VOL. 29 NO. 6
JUNE 1970

CHILTON'S THE ELECTRONIC ENGINEER

Not just PCs, but also the technology to make them are for sale, p. 51

Course on MOS ICs, part 5
Printed circuit boards, make or buy?
Frequency synthesizing with phase locked loops
Speed/power chart for digital ICs

...like more capacitance in aluminum 'lytics?

Get SPRAGUE Type 36D POWERLYTIC® CAPACITORS

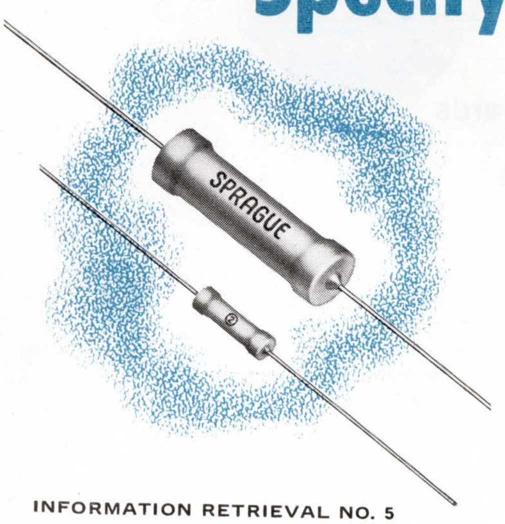
INFORMATION RETRIEVAL NO. 4

• Large cylindrical electrolytic capacitors for use in digital computer power supplies, industrial control equipment, energy storage applications, etc • Low impedance construction • Largest case (3″ dia. x 8⅝″ high) provides 650,000 μF at 3 volts! • Can be operated at +85 C • Tapped No. 10-32 terminals simplify filter bank assembly • Available with or without outer plastic insulating sleeves • **Request Engineering Bulletin 3431C**

4SC-9153R2

...need a reliable wirewound resistor?

Specify ACRASIL® PRECISION/POWER RESISTORS



INFORMATION RETRIEVAL NO. 5

• Excellent stability and reliability, even under extended load life, extremely high humidity, and other adverse operating conditions
• Expansion coefficient of silicone coating is closely matched to that of ceramic base to insure against damage to resistance winding
• Coating provides exceptional protection against moisture, shock, vibration, fungus • Available with standard and non-inductive windings
• Resistance tolerances as close as ±0.05% • **Request Engineering Bulletins 7450A and 7450.1**

4SR-8118R2

For Engineering Bulletins as noted above, write to: Technical Literature Service, Sprague Electric Co., 233 Marshall Street, North Adams, Massachusetts 01247.

SPRAGUE®
THE MARK OF RELIABILITY

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

'Sprague' and '②' are registered trademarks of the Sprague Electric Co.

CHILTON'S THE ELECTRONIC ENGINEER

June 1970 Vol. 29 No. 6

DEPARTMENTS

FEATURES

Cover

Whether single- or double-sided, with plated-through holes or without, round or square, big or small, etched to remove copper or plated with it, plated circuits can be bought or made. But, more importantly, the technology to make them is also available for a fee. See page 51.

THE ELECTRONIC ENGINEER

Vol. 29 No. 6 **June 1970**

K. Robert Brink, *Publisher*
Alberto Socolovsky, *Editor*
John E. Hickey, Jr., *Managing Editor*
Smedley B. Ruth, *Associate Editor*
Sheldon Edelman, *Western Editor S. F.*
Stephen A. Thompson, *Western Editor L. A.*
Arthur J. Boyle, *Technical Editor*
John McNichol, *Assistant Editor*
Dr. O. M. Salati, *Consultant*
Anne Axe, *Editorial Assistant*
Alice C. Bach, *Editorial Assistant*
Lynda Rothstein, *Editorial Assistant*
Deborah P. Wilkins, *Editorial Assistant*
Mae Moyer, *Editorial Reader Service*
Andrew Mittelbrunn, *Chilton Art Director*
Phaue Featherson, *Artist*
George Baker, Neil Regeimbal, *Washington News Bureau*

Chilton

Executive and Editorial Offices:
One Decker Square, Bala-Cynwyd, Pa. 19004
Tel. (215) SH 8-2000

Address Mail to: 56th & Chestnut Sts.
Philadelphia, Pa. 19139

Western Offices:
Stephen A. Thompson, 3727 W. 6th St., #202, Los Angeles, Calif. 90005
Tel. (213) DU 7-1271

Sheldon Z. Edelman, 199 First St. Rm. 335
Los Altos, Calif. 94022
Tel. (415) 941-6655

Chilton Officers & Directors: Chairman of the Board: G. C. Buzby; President: R. E. McKenna; Financial Vice-President: S. Appleby; Senior Vice-Presidents: J. Kofron, L. King; Publishing Vice-Presidents: C. W. Hevner, W. A. Barbour, R. H. Groves, K. Robert Brink; Treasurer: James Miades; Secretary: J. A. Montgomery, Jr.; Other Directors: T. J. Casper, S. H. Collmann, R. Rimbach, Jr., J. P. Kushnerick, R. O. Nelson; Asst. Secretary: I. C. Holloway.

Monthly publication of Chilton Company, Chestnut & 56th Sts., Phila., Pa. 19139. (Area Code 215) SHerwood 8-2000. Controlled circulation postage paid at Philadelphia, Pa. $1 a copy. Subscription rates U. S. and U. S. Possessions: 1 yr. $12.00; 2 yrs. $20.00. Canada 1 year $14.00; 2 yrs. $25.00. All other countries 1 yr. $20.00; 2 yrs. $35.00.

The Chilton Electronics and Instrumentation Group ● The Electronic Engineer ■ Instruments and Control Systems ■ Instrument & Apparatus News ■ Medical Electronics News ■ Electronic Component News

AN AMP FOR ALL REASONS

Whatever your reasons or critical parameters, Fairchild Controls has the amplifier to meet your needs. Fairchild Controls offers a wide selection of discrete, hybrid and monolithic amplifiers for industrial, military and commercial use.

And, Fairchild Controls has a computer programmed to help you select the amplifier best suited to your requirements. You can even rank your parameters in terms of priority and the Fairchild Controls computer will select, from over 70 amplifiers, the one that will give you optimum performance.

We'll be happy to send you our new "Selection Guide to Operational Amplifiers" to acquaint you with our full range of amps. But, our service does not stop there. Our field staff, in conjunction with our computer, stand ready to provide you with quick and reliable answers to any questions you have.

For more information, or a copy of the "Selection Guide," write Sales Manager, Fairchild Controls, 423 National Avenue, Mountain View, Calif. 94040.

423 National Avenue
Mountain View, California 94040
Telephone: (415) 962-3833

FAIRCHILD
CONTROLS

Circle 8 on Inquiry Card

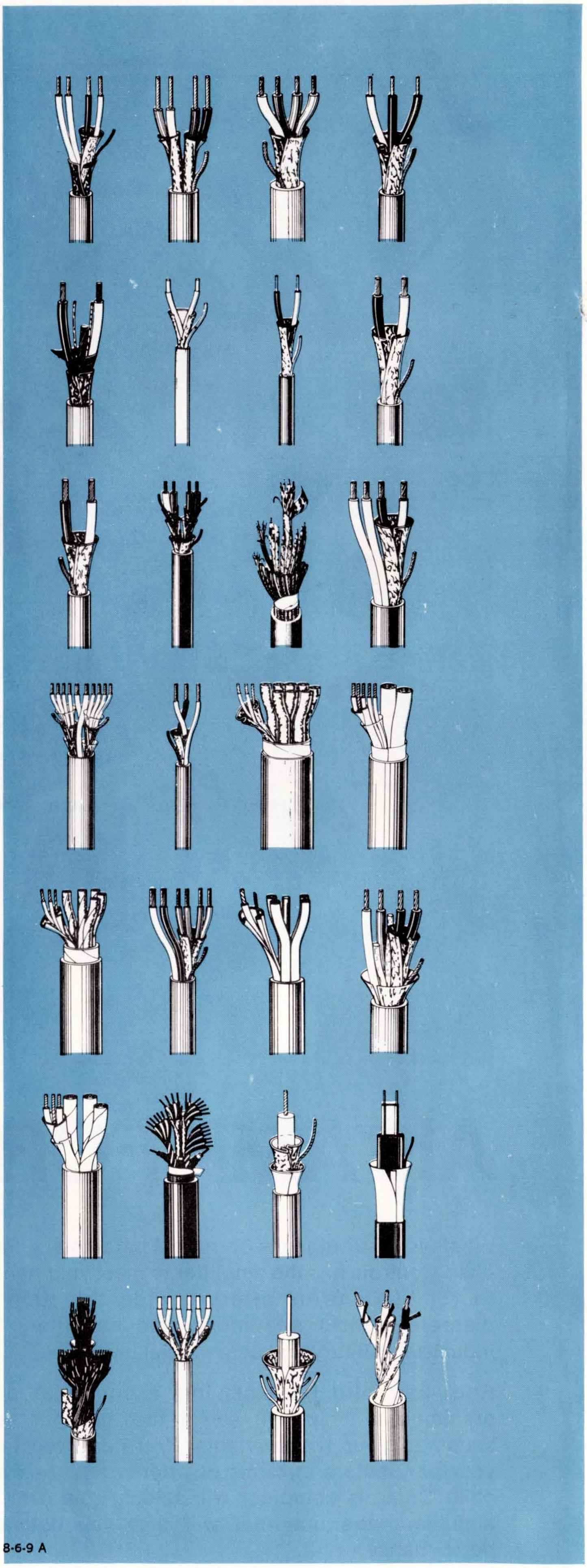
end your signal pollution problems

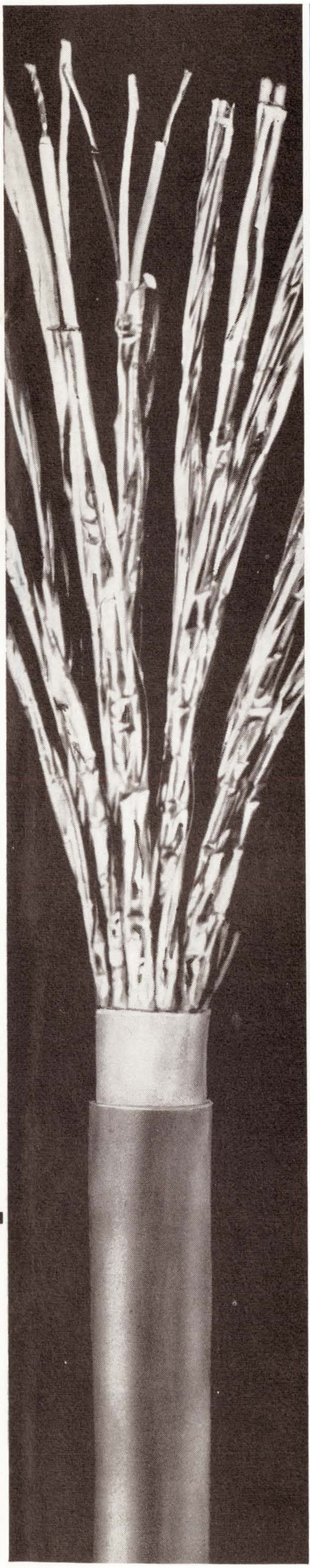
Beldfoil® ISO-Shielded™ Cable

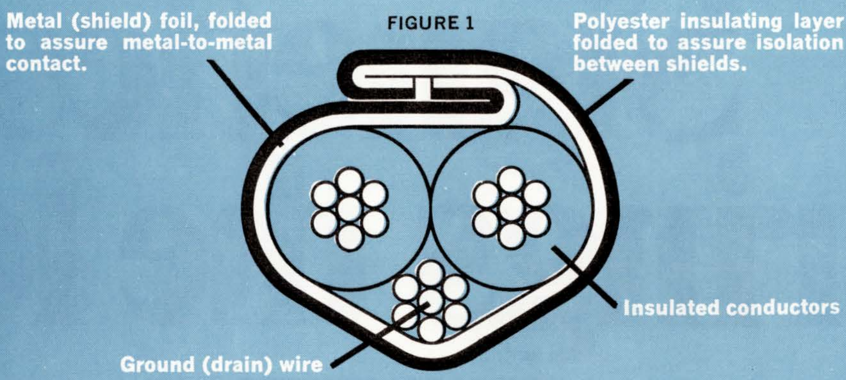
It's the cable with virtually perfect shielding. It's a Belden exclusive. Beldfoil ISO-Shield is like a continuous metal tube enclosing each pair of conductors in a cable. It locks out crosstalk or interference . . . whether from outside sources or between shielded elements in the cable.

Beldfoil is a layer of aluminum foil bonded to a tough polyester film (for insulation and added strength.) To form an ISO-Shield, we apply it in any one of several unique ways to meet the requirements of different applications. (See Figures 1 and 2, for example). Each gives more physical shield coverage than braided wire or spiral wrapped (served) shields. And greater shield effectiveness . . . even after repeated flexing.

Beldfoil ISO-Shielded Cables are small, lightweight. They terminate easily. They're modest in price. Your Belden Distributor stocks a wide variety of standard Beldfoil shielded cables as listed in the "Belden Electronic Wire and Cable Catalog" (ask him for the latest edition). And, should you have specifications no standard product can meet, ask him to quote on a specially engineered design. Or, if you choose, contact: Belden Corporation, P. O. Box 5070-A, Chicago, Ill. 60680. Phone (312) 378-1000.







Beldfoil Multiple Pair Individually Shielded Cable

The Figure 1 cross-section shows Belden's exclusive Z-folded Beldfoil ISO-Shield. Note the metal-to-metal contact between the two edges of the aluminum foil. In essence, you have a continuous aluminum tube. And the polyester layer on the outside of the fold assures the isolation between shields so necessary for best performance in the field.

Technical Data

Nominal values for multiple pair individually shielded cables containing 3 to 27 pairs (including 8769 and 8773 through 8778 Series cables)

Suggested working voltage: 300 volts rms max.

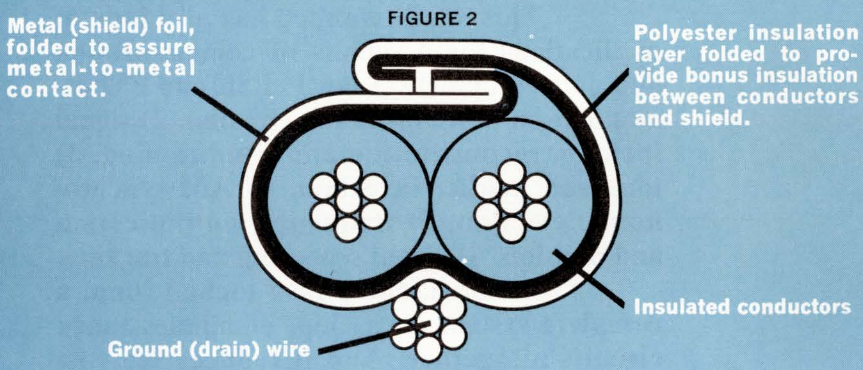
Working voltage between adjacent shields: 50 volts rms max.

Capacitance between conductors in a pair: 30 pf per ft. nom.

Capacitance between one conductor and other conductor connected to shield: 55 pf per ft. nom.

Capacitance between shields on adjacent pairs: 115 pf per ft. nom.

Insulation resistance between shields on adjacent pairs: 100 megohms per 1000 ft. nom.



Beldfoil Shielded Single Pair Cable

The Figure 2 cross-section shows the exclusive Belden Z-fold with the polyester insulating layer inward. This makes use of the high dielectric strength of the polyester film as bonus insulation between the conductors and the shield. (The cable jacket provides the primary insulation of the shield from outside objects or adjacent cables.)

Technical Data

Nominal values for 8451 Shielded Pair Cable

Suggested working voltage: 200 volts rms max.

Capacitance between conductors: 34 pf per ft. nom.

Capacitance between one conductor and other conductor connected to shield: 67 pf per ft. nom.

BELDEN

new ideas for moving electrical energy

Circle 9 on Inquiry Card

EDITORIAL

No, Virginia, you are too big for Santa Claus

The two electronic engineers sat late that night at the kitchen table, over a heap of papers that partially covered two coffee cups and a slide rule.

"This terminal will sell," said one of them, "and we can produce it for about $500. That's good. The least expensive one sells today for $4500—you know, the one that rents for $49.50 a month."

And on they went the rest of that night, and many other nights, until they had drafted a comprehensive financial and technical plan. Then, they talked to one of the best technicians in the computer company they worked for, and interested him in joining their budding venture. The technician quit his job and, supported by the two engineers, spent six months building a prototype in his garage.

In the meantime, they retained a lawyer who, in place of a fee, accepted a piece of ownership in the new company. When the prototype was ready, the engineers wanted to demonstrate the terminal to prospective customers to secure some preliminary orders. "Nonsense!" said the lawyer, "the first thing to do is to go public. By the time you fellows get the orders the shares will be on the market selling at a nice price and we'll be rich."

The two engineers spent another night over coffee and slide rules. They had hoped to get rich all right, but only after mass-producing the terminal. Right now, they only had a prototype that, even though it worked beautifully, had to be redesigned and debugged for production. In particular, they wanted to incorporate all the decoding, counting and memory circuits in a few MOS chips that they knew would take a year to design and produce. But—and the childhood image of a pot of gold that lies at the end of the rainbow glittered in their minds—after all, they were not financial experts, and maybe going public right now was the thing to do. Doesn't everyone?

"Sound convincing—no ifs or buts," they were told, and they did. The six prosperous-looking gentlemen from the underwriting firm listened attentively, one of them even seemed to understand what the engineers were saying. "Are you sure the MOS circuits will be ready in a year?" he asked. "We have a new MOS company in our portfolio, and they haven't delivered anything yet."

The engineers hesitated. Yes, they knew some companies had trouble delivering the type of MOS chips they would be looking for. Yes, to bring the price in to their range they would have to place large orders for those MOS ICs. No, they hadn't designed them yet.

Slowly, the rainbow seemed to fade, and the gold flashes at its end disappeared. They had to go back to work, and to the long stint of bootstrapping their company as they had planned before being dazed by the promise of instant riches.

"Before you go public," says Mr. Timothy Collins, president of Collins Securities Corp., "make sure you have made some sales. The public, who rushes to invest on technology it doesn't understand, is very unforgiving when it gets burned."

The two engineers may eventually get rich, but only after they prove their prototype, build a small production lot, and gear for mass production. One day, they will find themselves at the end of the rainbow, but by then they will feel they are not getting something for nothing—which is a principle that applies to things other than engineering.

Alberto Socolovsky
Editor

IT HAPPENED LAST MONTH . . .

The editors of THE ELECTRONIC ENGINEER have sifted through the various technical and significant happenings of the past month and selected the items that would be of the most interest or use to you.

Fallout from NASA know-how on CAD . . . The now defunct Electronic Research Center of NASA in Cambridge, Mass., had accumulated quite a bit of talent and knowledge in computer-aided design, particularly microelectronics. To avoid wasting this, NASA organized a 5-day course on the subject which took place in April at the Jet Propulsion Lab in Pasadena, Calif. Although the course was open only to JPL personnel, NASA's intention is to polish it and make it available to universities and industry. Robert L. Trent of the ERC is managing the course, and the lecturers at the JPL included Dr. William C. Happ of NASA—long experienced in CAD—plus specialists from industry.

CAD time-sharing service . . . General Electric has come up with new applications of computer time-sharing for the electronics industry. For example, they now have a computer-aided design (CAD) package which includes programs in digital system simulation, circuit design and electronic analysis, and dynamic system simulation. Applications for the programs include design proposals and evaluations, design engineering, reliability and quality assurance, hardware performance checkout, and the study of parameter variations, design alternatives and component tolerance. A significant feature of GE's time-sharing service and one that's available to all subscribers is its library of 350 programs stored in their computer systems. A user may write and store programs for his specific applications in the system, and these would be unavailable to other subscribers.

Technology for society . . . Cal Tech's Jet Propulsion Laboratory has established a Civil Systems Projects Office headed by Howard H. Haglund, former manager of the Surveyor moon-exploration spacecraft project. The laboratory's space-age capabilities will be directed towards solving problems in medical engineering, public safety support, urban land use and transportation. Three activities already designated are space technology applications, transportation technology and biomedical application of computer technology.

Environmental specs for plastic ICs? . . . The military is taking another serious look at the reliability of plastic-packaged ICs. By definition, they are not hermetically sealed; there are no tests for hermeticity without a cavity in the package. The real question is whether or not the packages admit moisture. Silicone material is moisture-resistant, but is also a lubricant, so it tends to admit moisture along the leads. To prevent wetting, some companies use a protective silastic coating over the chip. National Semiconductor was the only one of eight companies at a recent Washington meeting to submit complete reliability test results. The Rome Air Development Center is expected to use this and other data to establish a new set of environmental tests for plastic ICs.

Computer graphic display system . . . Corning recently entered the information processing field with the introduction of a time-sharing interactive graphic computer terminal designated the 904. The system offers graphic and alphanumeric display, a built-in electrostatic hard copy device, and a method for superimposing slide data over computer generated data. A unique principle of the terminal is its use of photochromic glass as a storage medium. The 904 is priced at $19,650 and is complete with a software package consisting of 57 FORTRAN IV sub-routines. It is designed for linkage to a time-sharing system through voice grade telephones.

