Flip-flops are listed in **Fig. 9** and are the standard D, J-K and R-S types you're all familiar with. The R-S flip-flops are simply quad NAND and NOR gates externally cross coupled to provide the set-reset function.

CMOS shift registers are listed in **Fig. 10**, and all use the standard D-type flip-flop cell of the 4013 flip-flops arranged in various combinations and lengths. The 18-stage static shift register (type 4006) uses negative edge triggering, in comparison with all the other D-type registers which use positive-edge triggering.

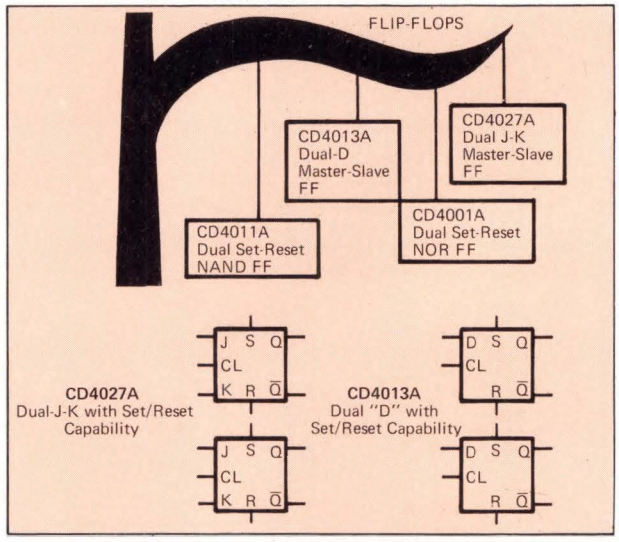

Fig. 9 — Dual flip-flops include a D- and a J-K-type. In addition, the standard quad NAND and NOR gates can be cross coupled to make dual R-S flip-flops.

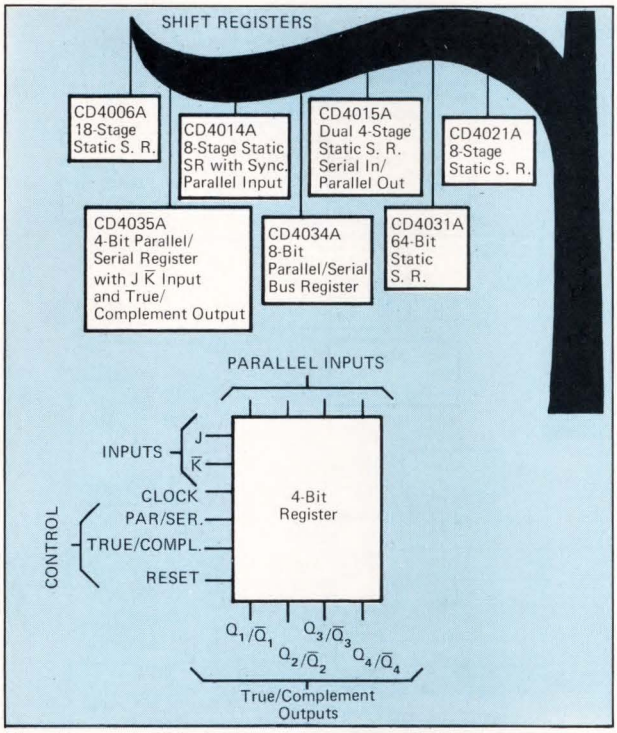

Fig. 10 — CMOS shift registers are available in many configurations. The longest static register presently available is 64-bits.

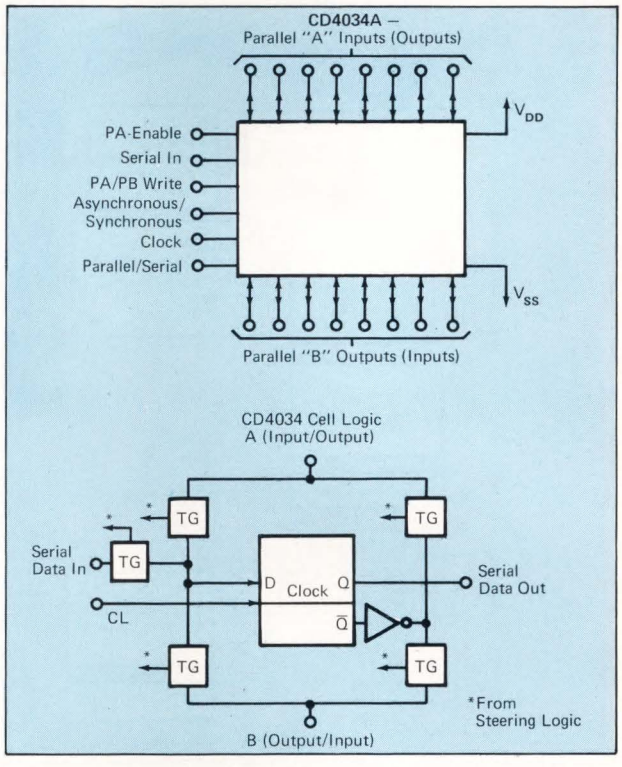

Fig. 11 — The 8-bit parallel/serial input-output bus register (type 4034) is totally programmable. Data may be entered or removed on any input or output in any desired mode. Transmission gates are used for this internal data routing, as shown in the cell diagram.

There are two types of 8-stage registers, the 4014 and 4021, both of which are static devices. Data entry for the 4014, however, must be synchronous with the positive clock edge, while parallel data input for the 4021 may be asynchronous. Both units are synchronous-input devices when operated in the serial-input mode. The longest static register presently available is the 64-stage unit.

The 4035, shown in the lower portion of **Fig. 10,** is a CMOS equivalent of the 9300 TTL shift register, with the addition of complementary outputs. Essentially, it is composed of four D flip-flops accessed by four parallel lines with all of the outputs available. This unit can also operate in straight serial mode. When operated in the serial mode, the J and K inputs are tied together internally, providing the functional equivalent of a D-type flip-flop. The operating mode, parallel or serial, is controlled by a single control line. Another control line sets the device to provide either true or complement output. This "True/compl" control is completely asynchronous. Transmission gates are used for data routing within the device, to provide this flexibility of operation.

Shift register provides super-versatility

The 4034A is a shift register that is worth a little more coverage. As shown in **Fig. 11,** it is an 8-bit parallel/serial input/output register, but it operates in every conceivable mode. Note that the arrows on the inputs and outputs are bidirectional, and this is what really happens. You can parallel data in on the top (or bottom), let it set there for a while, and then parallel it out on the same lines. As you can imagine, a device like that can save you a lot of hardware and wiring. It is completely programmable by the inputs shown on the left side of the package. Again, as you see from the cell structure, the device is a clever arrangement of D flip-flops and transmission gates.

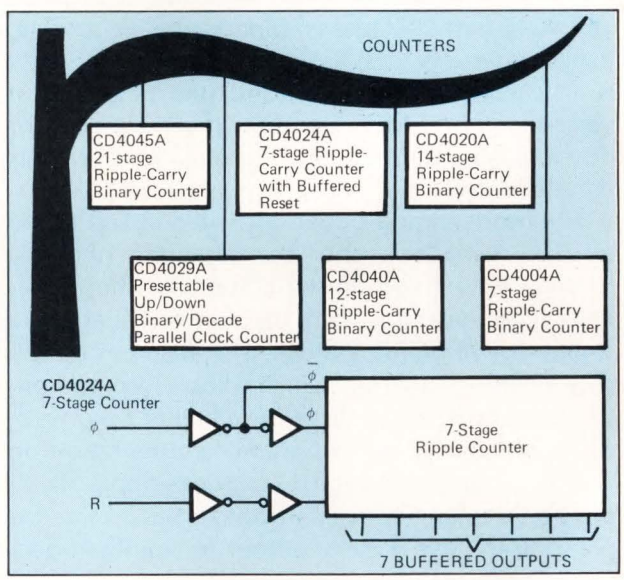

Fig. 12 — CMOS counters from 7 to 21 stages, including presettable, offer enough design versatility to solve most design problems.

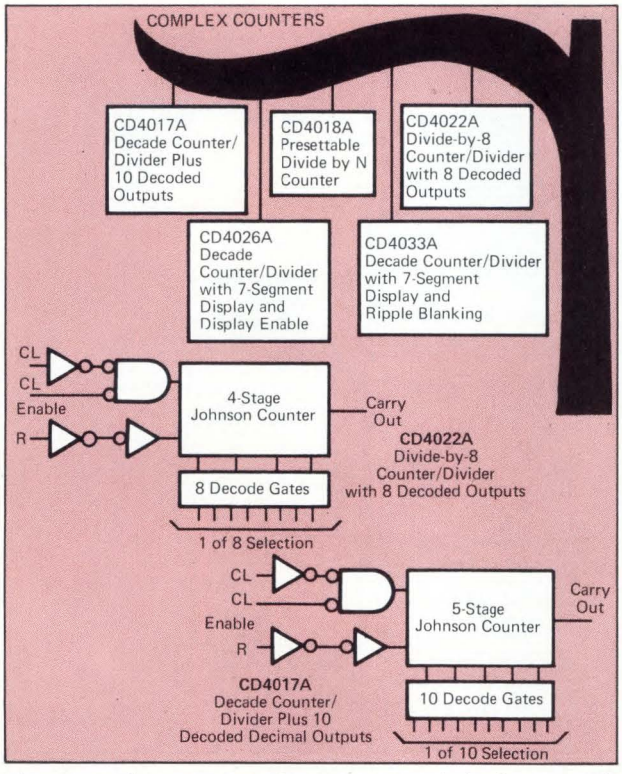

Fig. 13 — The more complex counters include devices with display blanking and leading-zero suppression to help conserve system power.

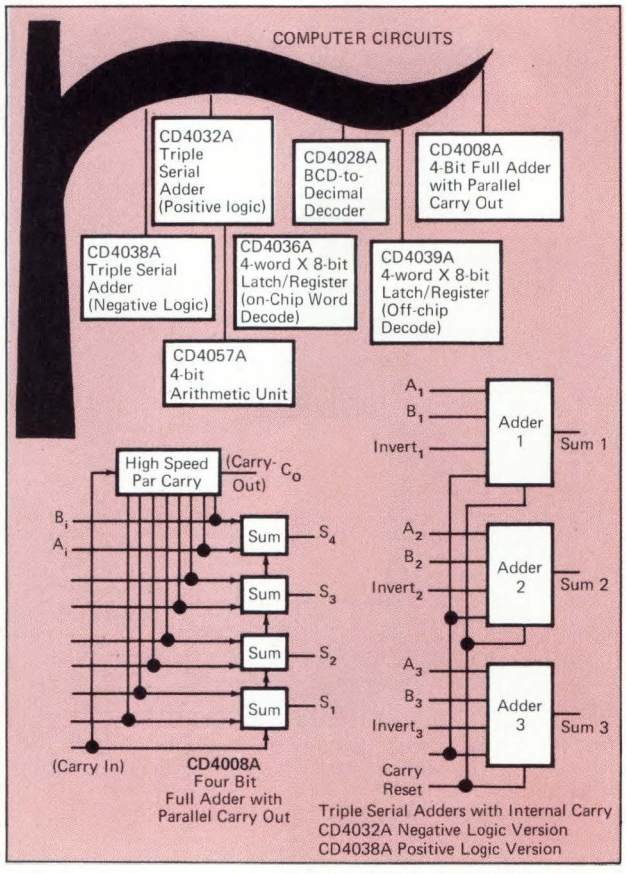

Fig. 14 — Computer circuits in CMOS 4000 include a new 4-bit arithmetic logic unit, parallel and serial adders and decoders.

Counters round out the family

Counters available in the CMOS 4000A Series, as shown in **Fig. 12,** are of two types, the Johnson (shift register) counter or a binary ripple-type counter. All of those shown in this section, except the 4029, are binary ripple type counters. The two 7-stage ripple counters are essentially the same, with the 4024 having a slightly improved reset capability. The 4020 and 4040 are actually the same chip with different metalization patterns. The 4045 has 21-stages of binary ripple counting, providing a very high functional density. The 4029 is a synchronous counter, and one of the most versatile of the CMOS counters. It can count up or down, it can count in binary or decade; and it has parallel entry.

The more complex counters listed in **Fig. 13** are on-chip variations and combinations of basic CMOS circuits and illustrate some of the higher level functions that can be accomplished in a single CMOS building block. The 4026 has a "display enable" function which allows you to continue counting while disabling a higher power display, obviously an important consideration in CMOS designs, and the 4033 provides ripple blanking (for blanking of insignificant zeroes on the display). Both have a carry output for multiple-decade counters.

The 4018, also a Johnson counter, can be used in a very simple counter configuration; it allows

TABLE I
Typical quiescent power dissipation of 4000A series CMOS devices

DEVICE:	μW 10V	μW 5V	DEVICE:	μW 10V	μW 5V
Gates			14-Stage Binary Counter		
NOR CD4000A, 01A, 02A, 25A	0.05	0.025	CD4020A	20	5
NAND CD4011A, 12A, 23A	0.05	0.025	18-Stage Static Shift Register CD4006A		
Dual Complementary Pair Plus Inverter CD4007A	0.05	0.025	1/N Counter CD4018A	10	2.5
Multiplexer (Bilateral Switch) CD4016A	0.1		1/8 Counter CD4022A	10	2.5
AND/OR Select CD4019A	2	0.5	Decade Counters CD4017A, 26A, 33A	10	2.5
Exclusive-OR CD4030A	1	0.25	Up/Down Counter CD4029A	10	2.5
Buffers			21-Stage Counter CD4045A	30	7.5
Inverting CD4009A	0.5	0.15	8-Stage Static Registers CD4014A, 21A	10	2.5
Non-Inverting CD4010A	0.5	0.15	Dual 4-Stage Static Register CD4015A	10	2.5
True/Complement CD4041A	0.2	0.05	64-Stage Static Shift Register CD4013A	20	5
Triple AND/OR Bi-Phase Pairs CD4037A	2	0.5	MSI 8-Stage Static Register CD4034A		
Flip-Flops			4-Stage Register CD4035A	10	2.5
Dual "D" CD4013A	0.2	0.05	Arithmetic		
Dual J-K CD4027A	0.2	0.05	Full 4-Bit Adder CD4008A	10	2.5
Latches			Serial Adders CD4032A, 38A	10	2.5
Clocked "D" CD4042A	0.2	0.05			
NOR R/S CD4043A	0.2	0.05			
NAND R/S CD4044A	0.2	0.05	Decoder BCD-to-Decimal CD4028A	100	2.5
Counters and Registers					
7-Stage Binary Counter CD4024A	10	2.5	Memories 4-word by-8-Bit NDRO CD4036A, 39A		

TABLE II
Typical output current capabilities of 4000A series CMOS circuits

DEVICE:	V_{DD} = 10V		5V	
	$I_D(p)$	$I_D(n)$	$I_D(p)$	$I_D(n)$
Gates				
NOR				
CD4000A, 01A, 02A, 25A	−1	2.5	-2^8	1
NAND				
CD4011A, 23A	−1.2	0.6	−0.5	0.5
CD4012A	−1.2	0.6	−0.5	0.25
Dual Complementary Pair Plus Inverter				
CD4007A	−2.5	2.5	−4.0	1
AND/OR Select				
CD4019A	−1.5	2.5	−0.5	1.5
Exclusive-OR				
CD4030A	−1.3	2.4	−0.6	1.2
Buffers				
Inverting				
CD4008A	−0.8	10	−1.75[a]	4
Non-Inverting				
CD4010A	−0.8	10	−1.75[a]	4
Triple AND/OR Bi-Phase Pairs				
CD4037A	−2.5	2.5	−1	1
True/Complement				
CD4041A				
True Output	−8	10	−2.8	3.2
Comp. Output	−3.6	4	−1.2	1.6
Flip-Flops				
Dual "D"				
CD4013A	−1.3	2.5	−0.5	1
Dual J-K				
CD4027A	−1.3	2.5	−0.5	1
Latches				
Clocked "D"				
CD4042A	−2	2	−1	1
NOR R/S				
CD4043A	−1	1	−0.5	0.5
NAND R/S				
CD4044A	−1	1	−0.5	0.5
Counters and Registers				
7-Stage Binary Counter				
CD4024A	−0.7	1	−0.3	0.5
14-Stage Binary Counter				
CD4020A	−0.5	0.6	−0.25	0.4
18-Stage Static Shift Register				
CD4006A	−0.3	0.5	−0.15	0.25
Counters and Registers (cont'd)				
64-Stage Static Shift Register				
CD4031A				
Q Output	−1.4	8	−0.64	2.6
$\overline{Q}$ Output	−0.4	0.4	−0.18	0.18
CL_D Output	−1.6	2.4	−0.8	0.8
MSI 8-Stage Static Register				
CD4034A	−0.25	0.5	−0.1	0.2
1/N Counter				
CD4018A				
Q5 Output	−1	1	−0.4	0.4
Other Outputs	−0.4	0.4	−0.15	0.1
1/8 Counter				
CD4022A				
Decode	−0.15	0.3	−0.075	0.15
Carry	−0.8	1	−0.4	0.5
Decade Counters				
CD4017A				
Decode	−0.2	0.4	−0.075	0.1
Carry	−1	1	−0.4	0.4
CD4026, 33A				
Decode	−0.6	0.5	−0.28	0.24
Carry	−1	1	0.4	0.4
21-Stage Counter				
CD4045A	−6	6	−2.5	2.5
Up/Down Counter				
CD4029A				
Q Output	−0.4	1.2	−0.24	0.8
Carry	−0.2	0.64	−0.12	0.16
8-Stage Static Registers				
CD4014A, 21A	−0.44	0.5	−0.16	0.3
Dual 4-Stage Register				
CD4015A	−0.44	0.5	−0.16	0.3
Arithmetic				
Full 4-Bit Adder				
CD4008A				
Carry	−1.5	1.5	−0.5	0.5
Sum[b]	−0.3	0.5	−0.02	0.02
Serial Adders				
CD4032A, 38A	−1.2	2.4	−0.4	0.09
Decoder				
BCD to Decimal				
CD4028A	−1.9	2.4	−0.9	1.2

[a] Output voltage V_0 = 2.5V
[b] V_0 (sum) = 3V

TABLE III
Typical propagation delays for the 4000A CMOS family. All values in nsec, output load capacitance = 15pF

Types	V_{DD}=10V		5V	
	HL	LH	HL	LH
Gates				
NOR				
CD4000A, 01A				
02A, 25A	25	25	35	35
NAND				
CD4011A, 23A	25	25	50	50
CD4012A	50	25	100	50
Dual Complementary Pair Plus Inverter				
CD4007A	20	20	35	35
Multiplexer				
CD4016A				
Turn On	20	20		
Signal In to Signal Out	10	10		
AND/OR Select				
CD4019A	50	50	100	100
Exclusive-OR				
CD4030A	40	40	100	100
Triple AND-OR Bi-Phase Pairs				
CD4037A	75	75	225	225
Buffers				
Inverting				
CD4009A	10	25	15	50
Non-Inverting				
CD4010A	10	25	15	50
True/Complement				
CD4041A				
True Output	40	45	65	75
Comp. Output	30	25	55	45
Flip-Flops				
Dual "D"				
CD4013A	75	75	150	150
Dual J-K				
CD4027A	75	75	150	150
Latches				
Quad Clocked "D"				
CD4042A	75	75	150	150
Quad NOR R/S				
CD4043A	75	75	175	175
Quad NAND R/S				
CD4044A	75	75	175	175
Counters and Registers				
7-Stage Binary Counter				
CD4024A	80	80	175	175
14-Stage Binary Counter				
CD4020A	150	150	450	450
Counters and Registers (cont'd)				
18-Stage Static Shift Register				
CD4006A	125	125	250	250
1/N Counter				
CD4018A				
$\overline{Q}_5$ Output	125	125	350	350
Other Outputs	200	200	500	500
1/8 Counter				
CD4022A				
Carry	125	125	325	325
Decode	200	200	400	400
Decade Counter				
CD4017A				
Carry	125	125	350	350
Decode	200	200	500	500
Up/Down Counter				
CD4029A				
Q Outputs	115	115	325	325
Carry	150	150	425	425
8-Stage Static Registers				
CD4014A, 21A	100	100	300	300
Dual 4-Stage Static Register				
CD4015A	100	100	300	300
64-Stage Static Shift Register				
CD4031A	200	200	400	400
MSI 8-Stage Static Register				
CD4034A	240	240	600	600
4-Stage Shift Register				
CD4035A	100	100	250	250
Arithmetic				
Full-Bit Adder				
CD4008A				
At Output				
From Sum Input	325	325	900	900
From carry input	325	325	900	900
At Carry Output				
From sum input	120	120	320	320
From carry input	45	45	100	100
Serial Adders				
CD4032A, 38A				
At Sum Output				
From A, B, or Invert. inputs	125	125	400	400
From clock input	250	250	800	800
Decoder				
BCD-to-Decimal				
CD4028A	100	100	250	250

preset inputs and provides Q outputs. The "D" input of the first stage is available for count-suppression feedback from the outputs of succeeding stages without any external reset circuitry.