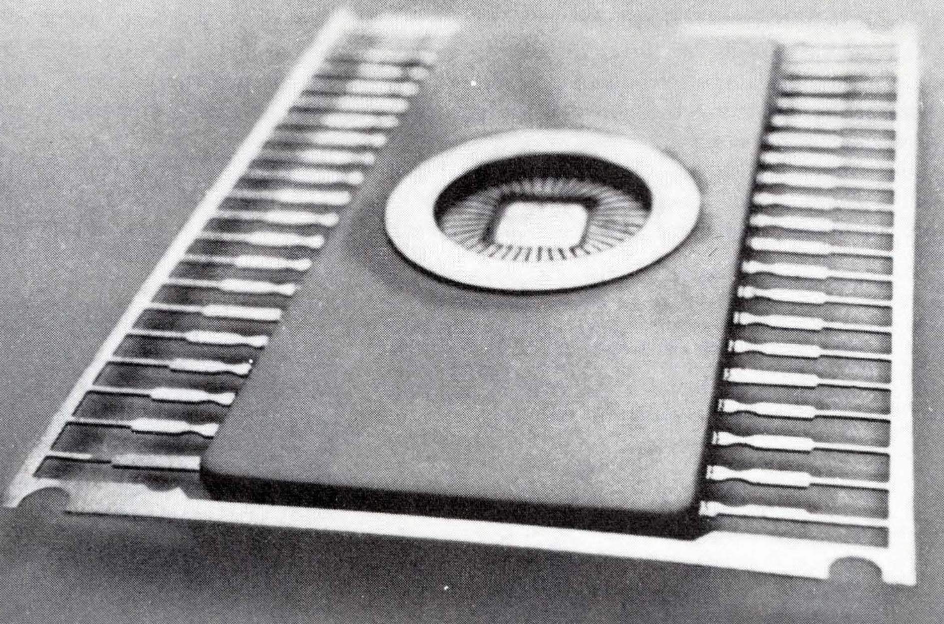
Monolithic alphanumeric readout . . . A monolithic, light-emitting diode alphanumeric readout is commercially available from Monsanto. Model MAN-3, a seven-segment display and totally monolithic semiconductor device, is the third in a series of solid state displays. The active light-emitting areas are planar, formed by zinc diffusion into n-type gallium arsenide phosphide wafers, and emit light from 6300 to 7000 angstroms. Suggested applications include digital displays in desk calculators, computers, and portable equipment.

Pay TV . . . New life may have been breathed into the pay TV issue with the Supreme Court's recent support of a lower court's decision. The lower court's decision was to permit the FCC to license pay TV. We say "may have been" because the opponents to pay TV are now seeking Congressional action to stop or at least severely limit the FCC's power in granting pay TV permits. The pay TV battle has been going on for at least a dozen years. If pay TV should ever come to pass, then a new sales area would open up for electronic products.

Lobbying unions . . . The second annual convention of the Council of Engineers and Scientists Organizations (CESO), an affiliation of engineering unions, was held in Washington, D. C. CESO, which has approximately 100,000 members in the United States and Canada, passed several resolutions including, in view of the "necessity of controlling the engineering population," an endorsement of a much broader educational base for engineers. This is in direct contradiction to the Engineers Joint Council (EJC) call for $500,000 from industry to encourage more young people to study engineering.

Sylvania introduces a new 40-lead, glass-ceramic, sandwich-type, unitized, hermetically sealable large scale integrated circuit package.

(whew.)



Here is the first glass-ceramic package in the IC major leagues. And that, friends, marks the beginning of the end of the LSI package shortage. *Write to: Sylvania Precision Materials, Parts Division, Warren, Pa. 16365. Or telephone: 814-723-2000. Ask for Bill Williamson.*

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

Simple, three-layer structure can do IC functions

Made with metal conductors, a layer of silicon dioxide and silicon base, this device can work for logic, memory and imaging applications.

Being developed at Bell Labs, a new class of devices offers imaging, logic, and memory functions at low cost. These new devices, called Charge Coupled Devices (CCD), can perform many functions of complex integrated circuits. Yet, they are simple, easily made, three-layer structures of silicon-silicon dioxide.

Because these devices are not restricted to materials in which it is possible to form a p-n junction, the technology can be applied to a wide range of semiconductor-insulator systems. In their designs, Bell Labs scientists used CCDs made of metal conductors, a layer of silicon dioxide and a base of silicon.

CCD devices create and store minority carriers, or their absence. This action occurs in a spatially defined depletion region, called a potential well, located on the surface of a semiconductor. (Minority carriers are holes at the semiconductor-insulator interface of an n-type semiconductor.)

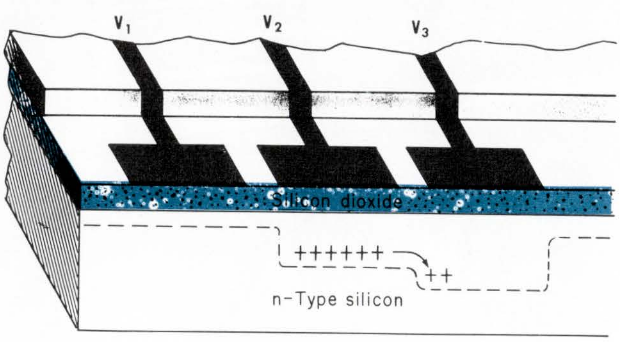
Unless these wells (charges) can be moved and detected, we merely have a "capacitor." To produce and move the potential wells, an array of electrodes are formed on the insulator-semiconductor layers. These electrodes create and move the potential wells when a voltage is applied to them.

At Bell Labs, scientists apply a voltage to the metal electrodes. This voltage is negative with respect to n-type semiconductor. When the voltage is first applied, equally divided between the semiconductor and the insulator, there are no holes at the semiconductor-insulator interface. If holes are introduced into the depletion region—by avalanche multiplication, light, or other means—they will collect at the semiconductor interface, causing the interface potential to become more positive.

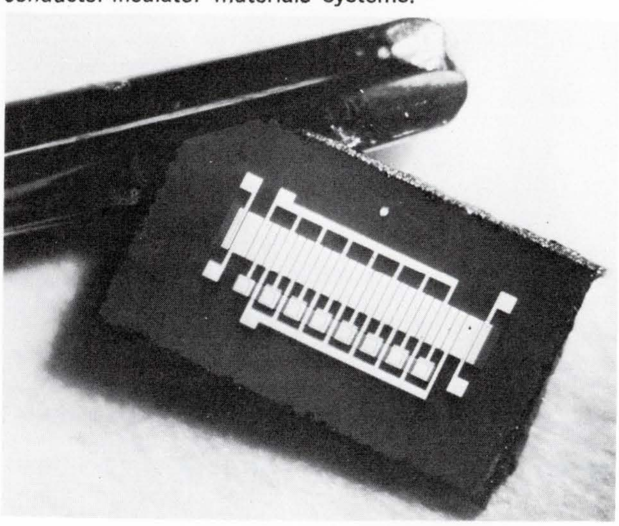
The minority carriers (in wells) may be then moved from under one electrode to a closely adjacent electrode on the same substrate by a more negative voltage applied to the adjacent electrode. The sequence is repeated to move the carriers in any desired direction. Because minority carriers may be stored and moved in precise patterns, in two dimensions, and can be detected and measured at some location, you could have a shift register. The basic shift register may be used as a recirculating memory or as a delay line.

CCDs could be an imaging device. Such a device would operate by shining a light image on the bottom of the semiconductor part of the device, creating electron-hole pairs. The holes would diffuse to the electrode side where they can be stored in the potential wells created by the negatively charged electrodes. Later, the image may be read out via shift register action.

Charge Coupled Device (CCD) is a three-layer structure having a metal conductor, a layer of silicon dioxide and a silicon base. The CCD creates and stores minority carriers, or their absence, in potential wells near the surface of the semiconductor. The minority carriers may be moved from under one electrode to an adjacent electrode by applying a more negative voltage to the adjacent electrode.



The experimental 24-plate, 8-bit shift register uses Charge Coupled Device (CCD) technology. For experimental reasons, this version is larger than final manufactured models. The technology is applicable to a wide range of semiconductor-insulator materials systems.



100,000-bit ROM is quick as a flash!

Optical read-only memories are here, at speeds, capacities, and costs that are real bargains.

Optical Memory Systems of Santa Ana, California, has developed a unique optical read-only memory (ROM). Their OM-1000 Series ROMs contain an array of GaAs light-emitting diodes (LEDs) and an array of light-sensing PIN diodes separated by an optical mask.

When an individual light source is addressed, the bit pattern of the mask determines which sensors are exposed or blanked, thus creating a multi-bit word. Any LED can transmit as many bits as there are sensors. In effect, there is a different mask associated with each source, so any configuration of bits can be realized.

Fewer components for more data

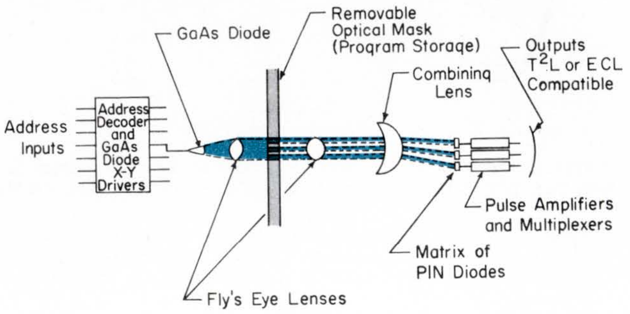
The capacity of the memory is the product of the number of sources times the number of sensors, with the mask providing the bit values. The standard configuration of 1000 LEDs and 100 sensors provides 100,000 bits of ROM with only 1100 elements, compared to one or even two circuit elements per bit in other memory types. Units are available in several organizations.

High-speed amplifiers associated with each sensor provide pulsed outputs compatible with TTL, RTL, or ECL logic. Access time is less than 60 ns and cycle time less than 100 ns. Outputs can be multiplexed to give any word length desired.

Large-scale changes are easy

The mask is a glass photographic plate that can be interchanged in seconds without altering the electronics of the memory. It's as simple as changing a slide in a home slide projector. OMS can supply masks constructed so that untrained personnel may change bit locations in the field. If a manufacturer needs to change an ROM subroutine, he can generate completely tested masks in-house and ship any number to his customers, without expensive field maintenance, downtime, or rewiring, which add substantially to the cost of a memory.

When a LED is selectively energized, a lens collimates the emitted light so that it impinges on the portion of the mask directly in front of it. Bit information is stored in the form of a pattern of opaque and transparent areas, corresponding to 0's and 1's, respectively. The resulting pattern is focused by the combination of a second lens and a larger lens, so that it registers properly on the sensor array. Three bits of 111 data are illustrated.



OMS can make masks for its customers and is working on a standard package that will cover all of the basic code conversions and table look-up functions. The standard 100,000 bit ROM package will include at least 50 masks. It costs about $1,000 to set up and generate the first mask and less than $50 for any thereafter. In quantity, mask sets containing over 5 million bits can sell for around $2,500. Initial mask costs are 1¢ per bit compares favorably to an initial cost of about $1.00 per bit for an LSI mask.

Downstream planning calls for using stepper motors to change the ROM program in 100,000-bit increments by indexing a roll of film that stores several million bits.

Mask tolerances are typically 5 mils, and many customers already have enough mask-making equipment to generate their own. OMS will also be marketing a mask-making kit for about $10,000.

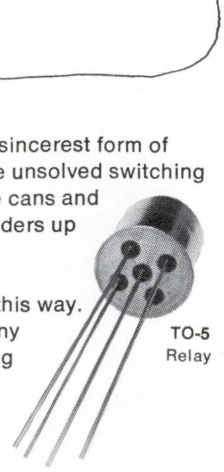
Speed, capacity, and cost look good

This type of optical ROM has the advantage of speed independent of capacity. An LSI ROM might have an access time of 60 ns for 500 to 1,000 bits; but the access time becomes much greater for 100,000 bits, which have to be mounted and logic-wired together.

The limit of single optical ROM capacity is not yet known. An array of 102,400-bit ROMs has been built and ¼ million bits/package seems within reach. The 100,000-bit production ROM is in a package 5½ in. in diameter and 12 in. long.

The 100,000-bit model costs about 4¢ a bit in quantities of 100 and 3¢ a bit in lots of 1,000. One cent a bit is predicted to be about two years away. In this type of memory, cost per bit continues to decrease with size. It does not level off as with other types of memories. Costs drop dramatically between 16,000 and 100,000 bits. Currently, 16,000-bit memories cost 10¢ a bit, but are expected to be lower within the near future. If you assume a 100,000-bit ROM costing $4,000 and add a 5-million-bit mask package at $2,500, the total cost per bit is only .13¢ with decoding and amplification. Initial deliveries have been slow, but Optical Memory Systems expects to provide 30-day delivery schedules by year end.

For further information, contact Optical Memory Systems, 1520 South Lyon St., Santa Ana, Calif. 92705. Circle 201 on Reader Service Card.



TO-5 Relay

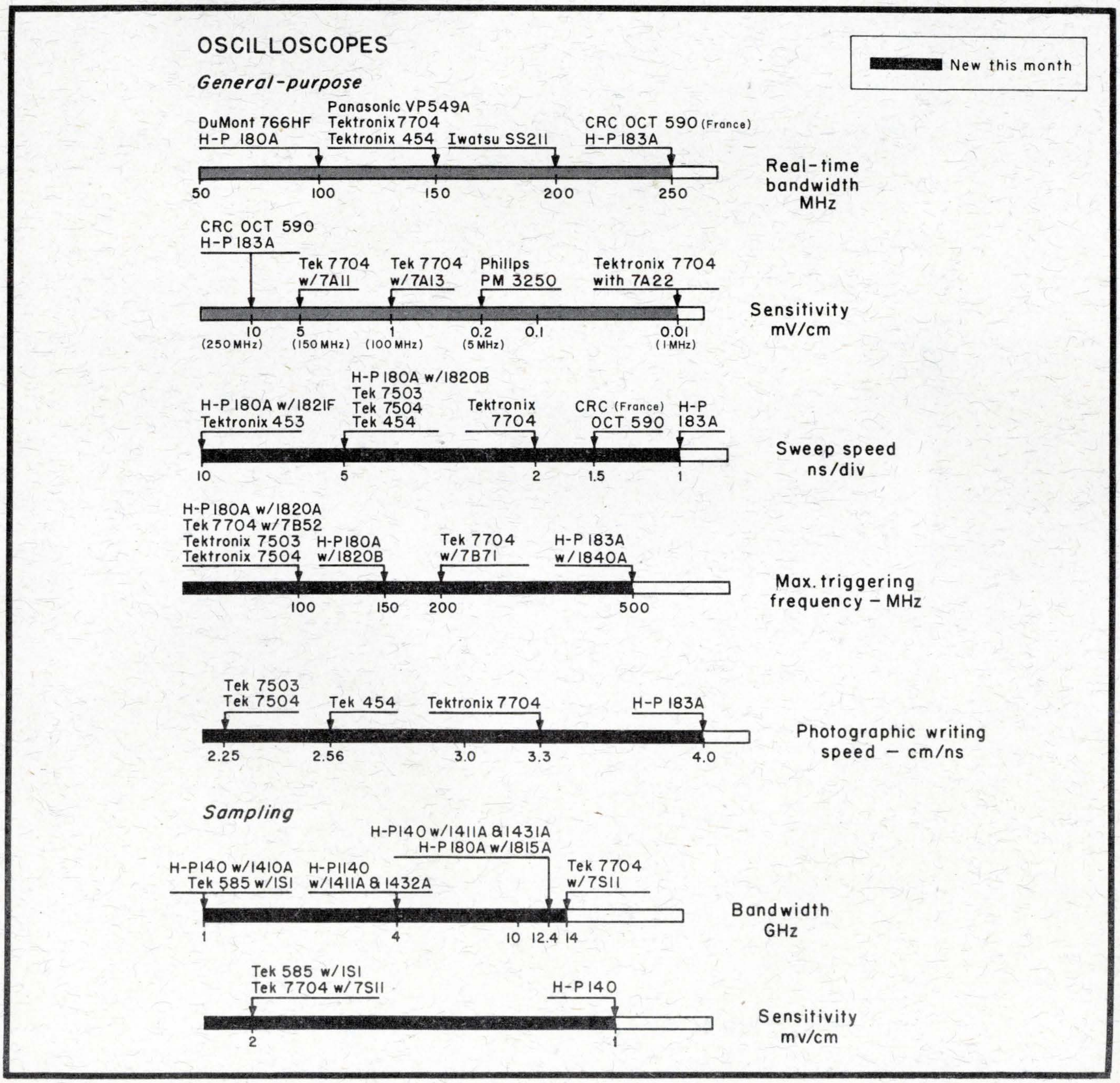
FOREFRONT

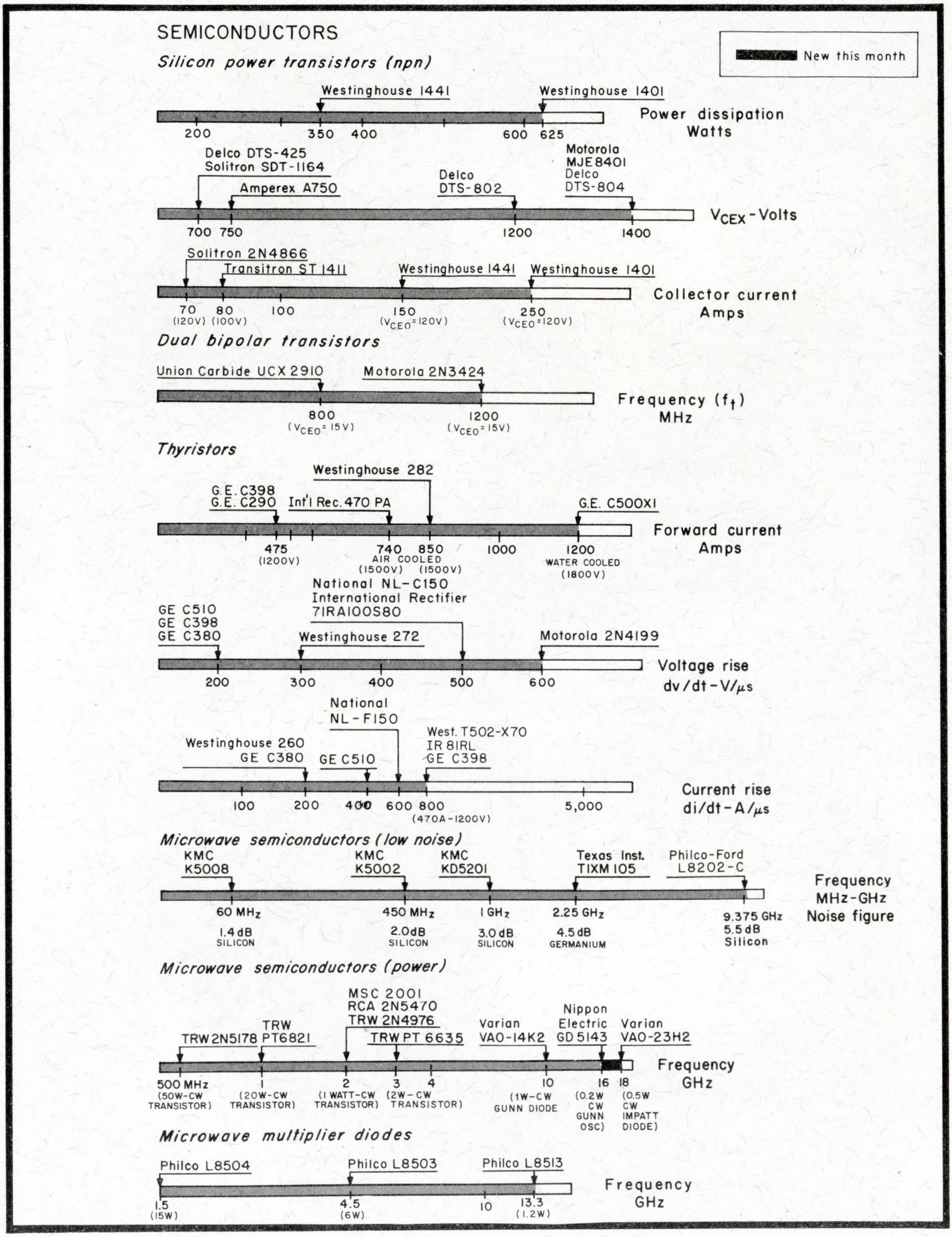
The EE Forefront is a graphical representation of the practical state of the art. You will find here the most advanced components and instruments in their class, classified by the parameter in which they excel.

A word of caution

Keep in mind the tradeoffs, since any parameter can be improved at the expense of others. If there is no figure-of-merit available, we either include other significant parameters of the same products, or we provide additional bar graphs for the same products.

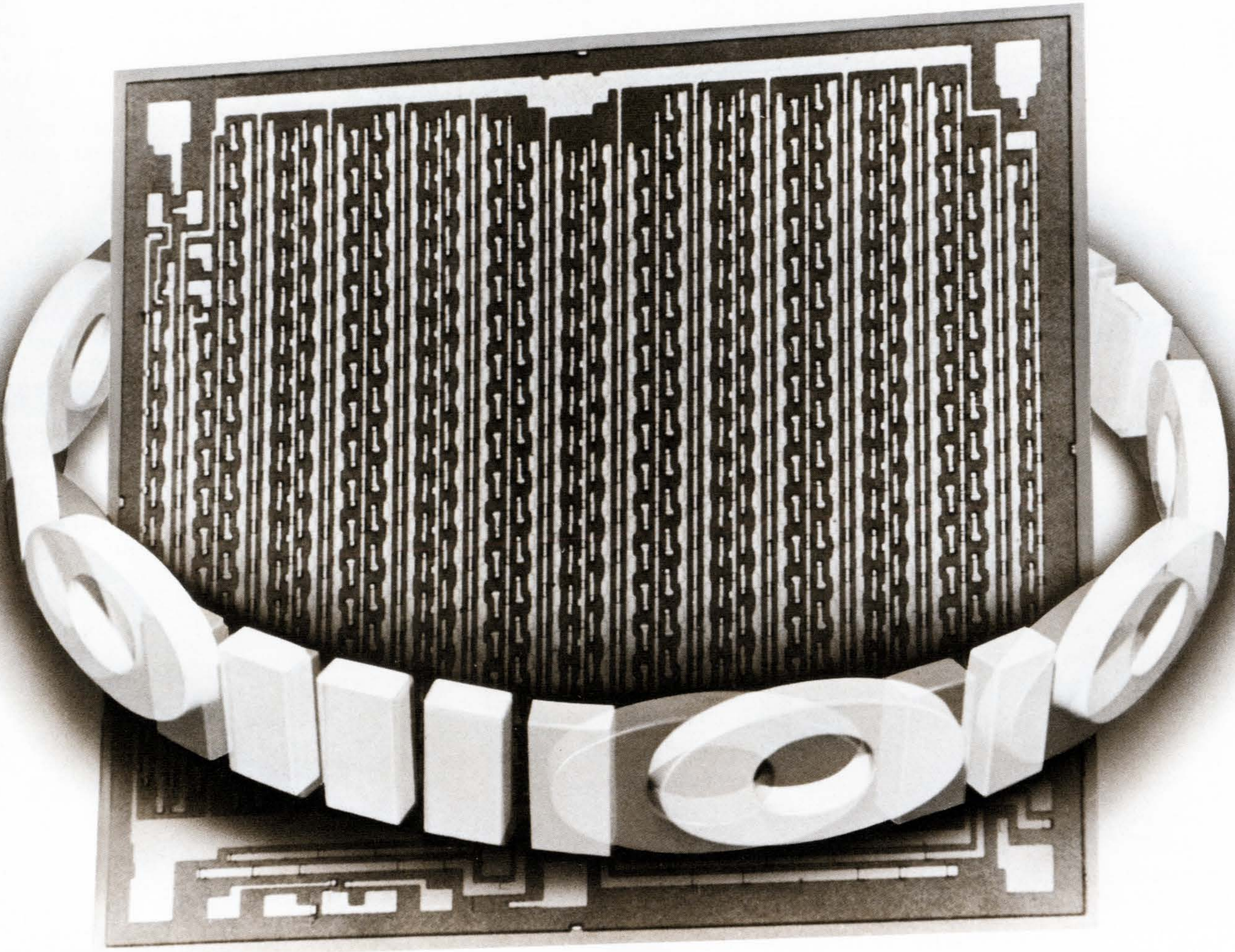
Do not use these charts to specify. Get complete specifications first, directly from the manufacturers.




SEMICONDUCTORS
New this month
Silicon power transistors (npn)
Westinghouse 1441
Westinghouse 1401
200
350
400
600
625
Power dissipation Watts
Delco DTS-425
Solitron SDT-1164
Amperex A750
Delco DTS-802
Motorola MJE8401
Delco DTS-804
700
750
1200
1400
V_{CEX} - Volts
Solitron 2N4866
Transitron ST 1411
Westinghouse 1441
Westinghouse 1401
70 (120V)
80 (100V)
100
150 (V_{CEO}=120V)
250 (V_{CEO}=120V)
Collector current Amps
Dual bipolar transistors
Union Carbide UCX 2910
Motorola 2N3424
800 (V_{CEO}= 15V)
1200 (V_{CEO}= 15V)
Frequency (f_t) MHz
Thyristors
Westinghouse 282
G.E. C398
G.E. C290
Int'l Rec. 470 PA
G.E. C500X1
475 (1200V)
740
850
AIR COOLED
(1500V)
(1500V)
1000
1200
WATER COOLED (1800V)
Forward current Amps
National NL-C150
International Rectifier 71RA100S80
GE C510
GE C398
GE C380
Westinghouse 272
Motorola 2N4199
200
300
400
500
600
Voltage rise dv/dt-V/μs
National NL-F150
West. T502-X70
IR 81RL
GE C398
Westinghouse 260
GE C380
GE C510
100
200
400
600
800 (470A-1200V)
5,000
Current rise di/dt-A/μs
Microwave semiconductors (low noise)
KMC K5008
KMC K5002
KMC KD5201
Texas Inst. TIXM 105
Philco-Ford L8202-C
60 MHz 1.4 dB SILICON
450 MHz 2.0 dB SILICON
1 GHz 3.0 dB SILICON
2.25 GHz 4.5 dB GERMANIUM
9.375 GHz 5.5 dB Silicon
Frequency MHz-GHz Noise figure
Microwave semiconductors (power)
MSC 2001
RCA 2N5470
TRW 2N4976
TRW 2N5178
TRW PT6821
TRW PT 6635
Varian VAO-14K2
Nippon Electric GD 5143
Varian VAO-23H2
500 MHz (50W-CW TRANSISTOR)
1 (20W-CW TRANSISTOR)
2 (1 WATT-CW TRANSISTOR)
3 (2W-CW TRANSISTOR)
4
10 (1W-CW GUNN DIODE)
16 (0.2W CW GUNN OSC)
18 (0.5W CW IMPATT DIODE)
Frequency GHz
Microwave multiplier diodes
Philco L8504
Philco L8503
Philco L8513
1.5 (15W)
4.5 (6W)
10
13.3 (1.2W)
Frequency GHz

No. 9-70

SEMICONDUCTOR
newsbriefs
PUBLISHED BY MOTOROLA SEMICONDUCTOR PRODUCTS INC.



Shift A Bit For Less

Motorola presents MOS at its economical best – the new MC1142G 200-Bit Dynamic Shift Register. Cost conscious designs will benefit by the MC1142G's "under 3¢/bit" price tag ($5.25 in 1K-up quantities) and even less for volume production requirements.

Constructed with P-channel enhancement mode devices in a single monolithic structure, the MC1142G contains a push-pull buffer for higher drive capability. The output is delayed 200 bit times from the input.

FEATURES

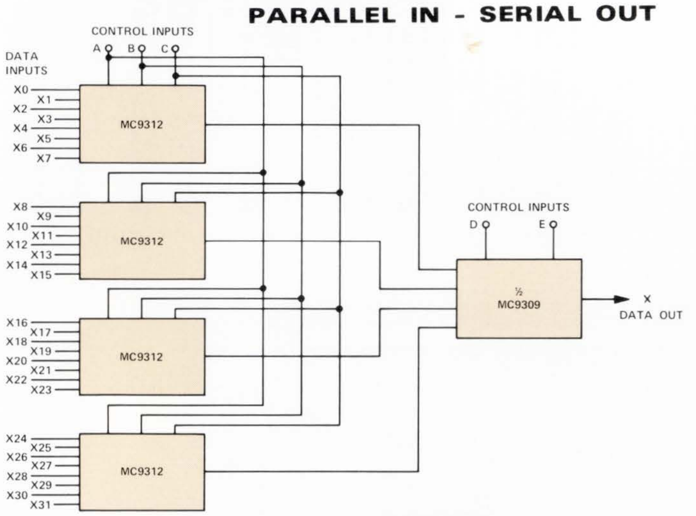
- 1.0 mW/Bit Power Dissipation @ 1.0 MHz
- 10 kHz to 1.0 MHz Operating Frequency Range
- Diode Protection on All Inputs
- Output Interfaces Directly With MDTL and MTTL
- Specified for Single or Cascade Applications

The MC1142G is recommended for delay line memories and sequential digital applications, utilizing a two-phase clock for minimum power dissipation.

Check your local distributor today for "off-the-shelf" evaluation devices which are supplied in a compact low-profile, 8-leaded metal can. You'll find it costs less to shift a bit with Motorola's MC1142G.

For details circle No. 150

SELECTION OF ONE-OF-THIRTY-TWO BITS
PARALLEL IN - SERIAL OUT



E	D	C	B	A	X
0	0	0	0	0	X0
0	0	0	0	1	X1
0	0	0	1	0	X2
0	0	0	1	1	X3
0	0	1	0	0	X4
0	0	1	0	1	X5
0	0	1	1	0	X6
0	0	1	1	1	X7
0	1	0	0	0	X8
0	1	0	0	1	X9
0	1	0	1	0	X10
0	1	0	1	1	X11
1	0	1	0	0	X20
1	0	1	0	1	X21
1	0	1	1	0	X22
1	0	1	1	1	X23
1	1	0	0	0	X24
1	1	0	0	1	X25
1	1	0	1	0	X26
1	1	0	1	1	X27
1	1	1	0	0	X28
1	1	1	0	1	X29
1	1	1	1	0	X30
1	1	1	1	1	X31

New MC9300/8300 "Compatibles" Broaden DTL/TTL Capabilities

Four new MC9300/8300 series complex functions are ready to serve as basic building blocks for systems utilizing any TTL family or DTL. The new devices are completely TTL/DTL compatible and are direct replacements (electrically and functionally) for older 9300/8300 devices.

As system building blocks, the new devices are really versatile. The MC-9300/8300 4-bit universal shift register, for example, provides the shift right, shift left, serial-to-serial, parallel-to-parallel, serial-to-parallel, and parallel-to-serial functions. And it also comes with a master reset input that sets all outputs to the logic "0" state (regardless of other input states), a parallel enable input, and J and K inputs providing full input logic capability for serial data entry.

Particularly useful for arithmetic operations (addition, subtraction, multiplication) as well as parity generation and checking, the MC9304/8304 dual full adder contains two independent, high-speed, binary full adders, and provides complementary SUM outputs. Adder one has a CARRY output while adder two has a CARRY output plus both active high and active low inputs. This input choice offers greater flexibility and helps minimize system package count.

The MC9309/8309 dual 4-channel data selector is particularly useful for data routing and sampling applications and may be used to convert 4 bits of parallel data to serial data. The device selects data present on one of four input lines, according to logic states of the control inputs, and routes that information to the output.

Another data routing natural is the MC9312/8312 8-channel data selector which is useful for routing data from one of eight sources, such as a bank of memories, when the memory address is presented to the select inputs.

The MC9300, 9304, 9309 and 9312 (full temperature range versions) are available in the ceramic dual in-line package (L suffix). The MC8300, 8304, 8309 and 8312 (0 to +75°C devices) are supplied in both ceramic dual in-line and plastic dual in-line (P suffix) packages. 100-up prices are: MC9300L - $13.00; MC8300L - $6.50; MC8300P - $5.05; MC9304L - $15.00; MC8304L - $7.50; MC8304P - $5.80; MC9309L - $10.60; MC8309L - $5.30; MC8309P - $4.10; MC9312L - $10.60; MC8312L - $5.30; MC8312P - $4.10.

These new DTL/TTL "compatibles" are immediately available from your nearby Motorola distributor.

For details circle No. 151

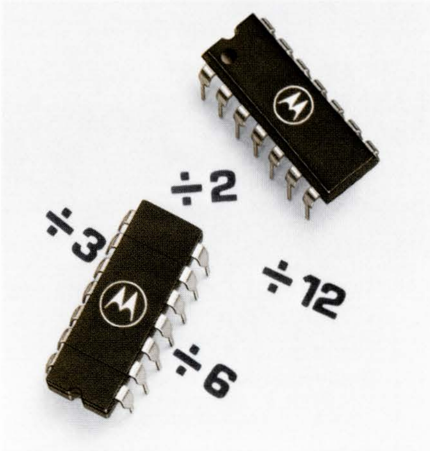
Counter And Shift Register Join 54/74 TTL Functions

Two new versatile complex functions – the MC5492/7492 divide-by-twelve counter and the MC5495/7495 4-bit universal shift register – have been added to Motorola's expanding 54/74 TTL line.

The MC5492/7492 is designed to provide a variety of counting moduli with no external gating. Comprised of a divide-by-two section and a divide-by-six section, the sections can be used independently, or can be connected to perform the divide-by-twelve function. The device is especially useful in any application requiring a division by 12, 6, or 3 such as time or measurement recorders.

The MC5495/7495 can be used in many part reducing, performance improving applications. The device performs as a right-shift/left-shift register, or as a parallel in/parallel out, parallel in/serial out, serial in/parallel out, serial in/serial out storage register, depending on the logic level present at the mode control input. Other applications include use as a divide-by-N counter, a programmable frequency divider, a programmable burst generator, and a 4-bit full adder and subtractor.

The devices are available in ceramic dual in-line packages (suffix L) for use over the full temperature range and both ceramic and plastic (suffix P) dual in-line packages for 0 to +75°C applications. Check your local distributor for "off-the-shelf" units. Prices (100-up) MC7492 – $4.15; MC7495P – $4.85.



The MC5492/7492 provides four divide-by functions in one package.

For details circle No. 152

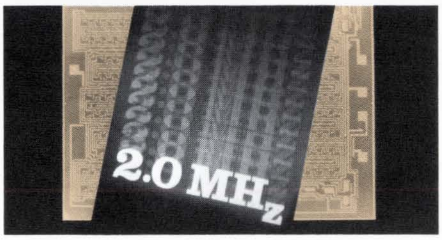
MOS Dual Static Shift Registers Twice As Fast

Forced to build your low-power system's static registers with bipolar flip-flops because available MOS can't keep up with the system clock?

Two new MOS devices from Motorola might just be the answer – they run at 2.0 MHz, twice the usual speed of a MOS static shift register.

Both the MC1160G dual 100-bit and the MC1161G dual 50-bit registers share these outstanding features:

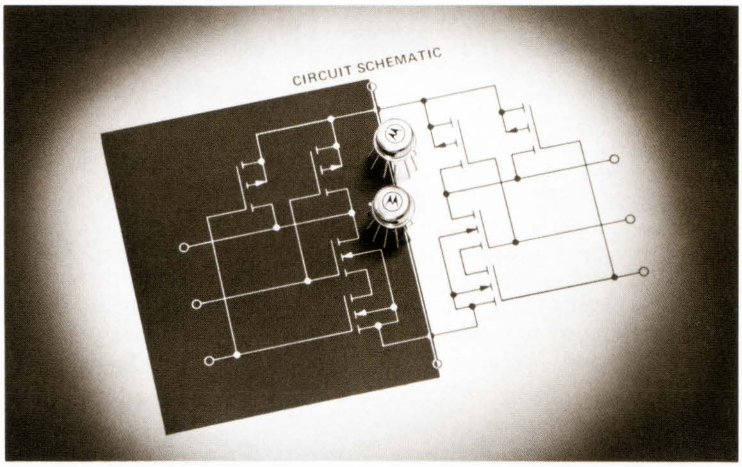
- Independent input/output lines for both devices in a package – plus the specs permit independent or cascade operation.
- Buffered outputs directly drive TTL.
- Common power supply and clock lines to both devices in a package.
- Diode protection on all inputs.



With features like these, the two registers are ideal used for delay lines or circulating data storage. And their dc operation holds your data without needing constant refreshment.

The MC1160G and MC1161G both come in a 10-pin metal can off-the-shelf for \$17.50 and \$9.00, respectively – 100-up.

For details circle No. 153



The MC2597, a typical MCMOS device, balances a miserly power consumption against a fearless 4.5 V noise immunity.

MCMOS "Power Saver" Circuits Make Debut

When your circuit requirements call for minimum power dissipation, high noise immunity, and operation over a wide variation of power supply voltages; you have a ready solution in **M**otorola's **C**omplementary **MOS.**

Two newly available MCMOS circuits, MC2597G and MC2598G, exhibit quiescent power dissipations of 100 nW, noise immunity of 4.5V @ V_{DD} = 10 Vdc, and will operate over power supply ranges of 5.0 to 15 Vdc. The MC2597G is a dual 2-input NAND gate and the MC2598G is a type D flip-flop with Direct Set and Direct Reset inputs, plus complementary outputs. As such, the MC2598G can be used as a one-bit shift register element, or as a type T flip-flop for counter and toggle applications.

Both devices are packaged in a compact, low profile, 10-leaded metal can. Obtain evaluation samples from your distributor at low, low 100-up prices of \$1.50 for the MC2597G and \$2.50 for MC2598G devices.

More MCMOS coming!

Shortly you'll be able to apply these additional "power savers" – the MC-2501L Quad 2-input NOR gate, MC2502L Dual 4-input NOR gate, and the MC2503L Dual Type D flip-flop. All three devices feature low power dissipation (100 nW type), will operate over input voltages from 4.5V to 20 Vdc, and offer high fanouts (>50). Check with your local Motorola representative for pricing and delivery.

For details circle No. 154

MTTL Complex Function Line Gains Nine New Members

Introducing nine new "cost cutting" complex functions for greater design flexibility. Leading off is the MC4002 dual data distributor, a very useful device for routing digital data from a single location to one of several registers or locations for further processing.

Where versatility is a prime consideration check the MC4023 4-Bit universal counter. It's a natural for use in frequency synthesizers, digital displays and A/D converters! You can connect the MC4023 to divide by any number between 2 and 12 (except 7 and 11). Other counters are limited in counting – so consider the MC4023's counting capability of 2, 3, 4, 5, 6, 8, 9, 10, or 12, a definite advantage – especially at 30 MHz! For additional utility, reset inputs are provided on each of the four flip-flops in the counter to allow direct setting of the Q outputs to zero any time during the counting cycle.

The MC4026/27 full adders are designed for standard serial and ripple-carry parallel adder systems while the MC4028/29/30/31 are a family of fast adders for parallel look-ahead carry adder applications where high-speed addition is required. And it's simple to build 8-stage look-ahead carry sub-systems when you combine the fast adders with Motorola's new MC4032 carry decoder.

TYPE NO.	FUNCTION	PRICES (100-UP)
MC4002P	Dual Data Distributor	\$ 7.05
MC4023P	4-Bit Universal Counter	5.20
MC4026F, L, P	Full Adder	4.05(F, L) / 3.45(P)
MC4326F, L		6.60
MC4027F, L, P	Full Adder	3.35(F, L) / 2.85(P)
MC4327F, L		5.10
MC4028F, L, P	Dependent-Carry Fast Adder	4.60(F, L) / 3.90(P)
MC4328F, L		7.60
MC4029F, L, P	Dependent-Carry Fast Adder	3.80(F, L) / 3.25(P)
MC4329F, L		5.80
MC4030F, L, P	Independent-Carry Fast Adder	4.60(F, L) / 3.90(P)
MC4330F, L		7.60
MC4031F, L, P	Independent-Carry Fast Adder	3.80(F, L) / 3.25(P)
MC4331F, L		5.80
MC4032F, L, P	Carry Decoder	3.20(F, L) / 2.70(P)
MC4332F, L		\$ 4.90

MC4000 Series (0 TO +75°C)
MC4300 Series (–55 TO +125°C)

F Suffix = Ceramic Flat Pack
L Suffix = Ceramic Dual In-Line Pkg.
P Suffix = Plastic Dual In-Line Pkg.

For details circle No. 155

Dual OP AMP Doubles Savings In Both Space And Cost

Suppose you have a dual design challenge . . . one that incorporates *both* limited space and limited budget – in addition to the usual high performance specifications.

Sounds almost insurmountable, particularly when you also want to utilize the standard benefits of monolithic integrated circuits!

Not any more – thanks to the new MC1558G dual operational amplifier. Here, essentially, are two industry-standard MC1741 op amps on one chip and in one hermetic package. Yet, the cost for this dual is very little more than the cost of one MC1741.

In addition to these space-saving, money-saving virtues, the MC1558 also offers all of the high-performance benefits of the MC1741:

- Internal frequency compensation.
- Short circuit protection.
- Wide common-mode and differential voltage ranges.
- Low power consumption.
- No latch up problems.

The MC1558 and MC1458 are both available from distributor stock in the 8-pin (TO-99) metal package. 100-up pricing is:

MC1458G – \$4.00
MC1558G – \$5.00

For details circle No. 156

There's Only One Truly Flexible IC Regulator For Lab Power Supplies

If you need a laboratory power supply (and, who doesn't) think about this:

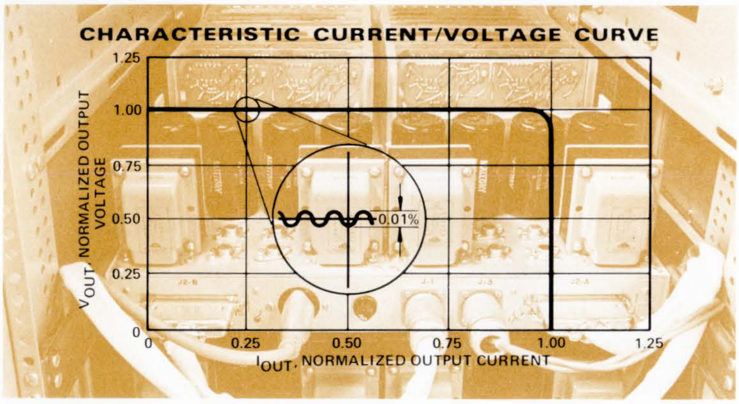
There's only ONE monolithic IC voltage regulator that offers a constant current source!

There's only ONE IC regulator where voltage is adjustable to zero (or, up to hundreds of volts)!

There's only ONE that provides automatic cross-over from voltage to current regulation! (See illustration).

For sheer versatility, the MC1566 is one of the most outstanding developments since the op amp. You can, for example, use the MC1566 in circuits for measuring a wide variety of circuit parameters, to perform remote sensing, or in a number of other applications.

As a power supply regulator, the MC1566 provides complete control over both voltage and current. With the MC-1566 in charge, your power supply changes from constant voltage to constant current smoothly, automatically and almost instantly. And, the crossover point is pre-determined and programmable. In short using the MC1566, it's possible to regulate voltage from zero up to a value limited only by the breakdown voltage of the series-pass transistor at the power supply output.



Voltage regulation of 0.01% is standard duty for the MC1566 lab quality regulator.

As a result, you can use just one IC for all of your regulation jobs from millivolt levels to hundreds-of-volts!

Some of the outstanding specs of the MC1566 and its 0 to 75°C mate, MC1466 are:

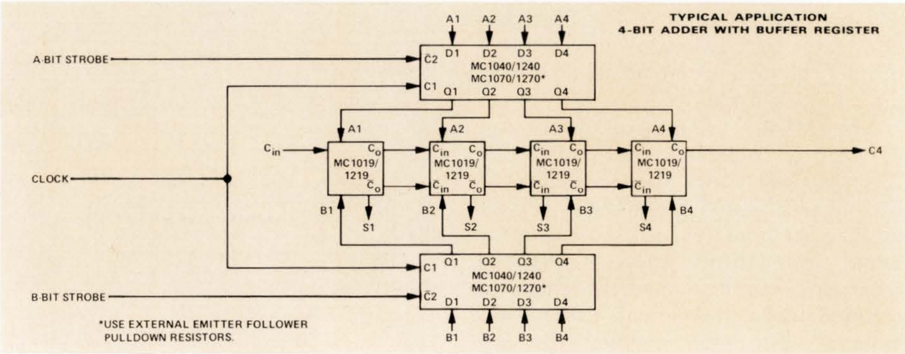
- Excellent Line Voltage Regulation - 0.01% +1.0 mV
- Excellent Load Voltage Regulation - 0.01% +1.0 mV
- Excellent Current Regulation - 0.01% +1.0 mV
- Short Circuit Protection

Both types are available now in the 14-pin dual in-line ceramic package.