Some of the circuits listed in Fig. 14 will obviously have other applications besides computers, but they are placed here for ease of classification. The 8-bit X 4-word registers, discussed earlier, are listed here because they can serve as a simple memory element, and when used in this function, they feature non-destructive readout operation. There are two basic types of adders available in the 4000A Series; either serial adders like the 4032 or 4038, or 4-bit parallel full adders like the 4008. The 4008, as shown in the lower section of **Fig. 14,** provides an internal "look-ahead carry" function and a carry output so that the units may be paralleled to provide whatever word length may be required.

Some typical operating characteristics

If you've begun to do some preliminary calculations for a CMOS system, the four accompanying tables will be of some assistance. Bear in mind that these listed characteristics are typical, and you'll have to consult the manufacturers' spec sheets for worst-case numbers.

Table I lists the typical quiescent power dissipation for each member of the basic 4000A family. Output current drive capabilities of the series will be found in **Table II,** and typical propagation delays are listed in **Table III.** Again these figures are only typical, and they're intended for your use in rough evaluations.

The CMOS design course, Part III, will cover in detail many of the system considerations involved in CMOS design. □

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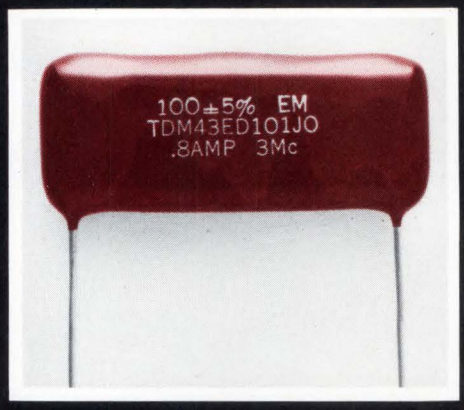

Typical TDM43 Capacitor, actual size

NEW in the industry—El-Menco TDM43 Transmitting Dipped Mica Capacitors are unequalled in small size and low cost for their ratings. Compared to conventional types with similar characteristics, they require only one-sixth as much space... save you 83% of the volume previously required. The superior coating transmits heat more efficiently, so you can use a smaller size for a given rating.

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Check the table below for representative values among the many standard TDM43 units available... or call or write Electro Motive if you have a special application or one in which pulse conditions are present. Technical literature available on request.

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Capacitance Value in pF	60 Hz Peak W.V.	Characteristic	Rated Current in amps. at Freq. of 3.0 MHz	1.0 MHz	0.3 MHz	0.1 MHz	Max. Dimens. in Inches L	W	T
47		C	0.50	0.10	0.07	0.03	2.010	.850	.220
1200	1500	F	4.90	3.80	1.20	0.42	2.010	.850	.230
2700		F	5.90	5.80	2.20	0.90	2.010	.850	.230
3300		F	6.10	6.20	2.60	1.10	2.010	.850	.230
5600	1000	F	6.50	7.30	4.10	1.80	2.010	.850	.240
9100		F	6.80	8.10	5.50	2.40	2.020	.860	.260
10,000		F	6.90	8.40	6.40	2.70	2.020	.860	.260
15,000	750	F	7.00	8.90	7.80	3.30	2.030	.870	.280
20,000		F	7.10	9.20	8.30	3.50	2.040	.880	.310
22,000		F	7.20	9.40	8.80	3.70	2.030	.870	.300
30,000	500	F	7.20	9.60	9.30	3.90	2.040	.880	.320
36,000		F	7.30	9.80	9.70	4.10	2.040	.890	.340
39,000		F	7.30	9.90	10.0	4.20	2.050	.890	.350
68,000	250	F	7.40	10.3	10.9	4.50	2.050	.900	.370
100,000		F	7.40	10.5	11.5	4.70	2.070	.910	.440

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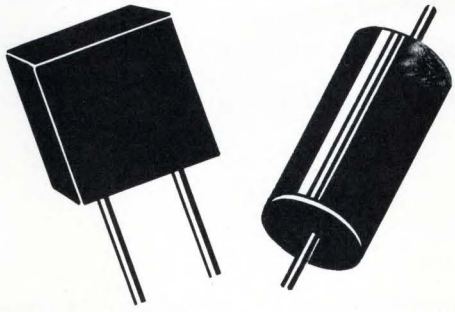


First of all, they don't have to be round. As a matter of fact, the most precise unit you can buy is square (see the picture above).

Secondly, make sure you're getting all you pay for. Every manufacturer lists the basic specifications—Tolerance, Size, Wattage, etc. but very few publish *all* the specifications . . . and those missing facts can be important.

In buying precision resistors make sure you know the Temperature Coefficient (a 25 ppm/°C 10K resistor at 25°C will be 10,009 ohms when measured at 60°C)—your .01% resistor could be .1% at the operating temperature.

Make sure you are told the inductance and capacitance. (A spiraled metal film *is* inductive.) If at your frequency, the X_L is 10% of the DC resistance, the resistance shift is 5000 ppm.

Ask for stability figures under load and on the shelf (two years from now you still want the performance you designed in).

Are you told the tracking characteristics between production runs of units? And what about tracking of various values?

You should be told all these things and more if you're buying precision resistors and paying the price. Ask Vishay for the facts—we'll tell you everything, not just what we want to accentuate. We'll tell you our limitations along with our strong points. Write us today—you may not need all of our ultra-precision specifications, but you should know they are available.

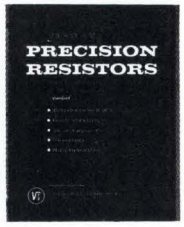
TYPICAL PERFORMANCE CHARACTERISTICS

Resistor Type	Metal Film	Wirewound	Vishay Bulk Metal Film
Typical rise time	10-100 nanoseconds	10,000 nanoseconds	1 nanosecond
Typical TC track			
Same value	25 ppm	5 ppm	3 ppm
Value one decade	35 ppm	10 ppm	3 ppm
Value two decade	50 ppm	20 ppm	3 ppm
Typical shelf life (1 year)	500 ppm Evaporated	25 ppm	25 ppm

MIL PERFORMANCE CHARACTERISTICS

PARAMETER		MIL-R-55182 Characteristic J	MIL-R-39005 Characteristic L	MIL-R-55182 Characteristic Y
Best T.C.		±25 ppm	±10 ppm	±5 ppm
Best Tolerance		0.1%	0.01%	0.01%
¼ watt size		RNR 65J	RBR 54L	RNC 90Y
Occupied board space		.188 x .625 plus lead space	.250 x .750 plus lead space	.110 x .310 no lead space
Wattage rated @		125°C	125°C	125°C
Max. ambient temperature		175°C	145°C	175°C
Maximum Permissible ΔR's	Temp. Cycling & Overload	.2%	.06%	.05%
	Dielectric withstand.	.15%	.01%	.02%
	Moisture Resistance	.4%	.1%	.05%
	Shock	.2%	.01%	.01%
	Vibration	.2%	.01%	.02%
	Low Temp. Operation	.15%	.02%	.05%
	High Temp. Exposure	.5%	.1%	.05%
	Life (2000 Hrs.)	.5%	.1%	.05%

Send for these Technical Bulletins



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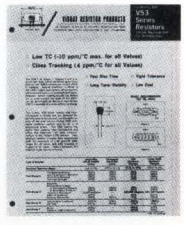

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Film-resistor specs: all you wanted to know but were reluctant to ask

Specifying film resistors properly is not as simple as one might think. For good design performance, understanding all parameters is essential.

Vernon Gray, Mepco/Electra, Inc.

It is not at all uncommon for many a designer to specify film-resistor components (metal, carbon and cermet) with only three parameters in mind: resistance value, tolerance and power dissipation. After all, one might ask, what is there to know about specifying film resistors? Quite a bit if one expects good performance from a design. This situation is further aggravated by the lack of industry-wide specification standardization. Indeed, many important parameters are actually omitted from some data sheets.

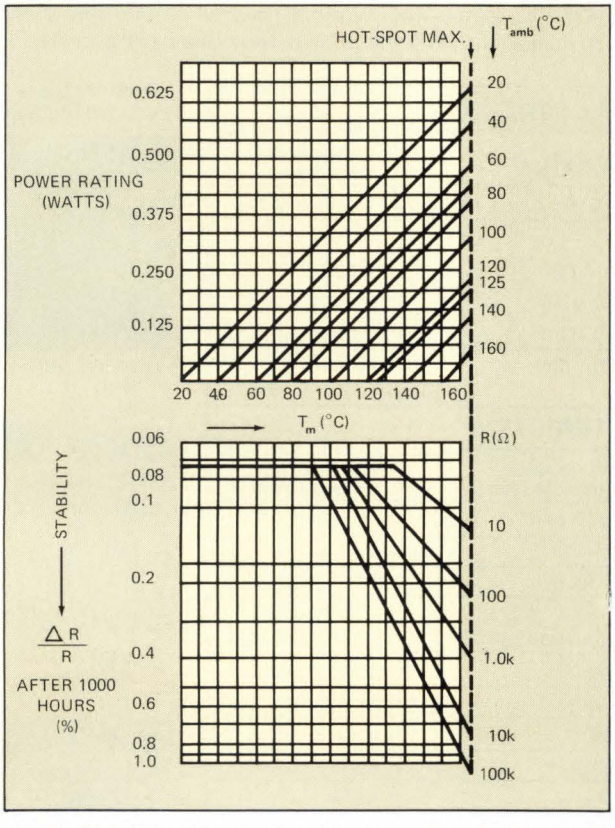

Fig. 1—Determine film-resistor time stability with this handy nomograph. The nomograph relates power dissipation, ambient temperature (T_{amb}), hot-spot temperature (T_m), resistance value (R) and maximum resistance drift ($\triangle R/R$) at 1000 hours of operation. The nomograph should not be extended beyond the maximum allowable hot-spot temperature. The resistance change for zero power indicates the storage stability at a given temperature, and the limiting voltage of the resistors has not been taken into consideration. The probability of the drift being less than the indicated value is 95%.

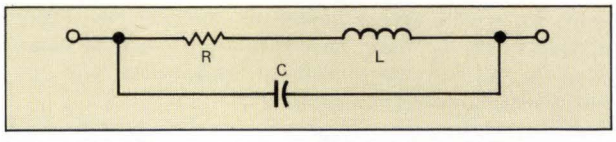

Fig. 2—Use this equivalent resistor circuit over the frequency range of dc to several hundred megahertz. It is assumed that skin effects are negligible, rendering the resistive component, R, of the impedance constant at all frequencies. The inductance, L, is usually negligible, while the capacitance, C, can be significant and generally does not vary more than ±20% with the resistance value.

The following parameters should therefore be reviewed by the reader as a guide to help him interpret, evaluate and select film-resistor components, whenever needed. The relative importance of each parameter depends on the particular application used.

Accuracy (tolerance) This is the maximum deviation from the nominal resistance value, usually expressed as a percentage of the nominal resistance (or the equivalent in parts per million). It should be understood that this accuracy specification is determined at the factory at the standard trimming temperature, which may vary from manufacturer to manufacturer and is calculated using a negligibly low test voltage and power dissipation.

A negligibly low test voltage and power dissipation means that the test voltage applied is not high enough to cause significant changes in resistance value, considering both the voltage coefficient of resistivity (defined later) or self-heating effects (see definition of power coefficient). Measurements at an ambient temperature other than that given by the manufacturer must allow for the temperature coefficient or T.C. (defined later) of the resistor.

Temperature coefficient of resistivity (T.C.) This is the maximum change in resistance per unit change in the temperature of the resistor, usually expressed

in ±parts per million of nominal value per degree Centigrade. A T.C. rating is generally associated with a specific temperature range over which the maximum T.C. is never exceeded.

The temperature here is *not* the ambient temperature but that of the resistor itself. However, in the absence of self-heating effects, if the resistor has had enough time to reach thermal equilibrium with its ambient, the resistor temperature may be the same as the ambient temperature. The preferred test method is to measure resistance (at negligible dissipation) at several different temperatures, holding each temperature long enough for the resistance to stabilize. (See later discussion of power coefficient for correction for significant power dissipation.)

Time stability The degree to which the initial resistance value is maintained to a stated degree of certainty (probability) under stated conditions of use, over a stated period of time. It is usually expressed in ±percent or ±per unit (ppm) change in resistance per 1000 hours of continuous use.

This parameter is very dependent on the conditions of use, drift being at a minimum for nominal ambient temperature and negligible dissipation and ambient temperature. It is also a function of nominal resistance value, with drift increasing significantly with increasing nominal resistance, as shown in the performance nomograph of **Fig. 1**.

Power (temperature rise) coefficient The maximum rise in "hot-spot" temperature of the resistor above the ambient temperature, per Watt of dissipation, assuming free air convection and negligible loss of heat through the resistor leads, after thermal equilibrium has been reached, usually expressed in degrees Centigrade per Watt.

Remember, this coefficient relates the rise in temperature (above ambient) to the power dissipated in it. Thus, if the power coefficient is 80°C/Watt, the power dissipated is 0.5W and the ambient temperature is 50°C, the final equilibrium "hot-spot" will be:

$$80°C \times 0.5 + 50°C = 90°C.$$

Note also that a "hot-spot" temperature of 90°C constitutes a 67°C temperature rise above a standard trimming temperature of 23°C.

Self-heating coefficient of resistivity The maximum change in resistance due to temperature change caused by power dissipation, at constant ambient temperature, usually expressed in percent or per-unit (ppm) change in nominal resistance per Watt of dissipation. This parameter is actually the product of the power coefficient and the resistor temperature coefficient.

Voltage coefficient of resistivity The maximum change in nominal resistance value due to the application of a voltage across the resistor, after correcting for self-heating effects, usually expressed in per-

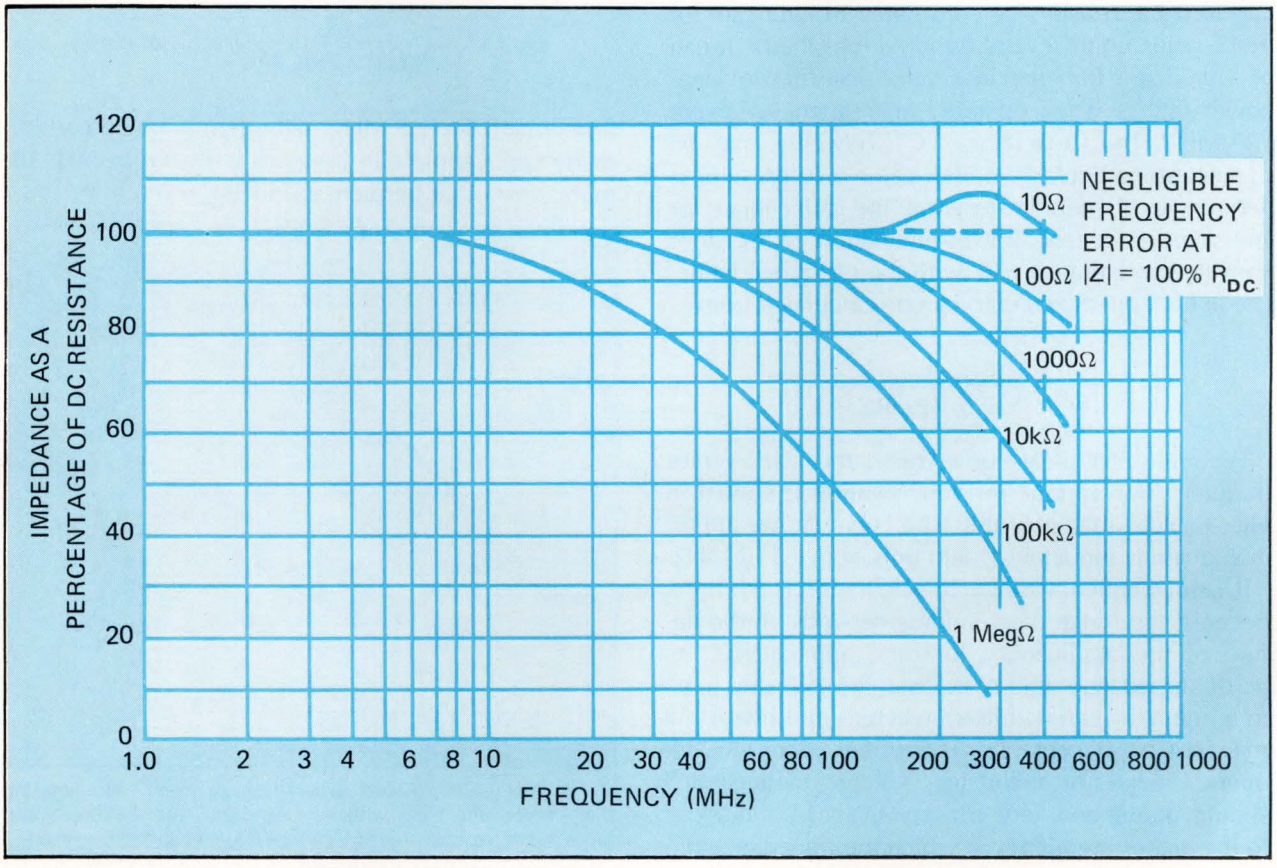

Fig. 3 – The ac/dc impedance ratio, |Z|/R as a function of frequency is shown above for various resistance values. Note that only the 10Ω curve shows any appreciable series inductance and only above 150 MHz.