For details circle No. 157

Latest MECL II Quad Latch Eliminates Display Tube Flickering

The MC1070/1270 quad latch features both clocked inputs and gated outputs. Its applications include use as a buffer register for temporary storage of binary information between arithmetic processing units. A complete data sheet gives information outlining a storage technique using the quad latch to eliminate display tube flickering when working at input counting rates above the response time of the display device.



The MC1070 (0 to 75°C version) is packaged in both flat pack (F suffix) and 14-lead plastic dual in-line cases (P suffix). MC1270 is supplied in a 14-lead ceramic dual in-line package (suffix L). 100-up prices are: MC1070F – \$9.50; MC1070P – \$6.50; MC1270L – \$7.70. Your local distributor has evaluation units "on the shelf."

For details circle No. 158

Control Full-Wave Power To 6000W With MAC35/36 Triacs

The new MAC35/36 triac team of "huskies" are straining in their traces, ready to pull a full, 25 amperes (rms) load in your demanding industrial/military control job. If it's economical, stepless 60 cycle power control in motors, heaters, welding gear or switching systems you need, these rugged types will easily handle 6,000 watts (240 V) in your circuits plus provide other advantages in ac designs, like symmetrical gating and holding.

The tough performers in this team were bred specially for their task. Just look at their pedigree: a low 1.5 V (max) on-state voltage at 35 A, uniform characteristics through all-diffused junctions, 225 A peak one-cycle surge current protection, and 4 mA (max) peak blocking current at V_{DRM}.

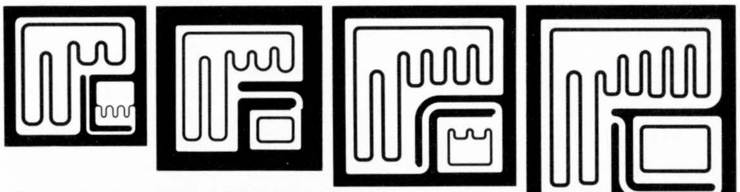
Turn-on time is a scant 1.0 μs, too, assuring efficient switching in all uses.

Even when cost is the prime consideration, the MAC35 series ensures optimum balance between price and continuous control performance – prices start as low as $1.70, 100-up!

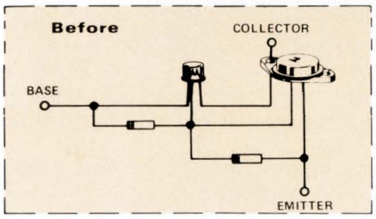
Evaluation units of the ½" flangeless pressfit and 9/16" stud types are available from your distributor. Send for information on your triac "husky" today and we'll mail an Application Note, AN466, "Circuit Applications For the Triac" and a data sheet that gives both average and rms current derating curves.

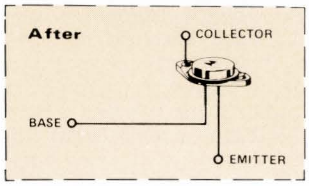
Series	Package	V_{DRM} Range V	$I_{T(RMS)}$ A	I_{GT} (typ) mA	I_H (typ) mA
MAC35-1 to 7	Pressfit	25 to 500	25	20	10
MAC36-1 to 7	Stud				

For details circle No. 159



Fabricated with Motorola's Epibase mesa process, the new MJ-900/1000 power Darlingtons save circuits components.





Power Darlingtons Revolutionize Today's World Of Silicon Power!

Now you can up op amp power, innovate with I/C's, obtain 1,000 dc gain and compress your costs with the new, "world-of-tomorrow," 5 A silicon power Darlington transistors!

First of their kind available in the industry, the MJ900/1000 series promise to revolutionize conventional, silicon power circuits requiring separate, "one-for-one," driver and output transistors and associated emitter-base resistors.

Your power operational amplifiers, for example, such as relay or solenoid drivers, power supply regulators, servo amplifiers and series pass regulators can now be designed around one, discrete device containing driver, output and resistors – all on one chip in one TO-3 power package. You can drive the new Darlingtons with power levels derived from integrated circuit logic gates and go from milliamperes to amperes directly, compatibly, easily.

You can cut your costs substantially by having only one device to install and heat sink. Reliability too is heightened, because of the lessening of component needs and variations.

And, with both NPN and PNP types available, you can build positive and negative-based systems. Or you can use them in complementary symmetry applications.

In addition to the new MJ900/1000 metal series, Thermopad plastic types will soon be introduced offering the designer even further economies.

Introduce your circuits to today's world of silicon power Darlington systems . . . write for complete data!

Power Darlington		I_C A	$V_{CEO(sus)}$ A	h_{FE} @ I_C	P_D W	I_{CBO} @ V_{CB} mA	SOA	Price 100 Up	
PNP	NPN	(Cont)		(min)				PNP	NPN
MJ900	MJ1000	5	60	1,000 @ 3A	90	0.2 @ 60V	3A @ 30V	$2.90	$2.50
MJ901	MJ1001	5	80		90			$3.30	$2.90

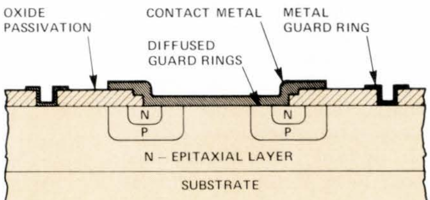
For details circle No. 160

New Plastic High Voltage Hot-Carrier Diodes Are Versatile, Rugged, And Inexpensive

MBD501 and MBD701, two new Motorola high-voltage silicon hot-carrier detector and switching diodes, offer designers outstanding qualifications as RF detectors in video and radar applications, and as ultra high-speed switches in digital logic applications.

All the typical cost advantages of Motorola's high volume plastic production capability are here, too. Low initial prices half those of competitive glass units for production run quantities, match manufacturing cost savings made possible by the package benefits. The TO-92 configuration is ideal for use in printed circuit board applications and lends ease to automatic insertion procedures.

UNIQUE DOUBLE GUARD RINGS ASSURE MBD501/701'S HIGH BREAKDOWN VOLTAGE



For details circle No. 161

The ruggedness of Motorola's void-free plastic package perfectly complements the reliable wire-bond construction of these devices to eliminate the fragility of "C" bend, "S" bend, and point contact diodes.

Key specs include low capacitance – 1.0 pF (max) @ V_R = 20 V – and extremely low minority carrier lifetime of 100 ps (max) @ I_F = 5.0 mA. $V_{(BR)}$ is 50 V for the MBD501 and 70 V for the MBD701.

NEW PRODUCT BRIEFS

HIGH POWER, P-I-N SWITCHING DIODES

– Enhance Phased Array Radar Designs

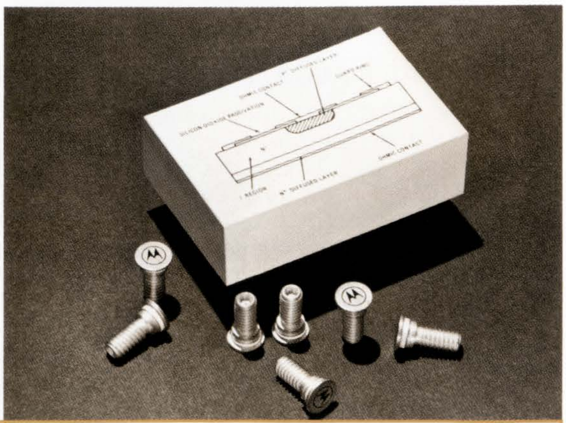
The high peak and average power handling capability of two new Motorola high-voltage P-I-N diodes provides a potential boost in range for phased array radar systems. These MPN3208 and MPN3209 800/900 Volt P-I-N diodes are primarily intended for high-power phase-shifter applications at frequencies through S-band, but are readily adaptable to other RF power control jobs, too.

Because these devices utilize a silicon-dioxide passivated junction, they exhibit excellent stability and a very low reverse leakage of only 100 nA @ V_R = 500 V. Thermal resistance is also low at just 4.0°C/W (max).

Their low forward series resistance of 0.4Ω (max) @ I_F = 150 nA is a significant factor in securing minimal circuit losses. Both the MPN3208 and the MPN3209 are packaged in a stud-based ceramic pill case designed to mount readily in the standard 8/32 tapped hole.

These state-of-the-art P-I-N diodes are available off-the-shelf today.

For a data sheet circle 162



PLASTIC SILICON NPN CORE DRIVER

– Gives Dollars Switching Performance For Pennies Admission

Availability of Motorola's new 2N5845 NPN Silicon Annular transistor is news, good news, for designers with core driver or medium-current switching applications. Here is a device with just about everything. 40V (min) BV_{CEO} @ 10 mA – high f_T – low saturation voltage – fast switching – rugged package – and a low, low cost indicated by the 1000-up price tag of only 44¢.

All this spells real value, and there's more. Even though the 2N2845 is supplied in the plastic TO-92 package, the chip is mounted on a copper lead frame that ups the total device dissipation to a full 500 mW @ T_A = 25°C. And, lead-forming to either the TO-18 or the TO-5 configuration is available, too.

When we say fast switching, we're talking about 40 ns t_{on} and 60 ns t_{off} at v_{CC} = 40V and I_C = 500 mA. $V_{CE(sat)}$ is 0.6V (max) @ I_C = 500 mA and the current-gain – bandwidth product is 200 MHz (min) @ 50 mA. The warehouse has been stocked with ample quantities to assure excellent delivery.

For a data sheet circle 163

SWITCHING CHARACTERISTICS

Time	Maximum Value	Conditions
Turn-On Time	40 ns	V_{CC} = 40 Vdc,
Delay Time	17 ns	I_C = 500 mAdc
Rise Time	28 ns	I_{B1} = 50mAdc
Turn-Off Time	60 ns	V_{CC} = 40 Vdc,
Storage Time	40 ns	I_C = 500 mAdc
Fall Time	30 ns	$I_{B1} = I_{B2}$ = 50mAdc

THREE NEW MHTL "NOISE REJECTORS"

– Ease Design of Industrial Environment Circuitry

Three new off-the-shelf members of Motorola's High Threshold Logic family, the MC679 dual lamp/relay driver, and the MC677 and MC678 hex inverters are ready to shrug off up to 6 V of electrical noise for designers of high-noise environment equipment.

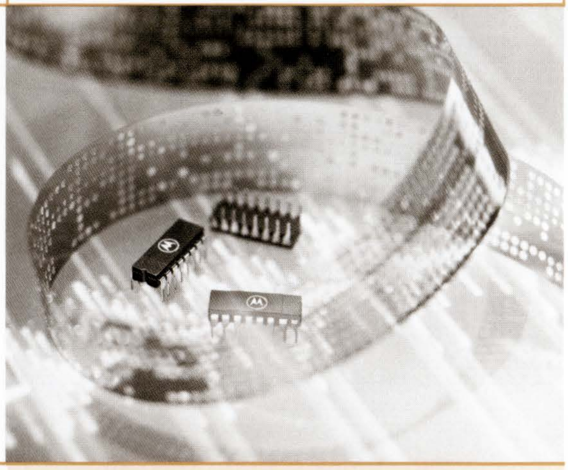
The output transistors of the MC679 can operate 28 volt lamps or supply up to 150 mA. It's a natural for driving register clock lines, capacitive loads, or discrete components.

Strobe inputs allow one MC677 to replace 1½ quad two-input NAND gate packages in many applications.

Its lack of output resistors permits the MC678 to drive low-current lamps, interface with discrete components or implement the "Implied AND" (wired-collector) function with minimum power dissipation.

In 1-k up quantities: MC677L/MC677P – $1.95/1.33; MC678L/678P/ – $1.87/1.27; MC679L/MC679P – $2.36/1.75.

For a data sheet circle 164



NEW PROGRAMMABLE UJT DEVICES

– Let You Tailor Their Specs For Your Circuits

Simply by varying the external resistors, you can "program" your own UJT specs into sensing, pulsing, timing, thyristor triggering and oscilator circuits with the new MPU131-133 series of plastic Unibloc UJT's.

R_{BB}, eta, I_V and I_P device characteristics can be varied by changing resistor values making the part ideal for multi-socket, high volume applications.

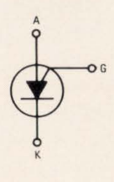
The MPU131 series is also ideal for battery-powered and other low-voltage circuits. And, base 2 of the unijunctions may be used as a low-impedance output.

Featuring high pulse output voltage of 15 V (typ) and low on-state voltage of only 1.5 V (max) the new programmable unijunction transistors (PUT) use an all-Annular fabrication thus affording long-term stability, reliability and low-leakage. Gate-to-anode leakage current is, in fact, a 5 nA maximum!

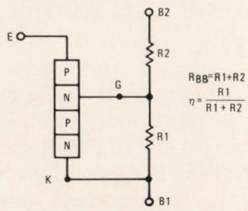
The MPU131-133 units are numbers 18, 19 and 20 in Motorola's complete UJT line and numbers 7, 8, and 9 offered in the ever-popular Unibloc plastic package. All are economical and all are available now!

For a data sheet circle 165

CIRCUIT SYMBOL



PROGRAMMABLE UNIJUNCTION

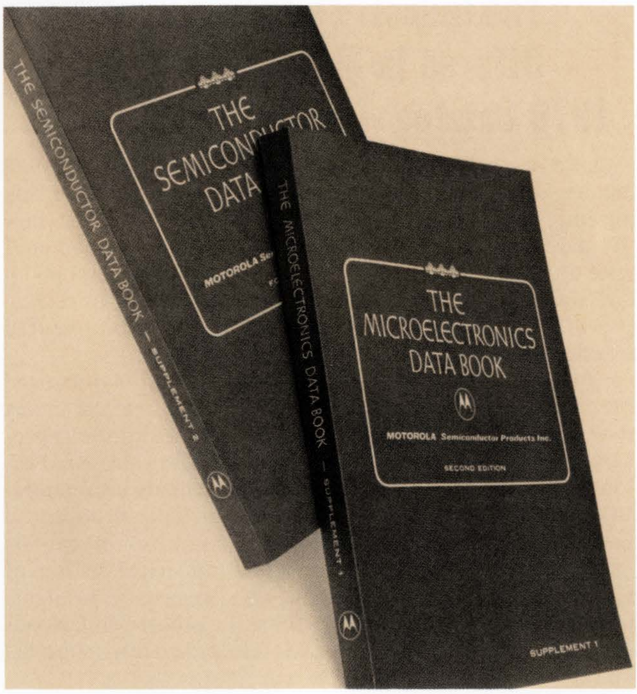


$R_{BB} = R1 + R2$

$\eta = \frac{R1}{R1 + R2}$

EQUIVALENT CIRCUIT WITH EXTERNAL "PROGRAM" RESISTORS R1 AND R2

PUT Series	I_P @ 10 V μA (max)		I_V @ 10 V mA (typ)		V_O @ 20 V V (max)	I_{GAO} @ 40 V nA (max)
	1 MΩ	10 KΩ	1 MΩ	10 KΩ	15	5
MPU 131	2	5	20	270	15	5
MPU 132	0.3	2.0	20	270	15	5
MPS 133	0.15	1.0	20	270	15	5



Supplements Ready For The Semiconductor And The Microelectronics Data Books

Supplement 2 to the 4th edition of the Semiconductor Data Book and the first supplement to the 2nd edition of the Microelectronics Data Book are fresh off the press and ready to bring your data book set completely up to date. If you're a data book owner and have subscribed to the updating service of either book you'll automatically receive your supplement for that book, or books. If you are not a book owner and would like to obtain either or both of the data books use the handy coupon. You may also order an updating subscription for either or both books (you receive the first two supplements to the corresponding book) or one or more of the supplements.

Use special coupon in this issue to order

New Master Selection Guide And Price List Available

The June/July, 1970 edition of the Motorola Master Selection Guide and Price List is ready. Compiled to make it easy for you to keep your files up to date, the new publication conveniently combines in one publication all the selector guides and price lists for every product line offered by Motorola.

The more than 100 pages in this edition cover all 17 major semiconductor categories and include a quick reference to new devices and price changes plus policies and ordering information — all in addition to the current prices of over 14,000 Motorola semiconductor devices.

For a copy circle No. 166

Tear Along Perforated Line and Drop in Mail (No Postage Required)

Please PRINT clearly (To expedite your literature we may have to use this as a return mailing address)

NAME ________ TITLE ________

COMPANY NAME ________

DIVISION ________ DEPARTMENT ________

COMPANY ADDRESS (Street or P. O. Box) ________

CITY ________ STATE ________ ZIP CODE ________

SEMICONDUCTOR
newsbriefs

Please circle the Reader Service number of item(s) you are interested in receiving from NEWSBRIEFS No. 9-70:

E.E.						
150	151	152	153	154	155	156
157	158	159	160	161	162	163
164	165	166				

List Application Notes you wish to receive below (by number):

________ ________ ________
________ ________ ________

Do you wish a Motorola Representative to contact you?

☐ VISIT ☐ PHONE . . . Phone No.________Area Code________

NOTICE: Requests for literature on items described in this publication cannot be honored after October 1, 1970.

QUANTITY COUPON

Semiconductor Data Book (4th edition)	Microelectronics Data Book (2nd edition)	
		Single copy @ $4.95 ea. . $____
		2-24 copies @ $3.50 ea. . $____
		25 or more copies @ $3.30 ea. $____
		Updating subscription @ $2.00 ea. . . . . $____
		Supplement #1 @ $1.00 ea. $____
		Supplement #2 @ $1.00 ea. $____
		Total . . . . $____

Fill in your name and address on the other side of this coupon. Tear along perforated lines and enclose in envelope with proper remittance.

FOLD HERE

FIRST CLASS
Permit No. 2565
PHOENIX
ARIZONA

BUSINESS REPLY MAIL
No postage stamp necessary if mailed in the United States

POSTAGE WILL BE PAID BY

Semiconductor NEWSBRIEFS No. 9-70
Motorola Semiconductor Products Inc.
P. O. Box 20924
Phoenix, Arizona 85036

FOLD HERE

For Fast Action!

. . . on delivery of literature for items described in this publication — fill out this coupon, fold as indicated and drop in the mail.

(NO POSTAGE IS REQUIRED)

Seal Here
(Please use tape — **do not staple)**

ORDER COUPON

Be sure to fill out **both** sides of this coupon, tear along perforated edge, and mail in envelope with check, money-order, or purchase-order (*) to:

Motorola Semiconductor Products Inc.
P. O. Box 20924
Phoenix, Arizona 85036

Note: (*)P.O.'s for less than $20.00 cannot be accepted. Make checks or money-orders payable to: Motorola Inc.

NAME TITLE

COMPANY

ADDRESS

CITY STATE ZIP CODE

The Industry's Fullest Line Offered In Motorola's New 1970 Catalog – Over 14,000 Items

Like a gracefully arching rainbow, the Motorola 1970 Condensed Catalog covers the solid-state world with a full, colorful spectrum of Motorola semiconductors. The new 104 page book bulges with the major electrical characteristics of nearly 14,500 items, altogether 20 pages and about 2,400 devices greater than the 1969 version. Representatives of nearly every kind of solid state device manufactured are offered.

To make it simpler to use, the new catalog is organized into three sections: Section I is an alpha-numerical index of device type numbers providing quick access to the appropriate table and page numbers in the catalog proper. Section II, the main listing, divides all components into natural categories and tabulates major electrical specifications so that easy component comparison or preselection can be made. Section III presents an alpha-numerical listing of military type semiconductors and also soon-to-be available devices. In addition to these sections, the outline dimensions for all packages in which any Motorola device is supplied are shown.

Highlights of additions to the new edition:

- New zener diode families, including low voltage avalanche zener regulator diodes and 500 mW Unibloc silicon-oxide passivated zener regulator diodes.
- Hot carrier power rectifier — 50 amperes.
- Silicon bidirectional triacs up to 25 amperes.
- Programmable unijunction transistor family.
- Silicon unidirectional and bidirectional switch family.
- New microwave devices including P-I-N switching diodes and hot-carrier diodes.
- Six new PNP silicon RF power transistors.
- New optoelectronic devices including a light-emitting diode.
- New family of dielectrically isolated MDTL integrated circuits.
- Nine additions to the MOS integrated circuit line including MCMOS devices.
- 31 *new* MTTL complex functions.
- 75 new linear integrated circuits featuring state-of-the-art introductions such as the MC1596, balanced modulator/demodulator, the MC1536 high voltage, internally compensated operational amplifier, the MC1566 laboratory specification voltage regulator, the MC1546 four-channel plated wire sense amplifier plus the industry's only four quadrant multiplier, the MC1595. For a copy see your franchised Motorola distributor.

Motorola Semiconductor Products Inc., P. O. Box 20924, Phoenix, Arizona 85036

SEMICONDUCTOR NEWSBRIEFS

NOTE: If Motorola's Literature Request Coupon is missing, use magazine's standard Reader Service Card.

THE WESTERN COLUMN

There are seminars and seminars

While some engineers are improving their professional skills through developmental seminars, others are attending quite another type of program. The American Institute of Aeronautics and Astronautics (AIAA), in cooperation with several job-counseling groups, recently sponsored its first workshop for job-hunters in Los Angeles. (Others will be held throughout the country.) The first of three weekly meetings was attended by 150 pre-registered applicants; 200 had to be turned away at the door; and the AIAA backlog is now over 500.

The workshop does not function as an employment agency. Instead, it teaches effective job-hunting. The first session is devoted to orientation and guidance, the second to resumés and the third to interviewing techniques and salary negotiations.

Seven aerospace engineers were in the group to which I was assigned. Their situations found them out of work or within a few days of a layoff. They asked hard questions such as "What can I do right now—today?" and "How can you find me a job when there are no jobs?"