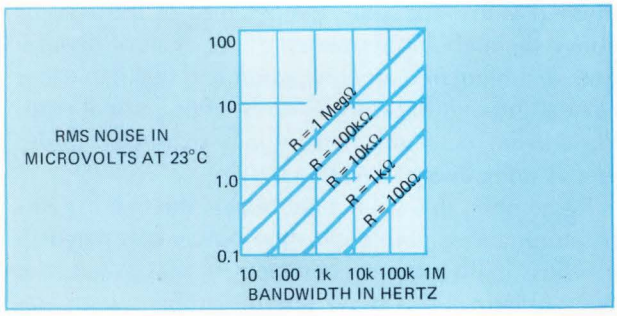

Fig. 4—Calculate the magnitude of thermal noise for any resistor with this nomograph. Thermal noise is inevitable and is sometimes called "white noise" because its energy level is the same at all frequencies.

cent or per-unit (ppm) change in nominal resistance per volt applied.

This parameter is a relatively small source of error and is *not* due to heating, but rather due to molecular distortion in the resistive material; however, an applied voltage can cause significant self-heating, and resistance changes due to temperature rise must be accounted for in measuring voltage coefficient.

Ac/dc impedance ratio The maximum ratio of the magnitude of the complex impedance "Z" to the dc resistance, at the frequency of interest. Looking at the simple equivalent circuit for a resistor in **Fig. 2**, one can see that with negligible "skin effect," the resistive component "R" of the impedance is generally constant at all frequencies. The inductance "L" can in some resistors be considered insignificant for frequencies up to several hundred megahertz. It can be significant for very low value resistors in large power ratings when operated at frequencies above 100 MHz. The capacitance "C", however, may be significant, particularly in high-value resistors at high frequencies. Generally speaking, the capacitance for any given style and power-dissipation rating does not vary more than ±20% with the resistance value. The ac/dc impedance ratio can be calculated from

$$\frac{|Z|}{R} = \frac{1}{\sqrt{1 + (2\pi fRC)^2}}$$

A family of typical curves of its the |Z|/R versus frequency for various resistance values is shown in **Fig. 3**. Note that only the 10Ω curve shows appreciable series inductance, and only above 150 MHz.

Useful frequency range This definition is arbitrary, because the range of usefulness depends on the nature of the application. In some applications, an ac/dc impedance ratio of 0.5 may be tolerable (e.g., in terminating certain filters), whereas in others, 0.99 may not be acceptable. The useful precision frequency range (for attenuators, voltage dividers, etc.) should be defined very conservatively by limiting it to the highest frequency at which the impedance differs from the resistance by more than the tolerance of the resistor. Thus, if a 1 kΩ ±0.5% resistor has a

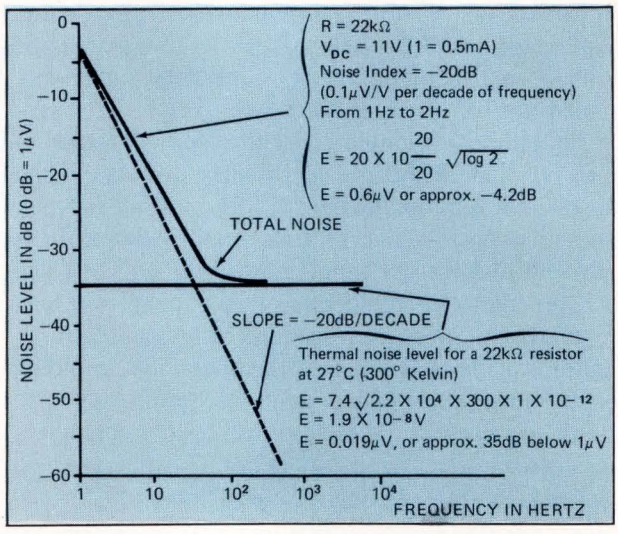

Fig. 5—To discover the relationship between film-resistor noise level and frequency, use this curve. At higher frequencies, current noise approaches thermal noise and finally falls below it. Note the constant energy level of thermal noise at all frequencies.

nominal shunt capacitance of 0.5 pF, then the useful frequency range is from dc to the frequency at which

$$\left(1 - \frac{|Z|}{R}\right) = 0.5\%$$

$$\text{or } \left(1 - \sqrt{\frac{1}{1 + (2\pi fCR)^2}}\right) = 5 \times 10^{-3},$$

from which f ≅ 2.5 MHz; although, as noted earlier, many applications can use such a resistor from dc to many times that frequency. Indeed, some film resis-

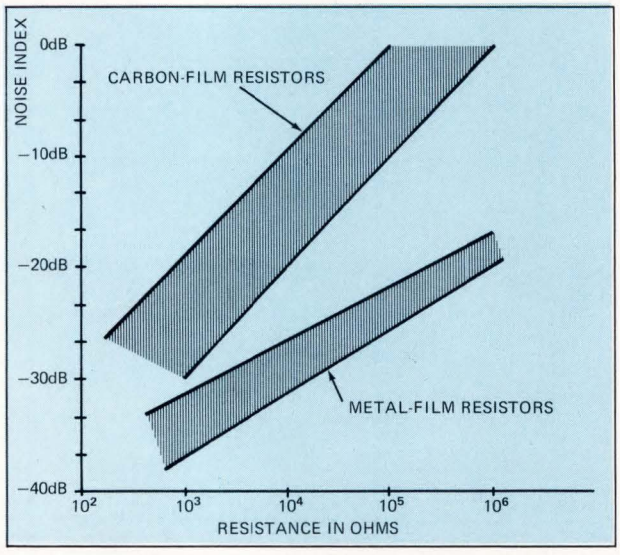

Fig. 6—Metal-film resistors generally have lower noise indices than carbon film types with increasing resistance values. Noise index is the ratio of the rms current-noise voltage (over a one-decade bandwidth) to the average (dc) voltage caused by a specific constant current passed through the resistor at a specified hot-spot tmperature.

tors are used in many applications approaching the gigahertz range. For example, the useful frequency range for terminating transmission lines and filter networks is at least 300 MHz, between 50 and 1000Ω, the range of values most often used for this purpose.

Failure rate The statistical probability of the incidence of "catastrophic" failure in a large number of identical resistors operated continuously for a given period of time under stated environmental conditions, usually expressed as maximum percentage of units predicted to fail under continuous service at maximum rated power (or voltage, if that limit is reached first), at 25°C ambient. This definition is for an industrial failure-rate specification. MIL failure rates are established by the applicable MIL standards, to which the reader is referred. Note that "specification" failure rates (as opposed to catastrophic failure rates) may be significantly higher—i.e., a resistor may exceed its stability limits, as given by **Fig. 1**, without failing catastrophically.

Thermal noise level The equivalent rms voltage value, over a stated bandwidth, of all energy components generated by the resistor at a stated resistor temperature, with no externally supplied current flowing through the resistor. The basic equation relating bandwidth, temperature and noise in any resistor may be derived from the theoretical Johnson thermal-noise equation, and has the form:

$$E_{(rms)} = 7.4\sqrt{RT\Delta f \times 10^{-12}},$$

where: R is the resistance in ohms; T is the temperature in degrees Kelvin (°C + 273); and △f is the bandwidth in Hertz over which the noise energy is measured.

The nomograph in **Fig. 4** can be used for calculation of the magnitude of thermal noise for any resistor. This inevitable thermal noise is sometimes called "white noise," because its energy level is the same at all frequencies. There is another noise component in film and composition resistors called "current noise" or "1/f noise," the energy of which is inversely proportional to frequency and is a function of both the current flowing in the resistor and the value of the resistor.

Current noise energy is almost exactly proportional, over wide ranges, to the square of the current flowing—i.e., to the square of the voltage across the resistor. Its variation with resistance, however, is a very complex function of the construction and metallurgy of the resistor. This parameter is discussed under "noise index."

Noise index The ratio of the rms current-noise voltage (over a one-decade bandwidth) to the average (dc) voltage caused by a specified constant current passed through the resistor, at a specified hot-spot temperature, usually expressed either in μV/V, or in decibels of voltage ratio.

$$\text{noise index} = 20 \log_{10}\left(\frac{\text{noise voltage}}{\text{dc voltage}}\right)$$

A useful form of the above equation gives the total noise voltage for a given bandwidth, f_1 to f_2:

$$E_{(rms)} = V_{dc} \times 10^{\left(\frac{N.I.}{20}\right)} \sqrt{\log\left(\frac{f_2}{f_1}\right)},$$

where V_{dc} is the IR drop across the resistor and N.I. is the noise index in dB. Test conditions must be controlled carefully to assure that the specified hot-spot temperature is established. The measurement must be made on an instrument especially designed to permit correction for its own thermal noise and the thermal noise of the resistor under test (usually negligible). If more than one decade of frequency is of interest, the rms noise voltages add as the square root of the sum of the squares, so that the resultant multi-decade noise level is given by

$$E_n = \sqrt{nE_1},$$

where E_n is the total voltage for n decades of frequency and E_1 is the noise voltage for one decade.

The curve in **Fig. 5** shows the relationship between noise level and frequency for a typical film resistor. At higher frequencies the current noise approaches the thermal noise and finally falls below it. The curve in **Fig. 6** shows how noise index can vary with resistance for film resistors.

Second- and third-order error sources There are other parameters which are usually of limited interest and are usually not specified because they are not always required for design evaluation. These include insulation resistance, insulation voltage limit, temperature retrace, voltage retrace, environmental retrace and thermal transient response. □

The "Film Resistor" handbook and catalog, from which this article was extracted, is available for more details and discussions of second- and third-order error sources. **280**

Author's biography

Vernon Gray is the product marketing manager for film resistors at Mepco/Electra where he has been employed for 9 years. Previously, Mr. Gray spent 13 years working at Weston Instruments. Vernon Gray holds a B.S. degree.

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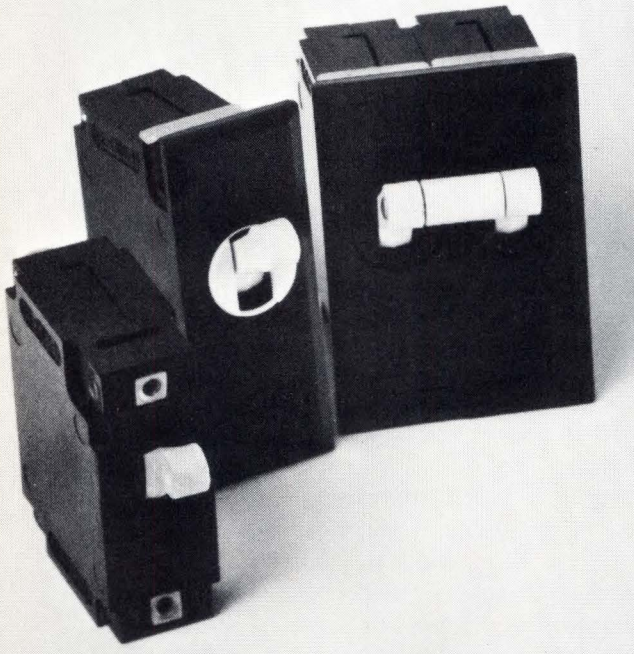

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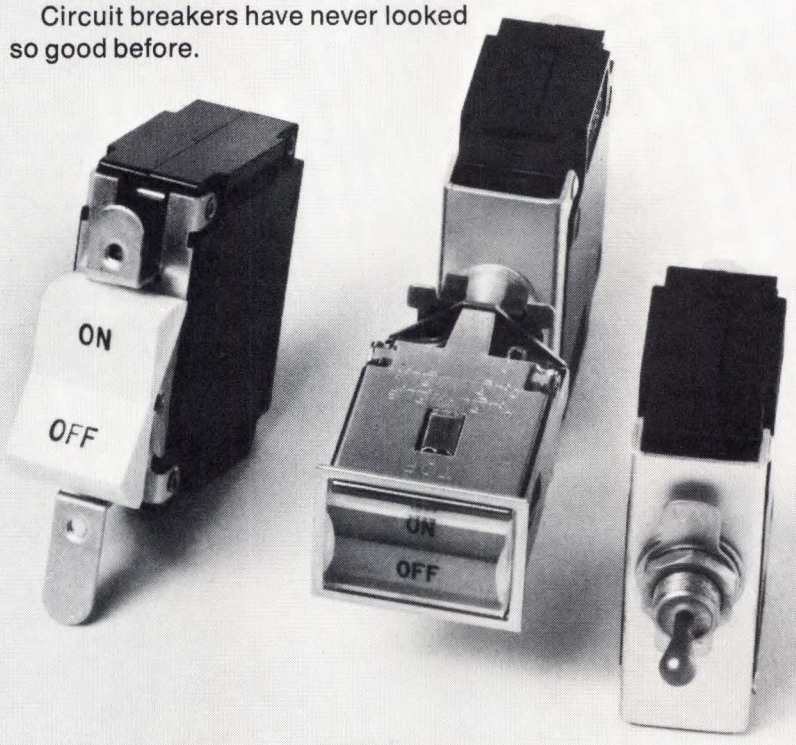

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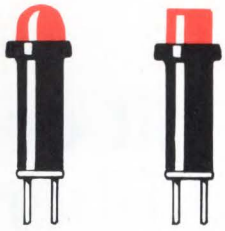

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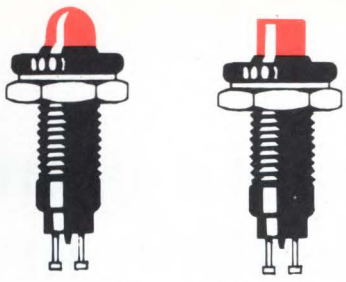

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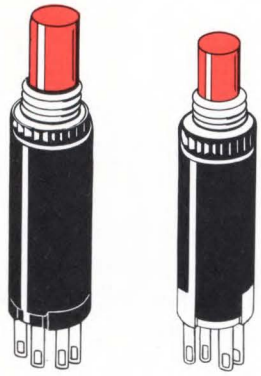

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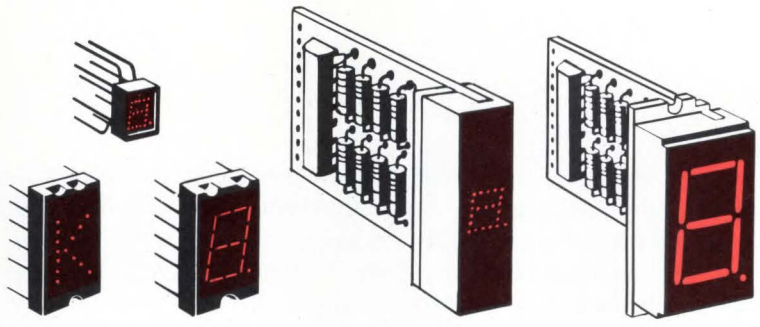

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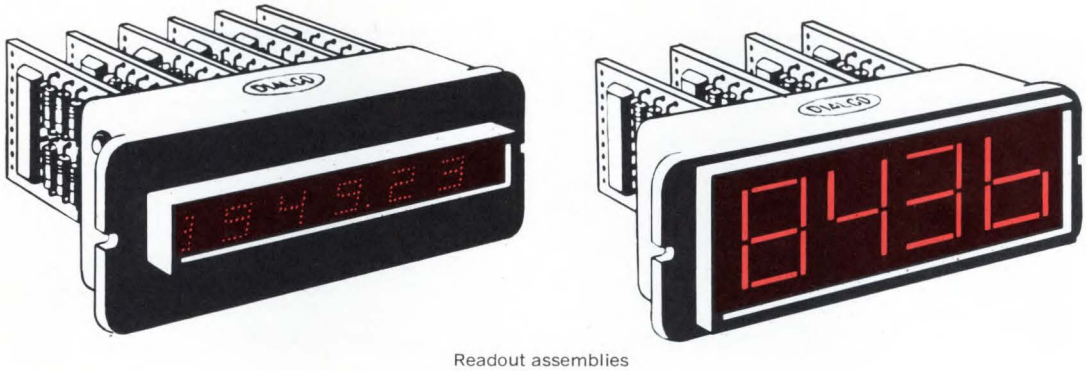

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CHECK NO. 18

Graphs eliminate hit or miss resistor selection in active filter designs

Instead of selecting random values of resistors and capacitors and then calculating to see how good your filter is, try this shortcut.

A. L. Gardner, General Electric Co.

Those who have designed relatively low-frequency low-pass, band-pass and high-pass active filters have experienced the tedium of almost randomly selecting resistor and capacitor values and then calculating the results to see how close they have come to the desired parameters. If the wrong values are selected on the first try, the entire process may have to be repeated several times.

One method for designing the filter in **Fig. 1** is to preselect standard values of C_f and C_d, and then calculate R_2 and R_3 using equations 3 and 6. This is fine unless you are a frequent user of active filters. If this is the case, you can save repeated time and effort by plotting the equations on log-log paper.

Generating the graphs

The basic low-pass filter circuit and a typical frequency curve is shown in **Fig. 1**. It is characterized by a "break" at ω_n, a peak proportional to the damping factor δ, and a fall-off of 40 dB/decade at fre-

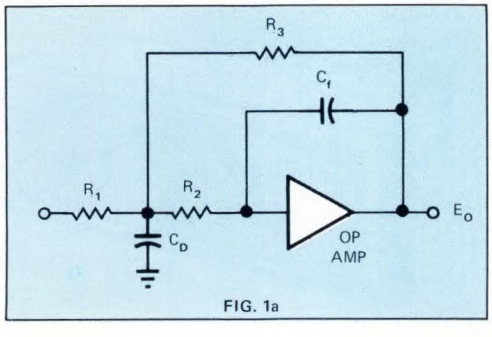


FIG. 1a

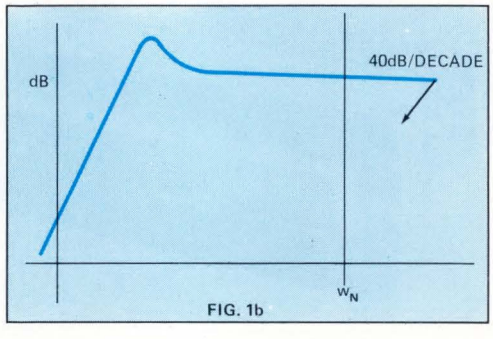


FIG. 1b

Analysis of the RC network of **Fig. 1a** yields the transfer function:

$$\text{Eq. 1}\quad \frac{E_o}{E_i} = \frac{R_3/R_1}{(R_2R_3C_fC_d)S^2 + \left[R_2C_f\left(1 + \frac{R_3}{R_1} + \frac{R_3}{R_2}\right)\right]S + 1}$$

where "S" is the LaPlace transform notation. Equating this to the classical resonance expression:

$$\text{Eq. 2}\quad \frac{F_2(S)}{F_1(S)} = \frac{A}{S^2/\omega^2_n + \frac{2\delta S}{\omega_n} + 1}$$

which yields the following relationships:

$$\text{Eq. 3}\quad \frac{1}{\omega^2_n} = R_2R_3C_fC_d$$

$$\text{Eq. 4}\quad \frac{2\delta}{\omega_n} = R_2C_f\left(1 + \frac{R_3}{R_1} + \frac{R_3}{R_2}\right)$$

$$\text{Eq. 5}\quad \text{dc Gain} = A = \frac{R_3}{R_1}$$

Solving for R_2 yields:

$$\text{Eq. 6}\quad R_2 = \frac{\delta \pm \sqrt{\delta^2 - \frac{C_f}{C_d}(1 + A)}}{\omega_nC_f(1 + A)}$$

Fig. 1 – Typical lo-pass active filter, response curve and analysis of the RC network.