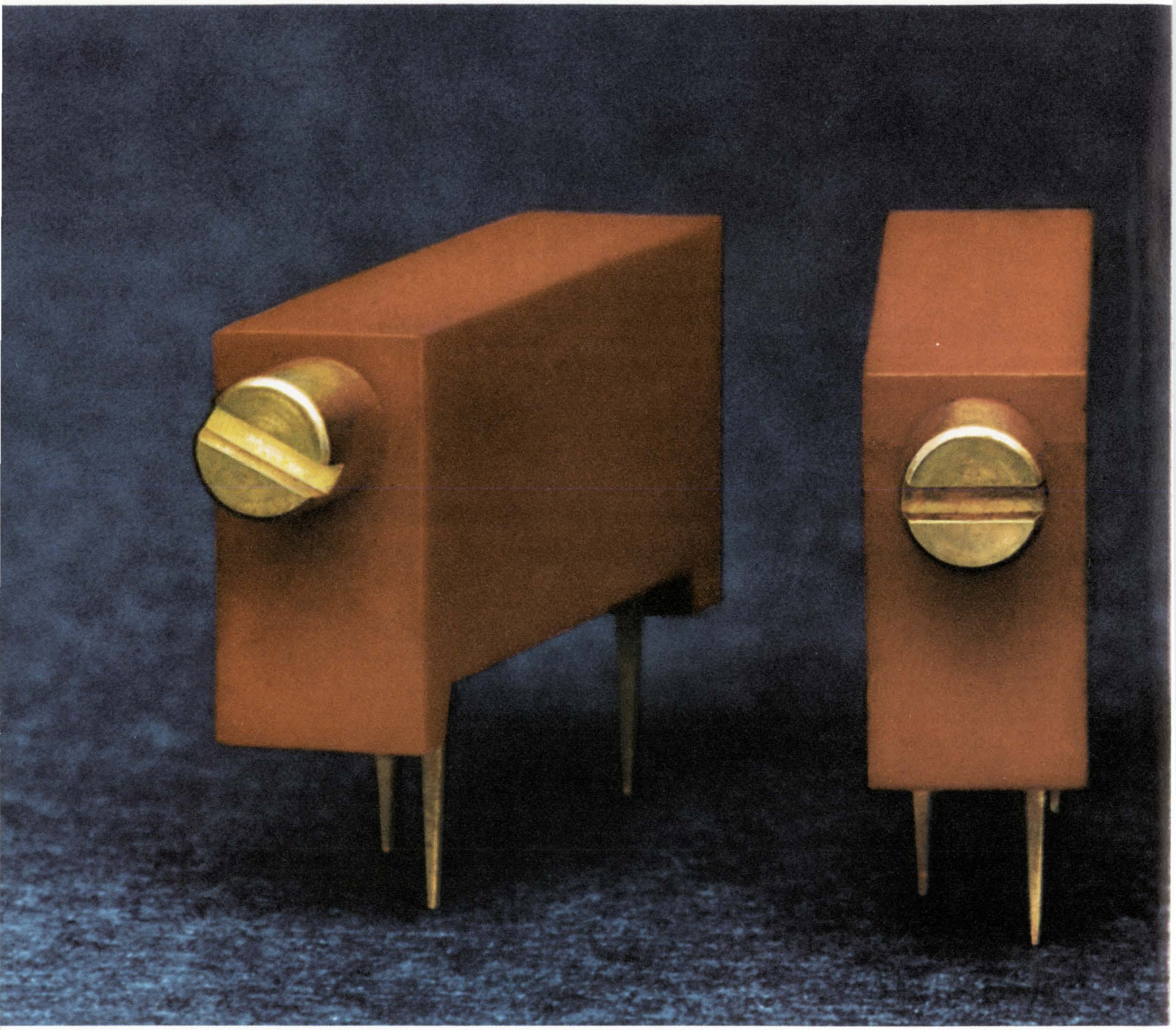
Space does not permit complete coverage of even one discussion, but some of the interesting tactics presented were:

- First, answer the question "What am I?" by listing your accomplishments.
- Specifically tailor those accomplishments for each company you approach.
- After an interview, show an interest. Write a thank you note; inquire about your status—you never know how close you are to being hired.

The AIAA workshops in Los Angeles are swamped with applicants, but the non-profit group they are patterned after, Thursday 13, can still handle prospective job seekers. Those outside Los Angeles can buy a package that contains their manual "Finding Your Place in Business." Kaye Kiddoo, Manpower Administrator for Lockheed Corp., thinks " . . . it's the best thing of its kind I have ever seen. It presents a real strategy for job-hunting." The package can be obtained for $5.00 from Thursday 13, 3435 Wilshire Blvd., Los Angeles, Calif.

Western Editor

Film-Mets? Wirewounds? Or Cermets?



What our extra choice means to you.

Circle 16 on Inquiry Card

BAY SOUNDINGS

There's been a lot of noise in the hybrid industry of late. And most of it has to do with the possiblity of a big new market, that of hybrid circuits with beam-leaded components.

There are two good reasons for the great interest in hybrids with beam-lead devices versus chip-and-wire types. Chips with beam leads are passivated and hermetically-sealed with a silicon-nitride coating. In addition, you can lay down all the leads of a beamed component at once, rather than sequentially. Also, there already exists automatic passivation equipment, and machines that can position beamed components to within 0.1 mil.

Manufacturers argue that hybrids with beam-leaded chips are not yet widely enough available to take a chance on a new manufacturing operation. Furthermore, there is certain reticence among those hybrid manufacturers who already have large investments in chip-and-wire bonders, trained operators, and so forth, to change their lines.

Raytheon Semiconductor is laying it on the line and announcing that it is in the hybrid business for beam-leaded components. The Mountain View, California firm will build the circuits on a custom basis. It has taken aim at aerospace and medical applications, which have the hi-rel, compact, circuit requirements that are a natural challenge for these hybrids.

Raytheon Semiconductor's reasoning and hopes for success in the beam-leaded field are based on these facts:

- It is already known as a major supplier of beam-leaded semiconductor components, and can also build beam-leaded passive components to complete the circuit.
- The technology of laying down beams is relatively simple; much of the work has, in effect, been done by the bonder manufacturers.
- The Semiconductor Division has not previously committed capital to chip-and-wire products on a price basis.
- No other hybrid house is building hybrids with beam-lead devices in volume for the open market.

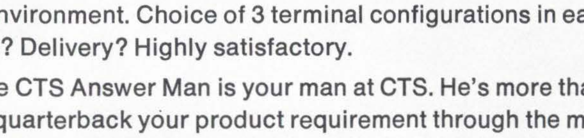
Based on its field inputs, Raytheon Semiconductor expects a million-dollar market this year mainly in low power, low voltage, highly stable linear circuits. And if Raytheon's entry into the hybrid field with beam-lead devices turns out to be the industry's long-awaited catalyst, next year's market size is anybody's guess.

Sheldon Edelman

Western Editor—San Francisco

Need high stability and low noise in trimming your circuitry?

The CTS Answer Man offers two new Cermet Rectilinear Trimmers



CTS Series 190 and 195 trimmers give you what you need: high stability and low noise. Settability is unusually easy—better than ±.025%. Noise is very low—on the average, ±0.5%. Moreover, there's maximum stability in resistance after setting—no matter how severe the environment. Choice of 3 terminal configurations in each series. Price? Delivery? Highly satisfactory.

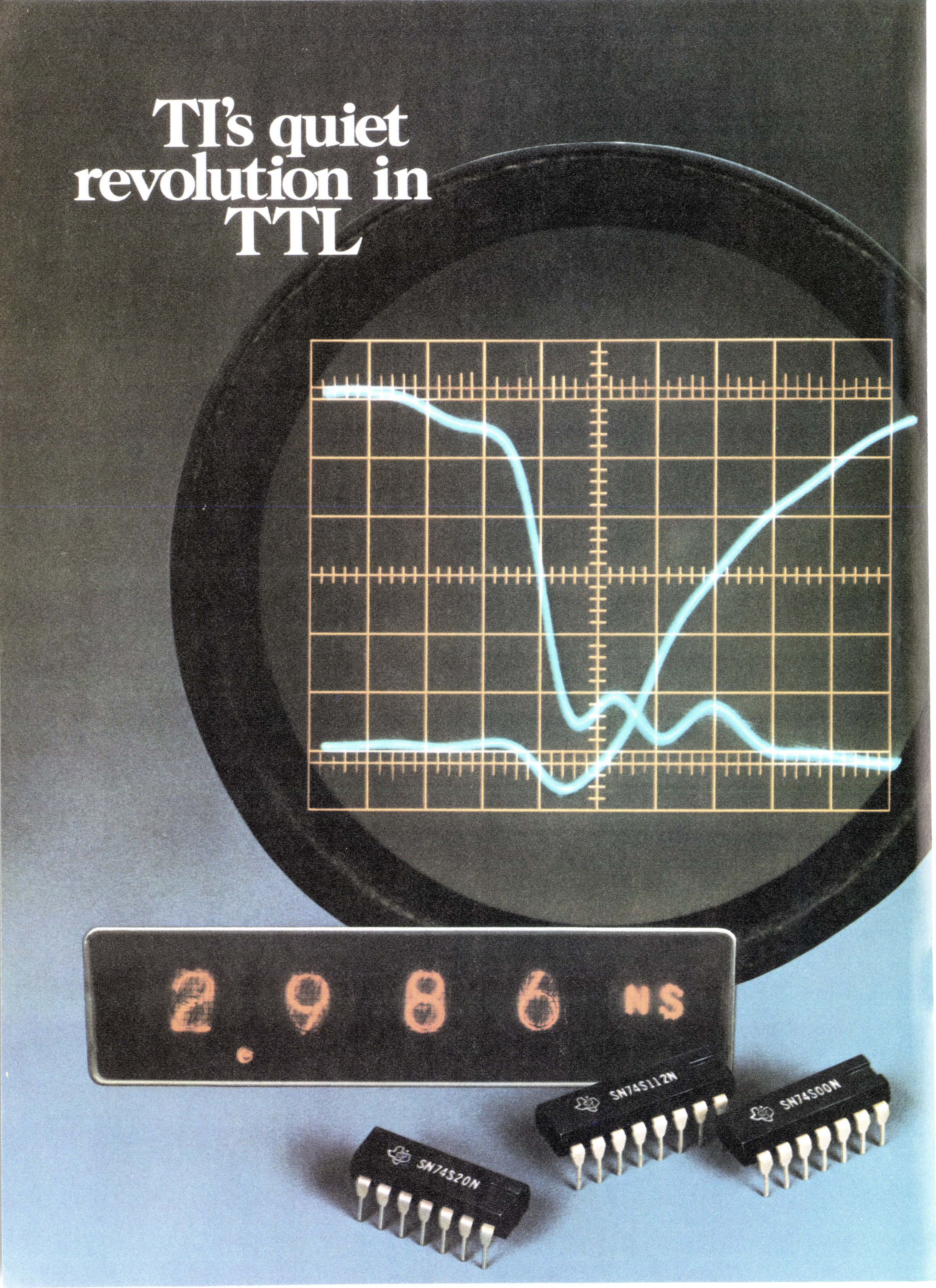
The CTS Answer Man is your man at CTS. He's more than a salesman—he'll quarterback your product requirement through the multi-resources of CTS. At his fingertips: broad production facilities, the latest technologies, plus 10 years of Cermet product experience. You can bet he'll come up with an answer every bit as good as our trimmers.

Trimmers. Potentiometers. Selector switches. Crystal products. Thick-film hybrid circuits. Cermet resistor modules. Loudspeakers. CTS makes them all in 10 U.S. and 8 foreign plants. And the CTS Answer Man stands ready to fit them to your application. To learn more, write:

CTS CORPORATION
Elkhart, Indiana

Trimmers shown actual size

TI's quiet revolution in TTL



3 ns at 20 mW.

A new technology is born with TI's Schottky-clamped 54/74 TTL.

Until now, speeds below 5 ns could only be achieved with current mode (unsaturated ECL-type) technology.

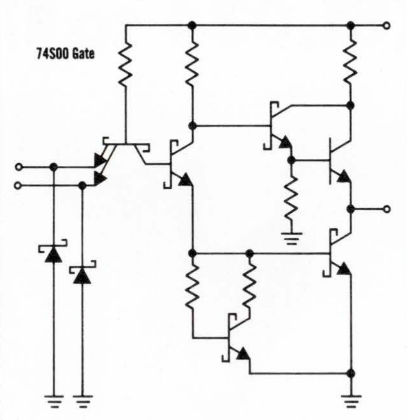
Now, TI has built integrated Schottky-barrier diode clamped transistors* into its popular Series 54/74 integrated circuits. Our new 54S/74S family combines the high speed of unsaturated logic and the low power of saturated TTL logic. The best speed/power combination yet – and priced below competitive ECL logic families.

You gain these advantages, compared to conventional TTL integrated circuit technology:

- Typical gate propagation delay: 3 ns.
- Power dissipation: 20 mW per NAND gate at 50% duty cycle.
- 100 MHz typical flip-flop clock input frequencies.
- Smaller device geometries reduce internal capacitance – and increase speed.
- Schottky-barrier diode input clamps provide fast clamping protection.
- Active pulldown network squares transfer curves and raises logical '1' output level.

---

*Texas Instruments has patented this technique in U. S. Patent number 3,463,975 titled "Unitary Semiconductor High Speed Switching Device Utilizing a Barrier Diode" issued August 26, 1969 (originally filed in 1964).



Series 54S/74S basic gate operation is compatible with existing 54, 54H and 54L families. All active transistors which saturate are Schottky clamped. Schottky input-clamped diodes offer superior input protection because of low forward voltage drop and fast recovery time.

And you also gain these advantages, compared to current mode logic technology:

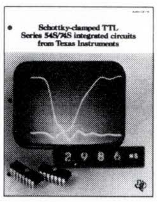
- Lower power dissipation.
- Better noise immunity. Typical d-c noise margins – more than 1V.
- Conventional PC boards may be used due to smaller line reflections with unterminated lines.
- Direct interface with all popular TTL and DTL families – same 5 V power supplies (critical regulation not required), same logic functions, same packaging.

Broad applications. Series 54S/74S Schottky TTL circuits are ideal for applications in all high-speed digital systems:

- Computer central processor units.
- Peripheral controls.
- Digital test and measurement equipment.
- Digital communications systems.

Now available in plastic dual-in-line packages are the SN74S00N – Quadruple 2-input positive NAND gates. The SN74S20N – Dual 4-input positive NAND gates. And the SN74S112N – Dual J-K negative edge triggered flip-flop (separate preset, clear and clock).

More are coming in 1970. TI is developing 13 circuits in the revolutionary 54S/74S series, including other standard TTL gates (NANDs, AND, HEX inverter, AND-OR-INVERT), dual J-K and D flip-flops, as well as MSI counters and shift registers. Ceramic DIPs and flat packs will be available soon.



For more information on the most significant TTL advance in four years, get our new Bulletin CB-118. Circle 175 on the Reader Service Card or write Texas Instruments Incorporated, P. O. Box 5012, MS 308, Dallas, Texas 75222. Or call your nearest authorized TI Distributor.

TEXAS INSTRUMENTS
INCORPORATED

Electrostatic charges in test chambers

Sir:
We have encountered a situation which might have significance throughout the military and aerospace electronics industry.

Potential overloading, permanent dielectric damage and/or false switching may be induced by build-up of large electrostatic field charges within environmental test chambers. These charge build-ups are generated by CO_2 gas discharge used for rapid cooling. MOS (and MOS-FETs) are most susceptible, due to the combined high impedance and relatively low dielectric strength at the "gate" of these devices.

We wonder if any of your readers have had similar experience and would appreciate letters relating background for and/or against the "damage" concept and also how they avoid the damage or meet the 5°C/min. rate of temperature decrease required by paragraph 5.3.1 of MIL-STD-781B (AGREE testing).

Norman W. VanIderstine
Reliability Engineering
General Dynamics
Electronics Division
1400 N. Goodman St.
Rochester, N.Y. 14601

EDITOR'S NOTE: Most manufacturers of MOSFETs protect against buildup of electrostatic charges by diffusing a zener diode across the gate, but this solution lowers the input impedance of the FET. Also, MOSFETs usually come packaged in conductive material, to avoid such buildup. In addition, they must be handled with great care to keep the leads shorted until the FET is connected in the circuit. If any readers can contribute some additional experience on the kind of environment Mr. VanIderstine describes, please write to him, or to **The Electronic Engineer.**

Engineering societies must work for engineers

Sir:
The report on the Cleveland IEEE meeting [Is anybody out there?, **The Electronic Engineer,** April 1970, pp. 42-45], conveyed the feeling of disappointment such sessions generally produce. There is no reason to expect useful action by the IEEE on subjects of interest to the working engineer, for the simple reason that it is controlled by and for the academic and research community. That this is true should be clear to anyone reading the Proceedings or the vast majority of the Transactions, or attempting to submit papers for publication.

This is not a criticism of the IEEE alone. The NSPE, ASME and most similar organizations are subject to the same malady. The academic community has tenure, prestige, time for professional societies, no restrictions on ability to publish—how can the working engineer compete?

I ask the IEEE to move towards representing the interests of the majority of its members. The first step should be to take over the "fringe benefit" functions of the private employer for its members. This should include life, medical and disability insurance, and pensions. The employer's share of present plans, and the engineer's payroll deductions should be paid to the Institute. Since such a large portion of present pension plans are forfeited by mobile engineers, there may be enough excess money, at present rates, to pay for the costs of administration. If not, I am sure that we would all be willing to pay more for a fringe package that would be portable, continuous between jobs, and adequate.

The next step could be a licensing function. The vast majority of engineers are not registered Professional Engineers, partly because their fields of competence did not exist at the time their State license exam was composed. While designation as "Engineer" by the IEEE may have no legal standing, it could become more important over a period of time.

Many other possible functions suggest themselves. However, what is needed now is a commitment. Is the IEEE to retreat from the problems of the working engineer and become a mere information service (mostly unintelligible), or will it start to face the real world?

Jerome V. White
IEEE Membership No. 125203
Program Manager
Systems Engineering Division
Sanders Associates, Inc.
Nashua, N. Hampshire

Don't bring back the transistor radio

Sir:
I fully subscribe to the implications of the editorial in the December 1969 issue of **The Electronic Engineer.**

Leon W. Zelby
Director
School of Electrical Engineering
College of Engineering
The University of Oklahoma

This column welcomes new companies or new divisions in the electronics industry.

Conversion modules for computers

The first snow of this past winter brought to New England not only ski enthusiasts, but a novice company as well. Datel Systems Corp., located at 943 Turnpike St., Canton, Mass., began plowing a trail for itself in the electronics industry in November, 1969. Formed to make ultraminiature A/D and D/A conversion modules, subsystems, and systems for the computer display area, data acquisition systems, and data transmission systems, its founders have future plans to produce A/D and D/A converter interface systems for minicomputers.

The four principals of the firm have been employed in the A/D and D/A converter field since the mid 1950's. Two of the founders, Nicholas Tagaris, president, and Arthur Pappas, treasurer, previously served as chief engineer and senior engineer, respectively, for Analog Devices, Inc. Datel has been financed by Private Venture Capital, an investment firm in Boston.

The company's products consist of three lines. One line, A/D converters, designated the ABC-E series, employs dual slope integration and resolutions of 8, 10 to 12 bits. They are available four weeks after ordering and range in price from $119 to $140. A second line is Datel's Successive Approximation Conversion Method which is subdivided into three families—ADC/L, ADC/M and ADC/H, each one available at 8, 10 or 12 bits. The ADC/L employs a 25-kHz conversion rate, the ADC/M a 250-kHz conversion rate, and the ADC/H a 2.5-MHz conversion rate. Prices for the three types range from $225 to $990 and they are available two weeks after ordering.

Third, the new company offers a line of D/A converters consisting of four groups. The DAC-HB, priced from $69 to $119, employs a resolution of 8, 10 or 12 bits. The DAC-I series, employing the same resolution as the DAC-HB, features a fast settling time—150 ns, and is available for $115 to $165. The DAC/V, featuring an input storage register, sells for $129 to $189. The DAC-H series, priced at $149 to $169, offers a 25-ns settling time.

In addition to the above, Datel also manufactures a product that, to their knowledge, is the smallest dc isolated power supply available anywhere. Its dimensions are 1 x 2 x .4 in. producing 5 V at 1 A or ± 15 V at 150 mA. Prices range from $59 to $89.

When asked about unique features of his firm's products, a spokesman for Datel responded "All of our converters are in an encapsulated modular package which can be mounted on PC boards. The converters are .4 in. high, versus our competition's, which are at least .6 in. high. You might say the key features of Datel's products are packing density, price (ours is lower because our fabrication techniques are different from our competition), and performance (equal or better than our competition). We use a thick-film fabrication technique which means that we replace discrete resistors with thick-film ladder networks. This reduces assembly time and cost."

Circle 499 on Inquiry Card

Rf power

In December of 1969 three men purchased one of the first lines in the rf power transistor business from ITT Semiconductor. ITT was on the verge of dropping the line, but these men caught it in time and the result was today's Kertron Inc., located in Riviera Beach, Florida.

Bill Kearns, former general manager at Solitron, led the group into the venture. Those joining with him were George Reiland, former plant manager at Solitron, and Francis T. Ryan, local attorney and former part owner of the past Minneapolis Lakers (these men are versatile!). Most of the engineering staff came directly from ITT at the time the purchase was made.

Kertron specializes in high power devices. Their primary product line spans a frequency range of 2 MHz to 1 GHz with powers from 1 to 100 W. A secondary line opening up for the new company includes low frequency power devices of up to 300 V breakdown and with currents up to 100 A. High or low power, all are discrete devices.

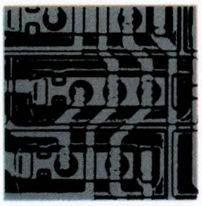
When the line was about to be dropped by ITT, what did these men sense that would make its purchase worthwhile? "Product orientation," says Jim Benjamin, engineering manager for the new company. "With concentration on the technical market and on customer needs rather than a high volume market, there can be great accomplishments (and profits!) in the field. We are involved in the custom business in that we specify out of standard production runs the products best suited to our customers' needs."

The company presently features several products that no other company can boast of. These include the 3TE610, a 100-W, 150-MHz device operating from a 40-V supply, and the 3TE611, a 75-W, 150-MHz device operating from a 28-V supply. The first device has been used in military and aircraft communications projects, and the second is said to be the highest power device operating from a 28-V power supply.

New products are on the way—ten to twenty are expected to be announced within the next four to six months. Many are in the high power area, further increasing the new company's power frequency capabilities. But that's not all that's new to Kertron—they just opened a 20,000 sq. ft. facility at 7516 Central Industrial Drive where the growing company (now over 70 people) will have access to new manufacturing equipment.

Circle 500 on Inquiry Card

To put a priority encoder on a single chip,



Fairchild introduces the first MSI 8-input priority encoder ever put in a single package. In fact, it's the first encoder of any kind ever put in a single package.