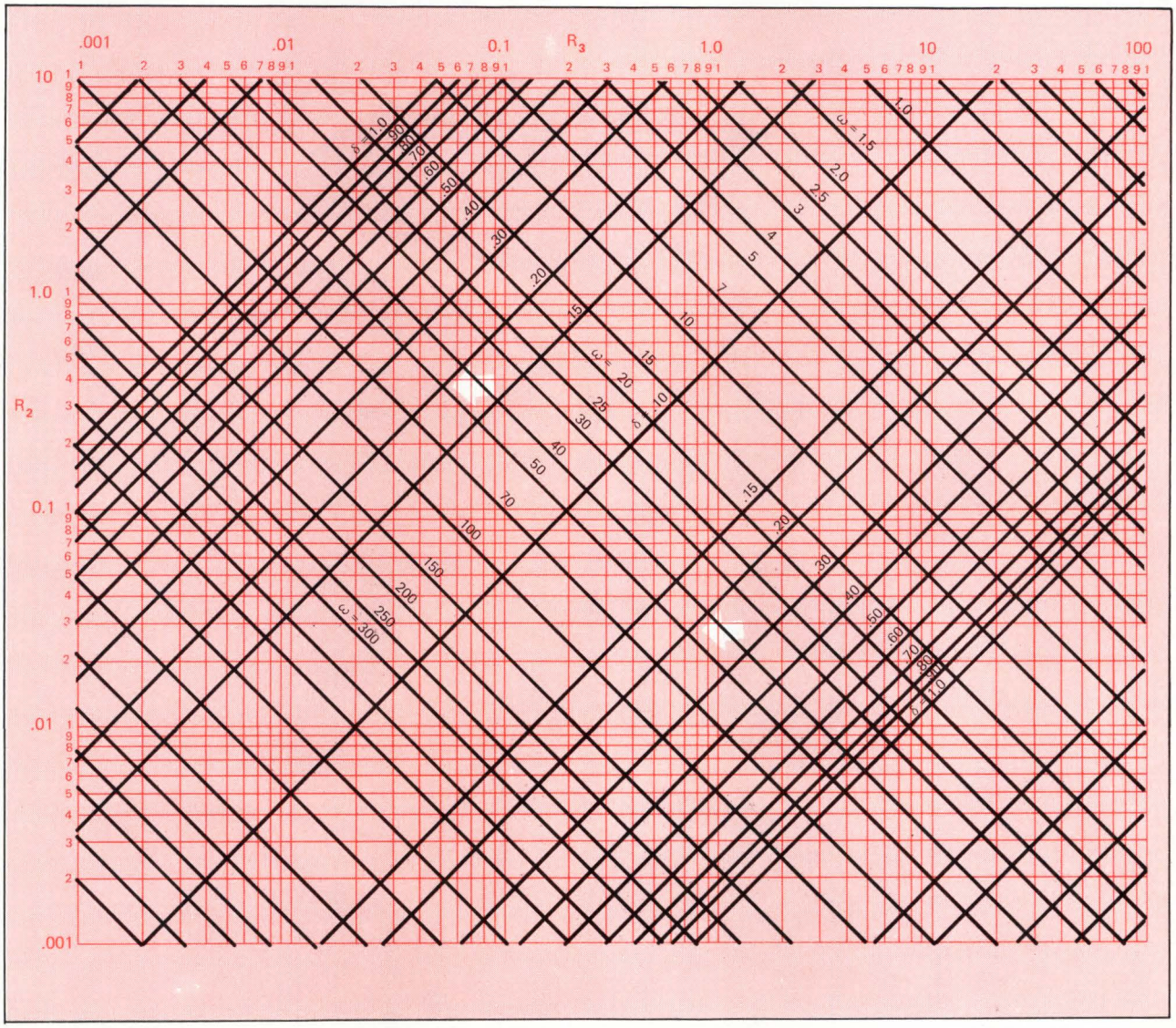


Fig. 2 – How to use the graph. In this case, all resistor values are in MΩ.

Use the following specifications:

ω_n = 50 radians/sec C_f = 0.01 mF

δ = 0.2 C_d = 2.0 mF

dc gain (A) = 1

At the intersections of ω_n = 50 and δ = 0.2 lines (2 places)

Find R_2 = 0.38 MΩ and R_3 = 0.052 MΩ

or R_2 = 0.028 MΩ and R_3 = 0.74 MΩ

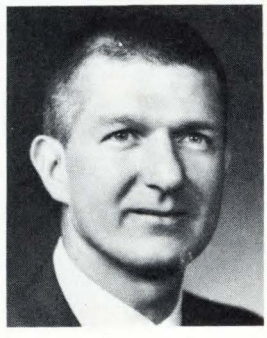
quencies above ω_n.

Fig. 2 is a typical plot where C_f, C_d and dc gain (R_3/R_1) are specified, and lines ω_n and δ are plotted against R_2 and R_3. R_2, plotted against R_3 for constant ω_n, is a straight line on log-log paper with slope −1. When plotted for constant δ, it is a straight line with slope +1.

Knowing the above makes it relatively easy to generate additional graphs for your own particular set of parameters. This shouldn't be too difficult a task because, given specific values of C_f, C_d, δ, ω_n and A, only two values of R_2 (and thus, two values of R_3) give enough points to draw one constant ω_n line and two constant δ lines on any log-log paper.

The only restrictions to accurate use of these graphs are shifts in parameters due to such things as op-amp offset current and frequency response. Excessive offset current, for instance, makes it impractical to use feedback resistors in excess of 1 or 2 MΩ with the 741 op amp. □

Author's biography



A. L. Gardner is a systems engineer at the G.E. Transportation Control Products Dept., Erie, PA. He has been employed at GE for 18 years and has had one patent issued. Mr. Gardner received both his BSEE and MSEE from NYU.

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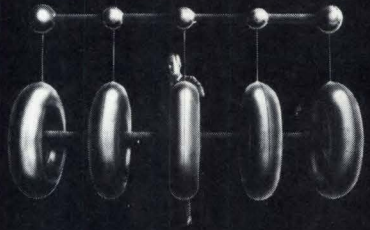

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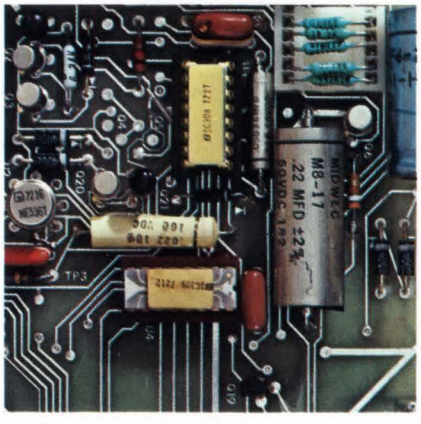

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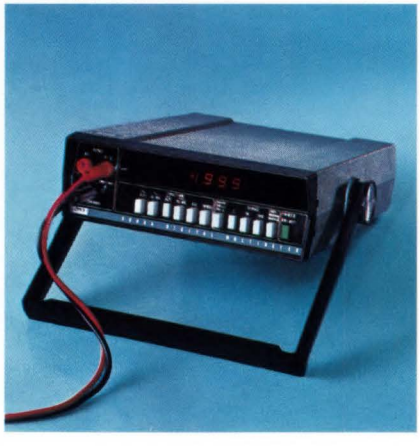

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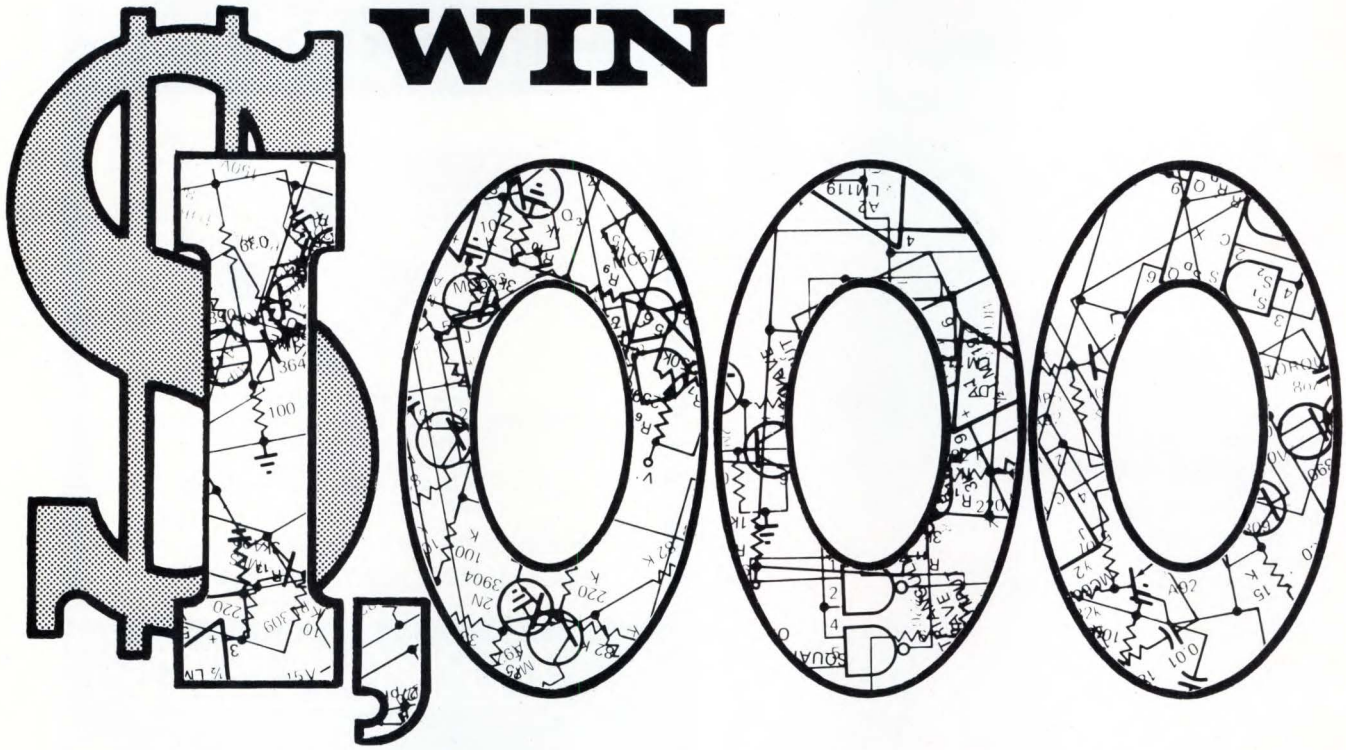

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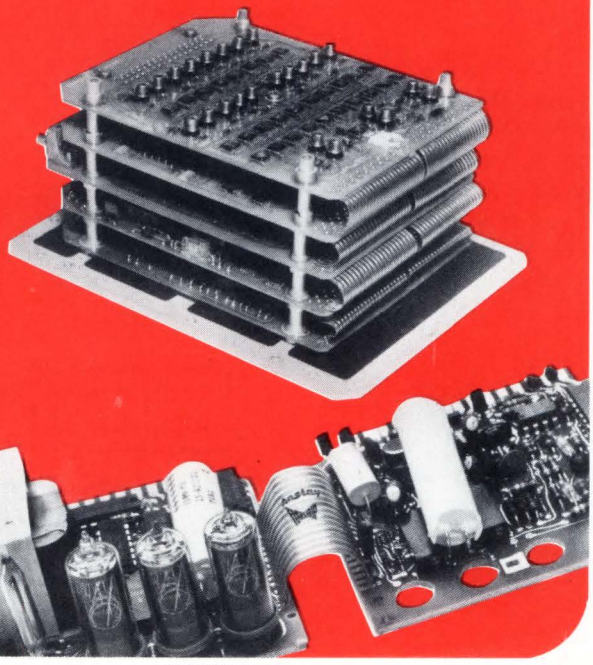

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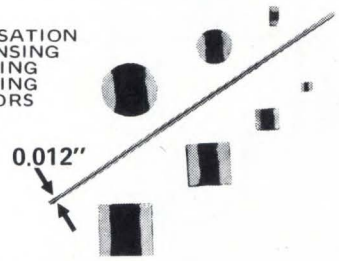

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CHECK NO. 22

EDN DESIGN AWARDS

Universal temperature controller

Leonard Accardi,
Consultant, Maspeth, NY

The usual requirements associated with the design of temperature controllers are: high precision of the controlled temperature, implying that the circuit has extremely high dc gain so that near zero error is required to produce the range of heater power necessary; wide dynamic response, so that the circuit can quickly respond to changing ambient conditions which cause more or less heating requirements; and last, and usually most difficult, insurance that the system will not oscillate about the desired temperature, since thermal path lags usually proliferate due to the nature of most thermal loads. From the circuit point of view, it is also usually desirable to have one side of the heater and thermal sensor grounded, operation from a single power supply, and a circuit of the dc proportional type rather than of the switching type to eliminate EMI and keep power supply loading as constant as possible.

The circuit shown simultaneously incorporates, without tradeoffs, every one of the desired features. The circuit is simple, and easily tailored to satisfy to any desired degree (up to a practical limit of about 0.001°C), the design requirements of any controller, for any load, using one or more thermistors as the sensor.

The principle of operation is as follows. In the saturated or warm-up phase, the thermistor resistance is high and the output of A_1 is close to ground. The output of A_2, including the booster inside its feedback loop, is thus highly pos. and max. power is applied to the heater. When the desired temperature is approached, the circuit enters the linear region, with the thermistor resistance value approaching 10 kΩ as the temperature increases until the stable steady-state resistance and thus, temperature is reached. The presence of any sustained oscillation about the desired temperature (as indicated by heater current oscillations at constant ambient) indicates that the system is not stable.

Customizing the stabilization for the particular application is most easily accomplished by measuring the frequency characteristics of the thermal load.

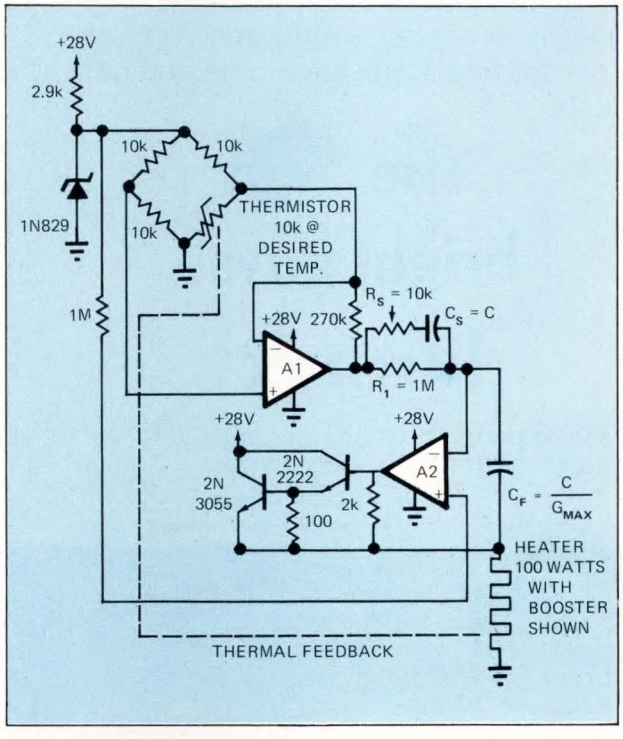

Fig. 1—Temperature controller circuit can be modified with suitable components to satisfy the requirements of almost any controller and any load.

First, the max. value of "pure gain" for which the system is stable is determined by using A_2 as a resistive gain amplifier and increasing the gain until the system begins to oscillate. The value of gain obtained (G_{max}) is thus the reciprocal of the thermal cir-

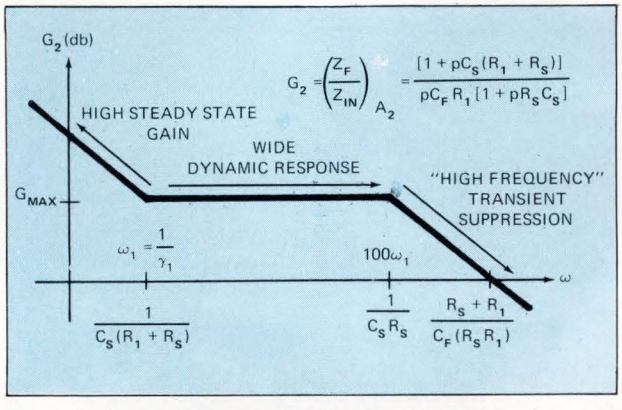

Fig. 2—Bode plot of the A_2 amplifier circuit is used for determining the values of capacitors C_S and C_F.

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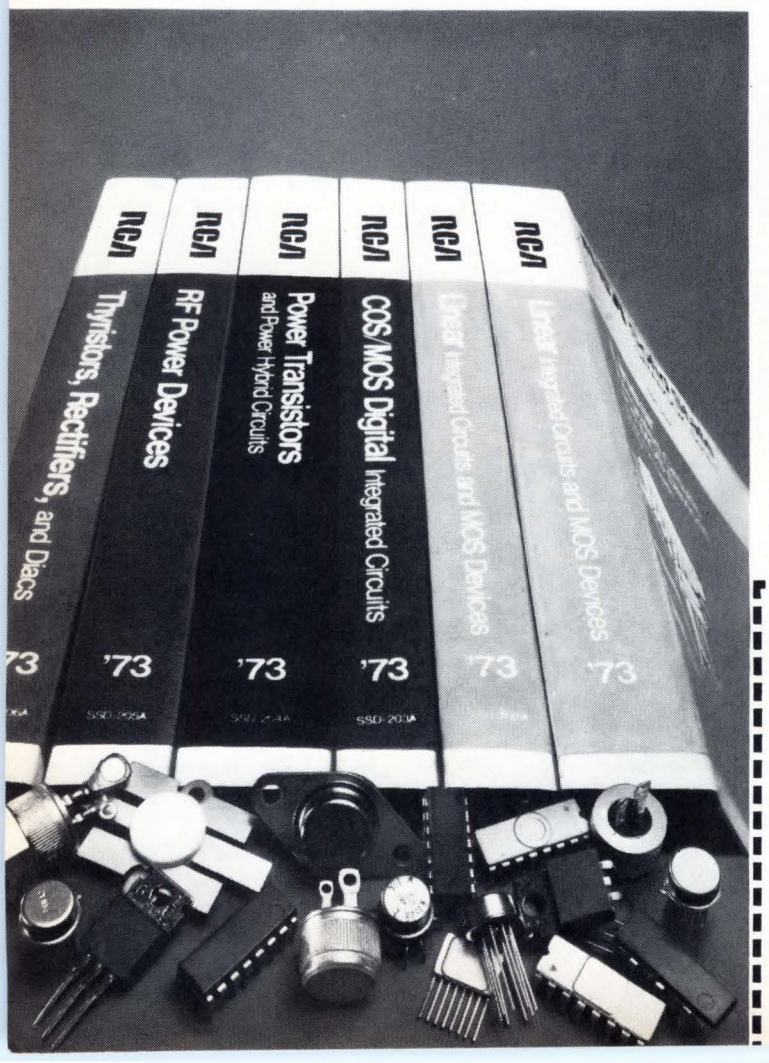

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CHECK NO. 39

cuit attenuation when the thermal circuit phase shift is 180°, since oscillations will begin when the loop gain reaches 1 at a phase shift of 180°.

Next, the first breakpoint of the thermal load (τ_1) is estimated by an open-loop experiment. τ_1 is actually the reciprocal of the angular frequency at which the thermal load phase-shift is 45°, and is established by applying a small step function of heat to the load via the heater and measuring the time constant of the resulting temperature vs time curve. If possible, a nickel-iron or platinum wire sensor is best for this experiment since its RvsT curve is nearly linear.

Having determined G_{max} and τ_1, the values of the integrating and differentiating capacitors are calculated as indicated on the Bode plot of the A_2 circuit in **Fig. 2**. This frequency-response curve then satisfies the remaining requirement of high steady-state gain (so that the steady-state temperature error is essentially zero) and the requirement of unconditional stability, since the phase shift at ω_1 is known to be 45° due to the A_2 circuit breakpoint placed at τ_1 and 45° lag due to the thermal load, a total of 90° lag. Stability is insured at higher frequencies, since the gain does not exceed G_{max} above ω_1.

This circuit has been successfully used in applications ranging from controlling the temperature of a 2 cu. in. shell of metal to controlling the interior of a 2 cu. ft. chamber with forced air circulation. □

To Vote For This Circuit
Check 150

Monolithic timer makes convenient touch switch

J. Courtenay Heater,
Claremont Men's College, Rolling Hills, CA

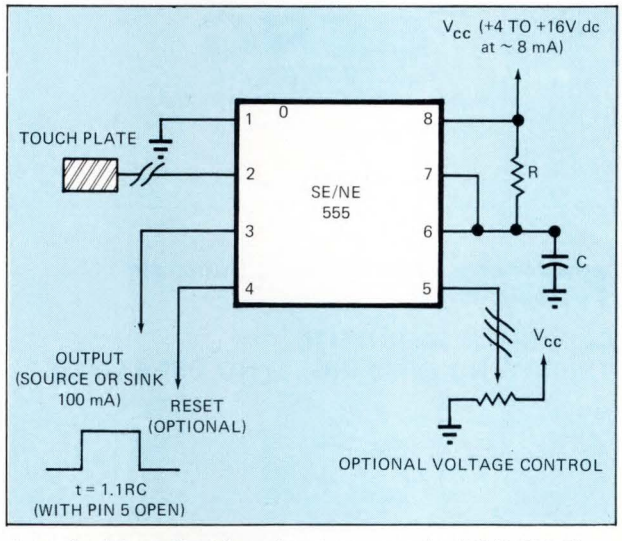
A versatile touch switch for security or convenience purposes can be constructed from the Signetics SE/NE 555 Monolithic Timer and just a few additional components.

Some of the virtually unlimited applications of the touch switch include: switchless keyboards, thief accunicators, activators for the physically handicapped, bounceless electronic switches (with no moving parts) and novelty controls.

The timer itself features either free-running or one-shot capabilities which can be controlled through the use of TRIGGER and RESET inputs. The characteristics of the output pulses are fully adjustable over a large duty cycle, with timing periods adjustable from μsec to hours. The output is capable of sinking 100 mA for either electromechanical activation or other interfacing applications. Supply voltages are non-critical as the device is specified for operation between 4.5 and 16V dc. For 5V operation, the device is directly TTL compatible and draws only 3 mA making it suitable for battery operation. At 16V, the timer draws on the order of 8 mA.

The trigger input on the device is the key feature in touchswitch applications. Requiring only 500 nA to fire at 1/3 the V_{cc} supply voltage (referenced to circuit ground), the device is easily triggered by the voltage differential found between a floating (non-grounded) human body and the circuit itself. This is 20V or more, depending on static build-up. The touch plate can be any conducting material with virtually no size limitations.

Once triggered, the device cannot be retriggered and it will time out. However, if the duration of



A touch plate at the trigger input converts the SE/NE 555 Timer into a versatile touch switch.

human contact exceeds the RC time constant of the timer, random spikes occur in the output after the time out. This can be avoided by making fairly large time constants, so that the device will not time out before contact is removed.

The duration of the output pulse is controlled by both the RC time constant and the control voltage input (pin 5). By varying the voltage at pin 5 the timing can be changed by about one decade. If the entire RC network is omitted and pin 7 is connected directly to pin 6, the circuit will latch ON when "touched".

Perhaps the best feature of all, though, is the low price (less than $1 in single units). □

To Vote For This Circuit
Check 151

Versatile circuit behaves like SCR

A.J. Baracz,
Picatinny Arsenal, Dover, NJ

The circuit shown is both a versatile electronic switch and a logic element which behaves similar to an SCR but has the advantage of several activation and deactivation modes and exhibits immunity to transients and common-mode voltages. The extreme stability of the circuit arises from the fact that the two complementary transistors are simultaneously driven into saturation or, alternately, into cutoff. Thus, the gain of the circuit in both stable states is zero, except for the brief transition period when a rapid cumulative action takes place.

The circuit can, in many cases, replace an SCR and can be used as a logic element by suitable routing of pulses. Operation always starts from the non-conducting state when the supply voltage is applied. A monostable action can also be produced by adding a simple time delay to supply the secondary triggering pulse.

The circuit can be activated in the following ways:

(1.) by application of a +Ve pulse to the base of Q_1

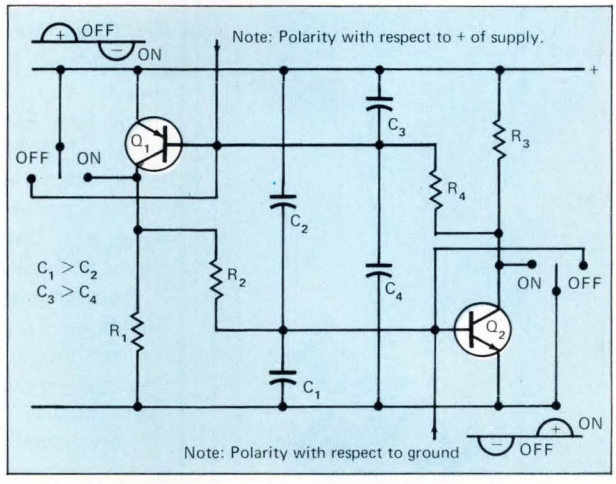
(2.) by shorting momentarily the collector of Q_2 to the ground.

(3.) by application of a −Ve pulse between the +Ve end of the supply and the base of Q_1

(4.) by shorting momentarily the collector of Q_1 to the +Ve end of the power supply.

The circuit can be deactivated:

(1.) by applying a −Ve pulse to the base of Q_2



Combined electronic switch and logic element can be activated and deactivated by a variety of signals. When the switches are used, the switch action is momentary.

(2.) by shorting momentarily the base of Q_2 to ground

(3.) by applying a +Ve pulse from the +Ve end of the power supply to the base of Q_1

(4.) by shorting momentarily the base of Q_1 to the +Ve end of the power supply

The circuit capacitors C_1 through C_4 provide a potential divider for the high-frequency component of the transient common-mode voltages. Transients exceeding ±50% of the supply voltage do not affect the circuit. □

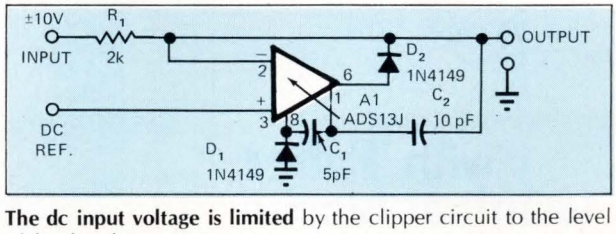
To Vote For This Circuit
Check 152

Precision clipper operates from millivolts to volts

R.S. Burwen,
Analog Devices, Norwood, MA

This precision clipper circuit limits very sharply the excursion of a dc input voltage to a level equal to a dc reference input. When the reference is 0, the circuit can be used as a half-wave rectifier for sinusoidal inputs at frequencies up to 100 kHz. The circuit uses feedback to overcome the breakover characteristics of diode D_2 thereby providing sharp clipping at signal levels from mV to V.

When the input voltage is more pos. than the reference, the output of A_1 is neg. and Diode D_2 is cut off. For input voltages more neg. than the reference, the amplifier output goes sufficiently pos. to cause D_2 to conduct and hold the output voltage at the reference level. For best performance the



The dc input voltage is limited by the clipper circuit to the level of the dc reference input.

circuit requires an amplifier capable of large differential input voltages without drawing input current, a high slewing rate and fast overload recovery to minimize the time delay in the conduction of D_2 while the amplifier output is swinging from neg. overload. The AD513J used in the application is stabilized in a manner that provides high slewing rate using capacitors C_1 and C_2. Because C_2 has little effect until diode D_2 begins to conduct, it does not

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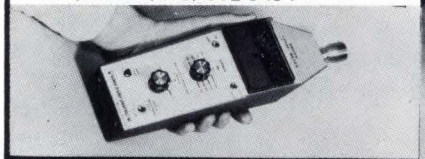

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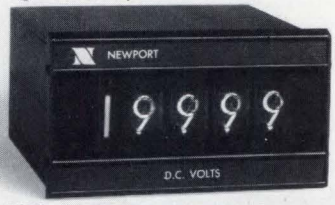

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Newport Digital Panel Instruments

CHECK NO. 31

provide feedback which would reduce the slewing rate, as does C_1.

When the dc reference is at ground potential, a diode, D_1, can be added to reduce the neg. output swing thereby lessening the time delay before D_2 begins to conduct.

The circuit is useful to millivolts levels at dc and low frequencies and at 10 kHz from 70 mV rms to 7V rms when D_1 is not used. With D_1, the circuit is useful at levels down to 0.3V rms at 100 kHz. By changing R_1 to two series resistors and tapping the output off the junction the circuit can be used as a function generator which provides unity gain for inputs more pos. than the reference and less than unity gain for inputs more neg. than the reference. The polarity can be changed by reversing D_1 and D_2. □

To Vote For This Circuit
Check 153

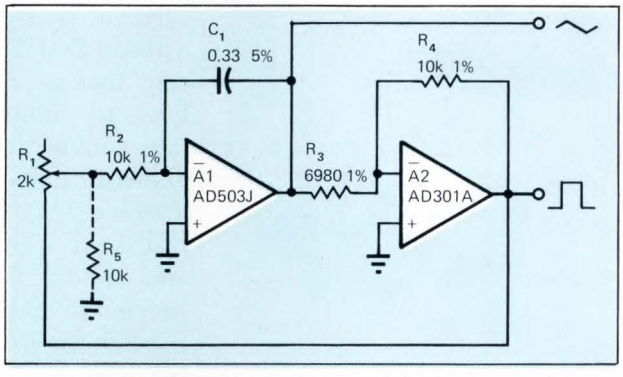
Triangular and square wave generator has wide range

R.S. Burwen,
Analog Devices, Norwood, MA

This oscillator circuit delivers ± 13V square waves and ± 10V triangular waves simultaneously. The values shown are for operation at 100 Hz. By simply scaling R_1, R_2 and C_1, a wide range of frequencies can be covered, even to below 0.1 Hz. The square-wave rise time is typically 1.5 μsec and the fall time 0.5 μsec.

The oscillator consists of an integrator, A_1, feeding a second amplifier, A_2, used as a comparator. Regenerative feedback through R_4 converts A_2 into a Schmitt trigger having ±10V hysteresis levels at the input. When the output of A_2 is pos., A_1 integrates in the neg. direction toward −10V. At this point, the input to A_2 reverses polarity, causing a neg. output from A_2. A_1 integrates in the pos. direction toward +10V, where the polarity reverses again.

The frequency is somewhat determined by the saturation voltages of A_2 and by the power supply voltages. The pos. supply has little effect, and it requires a 20% change in the neg. supply to produce a 1% frequency change. By using stable components, a frequency stability of 0.02%/°C is readily attainable. Capacitor C_1 is preferably a polycarbonate type for temperature stability. It is possible to change the duty factor by feeding a bias current to



A_1 operates as an integrator and A_2 as a Schmitt trigger in this triangular- and square-wave generator.

the input of A_1 and, in fact, this is a means of producing pulse-width modulation.

Operation at 0.1 Hz can be produced by changing R_2 to 10 MΩ. Tuning can be accomplished by potentiometer R_1 to as low as 2 kΩ by loading the arm with a 10 kΩ resistance, R_5. Best performance with such high resistance values is attained by using a lower-input-current operational amplifier for A_1, such as the AD503K, which is rated at 5 pA max. at 25°C. Alternatively, lower values of resistance can be used if C_1 is increased to produce a 3.3 sec time constant. □

To Vote For This Circuit
Check 154

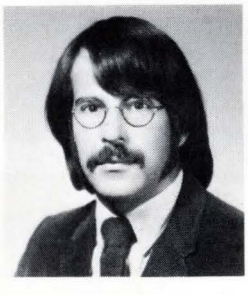
Rules & Announcements

Your vote determines this issue's winner. All circuits published win $20 cash. All issue winners receive an additional $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Saving Bond Grand Prize.

Vote now by circling the appropriate number on the reader inquiry card.

Submit your own circuit, too. Mail entries to Circuit Design Program Editor, EDN, 221 Columbus Ave., Boston, MA 02116.

Readers have voted: Lee J. Mandell winner of the August 15 Savings Bond Award. His winning circuit is "Sine-wave synthesizer has low harmonic distortion". Mr. Mandell is with Litton Industries, Van Nuys, Ca.



12-bit DAC expands for 16-bit operation

PROGRESS IN CIRCUIT MODULES

Teledyne Philbrick has developed a 16-bit DAC based on the concept that a 12-bit DAC that is linear to within ±0.01% is accurate enough to be used as the 12-least-significant-bit portion of a 16-bit DAC. Since Philbrick already has a line of modular 10- and 12-bit DACs, they only needed to develop an adapter to provide the first 4 bits of the 16-bit converter.

The 16-bit DAC consists of 2-in.x2-in.x0.4-in. modules. One is the standard 4004 current-output 12-bit DAC and the other is the new 4012 current-output 4-bit expander module. The 4-bit expander provides the 4 most significant bits and a stable precision reference, suitable for 16-bit accuracy. The complete 16-bit converter operates from this precision reference. The 12-bit module receives the reference from the expander via its external reference pin.

Only one adjustment is required to couple the 4012 and the 4004. The 4004 has been individually trimmed to its own specific zener reference; therefore, it is necessary to use a series-trim resistor to normalize the output of the 4004 so that it will accurately sum with the output of the 4012. This is a simple adjustment and will be performed by Philbrick upon request (Philbrick will supply 2 modules, 4004 and 4012, with the precision coupling resistor).

The converter system features 16-bit resolution from 0°C to 70°C and maintains ±½ LSB linearity from 15° C to 35° C. The output is a current which varies from 0 to +4 mA for all zeroes to all ones, respectively, at the digital inputs (straight binary code). The output impedance of the converter is 5 kΩ and 80 pF. The DAC will settle to within 0.01% of final value in 300 nsec and to within 0.001% in 1 μsec when terminated in 125Ω to ground. The gain T.C. (including the effects of the internal reference) is 7 ppm/° C and the offset T.C. is less than 1 ppm/° C. The complete system operates from standard ±15V supplies.

A voltage-output version is also available. In this case, a 4013 expander, also packaged in 2-in. x2-in.x0.4-in. module is used instead of the 4012. The 4013 includes an internal op amp to provide 0 to −10V out at 15 mA, with a settling time of 5 μsec to within 0.01% of final value. The op amp provides the necessary speed, accuracy, stability and package size required for 16-bit operation as described above.

Why should you buy two modules and a resistor instead of a completely packaged 16-bit converter? One good reason is that the Philbrick combination is priced at less than $500 for the 4004-4012 system in single quantities.

Teledyne Philbrick, Allied Dr. at Route 128, Dedham, MA 02026. Phone (617) 329-1600. **257**

Bi-color and ac-dc compatible LED lamps available in a lensed 2-lead package

PROGRESS IN DISPLAYS

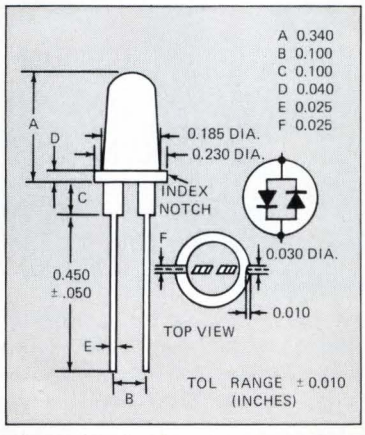
A new series of GaAsP indicators, operable from ac voltage or dc voltage of either polarity, offers greater applications diversity and immunity to transient reverse current destruction has been introduced by Monsanto.

The ac LED devices consist of two LED dies parallel connected with anode to cathode and cathode to anode in a 2-lead diffused epoxy header. Single LED dies typically have an absolute maximum rating of 3V reverse voltage. With two diodes connected in a complementary-parallel configuration, the danger of damaging the indicator with reverse transients is avoided, and a host of ac operation applications is opened.

Of particular interest for ac use is Monsanto's bi-color device, the MV5491, which has one red die and one green die in a clear diffused epoxy header. Biased in one polarity, it is bright green; Biased with the opposite polarity, it is bright red; driven with an alternating signal, it gives a distinct bi-color indication. MV5491 red/green indicator can thus be used as a true 4-state, 2-lead indicator without a need for winking, dimming, pulsing or flashing techniques. In addition, used as a go/no-go indicator, the 2-color device has an advantage over any on-off indicator, which has the inherent uncertainty of lamp failure (and thus may require a means for "lamp test").

The packages' dimensions are identical with Monsanto's MV-5020 series. The series will have six-color combinations. The first two of the series, the MV5094 and the MV5491, are now available from stock.