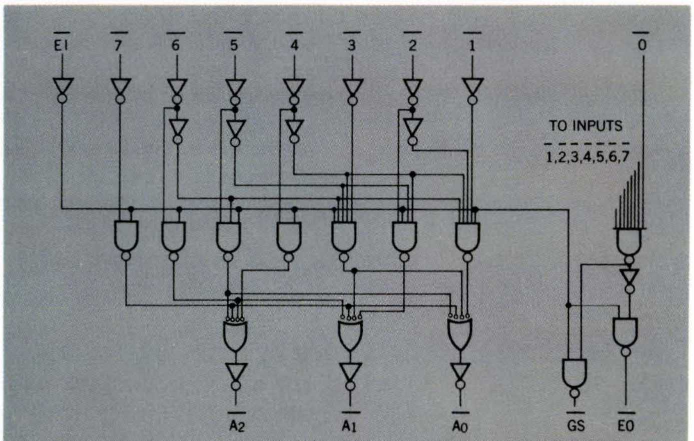
The new 9318 accepts data from eight active low inputs, selects the most significant input signal, and provides a binary representation of it on the three outputs. Input and output enables permit encoders to be cascaded without using additional components. This allows priority encoding of any number of input signals. Also, a group signal output is provided to show when any input is active.

In the tradition of Fairchild's MSI family, the 9318 is a highly versatile, highly reliable device. It can be used in code conversions, multi-channel D/A conversions, and decimal to BCD conversions. It will find application in priority interrupt systems, associative memories and keyboard encoders as well as a number of control applications.

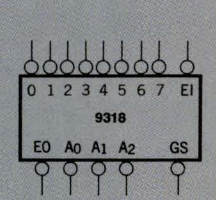
The 9318 is TTL and DTL compatible and has a typical power dissipation of 200mW. It comes in DIP and Flatpak in both military and industrial temperature ranges.

To order the 9318, call your Fairchild distributor and ask for:

PART NUMBER	PACKAGE	TEMPERATURE RANGE	PRICE (1-24)	(25-99)	(100-999)
U7B931859X	DIP	0°C to + 75°C	$15.35	$11.80	$10.25
U7B931851X	DIP	−55°C to +125°C	30.70	23.60	20.50
U4L931859X	Flat	0°C to + 75°C	16.90	13.00	11.30
U4L931851X	Flat	−55°C to +125°C	33.80	26.00	22.55



8-Input Priority Gating System Using Discrete ICs



8-Input Priority Gating System Using New 9318

you have to get serious about MSI family planning.

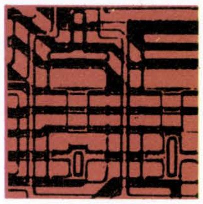
We put together a family plan by taking systems apart. All kinds of digital systems. Thousands of them.

First we looked for functional categories. We found them. Time after time, in a clear and recurrent pattern, seven basic categories popped up: Registers. Decoders and demultiplexers. Counters. Multiplexers. Encoders. Operators. Latches.

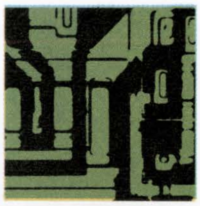
Inside each of the seven categories, we sifted by application. We wanted to design the minimum number of devices that could do the maximum number of things. That's why, for example, Fairchild MSI registers can be used in storage, in shifting, in counting and in conversion applications. And you'll find this sort of versatility throughout our entire MSI line.

Finally, we studied ancillary logic requirements and packed, wherever possible, our MSI devices with input and output decoding, buffering and complementing functions. That's why Fairchild MSI reduces—in many cases eliminates—the need for additional logic packages.

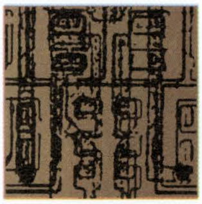
The Fairchild MSI family plan. A new approach to MSI that's as old as the industrial revolution. It started with functional simplicity, extended through multi-use component parts, and concluded with a sharp reduction in add-ons. Simplicity. Versatility. Compatibility. Available now. In military or industrial temperature ranges. In hermetic DIPs and Flatpaks. From any Fairchild Distributor.



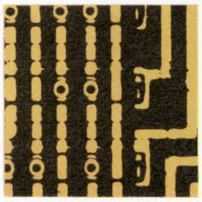
OPERATORS
9304 – Dual Full Adder/Parity Generator



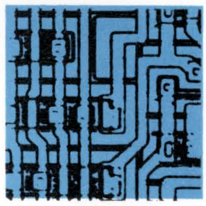
LATCHES
9308 – Dual 4-Bit Latch
9314 – Quad Latch



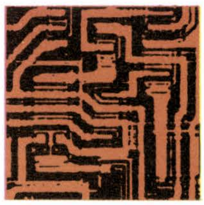
REGISTERS
9300 – 4-Bit Shift Register
9328 – Dual 8-Bit Shift Register



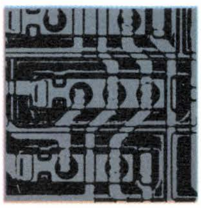
MULTIPLEXERS
9309 – Dual 4-Input Digital Multiplexer
9312 – 8-Input Digital Multiplexer



DECODERS AND DEMULTIPLEXERS
9301 – One-Of-Ten Decoder
9315 – One-Of-Ten Decoder/Driver
9307 – Seven-Segment Decoder
9311 – One-Of-16 Decoder
9317 – Seven-Segment Decoder/Driver
9327 – Seven-Segment Decoder/Driver



COUNTERS
9306 – Decade Up/Down Counter
9310 – Decade Counter
9316 – Hexidecimal Counter



ENCODERS
9318 – Priority 8-Input Encoder

FAIRCHILD
SEMICONDUCTOR

FAIRCHILD SEMICONDUCTOR A Division of Fairchild Camera and Instrument Corporation Mountain View, California 94040, (415) 962-5011 TWX: 910-379-6435

CALENDAR

JUNE

	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

June 15-16: Solid State in Industry—The New Generation of Industrial Control, Statler Hilton, Cleveland, Ohio. Addtl. Info.—Andy Humphrey, Reliance Elec. & Engrg. Co., 24701 Euclid Ave., Cleveland, Ohio 44117.

June 15-19: International Symposium on Information Theory, Noordwijk, The Neatherlands. Addtl. Info.—P. E. Green, Jr., IBM Res. Ctr., Box 218, Yorktown Heights, N.Y. 10598.

June 16-18: NEPCON '70 EAST, New York Coliseum, N.Y. Addtl. Info.—M. S. Kiver, Conf. Chairman, Industrial & Scientific Conf. Management, Inc., 222 West Adams St., Chicago, Illinois 60606.

June 16-18: NIEE All-Industry Show, New York Coliseum, N.Y. Addtl. Info. —Mr. Austin G. Cragg, Exposition Manager, Technical Industry Expositions, Inc., 34 West Putnam Avenue, Greenwich, Conn. 06830.

June 17-19: IEEE Pulp and Paper Industry Technical Conf., Hotel Vancouver, Vancouver, British Columbia. Addtl. Info.—The Institute of Electrical and Electronics Engineers, Inc., 345 E. 47th St., N.Y., N.Y. 10017.

June 23: Instrumentation Forum, Holiday Inn, Newton, Mass. Precision Measurements Assoc., Boston Section, 30 Winship St., Malden, Mass. 02148.

June 18-19: Solid State Sensors Symp., Hotel Radisson, Minneapolis, Minnesota. R. S. Dyck, Fairchild Semiconductor, 4001 Miranda Ave., Palo Alto, Calif. 94304.

June 21-25: Design Automation Workshop, Sheraton Palace Hotel, San Francisco, Calif. H. Freitag, IBM Watson Rss. Ctr., Box 218, Yorktown Heights, N.Y. 10598.

June 24-26: Joint Automatic Control Conf., Georgia Inst. of Tech., Atlanta, Ga. D. Lyons, Dept. of Textile Sci., Clemson Univ., Clemson, S. Carolina 29631.

June 24-26: Joint Automatic Control Conf., Georgia Institute of Technology, Atlanta, Georgia. Addtl. Info.—J. J. Donohue, The American Society of Mechanical Engineers, United Engineering Ctr., 345 E. 47th St., N. Y., N.Y. 10017.

JULY

			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

July 12-17: Summer Power Meeting & EHV Conf., Biltmore Hotel, Los Angeles, Calif., Tech. Conf. Svcs., 345 E. 47th St., New York, N.Y. 10017.

July 21-23: Conf. on Nuclear & Space Radiation Effects, San Diego Campus, Univ. of Calif., San Diego, Calif. Addtl. Info.—Richard Thatcher, Battelle Mem. Inst., 505 King Ave., Columbus, Ohio 43201.

'70 Conference Highlights

WESCON — Western Electronic Show and Convention, Aug. 25-28; Los Angeles, Calif.

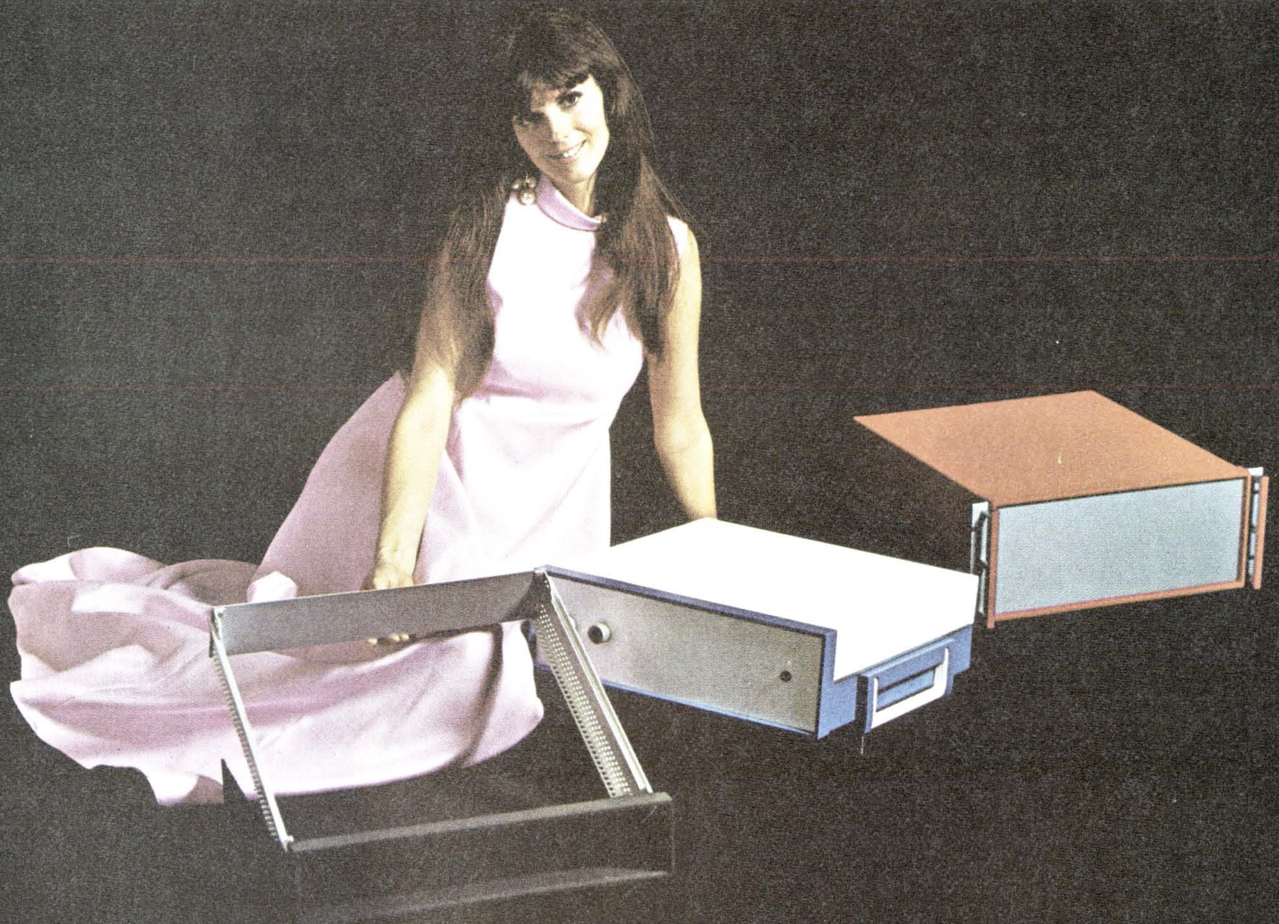
NEC—National Electronics Conference, Oct. 26-28; Chicago, Illinois.

NEREM—Northeast Electronics Research Engineering Meeting, Nov. 4-6; Boston, Mass.

Call for Papers

Nov. 4-6: NEREM, Sheraton Boston Hotel and the War Memorial Auditorium, Boston, Mass. Submit three copies of a 35-40 word abstract and three copies of a 600-1000 word condensed version of the paper. Mail to Program Chairmen, IEEE Nerem-70, 31 Channing St., Newton, Mass. 02158.

Dec. 9-11: Fourth Conference on Applications of Simulation, Waldorf-Astoria, New York. Submit 5 copies of the paper by July 6, 1970 to Michel Araten, Program Committee Chairman, Celanese Chemical Co., 245 Park Ave., N.Y., N.Y. 10017.



COURSES

RCA Institutes: Rather than just telling you what seminars and courses are available this month, we'd like to tell you a little bit about one that Steve Thompson, our Western Editor, recently attended. It was the week-long Digital Communications seminar sponsored by RCA Institute for Professional Development.

The subject matter was presented by breaking the communication channel into its constituent parts and working from the data source at one end and the data storage at the other inward towards the noise in the channel. Encoding and decoding modulation and demodulation, channel capacity and noise are other aspects of the subject covered. The course was comprehensive, more than enough information for a one-week course, and was presented by knowledgeable instructors.

If this one sounds interesting to you and you'd like more information on this or any of the other courses RCA sponsors, write to RCA Institute for Professional Development, Box 962, Clark, N.J. 07006.

Technical Writers' Institute: June 15-19, Troy, $225. The program has been designed to demonstrate how each person's job relates to the broader field of technical communications. Discussions and exercises in writing and editing begin the course, followed by techniques of technical reporting, proposal writing, etc. Rensselaer Polytechnic Institute, Troy, N.Y.. 12181.

Computer-Aided Mathematical Modeling: June 15-19, Syracuse, $250. Modern techniques of formulating realistic mathematical models and applying them to problems of engineering analysis, design and optimization will be examined. Use of analog and digital computers will be demonstrated, with emphasis on current developments in time-sharing systems and simulation programs. University College, 610 E. Fayette St., Syracuse, N.Y. 13202.

Computer Graphics for Designers: June 15-26, Ann Arbor, $450. This introduces design engineers to principles of graphic manipulation and application of computer graphics as aids in improved design methods. Univ. of Michigan, Engineering Summer Conferences, Chrysler Center, North Campus, Ann Arbor, Mich. 48105.

Parametric Design of Digital Filters: June 16-19, Washington, D.C., $275. Methods for the design and realization of digital filters using z-transformations applied to continuous filter transfer functions will be covered in this course. Emphasis will be on the application of Laplace transform and Fourier Series methods to achieve recursive and non-recursive designs. Technology Service Corp., 225 Santa Monica Blvd., Santa Monica, Calif. 90401.

Digital Process Control: June 22-26, Philadelphia, $250. This course will cover the application of the digital computer to the control of complex processes and interactions. Lectures will include basic control concepts and modern digital techniques. Computer architecture and control software will be reviewed and related to on-line system implementation. Instruments and Control Systems, 1 Decker Sq., Bala Cynwyd, Pa. 19004.

Computer Control: June 29-30, Philadelphia, $175. This course will detail the management, economic and technical aspects of digital computer control. A series of lectures and discussions will outline control philosophy, computer concepts and project implementation. Instruments and Control Systems, 1 Decker Sq., Bala Cynwyd, Pa. 19004.

Data Communication: July 6-18, Ames, $600. Digital computer fundamentals and data transmission concepts and applications will be covered. Topics such as information rate, system capacity, coding schemes, and bandwidth vs time relationship and noise will be included. Iowa State University, Ames, Iowa 50010.

Inter-System Electromagnetic Compatibility: Aug. 18-27, Syracuse, $375. The purpose of this course is to review electromagnetic compatibility as a problem-oriented specialty interfacing with the technical specialties of components, circuit design, systems design and evaluation, antenna development and signal processing. Continuing Engineering Studies Program, Technical Resources Center, 610 E. Fayette St., Syracuse, N.Y. 13202.

LINEAR

Last month, we told you why we didn't make the "Super" Op Amp. We said that ideal op amps exist only in textbooks and real applications in the real world need a family of op amps to meet a family of requirements. Which got us into a discussion of our family of fifteen different op amps.

This month, we've got another op amp story. This one has a Moral:

EDITORIAL

You Can't Afford to Wait Until the Price Goes Down

Once upon a time (5 years ago to be exact), Fairchild designed an Op Amp. It was called the μA709. It cost $64.00 and people bought them as fast as we knew how to make them. (Maybe even faster.) Some people didn't buy the μA709. They said the price was too high. And so, they built their systems the old way.

Then, as time passed, the popularity of the new μA709 grew and grew. And the price went down and down. So fast, in fact, that the companies who first used them were surprised. And happy. Their systems performed better and were more profitable than those of their more cautious fellows. Today, these companies are reaping the benefits of their foresighted decisions of those pioneer days.

Today, the μA709 sells for $1.90. MORAL? When you see a new LIC such as the μA725, μA741 or μA796, think of the lesson of the μA709. You can't afford to wait until the price goes down.

Digest
of Communications and Consumer Circuits

Here's a list of the most popular consumer industry LICs from the only major supplier in the world that spends all of its time making circuits and none of its time making television sets. (We don't make radios either.)

μA703 RF-IF Amplifier
Symmetrical Limiting
Internally Biased
Forward Transadmittance – 35mmhos
Best selling IF amp in the business
Reader Service Number 180

μA732 – FM Stereo Multiplex Decoder
Stereo Switching, Audio Muting, Stereo Lamp Driving Capability
45dB Channel Separation with Minimum Component Count
(Replaces MC1304)
Reader Service Number 181

μA739 – Dual Low Noise High Gain Operational Amplifier
Great for Stereo Phono Inputs
1μV RMS Noise Voltage (Audio Band)
High Gain
High Output
Very Low Distortion
Reader Service Number 182

μA742 – "TRIGAC" Zero-Crossing A.C. Trigger
Economical Solid State Power Control for Consumer and Industrial Applications
Minimum External Component Count
2 amp Peak Output
Reader Service Number 183

μA746 – Color TV Chroma Demodulator
The Industry's Best Seller!
Low Output Drift
10V P-P Output Swing
Doubly Balanced Demodulators
Internal NTSC Matrix
Reader Service Number 184

μA749D – Dual Operational Amplifier
Perfect Stereo Tape Recorder Input Amplifier
Very Economical
Compact TO-5 Package
Reader Service Number 185

μA754 – TV/FM Sound Channel System
Gain, Limiting, Detection and Audio Preamplifier
100μV Sensitivity
Can drive output device to 4 watts
High Performance
Low Price!
Reader Service Number 186

μA757 – Gain Controlled I.F. Amplifier
70dB Gain
70dB AGC Range
300mV Signal Handling Capability
Stable Characteristics Despite Supply and Temperature Changes
Reader Service Number 187

μA796 – Modulator – Demodulator
Double-Balanced Modulator
Demodulator on a Chip
Use in AM, FM, SSB, Phase Lock Loop, Disc and Tape Systems
(Replaces the MC1596)
Reader Service Number 188

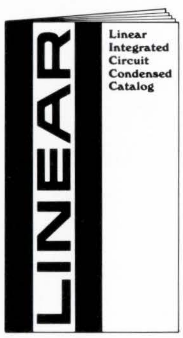
SAVE $1.10 SAVE $1.10

Bargain Corner

Keep your eyes peeled for this space. Almost every month it will carry glad tidings of new prices. For example:

IF/Limiting Amplifier
μA703E – was \$2.10 now \$1.00*
(U5Z7703394)
*Price based on 100 pieces.

SAVE $1.10 SAVE $1.10



Hot Off the Press

You can take it with you. We've just published an all-new Fairchild Linear Condensed Catalog. It's pocket sized so that you can lug it around with you. For a free copy, use reader service card number below:

Reader Service Number 189

WIN $100 WIN $100

We're About to Announce the *First* Winner

By now you ought to be down to the final strokes of preparing your entry in our recently announced Linear Applications Contest. Here are the rules, remember?

1. Get all the facts on a Fairchild Linear IC.
2. Design the world's greatest application for it.
3. Send to: Fairchild Linear Contest, P.O. Box 880 A, Mountain View, California 94040.

All entries will be judged by the editors of EEE Magazine. They will select the most imaginative application and give us the designer's name. We'll publish the winning design and give the winner \$100 upon publication. Ready. Set. Design!

WIN $100 WIN $100

FAIRCHILD SEMICONDUCTOR

FAIRCHILD SEMICONDUCTOR A Division of Fairchild Camera and Instrument Corporation Mountain View, California 94040, (415) 962-5011 TWX: 910-379-6435

The New μA796:

We Knew It Was Going To Be Versatile, But We Didn't Know How Versatile.

The new low-cost μA796 Doubly Balanced Modulator/Demodulator is finding its way into an amazing variety of systems.

Communications-gear engineers are taking advantage of its great versatility and high carrier suppression in modulators and demodulators for single sideband, suppressed carrier and phase shift key transceivers. It's also being used as a synchronous AM demodulator, a quadrature FM demodulator, and as a phase comparator for phase locked loop receivers.

Digital tape/disc memory designers are utilizing the μA796's unique properties in fast differentiators and phase correcting circuits for NRZ or phase encoding systems, while remote D.C. R-G-B gain controls, color shade and keystone corrections are practical for color TV broadcast equipment use. Other possibilities lie in signal chopping, frequency changing, linear mixing and more.