The MV5094 red/red indicator will emit a bright light (½ MCD) when driven with 20 mA, dc or ac rms, appearing constant to the eye for ac frequencies of 50 Hz and above (with a proper current control series resistor). The red die used in the MV5491 emits 0.5 MCD with $I_f = 20$ mA, and the green die emits 0.2 MCD at the same current. Since the human eye is more sensitive to green light energy than it is to the red, a 20-mA drive produces red or green light that appears about the same in brightness.



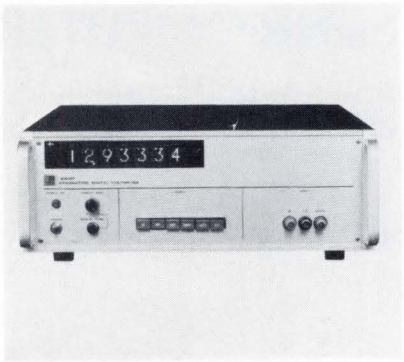
Lead spacing in the new ac indicators is compatible with many standard packages, including the TO-92, the TO-46, the TO-18 and most DIPs. The two dies are placed near the center of the epoxy header, which is diffused such that either die will light the indictator.

Both the 2-color indicators and the single color indicators in the 5094 series have unique advantages in various applications.

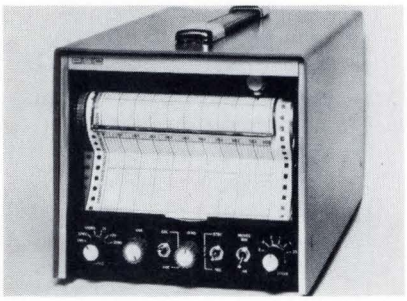
One obvious application for the red/red, green/green and yellow/yellow LED devices is replacement of other types of ac lamps with reliable, long-lived solid-state indicators. Idiot lights, pilot lamps and various status indicators are examples.

The red/red MV5094 is 99¢ in 1000-piece lots, and the red/green MV5491 is $2.45.

Monsanto Commercial Products Co. Electronic Special Products 10131 Bubb Rd. Cupertino, CA 95014 Phone (408) 257-2140. **258**

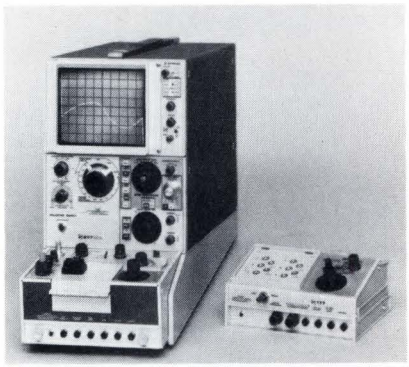


PRECISION 7-DIGIT DVM PROVIDES ACCURACY OF 0.0003%. The Model TR6567 has 4 dc-voltage ranges from 1V up to 1000V full scale and provides resolution of 1 μV on the 1V range. A patented dynamic scale spread method permits the high accuracy of 0.0003% to read $\pm$1 digit on the 1V range. When combined with an external amplifier, the meter is capable of 10 nV/digit resolution. $2600. Takeda Riken Industry Co., Ltd., c/o Miida Electronics, 866 2nd Ave., New York, NY 10017. Phone (212) 973-6926. **194**



PORTABLE 5-LB STRIP-CHART RECORDER. Model 714 with optional battery power measures only 5 in. high by 6 in. wide by 10 in. deep and utilizes 4-in. calibrated grid-chart paper in 24-ft. rolls. The recorder is accurate to $\pm$0.5% of full scale. It features 12 chart speeds, has an input resistance of 10 MΩ on all ranges and a disposable nylon tipped pen with a response time of 30 in./sec. Precision Standards Corp., 1701 Reynolds, Santa Ana, CA 92705. Phone (714) 546-0431. **195**

$\pm$3999-COUNT DIGITAL PROCESS MONITOR DISPLAYS IN ENGINEERING UNITS. A low-cost ($325), panel mounted digital process monitor that features accurate digital displays of engineering units is the Model 400P, which operates with any process transmitter having a linear signal, relative to the parameter being monitored. The unit inserts directly into the data loop without affecting the transmitter accuracy or performance. Newport Laboratories, Inc., 630 E. Young St., Santa Ana, CA 92705. Phone (714) 540-4914. **196**

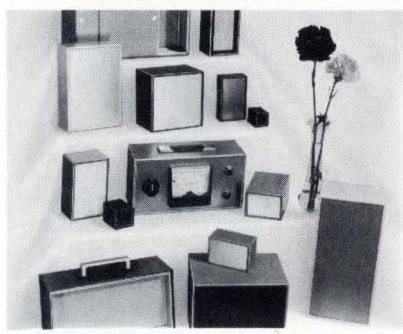


LOW-COST LINEAR IC/TRANSISTOR CURVE TRACER. The 577 Curve Tracer is a measurement system for ICs as well as transistors and other components. It diplays linear IC parameters for op amps, dual op amps, comparators, differential and sense amplifiers, IC regulators, and parameters of transistors, FETs, tunnel diodes, SCRs and zener diodes. The 577 has storage display and starts at $1175. Tektronix, Inc., P.O. Box 500, Beaverton, OR 97005. Phone (503) 644-0161. **193**

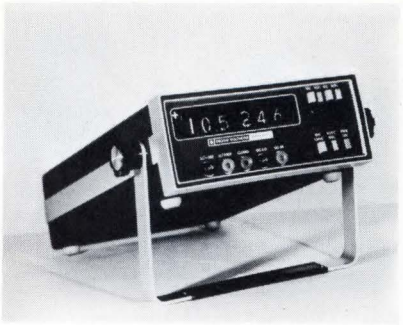
BIPOLAR 3½-DIGIT DPM FEATURES 0.05% ACCURACY AND 1-YEAR WARRANTY. Model 36 DPM features 0.05% accuracy with negligible warmup time, 50-ppm/°C stability over 0°C to +50°C (operating range) and a full 1-year warranty. Offered in two autopolar ranges ($\pm$1.999V or $\pm$199.9 mV full scale), it has a floating differential input which provides 1000 MΩ input impedance and 70 dB CMR. Autopolarity, automatic blanking and programmable decimal points are included. From $95 (100 quantities). Gralex Industries, 155 Marine St., Farmingdale, NY 11735. Phone (516) 694-3607. **192**

PROGRAMMABLE SYNTHESIZER HAS SQUAREWAVE, TRIANGULAR AND SINUSOIDAL OUTPUTS. The SSN programmable synthesizer provides crystal controlled triangular and sinusoidal waves from 0.01 Hz to 120 kHz (squarewave up to 1.2 MHz). It has 3 separate paralleled outputs with fixed phase relationship for square, triangular and sinusoidal signals. It also features electronic frequency programming (BCD neg. code) with 100-μsec response time (10 msec after switchover) with no overshoot. $3900. Rohde and Schwarz Sales Co. (USA) Inc., Passaic, NJ 07055. Phone (201) 773-8010. **191**

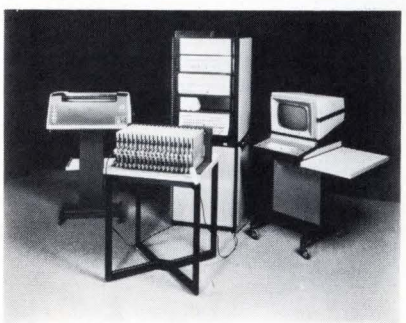
FULLY PROGRAMMABLE DISTORTION ANALYZER. Model 334A-H25 has all the capabilities of the standard Model 334A plus complete programmability of all functions, ranges and settings. Remote control is by parallel BCD TTL. A dc output and an interrogation circuit have been added so that an external controller can determine the status of the instrument during measurements. The Model 334A-H25 can be manually controlled with back-lighted front-panel pushbuttons. $3600. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **190**



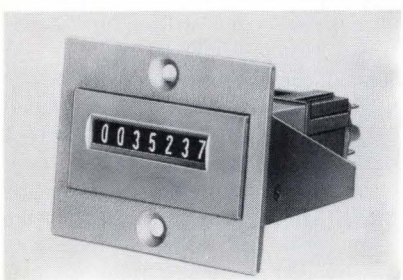
VERSATILE CASES FOR HIGH-STYLE CABINETS AT LOW COST. Clever use of standard parts, optional accessories and modern finishes combines high styling with functional beauty in Vector's new line of card cases. Called MultiMod, the system provides 27 basic models with interior sizes ranging from 2 to 207 in^3. Sleek aluminum extrusions ranging in width from 1.6 to 4.5 in. provide the package foundation. All cases have 4 internal surfaces with parallel 0.075-in. grooves for positioning and holding circuit boards, mounting or shielding plates. Durable baked-on painted finishes in dove grey, beige, blue and green complement clear and color anodized finishes in gold, blue and black. From $2.40 to $10. Vector Electronic Co., 12460 Galdstone Ave., Sylmar, CA 91342. Phone (213) 365-9661. **189**



5½-DIGIT HIGH-PERFORMANCE MULTIMETER. The new high-performance 5½-digit multimeter Model MX-1 is based on its MIL-spec counterpart. The meter has 5 dc-voltage ranges from 0.1 to 1000V full scale, auto/manual ranging, a wide range ratio capability, a fast active filter and a sixth digit for 20% over-range — all for $1000. Non Linear Systems, Inc., P. O. Box N, Del Mar, CA 92014. Phone (714) 755-1134. **197**



BACKPLANE TEST SYSTEM NEEDS ONLY A TWO-CABLE INTERCONNECTION. A new computer operated backplane test system requiring only a 2-cable interconnection to the backplane under test is the N151 system, which is self-programming and will record all shorts and opens, in the user's nomenclature, on either a CRT display or a printer. Magnetic-tape cartridges are used for program storage. The N151, including computer, CRT display and keyboard, Printec line printer, magnetic-tape unit, and all necessary software, is priced at $35,000, plus $5 per point for fixture cards. Teradyne, Inc., 183 Essex St., Boston, MA 02111. Phone (617) 482-2700. **198**

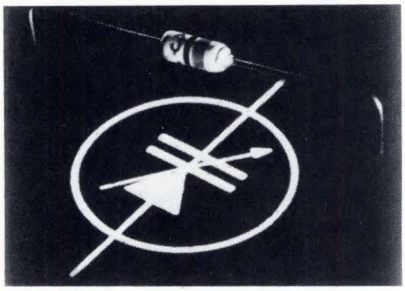


7-DIGIT NONRESETTABLE TOTALIZER COUNTER. New 7-digit nonresettable totalizer counter Model GO401 features counting speeds from 10 to 25 counts/sec. The GO401 may be flush or panel mounted. Digits are 0.08 X 0.16 in. white-on-black. Specifications include: 6 to 220V dc; 24 to 220V ac, min.; counting speeds for ac operation of 10/sec, for dc operation of 25/sec ; and an effective operating temperature range of −10°C to +50°C. Hecon Corp., P. O. Box 247, Eatontown, NJ 07724. Phone (201) 542-9200. **199**

DIGITAL OHMMETER READS LOW RESISTANCE WITHIN ±0.02%. Model SP 3789 gives automatic measurements of resistance below 200Ω at a basic accuracy of ±0.02% +1 digit. Four ranges cover values from 10μΩ to 200Ω. Special circuit design not only cancels the effect of thermal emfs but allows test leads to have up to 5Ω resistance with no effect on accuracy. Measurements are displayed on a 4-½-digit LED readout. Electro-Scientific Industries, Inc., 13900 N. W. Science Park Dr., Portland, OR 97229. Phone (503) 646-4141. **200**

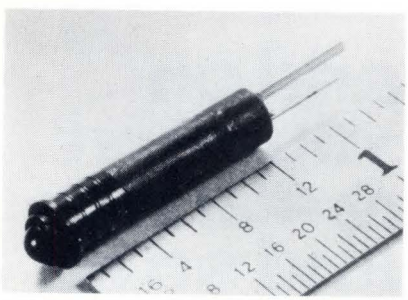
PICOAMMETER MEASURES FROM 10 μA TO 100 pA FULL SCALE. Features and characteristics of the Model 1012 picoammeter include a dual output for recorders or oscilloscopes and a bipolar output. This instrument has eleven bipolar ranges for measuring this wide range of current and a resolution down to 1 pA on the most-sensitive scale (10 μA full scale). Emitronics, Inc., Gencom Div., 80 Express St., Plainview, NY 11803. Phone (516) 433-5900. **201**

PSEUDO-RANDOM NOISE GENERATOR. The new Model 108 provides either white or pink Gaussian noise from dc to 50 kHz. Its output is switch-selectable from 0.03 through 3V rms fullscale. The generator utilizes a crystal controlled clock, plug-in PC-card construction and has clock, binary, sequence and sync output rear-panel connectors. A one-year warranty is included. $437. Testronic Development Laboratory, P.O. Drawer H, Las Cruces, NM 88001. Phone (505) 382-5574. **202**



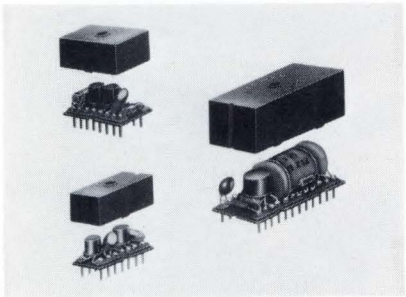
HIGH Q VVCs HAVE RECEIVED JAN AND JANTX APPROVAL. 1N5461 B and C through 1N5476 B and C series of Varactor diodes feature nominal capacitance values of 6.8 through 100 pF, min. and Q as high as 600 at 50 MHz. A max. temperature coefficient is also guaranteed. These diodes are supplied in standard DO-7 packages with weldable and solderable leads. Teledyne Crystalonics, 147 Sherman St., Cambridge, MA 02104. Phone(617)491-1670. **248**

DIP STRIPS ACCOMMODATE JUMBO LSI/MSI PACKAGES. A new line of DIP Strip Connectors, designed to be used in pairs, provide convenient sockets for 24- 28- and 40-lead packages recently introduced by LSI/MSI manufacturers. Contact spacings on 0.100 in. centers conform to standard lead frame dimensions while strip pairs are positioned according to package width. Contact resistance is less than 15 mΩ. Stanford Applied Engineering Inc., 2165 S. Grand Ave., Santa Ana, CA 92705. Phone(714)540-9256. **249**

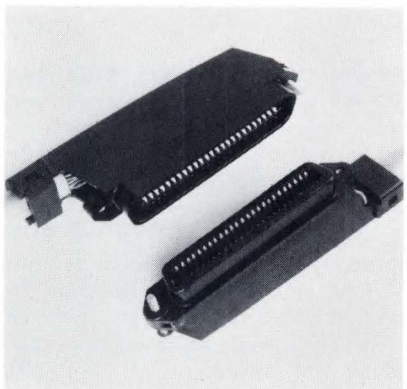


LED LINE COMES IN 3 CIRCUIT CONFIGURATIONS. The front-panel mounting units have built-in resistors which enable them to operate directly from the voltage specified. Operating characteristics are 5V at 20 mA, 10V at 20 mA, and 15V at 20 mA. Each unit has an overall length of 1 3/16 in. and a diameter of 0.255 in. Each configuration has two output leads with one flat to denote polarity. Shelly Associates, Sub. of Datatron, Inc., 1562 Reynolds Ave., Santa Ana, CA 92711. Phone(213)451-8491. **244**

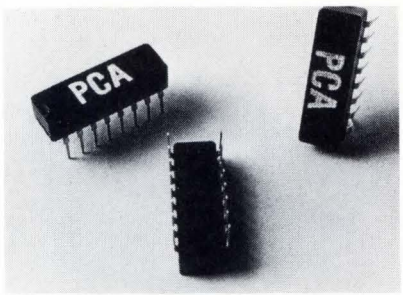
LIQUID CRYSTAL READOUTS AVAILABLE IN OEM QUANTITIES. The 3-digit units draw only 10 μA at 30-40V, 20 Hz to 10 kHz. Standard CMOS driving ICs can interface directly with the readouts. Standard units include 3, 3½ and 8-digit models. Each digit is separated by a decimal point. The price for a 3-digit evaluation unit in single quantity is $50 and is available immediately. Above 10,000 units, OEM discounts are available. Radionics Laboratory Inc., P.O. Box 211, Kingston, NJ 08528. **251**



14-, 16- AND 24-PIN HEADERS WITH TALL COVERS ACCOMMODATE LARGE COMPONENTS. Tall covers enable larger ICs and discrete components to be soldered between the contact extensions to form a convenient plug-in package. The 14 and 16 pin versions will house components up to 0.3 in. high while the 24 pin type will accommodate components up to 0.5 in high. Jermyn, 712 Montgomery Street, San Francisco, CA 94111. Phone(415)362-7431. **252**



50 WIRES TERMINATED SIMULTANEOUSLY IN NEW CONNECTOR. With a single stroke of the tooling, 50 wires are simultaneously cut to length and terminated to the CHAMP 25-pair cable connector. Designed specifically for the 25-pair cables commonly used in the communications industries, this new cable connector is intermateable and interchangeable with similar connectors currently in use. AMP Inc., 449 Eisenhower Blvd., Harrisburg, PA 17105. Phone(717)564-0101. **245**

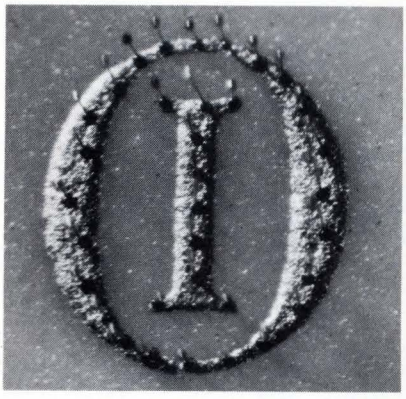


DIP TRANSFORMERS ARE LOW COST. These new low profile under 0.2 in. — 16 pin multiple dual-in-line packaged transformers are available with one to one and two to one turns ratio with OCL up to 500 μH. Price in production quantities is under $1 each. PCA Electronics Inc., 16799 Schoenborn St., Sepulveda, CA 91343. Phone(213)892-0761. **247**

PRECISION RESISTOR FEATURES HIGH STABILITY. It is a Type S precision wirewound resistor, oil impregnated and hermetically sealed to reduce thermal effects of humidity and atmosphere. The outer shell is made of hot tinned extruded brass, with end seals of hermetic sealing glass bonded to metal. Specifications are accuracy to better than ±0.001% and long term stabilities to better than ±0.0005%/year. Nytronics, Inc., Darlington Div., Orange St., Darlington, SC 29532. Phone(803)393-5421. **246**

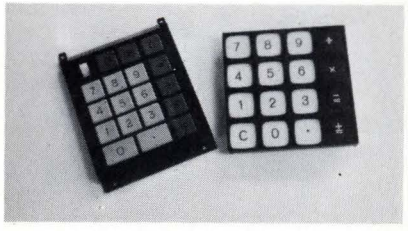
7-SEGMENT READOUTS ARE TTL COMPATIBLE. The Minitron readout is a miniature direct-viewed incandescent filament display, housed in a standard metal 16-pin dual in-line package with a hermetically sealed front lens. Low current drain minimizes power supply requirements. Cost is $2.70 to $3.95 each, depending on quantity. A sample introductory offer provides 3 units for $10.50. Luminetics Corp., 1150 NW 70th St., Ft. Lauderdale, FL 33309. Phone(305)974-5403. **253**

SILVER EPOXY IS EASIER TO USE IN MICROELECTRONICS. A 2-component silver epoxy system that is much easier to use than conventional types in chip bonding applications in microelectronics and optoelectronics has been developed by Epoxy Technology. Called Epo-Tek H21D, the epoxy is the first to have silver powder dispersed in both the epoxy itself and the hardener. Shelf life is one year, and it can be used with wire bonding operations in the 300-400° C range. Epoxy Technology, Inc., 65 Grove St., Watertown, MA 02172. Phone (617)926-0136. **250**



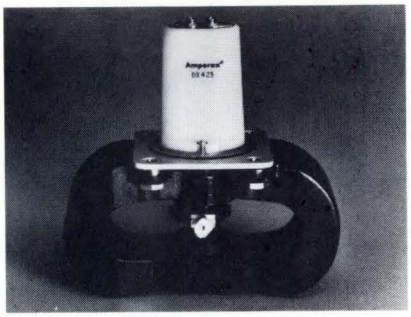
NEW AU 99+ GOLD CONDUCTOR PASTES. The new family of glass-free gold conductor pastes is designed for application directly on alumina and beryllia ceramics. A unique bonding mechanism eliminates the dependence of adhesion on the weak gold-glass mechanical bonding in conventional systems. Pull strengths in excess of 5000 psi have been measured on both alumina and beryllia. Available in 60%, 75% and 90% solids of viscosities suitable for dispensing, screening and fine-line screening. Owens-Illinois, Inc., Box 1035, Toledo, OH 43651. Phone(419)242-6534.
254

HIGH DENSITY PACKAGING SYSTEM FOR ECL INTRODUCED. The panel has a third (voltage) plane in addition to the usual ground and V_{CC} planes. The added plane, for V_{TT} (−2V) allows the boards to control impedance of transmission paths while maintaining max. logic-power efficiency. The panel series, designated 8136-ECL1, is available in multiples of 30 DIP patterns up to 180 patterns. Augat Inc., 33 Parry Ave., Attleboro, MA 02703. Phone(617)222-2202.
256



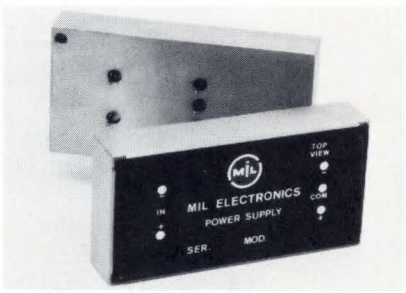
2 CALCULATOR KEYBOARDS DEBUT AT ATTRACTIVE VOLUME PRICES. Switches in these conductive elastomer keyboards are adhesive-bond sealed and impervious to dust and moisture. Depth behind calculator case is 0.200 in. for the SK model. Volume pricing below $3.50. The DK series features a bezel grid to guide the fingers. Depth behind case can be zero to 0.110 in. max. Volume pricing below $2.75. Flex Key Corp., 18 Sargent St., Gloucester, MA 01930. Phone (617)281-2040.
255

CIRCUITS

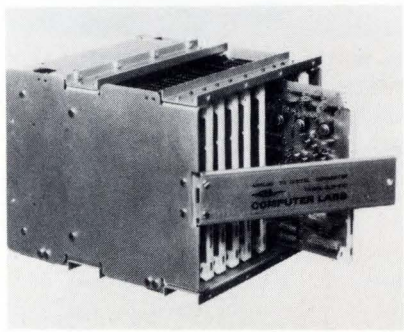


95-GHz, 8.2-kW COMMERCIALLY AVAILABLE MILLIMETER MAGNETRON. A new 3.2-mm magnetron for very high-resolution radar systems, designated DX423, operates at 96 GHz and delivers peak output power of 8 kW. The DX423 uses a short pulse length (10 to 200 nsec at a max. duty cycle of 0.0002). This plus the 3.2-mm wavelength provide extremely high resolution both in range and angle. Amperex Electronic Corp., Hicksville Div., Hicksville, NY 11802. Phone (516) 931-6200. **177**

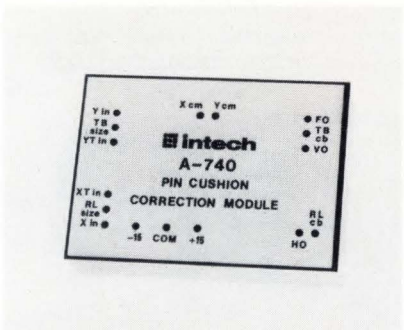
MINIATURE CRT POWER SUPPLY. Specifically designed for electrostatically focused flat faced CRTs, a new miniature (20 in.^{3}) power supply is adjustable from 2100 to 2900V dc. (0.5% regulation). The focusing output linearly follows a parabolic control signal with a response time of 10 μsec at a bandwidth of 0 to 100 kHz. Other outputs are 12 kV (1% regulation), 350V dc (1% regulation). CAPITRON Div. of AMP Inc., Elizabethtown, PA 17022. Phone (717) 564-0101. **178**



DC-TO-DC 3W SUPPLIES. A new line of over 200 models of a 3W, highly regulated (0.1%) dc-to-dc power supply is available. These units feature single or dual preset output voltages from 4 to 46V, PC-board mounting, an enclosed metal case, current limiting, and −55°C to +100°C operating temperature range. Designated Series "D," they start in price from $135. Mil Electronics, Inc., 176 Walker St., Lowell, MA 01854. Phone (617) 453-4142. **179**



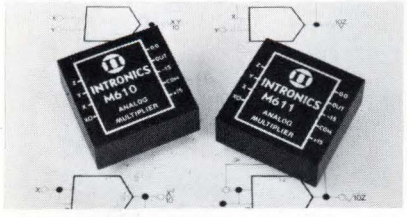
HIGH-SPEED A/D CONVERTERS SMALL IN SIZE AND COST. Computer Labs' new CLB "Bare Bones" Series of A/D converters offers high-speed conversion in a small size at economical prices. Units are 7x8x9 in. and include track-and-hold circuits. Examples: 0605 (6-bit), 0705 (7-bit), 0805 (8-bit) and 0905 (9-bit) 5-MHz units cost $2800, $2900, $3000 and $5550, respectively. Computer Labs, Inc., 1109 S. Chapman St., Greensboro, NC 27403. Phone (919) 292-6427. **180**



PLUG-IN MODULE CORRECTS FLAT-SCREEN CRT DISTORTIONS. The A-740 module performs all mathematical operations necessary to correct for the pincushion effect seen on flat or semi-flat CRTs. It also corrects dynamic focus distortions. Correction accuracy is within 99.8%; bandwidth is 10 MHz; and slew rate is 40 V/μsec in both horizontal and vertical axes. The 3.5x2.5x0.87-in. unit costs $495. Intech Inc., 1220 Coleman Ave., Santa Clara, CA 95050. Phone (408) 244-0500. **181**

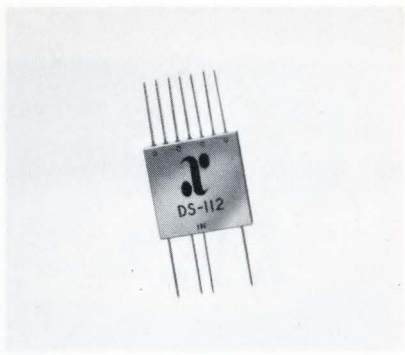
ULTRA HIGH-SPEED, HIGH-ACCURACY D/A CONVERTER Model 395-12A settles in 50 nsec with 12 bits of resolution. It is particularly suited for use in CRT and graphic display systems. Linearity is ½ LSB (±0.0125%). The 2x2x0.4-in. module has accuracy vs temperature of 30 ppm/°C over 0°C to +70°C. Units may be operated either unipolar or bipolar. $125. Hybrid Systems Corp., 95 Terrace Hall Ave., Burlington, MA 01803. Phone (617) 272-1522. **182**

MINIATURE 4-QUADRANT MULTIPLIER. Series MU4000 multipliers are miniature (½ cu. in.), encapsulated, hybrid, 4-quadrant units that require no external adjustment or amplification and are extremely rugged and lightweight (less than 1 oz). A few of the many possible applications with these units include autocorrelators, displays, analog computers, watt meters, modulators and demodulators. GPS Corp., 14 Burr St., Framingham, MA 01701. Phone (617) 875-0607. **183**



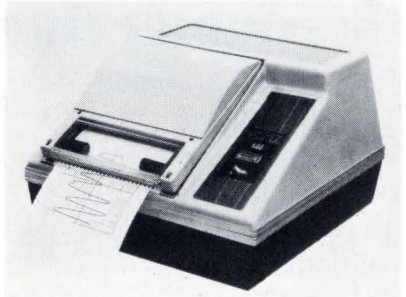
ANALOG MULTIPLIER/DIVIDERS FEATURE 0.25% ACCURACY, DRIFT ONLY 100 μV/°C. Models M610 and M611 transconductance multipliers are capable of multiplication, division, squaring and square rooting with no external trimming. Specifications include a 300 kHz min. bandwidth, 0.25% (M611) and 0.5% (M610) accuracy, 100 μV/°C (M611) and 200 μV/°C (M610) offset drift and 0.01%/°C (M611) and 0.02%/°C (M610) scale factor drift. Prices are $85 for the M610 and $125 for the M611. Intronics Inc., 57 Chapel St., Newton, MA 02158. Phone (617) 332-7350. **184**

4-WAY POWER DIVIDER/COMBINER IS 0.15 IN. HIGH. A subminiature 4-way power divider/combiner which provides 30 dB isolation from 10 to 500 MHz is available. The low-profile (only 0.15 in. high) Model DS-112 is designed for convenient stripline mounting and is RFI shielded and hermetically sealed in a metal package. It is built to meet MIL-E-5400 specifications and costs $90. ANZAC Electronics, 39 Green St., Waltham, MA 02154. Phone (617) 899-1900. **185**



TWIN-CASSETTE DATA TERMINALS FEATURE LOW PRICES. The KSR version features quiet, 30 cps electronic printing. The new twin-cassette ASR model offers data transmission rates of 10, 15, 30 and 120 cps, a simultaneous transmit and receive capability and simultaneous on-line transmission and off-line data preparation. The Model 733 ASR terminal is $2750 and Model 733 KSR terminal is $1500. Texas Instruments Inc., P.O. Box 1444, Houston, TX 77001. Phone (713) 494-5115. **170**

ECONOMICAL HIGH-SPEED SERIAL PRINTERS FOR NOVA MINIS. The two 165 cps printers print 10 cpi, with up to 132 char/line. Each has a full-line buffer capable of receiving characters in parallel. One model uses a 5x7 dot matrix and has a 63-character set with expanded characters. Price is $4500. The second model, priced at $4900, has a 9x7 matrix and a 64-character set. Both use the same I/0 interface and control priced at $1600. Data General Corp., Southboro, MA 01772. Phone (617) 485-9100. **171**



FACSIMILE RECORDER PROVIDES HARD COPY FOR CRT DISPLAY TERMINALS. The ALDEN 600 "Push to Print" recorder provides clean, crisp CRT recordings at 30 lines/sec, or 20 sec for a 600-line frame, 30 sec for an 800-line frame. Recordings are instantly visible and require no further processing. Cost of supplies is less than 1¢/frame. $2400. Electronic & Impulse Recording Equipment Co., Inc., Alden Research Ctr., Westboro, MA 01581. Phone (617) 366-8851. **172**

16-BIT MINI WITH 32K MEMORY. The D-116 includes four full 16-bit accumulator registers, DMA data channel operations at a memory speed of 1.2 μsec. Available software includes an assembler and editor, a debugger and a Basic compiler. The D-116 minicomputer, complete with 32k of core memory, central processor, power supply, TTY interface and I/0 capability for four peripherals, sells for $18,050. Digital Computer Controls, Inc., 12 Industrial Rd., Fairfield NJ 07006. Phone (201) 227-4861. **173**

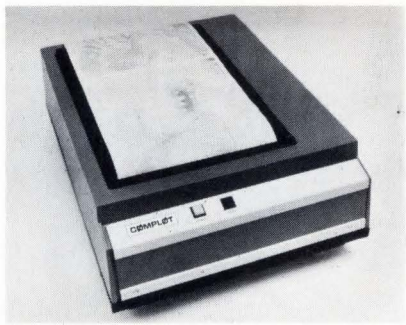
MINI ELECTRIC INPUT/OUTPUT KEYPUNCH. The Model 404 Vari-Punch automatically punches and prints numeric data on standard tab cards or multiple copy tab card sets, from signals generated by cable connected equipment such as mini computers, I/0 typewriters and instrumentation. It can also control other devices such as adding machines through self-generated output signals. Average production exceeds 3 cards/min. $1095. Varifab, Inc., 1700 E. Putnam Ave., Old Greenwich, CT 06870. Phone (203) 637-1434. **188**

CARTRIDGE RECORDER FOR HIGH RELIABILITY DATA RECORDING. The tape drive on Model 330 is fully bi-directional at 25 ips normal speed, resulting in a data transfer rate of 40,000 bps at 1600 cpi recording density. Forward and reverse search modes, as well as rewind speed, are 90 ips. One, 2 and 4-track versions are available. $200 for mechanism to $750 with 4-track write electronics. Kennedy Co., 540 W. Woodbury Rd., Altadena, CA 91001. Phone (213) 798-0953. **175**

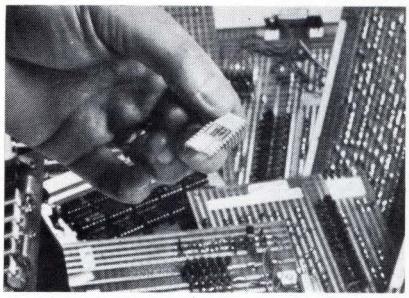
PROGRAM DEBUGGING AID FOR THE PDP-8/E, 8/F, 8/M. The CIS 110A hardware breakpoint module provides the capability to halt PDP-8E programs at selected memory locations. The unit consists of a switch panel assembly, cable connected to a pc board which plugs directly into any unused OMNIBUS slot. No modifications to the computer are required. Computer Interface Systems, Inc., Box 58, Piscataway, NJ 08854. Phone (201) 463-8279. **176**

MICROPROGRAMMABLE COMPUTER/CONTROLLER SELLS FOR UNDER $600. The 8-bit C•A•S•H-8 offers a 16-bit microprogram instruction set with execution times of 200 nsec. Over 53 instructions within five instruction classes are standard. It is ideal for peripheral interfacing and dedicated applications. C•A•S•H-8 is packaged on two plug-in cards which contain the processor and up to 512 words of TTL ROM. The ROM may be extended up to 65k words. Standard Logic Inc., 1630 S. Lyon St., Santa Ana, CA 92705. Phone (714) 835-5466. **186**

MINICOMPUTER FEATURES EXPANDED INSTRUCTION SET. The Micro 1600/30 instructions execute 50% faster than the 800 Models and 40% faster than the 1600 Models. Two new instructions control 7 interrupts which can be generated or acknowledged between two CPUs when the Micro 1600/30 is used as one processor of a Micro 1600D dual processor. A third new instruction provides special subroutine linkage for easy passage of multiple arguments. Microdata Corp., 17481 Red Hill Ave., Irvine, CA 92705. Phone (714) 540-6730. **187**



ELECTROSTATIC PRINTER/PLOTTER. Model CPE-57 produces tabulations of data, drawings, maps, charts, graphs and other graphic design on 11 in. wide paper. It provides 1228 in^2 of plotter output per minute or 733 lpm of alphanumerics. The unit is available in three models: as a non-impact printer for $6500; as a plotter only for $7000; and as a combination printer/plotter for $8000. Houston Inst., 4950 Terminal Ave., Bellaire, TX 77401. Phone (713) 667-7403. **174**



ONE-CHIP CLOCK CIRCUIT FILLS VARIETY OF TIMEKEEPING APPLICATIONS. A microprogrammable MOS clock circuit, designated the MK 5017 P, has several ROMs that can be programmed through the gate mask for a score of specialized applications including household clocks, industrial timers and elapsed-time indicators. Features include 4- or 6-digit display; clock radio; and 12 or 24 hour operation. MOSTEK Corp., 1215 W. Crosby Rd., Carrollton, TX 75006. Phone (214) 242-0444. **220**

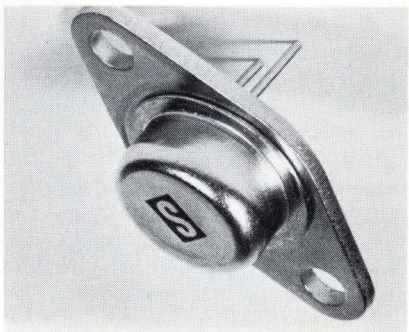
VERY HIGH VOLTAGE SCRs AND DIODES CARRY UP TO 625A. These solid-state power devices have been designed for applications such as high-voltage dc transmission, tap charges for ac motors and dc drives operating from voltages above 1000V. Transient voltage ratings are up to 5.5 kV. The average current range is from 200A to 625A, with double sided cooling. Westcode Semiconductors, 282 Belfield Rd., Rexdale 605 Ontario, Canada. **227**

MICROWAVE TRANSISTORS FEATURE LOW NOISE. A new microwave small-signal transistor with guaranteed max. noise figure of 2.3 dB at 2 GHz and 3.3 dB at 4 GHz is priced at $90 (in 100+ quantities). This NPN transistor comes in a rugged, 100-mil-sq ceramic-metal tripline package with an f_{max} of 14 GHz. Typical noise figure for the transistors is 2.0 dB at 2 GHz and 3.0 dB at 4 GHz. Output is about 10 dBm with a bias of 10V and 10 mA. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **235**

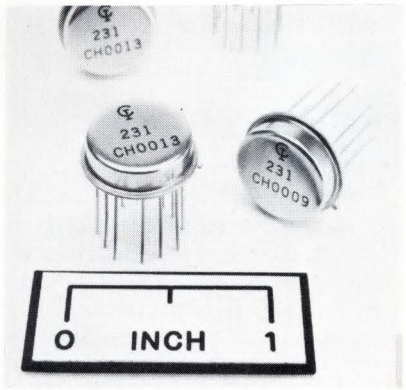
RE-PROGRAMMABLE MEMORIES DEVELOPED WITH MNOS TECHNOLOGY. The NOM100 and NOM300 Series, are single, dual and quad MOS transistors and have an 8x8 (64-bit) MNOS memory array. A 1-bit memory function is achieved by programming the threshold voltage of each MNOS transistor positive or negative by the applications of a large positive or negative gate voltage. Storage time is at least one year. Plessey Co. Ltd., Wood Burcot Way, Towcester, N. Hamptonshire, England. **225**