Here Are The Specs:

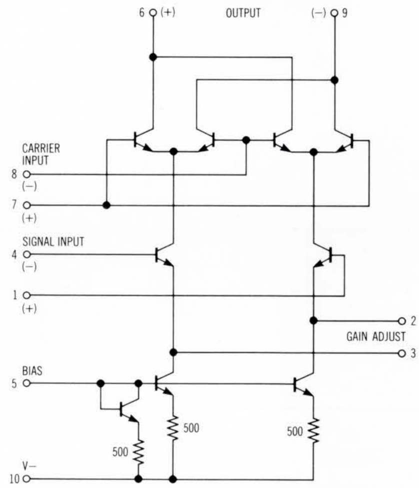
Carrier Suppression	65dB
Transadmittance Bandwidth	
Carrier Port	300MHz
Signal Port	80MHz
Signal Gain	3.5V/V
Input Impedance (signal port)	200KΩ
Input Offset Current	0.7μA
Differential Output Swing	8.0 volts p-p

Here Are The Prices:

U5F7796312
−55°C to +125°C $4.95 @ 100 pcs.

U5F7796393
0°C to +70°C $2.25 @ 100 pcs.

μA 796 DOUBLY BALANCED MODULATOR/DEMODULATOR



Good Old μA723:

Everybody's Favorite Voltage Regulator.

Fairchild's μA723 is the only voltage regulator on the market that can handle just about any power supply application. It works from both positive and negative sources in series, shunt, or as a switching regulator.

If 2 to 37 volt output range isn't enough, it can also be used in a floating mode.

On one chip, you get a temperature-compensated ±3% absolute accuracy zener diode reference, an error amplifier, a 150mA series pass element, short circuit protection and a zener level shifter.

The μA723 was the first monolithic linear circuit to employ a J-FET as a current source for voltage reference. An external series pass element can be added if larger output currents are needed. An internal feature — remote shut-down — may be used to conserve system power when a section of logic is not being used.

The μA723 also features .01% line regulation, .03% load regulation, .003%/°C temperature coefficient and ripple rejection of 74dB.

The most popular applications for the μA723 include laboratory power supplies, isolation regulators for low-level data amplifiers, airborne power supplies and local on-board card regulators.

The μA723 and Foldback Current Limiting

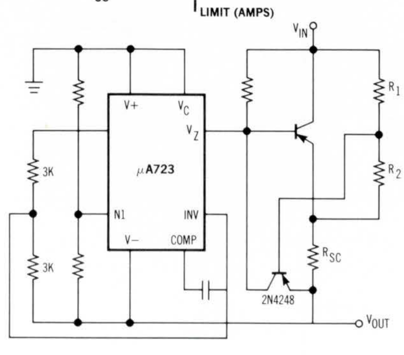
The μA723 includes adjustable current limiting. As an alternative to the standard current limiting techniques, foldback current limiting may be used to advantage in any power supply situation in which the output device power dissipation under short circuit conditions becomes intolerable due to device and/or heat sink limitations. This technique utilizes positive feedback to accomplish the foldback action of reducing both the output voltage and current during overload conditions.

FOLDBACK CURRENT LIMITING
NEGATIVE REGULATOR

$$R_1 = \frac{V_{IN}\ MAX}{10^{-3}\ AMP}$$

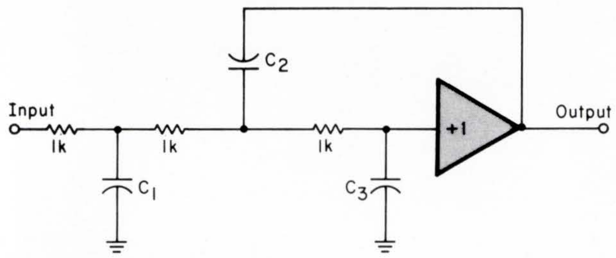
$$R_2 = 510\Omega$$

$$R_{SC} = \frac{0.51 - \dfrac{(V_{IN} - V_{OUT})\,510}{R_1}}{I_{LIMIT\ (AMPS)}}$$



Three-pole active filter

Changing capacitor values gives six different responses from this circuit.



dB Ripple	$C_1(\mu F)$	$C_2(\mu F)$	$C_3(\mu F)$
0*	0.2217	0.5645	0.03222
0.1	0.2092	0.7627	0.01542
0.5	0.3049	1.523	0.01213
1	0.3731	2.353	0.009346
2	0.4797	4.287	0.0005997
3	0.5775	6.910	0.004031

*Butterworth

By Russell Kincaid
Sanders Assoc. Inc., Nashua, N. H.

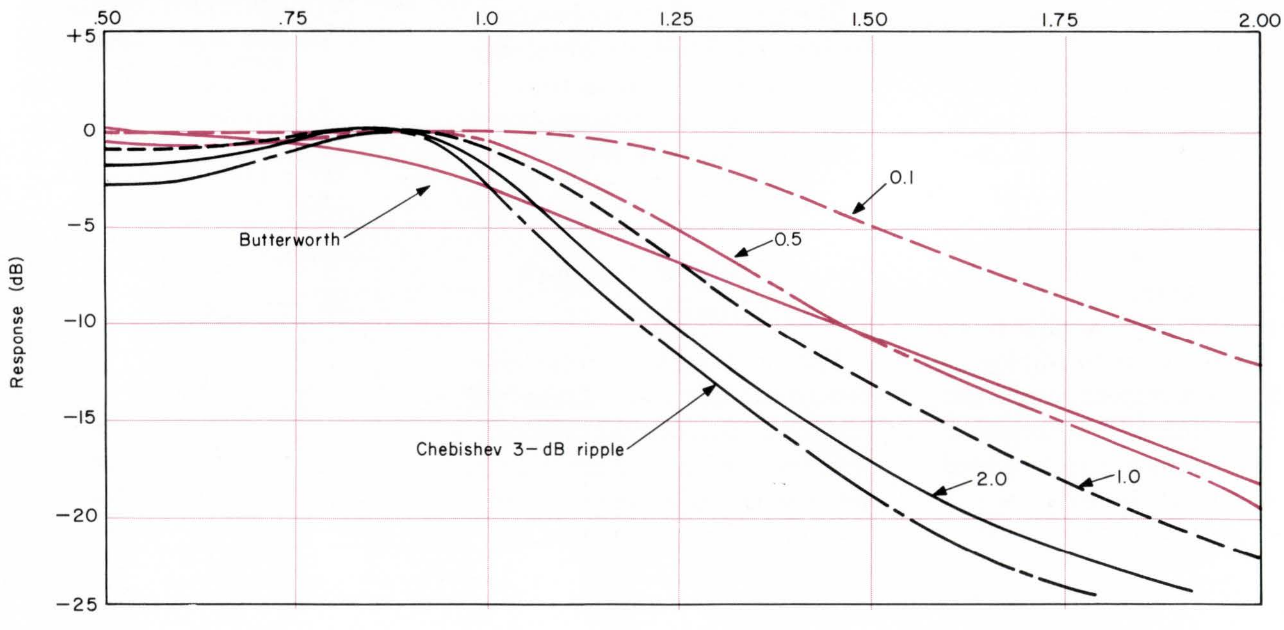
This three-pole active filter has 0-dB insertion loss. You can get a Tchebycheff or Butterworth response with a cutoff frequency by using the tabulated capacitance values and the 1-kΩ resistances shown. To change the cutoff frequency by a factor K, divide the resistance or capacitance values by K. As another option, you can change the impedance levels by multiplying the resistance and dividing the capacitance values by a constant factor.

The amplifier in the circuit should have unity gain, a high input impedance and low output impedance over the frequency range of interest. The amplifier can be a single transistor emitter-follower if the performance is not critical.

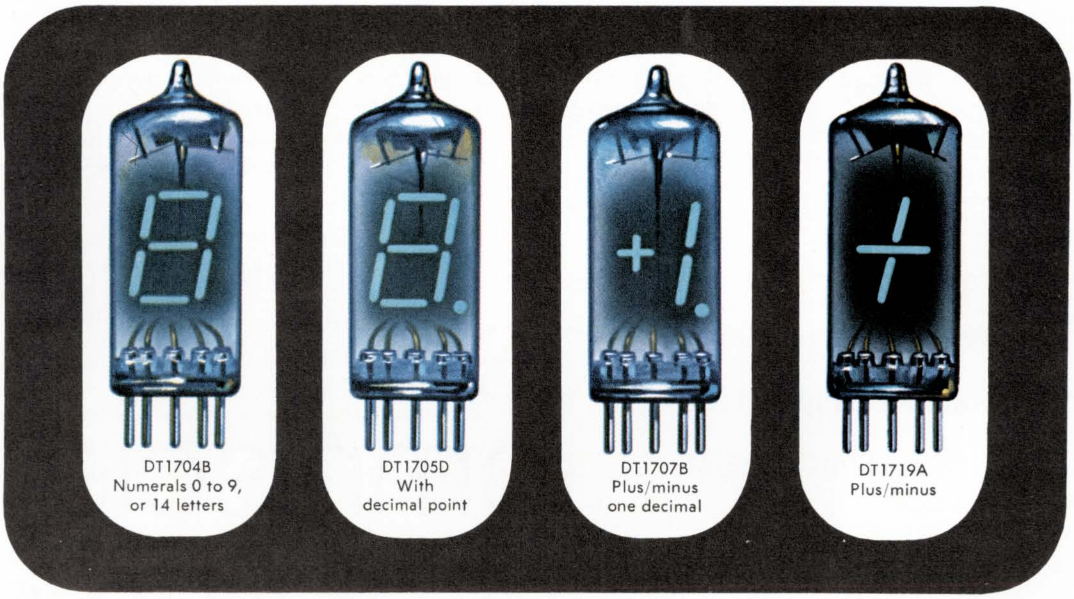
The graph shows the theoretical response of six configurations possible from the circuit. The actual responses will typically be within 1 dB if you use 1% components. By the way, the 3-dB ripple filter is more critical of component tolerances than the lower ripple types.

INFORMATION RETRIEVAL
Circuit design

Response in dB versus normalized frequency

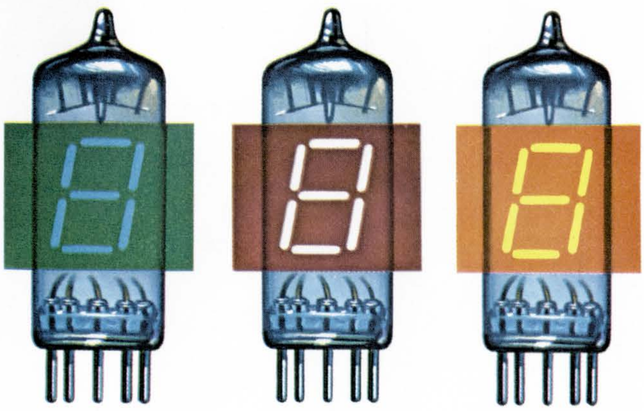


The Tung-Sol® development that created a whole new set of digital display standards



STANDARD CONFIGURATIONS

Low-voltage, low-power drain (25 V and 1.6 V) permits battery-operated applications. Standard miniature tube base. Inexpensive logic/driver requirements. Meets MIL specs. Space-age-type segmented character. Single plane display. Standard alphanumeric, or special symbols. Optimum visibility under ambient light conditions. Common filters provide unlimited color selection for identification, or to heighten contrast. Circuit-board mounting, with solderable-lead option. Write, or phone for detailed technical information and pricing.



Standard filters provide color variation

DIGIVAC S/G T.M.

VACUUM FLUORESCENT DISPLAY

TUNG-SOL DIVISION
WAGNER ELECTRIC CORPORATION
630 W. Mt. Pleasant Avenue
Livingston, N.J. 07039
TWX: 710-994-4865
Phone: (201) 992-1100; (212) 732-5426

The new HP 3480 A/B Digital Voltmeter is more than a digital voltmeter. It's an advance in the state-of-the-art. It's the omniscient triskelameter that sees all the values you are measuring. It's really a measuring instrument that is ideally suited for bench *and* systems applications.

The HP 3480 A/B is the first DVM capable of making 1000 correct dc or ohms readings per second. It takes the 3480 less than 1 ms to respond to a full scale input and digitize the input signal.

The HP 3480 A/B is the first 4-digit multifunction DVM having an ac converter that is true rms responding to eliminate large errors caused by harmonic distortion or noise and extends your measurement capability to include the rms value of non-sinusoidal wave forms. The 3480 A/B has a 100 mV range and covers from 1 Hz to 1 MHz and will measure ac *plus* dc.

The HP 3480 A/B DVM is ideal as a bench instrument. No other instrument — single purpose or multiple function — equals the 3480 A/B. Top performance in measuring dc, three-terminal dc ratio, true rms ac, ac-plus-dc in one measurement, and ohms is assured by the accuracy designed into the instrument.

You get four-digit readout plus 50% overranging which results in greater resolution and less range change. The high dc input resistance ($>10^{10}\Omega$ on the lower three ranges) reduces the possibility of loading errors.

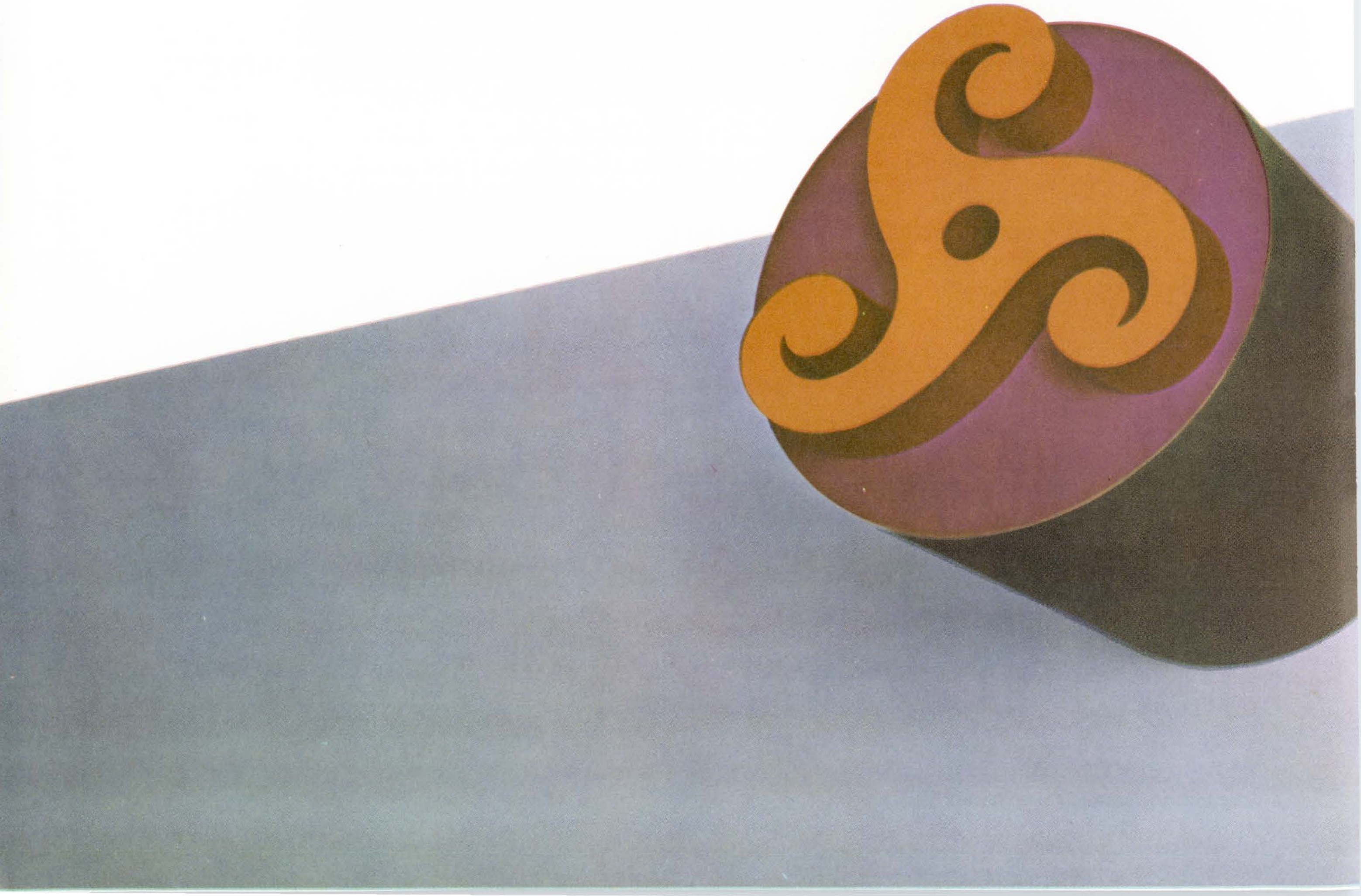
True rms ac conversion makes the 3480 A/B immune to large errors caused by small amounts of harmonic distortion and expands the range of precision ac measurements to non-sinusoidal wave forms.

The wide bandwidth (1 Hz to 1 MHz) and the capability of making ac-plus-dc measurements gives the 3480 A/B a broader range of applications not available before. And, the high ac and dc sensitivity (100.00 mV full scale) reduces the need for preamplification.

HEWLETT hp PACKARD

never before has there been a DVM so ideally suited for bench and systems use as

the omniscient triskelameter



The HP 3480 A/B DVM is ideal as a systems instrument. Up to this time, DVM's have been the slowest part of a measurement system. Now, the system doesn't have to wait for the DVM. The HP 3480 A/B DVM can make up to 1000 dc and ohms readings per second. You can save automatic test time and increase production—or you can appreciably reduce computer idle time.

The 3480 A/B is fully guarded to improve common-mode rejection. There is a switchable 3-position input filter to give you the optimum trade-off between noise rejection and speed. The 3480 A/B is fully programmable including range, function and filter position.

With the optional isolated BCD and isolated remote control you can reduce errors created by ground loops, improve your common-mode rejection even more, and make floating measurements into a guarded system.

Modest prices, too! All the capability packed into the 3480 A/B is not expensive. Prices range from $1150 for one range of dc to $3375 for multifunction ac, dc, ohms capabilities with isolated BCD and isolated remote control.

For the best in bench and systems DVM's, get the omniscient triskelameter—the new HP 3480 A/B DVM. Ask your local HP field engineer for full particulars, or write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin—Geneva, Switzerland.

Circle 27 on Inquiry Card

090/9

Heads: You win.

Tails: You win again.

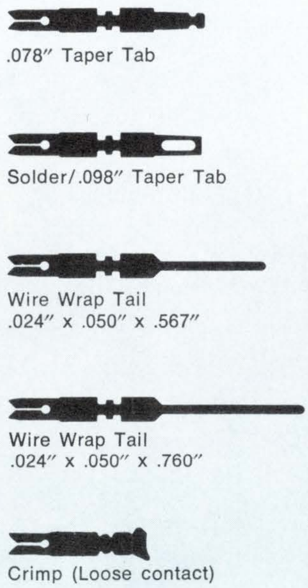
Elco rack-and-panel connectors give you a better head start.

And a choice of tails.

The head start is the connecting end of an Elco connector: the patented Varicon™ contact that fully meets the requirements of MIL-E-5400. The four mating surfaces of this unique contact are coined to an exceptional hardness and wipe clean with each make. Once the contacts are joined, the inherent springiness of the gold/nickel-plated phosphor bronze and the fork-like design make a superior, gas-tight fit.

Because the contacts are free floating, they align perfectly. A few contacts or 100 or more, all fit precisely together every time, over a long service life. There's no contact chatter. Nobody else gives you a contact head quite like the Varicon.

And nobody else gives you the choice of tails you get with Varicon. You can wire-wrap, crimp, clip, stake, or solder them. Whatever terminating technique or combination of techniques your assembly lines are set up for, we'll furnish the appropriate tail. If staking or crimping is your style, we can supply the equipment too. Manual or automatic. Purchase or lease.



Elco rack-and-panel connectors come in standard rectangular models, or as miniature connectors, or in modular units. You can have them with 2 Varicon contacts, or up to 140, or anything in between.

In short, our line of Varicon rack-and-panel connectors has a lot going for it. Except price. Though it's a precision component, the Varicon contact is easily produced in high speed progressive dies. There's no expensive machining, no waste. When you can turn out millions of Varicons a week, you don't have to charge a fortune for them.

There's a lot more to be told about Varicon connectors. It's all in our 28-page rack-and-panel connector guide, and we'll be happy to send you a copy. Just write, wire, call, or TWX us. Elco Corporation, Willow Grove, Pa. 19090. (215) 659-7000. TWX 510-665-5573.

ELCO Rack-and-Panel Connectors

Printed circuits—make or buy?

The costs involved, and your familiarity with the new processes, will decide which route you should take.

By Jack Froelich, Contributing Editor

A printed circuit can be made by using a sunlamp, a couple of basins and a bench-drill. On the other hand, you can spend from $250,000 to $2½ million to set up a plant to manufacture reliable printed circuit boards. The boards can cost from less than 1¢ each to $2500.

The interdisciplinary boards

The design and fabrication cycle or a printed circuit board exposes you to all the physical sciences—electrical and mechanical engineering disciplines are only a beginning. Before you are through, physics, chemistry, photography, metallurgy, computer technology and the graphic arts may all have been called into play.

The printed circuit board, one of the basic elements in any electronic equipment, interconnects the functional components of a circuit and, in general, replaces handwiring. The manufacture requires conductive paths to be photographically and chemically reproduced on the surface of an insulated substrate, and terminal areas to be provided to mount the electronic components. Soldering, in all its varieties—hand, dip, flow, and reflow—is the most common method used to connect the components. Or, you can weld them, or even make pressure-fitted gas-tight joints.

What it costs to buy

At present the market for all types of printed circuit boards is running around $500 million a year, and may increase to $950 million by 1975. About two-thirds of all the printed circuits manufactured are produced "in-house" with IBM and Western Electric leading the field. Computer manufacturers, the entertainment industries, and communication people also tend to make their own boards. The remaining one-third of the printed circuits are manufactured by independent companies, ranging from the large—such as Cinch-Graphic, Lockheed and Photocircuits and Sylvania—to medium size (50 to 250 employees), to small houses geared for small quantities and quick delivery. The larger independent manufacturers make anything their customers demand, from high-volume simple single-sided boards to the complex multi-layer printed circuits. They even set up special lines inside their own plant for high-volume orders.