MOSFET HAS PROTECTED GATE. The MEM711 is an N-channel enhancement-mode device featuring high switching speeds, threshold voltage below 1.5V and 1 nA max. leakage. The MEM711 is useful in switching circuits and portable RF communication equipment where it replaces the unprotected types 3N169, 3N170 and 3N171. Price is $0.93 in 100-piece quantities. For evaluation samples call TOLL FREE 800-645-1247. General Instrument Corp., Semiconductor Div., 600 W. John St., Hicksville, NY 11802. Phone (516) 733-3141. **223**

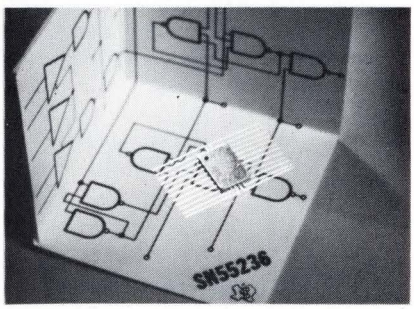
400V, 90A SWITCHING TRANSISTOR. The PT-3503 through PT-3513 series, silicon power transistors feature collector breakdown voltages, $V_{CEO(sus)}$, of 325 and 400V and have h_{FE} specified at 90.A Devices have t_{rise} and t_{fall} times of less than 500 nsec and are rated at 200W at 100°C in the JEDEC TO-63 package. Prices from $123.50. Power Tech, Inc., 9 Baker Ct., Clifton, NJ 07011. Phone (210) 478-6205. **222**



TRIPLE DIFFUSED SILICON POWER TRANSISTORS ARE RATED AT 400V, 5A. Indentified as the SDT 1301 through SDT 1304 Series, the transistors are packaged in a TO-66 case. Typical characteristics include I_{CBO} at elevated temperatures of (typically) 1.0 mA each at 150°C and $V_{CE}(sat)$ less than 0.5V each at 1.5A. The units are priced at $1.80 each in quantities of 100. Solitron Devices, Inc., Semiconductor Div., 1177 Blue Heron Blvd., Riviera Beach, FL 33404. Phone (305) 848-4311. **234**



DUAL MOS CLOCK LINE DRIVERS ARE RATED AT 1A. Hybrid MOS clock line drivers offering peak output currents of +1.0A and output voltage swings of up to 30V have been introduced. Typical rise and fall times are under 50 nsec when driving 1000 pF loads. The CH0009 series may be direct-coupled to the driving source, or may be used in capacitor-coupled applications. The CH 0013 series is designed for capacitor-coupled use. Cermetek, Inc., 660 National Ave., Mt. View, CA 94040. Phone (415) 969-9433. **232**



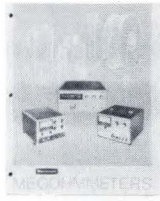
SENSE AMPLIFIER/DATA REGISTER HAS ±2 mV THRESHOLD SENSITIVITY. A dual sense amplifier/data register IC designated the SN55236, is believed to be the first MSI sense amplifier ever produced. It is designed for use in high-speed core memory systems. It contains a built-In data register with an option for external data inputs. Priced at $23.17 in 100-piece quantities. Texas Instruments Inc., P. O. Box 5012, Dallas, TX 75222. Phone (214) 238-3741. **224**

HIGH CURRENT THYRISTORS DESIGNED FOR FUSELESS APPLICATIONS. This thyristor line ranges from 180A to 4000A, with voltages as high as 2000V on the 28mm, 33mm and 52mm units. Single cycle surge ratings are up to 40,000 A. "Fuseless" applications include both circuit breaker protection and "Ride Through" systems in which no interruption is permitted. Power Semiconductor, Inc., 90 Munson St., Devon, CT 06406. Phone (203) 874-6747. **231**

LITERATURE

ELECTROSTATIC PRINTER/PLOTTER. A 6-pg. fully illustrated brochure describes the new CPE-57 printer/plotter. It outlines the functions of the printer/plotter in producing charts, graphs, alphanumerics, maps, drawings and other graphics using the electrostatic principle of operation. Also included is a description of computer graphics plotting, non-impact line printing and software, as well as pricing and ordering information. Houston Instrument, 4950 Terminal Ave., Bellaire, TX 77401. **205**

ELECTRO-OPTICS CATALOG combines IR emitting diodes, injection lasers and silicon photo-detectors in a 20-page booklet. Catalog OPT-100B, entitled "RCA Solid-State Infrared Emitting Diodes, Injection Lasers, Silicon Photodetectors," has been completely revised and updated to include all pertinent data on each device type. The section on silicon photodetectors is completely new. RCA Commercial Engineering, Harrison, NJ 07029. **211**



WIDE-RANGE MEGOHMMETERS are fully described in a new 8-page brochure. Bulletin 501 includes the Model L-8 high-precision, wide-range megohmmeter which measures from 10^5 to $10^{16}\Omega$ with adjustable limit control; the Model L-9, a fully programmable digital megohmmeter with a variety of control and recording outputs; and the Model L-10, a compact, low-cost megohmmeter. Beckman Instruments, Inc., 89 Commerce Rd., Cedar Grove, NJ 07009. **207**

DISC TESTING GUIDE. A 24-pg. guide to magnetic disc testing, written with the quality assurance, design and production man in mind deals with such areas as the resasons for testing substrates, discs and packs, magnetic recording theory, disc characteristics, magnetic recording techniques as well as equipment selection and costing — even provides a worksheet for cost estimating your own equipment requirements. The text is well illustrated with diagrams and photos. Computest Corp., 3 Computer Dr., Cherry Hill, NJ 08002. **213**

STEPPING SWITCHES. A new catalog is available with 56 pages of updated information on a standardized line of rotary stepping switches intended for a broad industrial audience. The booklet provides detailed information on open or enclosed, spring-driven or direct-drive, bracket-mounted or quick-mount stepping switches. A thorough introduction to the design and construction of stepping switches, their uses, physical and electrical characteristics, circuitry and optional features are included. C. P. Clare & Co., 3101 W. Pratt Ave., Chicago, IL 60645. **208**

HIGH-VOLTAGE POWER SUPPLY CATALOG. A new six-page condensed catalog describes a line of high-voltage power supplies. The foldout catalog contains information on solid-state, regulated and unregulated, miniature, modular and series-regulated high-voltage power supplies. A special section outlines specific design problems the manufacturer has solved including a multiple-output CRT supply, a 15-kW sputtering supply, an electrostatic flocking supply, and digitally programmable power supplies. Spellman High Voltage Electronics Corp., 1930 Adee Ave., Bronx, NY 10469. **209**

DATA COMMUNICATION SYSTEM. — A new 6-pg. brochure describes the TCP-64 teleprocessing system, which is a general purpose, stored program communications control system, utilizing conventional common carrier facilities for a variety of digital communications applications. Complete details of the system components and block diagrams of several major configurations are also included. Telefile Computer Products, Inc., 17785 Sky Park Circle, Irvine, CA 92664. **218**

6140 COMPUTER SYSTEM. A comprehensive, 20-pg. manual describes the 6140 Mission-Matched™ computer system for high-performance, economical solutions for real-time dedicated applications. The manual details hardware and software features, real-time applications, system's capabilities, a full range of available peripherals and the system's instruction set. All 20-pp. are well illustrated with photographs and diagrams. EMR Computer, 8001 Bloomington Freeway, Minneapolis, MN 55420. **219**

DISC CONTROLLER. A new data sheet describes the DC-16 disc controller, a completely self-contained (including power supply, cooling fans, mounting slides and hardware), ready to use interface between any 16-bit processor and up to eight IBM 2311 and 2314 compatible drives. The data sheet includes a description of the DC-16, controller features, a list of available DC-16 interfaces and a list of options. Telefile Computer Products, Inc., 17795 Sky Park Circle, Irvine, CA 92664. **212**

TOP/FRONT LOADING DISC DRIVE. An 8-pg. brochure provides a detailed description of Pertec's D-3000 Series disc memory drives available in single or dual disc versions, on both top and front loading configurations, 2315 or 5440 cartridges. Contained in the new brochure are interface descriptions and specific input/output lines in addition to configuration features and detailed specifications. Pertec, 10880 Wilshire Blvd., Los Angeles, CA 90024. **215**

DATA COLLECTION SYSTEM. The MDS Source Data Collection System is described in 12 sections, each of which details the unit's construction, assembly details, life expectancy, pricing and major features. Each fact sheet also includes details on electrical and mechanical or operating specifications. Mohawk Data Sciences Corp., Colorado Instruments Div., Broomfield, CO 80020. **214**

STAND-ALONE GRAPHICS TERMINAL. Useful tools: that's the way Vector General characterizes their new line of free-standing interactive graphics terminals, Vectorgraphics 11, in their latest 10-pg. brochure. Designed for the end-user, all models of Vectorgraphics 11 use the PDP-11 computer and feature expandable hardware/software, a variety of configurations and complete software packages. Vector General, 8399 Topanaga Canyon Blvd., Canoga Park, CA 91304. **216**

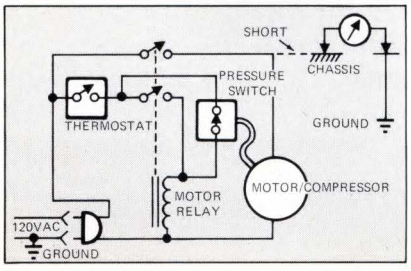
signals and noise

The refrigerator paradox answered . . .

In our June 1 issue, Dennis Morgan of GE presented an interesting problem. It seems that when Eddie engineer, BSEE '72, dashed to his refrigerator for a beer during a TV commercial, he got quite an electrical shock. A check with his VOM showed full line potential on the refrigerator frame, no matter which way he plugged the line cord in.

This, naturally prompted many replies from our readers running the gamut from humorous to the very practical. Jim Rose suggests that Eddie lay off the beer and read the instruction manual. Phil Kane replies, "Theoretically, this is a new engineer — as a former engineering school instructor, I wonder what they are teaching in lab courses — I used to teach a very informal session called, 'How not to get zapped'. (In return, my students taught me some interesting occupations such as wiretapping and lock-picking!!)" — *Ed. note: Useful but certainly not encouraged even in these days of high engineering unemployment.*

On the more practical side, Chet Savelle recommends that Eddie disconnect the refrigerator lest he kill someone, set his VOM on the "Ohms" scale, determine which side of the line is shorted — and then fix it. Like many others, he then recommends that a 3-wire cord be connected to the refrigerator, and a proper grounded receptacle be installed.



Shown below is a letter from Mr. Morgan along with the correct solution.

Dear Sir:

The circuit diagram shown below indicates the location of the fault. As can be seen, when the line plug is in the indicated position and the motor is running, the chassis is hot with respect to ground. If the plug is removed and reversed, the pressure switch opens and remains open for a few minutes until the pressure dies down, and the motor can be easily restarted. Meanwhile, the chassis is still hot with respect to ground via the path through the motor!

In reply to certain suggestions to return the refrigerator to GE with a letter to Ralph Nader, I must emphatically state that the perverted appliance was not of GE vintage. Furthermore, I have since acquired a new GE refrigerator — complete with 3-prong grounding plug!

D. R. Morgan
General Electric Co.
Electronics Laboratory

We struck a nerve . . .

The article in our September 1, 1972 issue on IBM's Non-Territorial Office has drawn lots of comments — most of them ranging from a cool "interesting" to an enthusiastic "great idea". We would like to share some of the reactions with you.

. . "The idea stinks — a typical female chauvinist ploy to downgrade males!"

. . "Article just turns one apple green with envy. Would like to hear more on the subject."

. . "Naturally the open-space office is enthusiastically embraced by the IBM-ers. The dissidents are now ex-IBM-ers. An utterly retrograde concept".

. . "Also sounds quite non-human. Lack of space for personal items (i.e., kids' pictures) means no personal identity encouraged; leads to one's becoming a very efficient machine".

. . "Not enough wall space to hang drawings, wires, etc. Not enough table space to work on. Too much expensive square footage not being used. It looks nice but it's not functional enough".

. . "I once worked in an engineering office having some of the features listed. The creative productivity and group spirit was terrific!"

. . "Is typical of the depersonalization which pervades modern man's life. Another step towards the human ant hill."

. . "Concept is intriguing as all hell, but in the final analysis, turned me off."

Now who said that engineers aren't open-minded to new ideas???

Which company is yours?

In a company where high rewards attend successful innovation, however trivial, and discredit dogs the proposer of ideas that fail, it is almost certain that proposers of new ideas will be ultraconservative — making sure they propose only ideas that will work and have immediate appeal. In a company where the proposer of an idea that failed is recognized and approved for the innovative quality of his idea regardless of its failure, the company will probably be apprised of new and daring ideas in their early stages.


"I've had a lot of experience with this type problem. Put a couple of do-funnys here and a whatchamacallit there."

ADVERTISERS INDEX

Application Notes

ALL ABOUT TESTING DIGITAL ICs IN-CIRCUIT. A 20-pg. brochure, "The IC Troubleshooters" describes the whole family of Logic Probes, Logic Pulsers, Logic Clips, Logic Comparators and accessories which HP has developed over the last couple of years, and gives specifics on how to cut down-time by fast, on-the-spot, in-circuit troubleshooting. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. **238**

A 12-BIT D/A CONVERTER USING IC CURRENT SWITCHES is the subject of an 8-pg. application note describing in complete detail how to build a 12-bit digital-to-analog converter using the Intersil 8018A family of high speed IC current switches. Intersil, 10900 N. Tantau Ave., Cupertino, CA 95014. **236**

"TECH TIPS" 3-2 CAUTIONS AGAINST SCR BIAS under reverse voltage. Written by application engineer J. D. Balenovich, "Positive Gate Bias While an SCR is in a Reverse Blocking Mode" is the latest in the "Tech Tip" series of short articles on the selection, application, use and maintenance of power semiconductors. For a copy of "Tech Tips 3-2," write Mr. J. L. DeFazio, Marketing Services Manager, Westinghouse Electric Corp., Semiconductor Div., Youngwood, PA 15697. **237**

MICROWAVE DIGITAL RADIO PRIMER is written to afford an elementary understanding of digital modulation of microwave radio. Subjects treated include digital modulation, T-carrier on microwave radio, characteristics of digital microwave, a comprehensive glossary of microwave digital radio terms and an appendix on the switched telecommunications network. Avantek, Inc., 2981 Copper Rd., Santa Clara, CA 95051. **203**

POWER SUPPLIES. A "Design As You Order" catalog allows the user to specify and order custom single or multiple output power supplies. The complete power supply ordered is provided in an encapsulated miniature package that is pre-tested and ready for use in the system. No special engineering or set up charge is applied providing the standard design rules are followed. Farrell-Bergmann, Inc., 15233 Ventura Blvd., Suite 1014, Sherman Oaks, CA 91403. **204**

SYNCHRONOUS MOTORS. Small synchronous motors, their types, operating characteristics and capabilities, are described in the "Chief Engineer's Handbook" article of the July-August issue of Bodine Electric Company's "Motorgram" (Vol. 52, No. 4). Also included in the publication are data on Bodine's new line of 42A permanent-magnet dc motors, plus two case-history applications. Bodine Electric Co., 2500 W. Bradley Pl., Chicago, IL 60618. **239**

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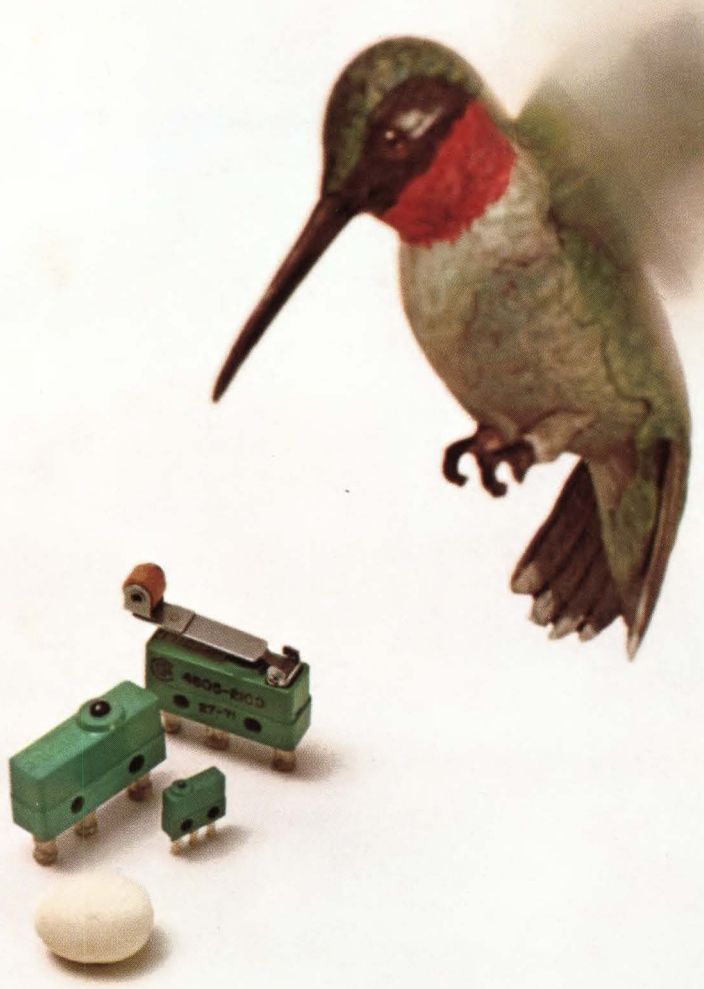

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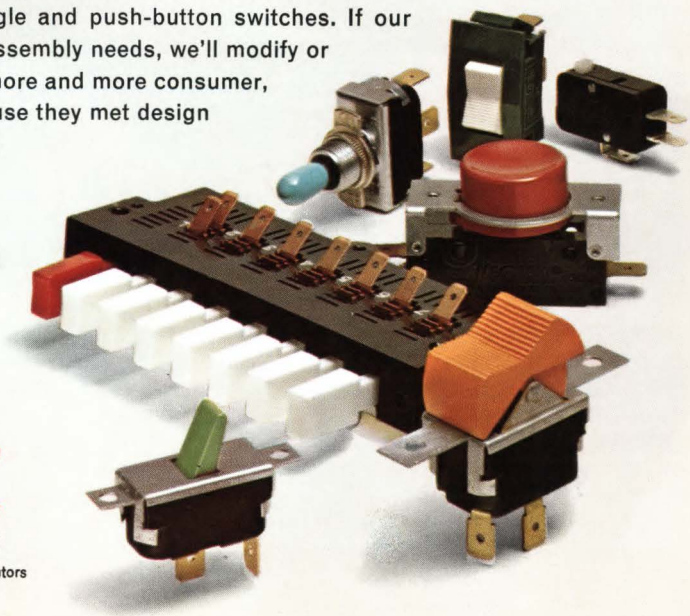

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