The types of boards manufactured are broken down as follows:

Type of PC	% of market
Single-sided boards (S)	20
Double-sided boards (D)	55
Multi-layer boards (M)	22
Flexible-circuitry	3

About one-third of the entire market is federal. Table I lists the type of boards used for the major applications, and Table II provides some typical figures for boards that vendors make today in volume.

Moment of truth

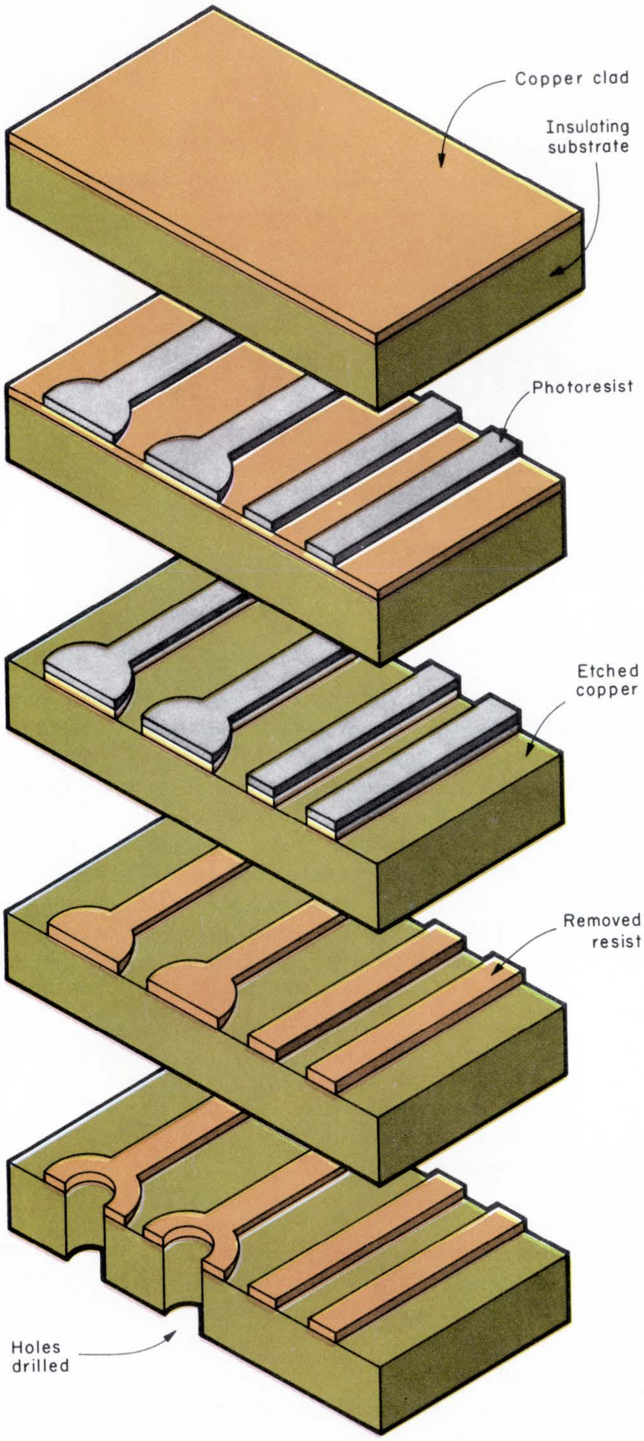
Before deciding whether to make circuit boards in-house or buy them, you should know the answers to these questions:

What is the product? What quantity? Is it a high volume commercial application requiring elaborate tooling and automation? Is it a relatively sophisticated board with yearly requirements in hundreds or thousands? How many do I need this year, next year, in five years?

What equipment will I need? How much will it cost? Making reliable printed circuit boards is a complicated multi-step operation and will require some or all of

(*text continues on page* 56)

←Circle 28 on Inquiry Card



From single-side

Printed wiring was invented by Paul Eisler in England during World War II. Its first major application was for artillery proximity fuzes, thanks to printed wirings' advantages of compactness, ruggedness and reliability.

The type of circuit board first manufactured—and still the most widely used — is the single-sided printed-circuit board. A conductive conductor pattern provides wiring on one side of a rigid insulating substrate, the components being mounted on the other side. Single-sided boards are generally used with discrete components, relatively simple circuitry, and a low component density per square inch of board. This type of board continues to be used by the millions in the radio and television industry.

Miniaturized components, the transistor, integrated circuits, higher switching speed—all required greater wiring density, more connections, and more holes per square inch, as well as more conductors and smaller spacing between conductors. Advancing printed wiring technology met the challenge by providing conductors on *both* sides of the substrate, plus electrical connections between both sides of the board.

The hole problem

The vital connection between the conductors on either side of the boards was first a simple jumper wire, placed through a hole, clinched and soldered to the pad on both sides of the board. Simple but slow! Eyelets—inserted by machine to improve uniformity and decrease cost—were also widely used.

The most popular method today is chemical, consisting of plating the walls of a hole. The conventional plated-through-hole process starts with an insulating laminate clad with copper-foil on both sides, through which holes are drilled in appropriate locations. Copper is deposited first chemically (electroless copper), then electrochemically over the entire board surface, and through the holes.

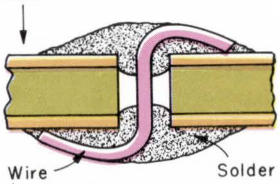
Print-and-etch process for a single-sided board starts with a copper-clad insulated substrate. Photo-resist (positive or negative), photo printed or screened onto the copper, masks the areas that will become conductors on the board. The unmasked copper is etched away. After removing the resist, the operator drills the holes for the components' leads. The main advantage of this method is simplicity. Its main reliability problem is that the etchant not only removes the unmasked copper, but also undercuts the edge of the copper lands. When the board is dip-soldered later, solder slivers will hang from the undercut copper, forming bridges and producing shorts.

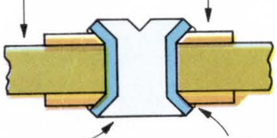
to multilayer

Now a 'resist' negative pattern is applied to both sides of the board, covering all areas of the foil where copper conductors are *not* required. The next step is to electro-deposit a thin layer of etch-resistant plating—usually solder or gold—which adheres to the exposed copper. After removing the resist, the conductor-paths are obtained by etching away the exposed, unplated copper. This explanation, although simplified, illustrates the multi-step technology inherent in the manufacture of printed-wiring—a reliable process evidenced by the millions of plated-through holes produced every day.

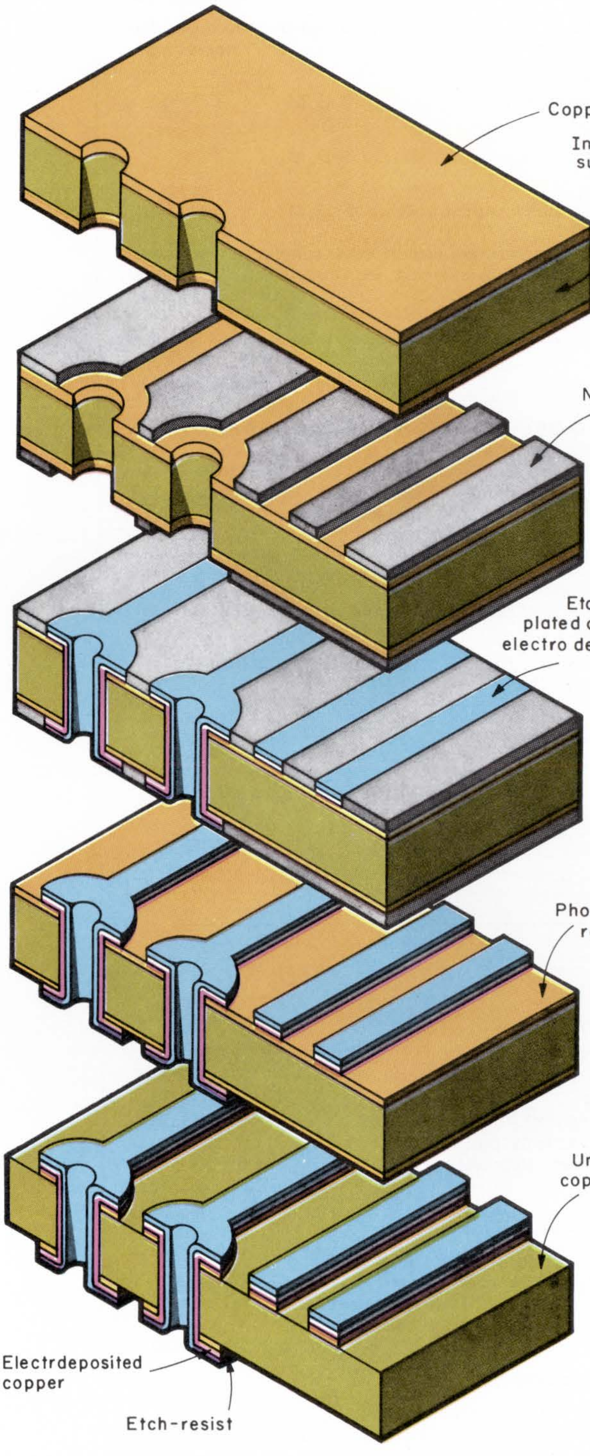
For even greater wiring densities—such as in computer back-planes—the multi-layer printed-circuit was developed. It consists of a series of layers of circuit boards, bonded together to produce a monolithic assembly with internal and external connections to each layer of the circuitry. Multi-layer boards often have one or more copper planes devoted to grounding, to supply busses, and to transmission lines. The number of layers, which can be as high as thirty, is generally between five and eight layers.

The processes for fabricating multi-layer boards are basically similar to those used for manufacturing single- and double-sided boards, plus the lamination. Again, there is a tremendous diversity of processes to manufacture multi-layers and to obtain the inter-layer connections. Multi-layers, which are the most expensive printed circuit boards, are normally produced in smaller quantities than the single- and double-sided boards. The cost of a multi-layer board is higher than that of a double-sided board by 10-15% per layer.





Mechanical interconnections for doubled sided boards. Although largely superseded by plated-through holes, these methods are still used for prototype boards and in some military applications.



Conventional plating of holes, for a double-sided board, starts by sensitizing the holes of a punched board with a chemical that provides a base for copper. The second step applies resist to those areas where copper will not go. Electrodeposited copper adheres to the holes' walls and is built up to about 1 mil. Both the resist and the unwanted copper are then removed.

TABLE I

Entertainment (radio, TV)	S and D	(more single-side boards)
Appliances	S and D	(more single-side boards)
Industrial	S and D	(double-sided increasing)
Computers — central processor	S, D, M	
Computer — peripheral	S, D, M	
Federal — military, airborne, aerospace	S, D, M	

Applications for printed circuit boards, listed in increasing order of complexity and cost. (S: single-sided; D: double-sided; M: multilayer)

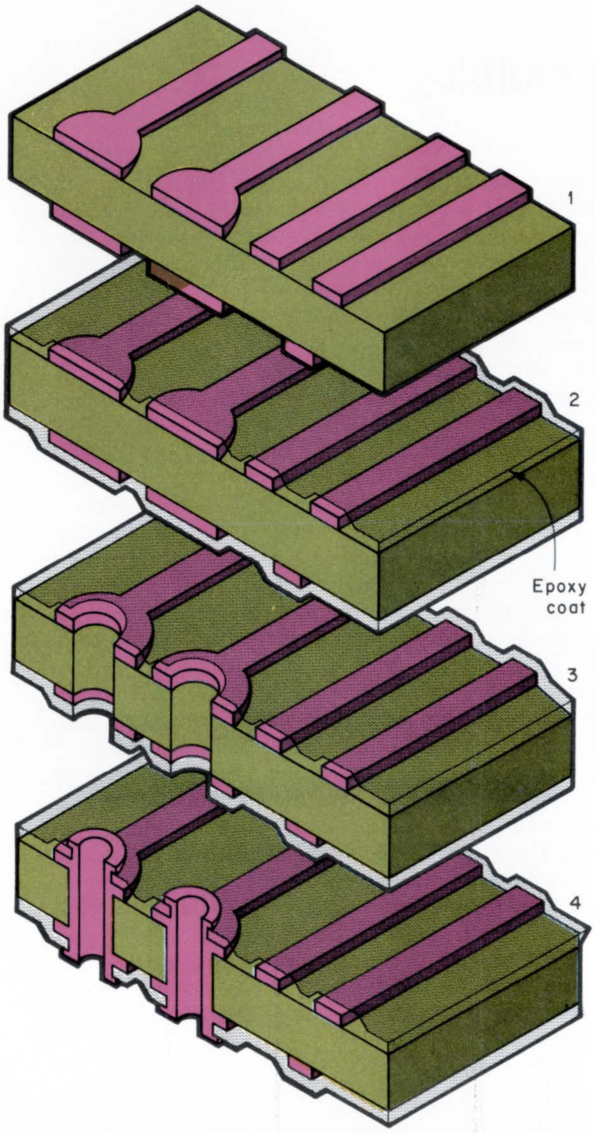
TABLE II
COST AND DELIVERY FOR TYPICAL BOARDS

Type of PC board	Single-sided	Double sided, with plated-through holes	Multilayer (6-8 layers)
Quantity	5000	1000-5000	50-100
Width of conductors	20 mils	15 mils	10 mils
Hole density (holes/sq. in.)	3 to 5	10 to 15	40 to 50
Tolerance in location of holes	±5 mils	±4 mils	±4 mils
Cost (¢/sq. in.)	0.8 to 1.3	10 to 15	$1.00/sq. in.
Delivery (weeks)	4 to 6	4 to 6	12 to 16

TABLE III

1. **Equipment:**	
Cameras	$30,000.00
Automatic perforating equipment	50,000.00
Plating	100,000.00
Cleaning and finishing	20,000.00
Ovens, screens, jigs, routers, saw, shears, degreasers	50,000.00
	$250,000.00
2. **Engineering and installation:**	
Waste treatment, water filtration, acid-proof floor, special electrical installation, ventilation, dust filtration, air conditioning, steam, air-pressure, etc.	$120,000.00
3. **Quality assurance:**	
Material test equipment, ovens, microscopes	20,000.00
4. **Start-up and training:**	
10% of first year's requirements	100,000.00
5. **Raw material inventory**	30,000.00
6. **Work in process inventory:** (one month)	80,000.00
7. **Expendable supplies**	20,000.00
Total	$620,000.00

Capital investment required to make $1,000,000 worth of printed circuit boards per year. (Source: Photocircuits Corp.)



NT-1 process was designed by Photocircuits to produce densely patterned printed wiring. It uses a special insulating substrate—a copper-clad laminate with a catalytic base that provides a foundation for the electroless copper of step 4. The major steps of the process are: (1) The conductor pattern is formed by photo-printing and etching copper on both sides. (2) a permanent epoxy coat on each side forms a solder mask which prevents bridging during dip-soldering, and acts as a conformal coat. (3) Holes are drilled through the epoxy, copper pads and catalyzed laminate. (4) The board is immersed in a plating solution of electroless copper which deposits copper in the holes, thus interconnecting both sides of the board. The copper buildup projects slightly over the epoxy, forming a bead that greatly assists solderability. Finally, a coat of lacquer is applied to protect the exposed copper of the hole.

The prime movers

"Photocircuits has been responsible for most of the innovations in printed circuits," says Stanley J. Feldman, manager of Manufacturing Engineering at Redcor Corp. And, as atypical as this sounds in electronics, where progress usually takes place across a broad front of companies, Photocircuits has an impressive record of original developments in manufacturing technology for printed circuits. A few of their best known ones are

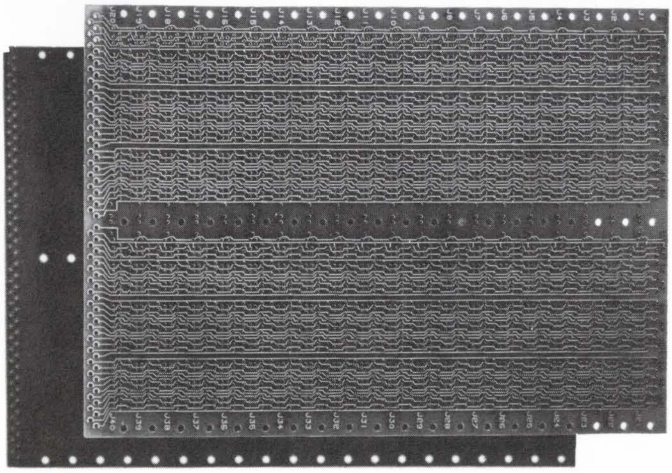
• the copper-clad epoxy-glass laminate, developed in 1952, which replaced the phenolic-base laminates in many military and most industrial applications;

• a method to deposit ductile "electroless" copper on a catalyzed laminate. This development allows copper to be added to an insulating base, as opposed to etching the copper of a laminate. It has made a new and economic process for "plated-through" holes possible in printed circuits, and is incorporated in other manufacturing processes developed by Photocircuits such as NT-1 and "Catelec."

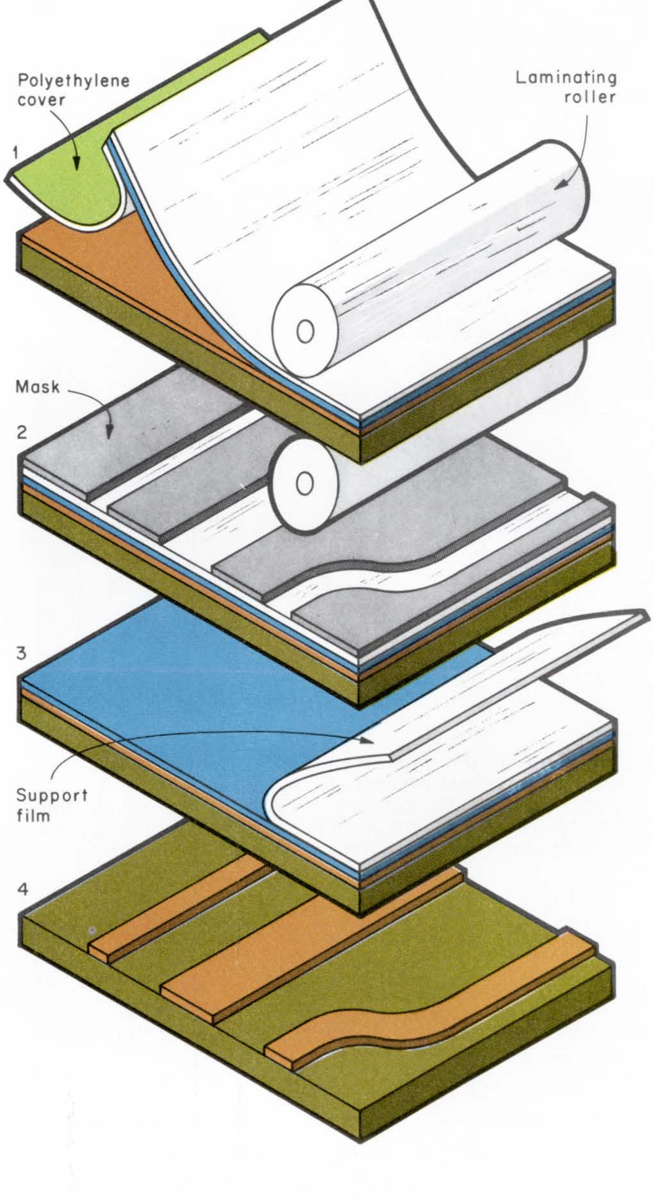
Their latest process, still under development, is called "Multiwire." Directed at numerically-controlled point-to-point wiring of very high density (25-mil grid), it bonds fine insulated wire to an insulating board, which is then drilled and the holes metallized to receive the components.

Photocircuits sells their processes worldwide through a patent-licensing program, which allows the licensee to use not only the patented development, but also the improvements that any other licensee may make to the process.

Another important development, this one on photo-resists, was introduced by DuPont in 1968. Called Riston®, it consists of a solid photo-resist that the user laminates under heat and pressure to the printed-circuit board instead of impregnating the board with the popular liquid resists.



High-density circuit board, made with the NT-1 process.



Riston®, a solid photoresistive film, comes sandwiched between two 1-mil films, one of Mylar polyester, and the other of polyethylene. (1) The photoresist is laminated under heat to the copper-clad board after peeling the polyethylene film. Since the Mylar film that remains is transparent, the mask can be applied in direct contact with it, as in (2). After exposure to ultraviolet light through the polyester film, this film is peeled back (3) to permit washing the unexposed resist away. Since the photoresist is solid, it has uniform thickness and neat sidewalls, and it covers the board's holes without penetrating in them. After etching the copper away (4), Riston is stripped with the same solutions used for liquid resists.

Automation in the manufacture of PC boards has advanced to the point where not only the artwork, but even the tooling, can be determined and controlled by the computer. Here a layout is digitized to feed the inputs to the computer (Photo courtesy of Photocircuits Corp.).

(*continued from page* 51)

the following plant and equipment during the fabrication cycle.

(a) **Plant space**

(b) **Photo-lab**—Camera and darkroom; equipment to apply and develop photo-resists. Also, a thermal press for laminated photo-resists (such as Du Pont's Riston®).

(c) **Drilling machines**—they range from a single-spindle manual-operated type to tape-programmed numerically controlled machines.

(d) **Panel and hole cleaning machines**—to prepare the substrate for screening and plating operations. Can range from hand scrubbers to semi-automatic cleaners.

(e) **Plating and etching facility**—the heart of the printed circuit process. You may need to plate copper, nickel, gold, rhodium, with equipment ranging from simple tanks to automated lines.

(f) **Fabrication equipment**—Some or all of the following: screens, jigs, ovens, routers, shears, punches.

(g) **Quality assurance:** Control of plating thickness and quality can occupy the corner of a desk or a complete lab. Both destructive and non-destructive tests may be required.

(h) **Installation:** A plating line requires heavy duty electrical fixtures, acid-proof floors, air-conditioned and dust-free areas. Waste treatment for the neutralization and disposal of dangerous chemicals is important.

The list is formidable. But whether the electronic equipment you are designing contains thirty boards with different circuit functions, or even one large double-sided board with plated-through holes, their fabrication may require every item mentioned above.

The total investment for such equipment starts at $50,000 and goes up from there. A study made by Photocircuits for a small facility in California (shown in Table III), gives an entire capital outlay of $620,000 for a $1,000,000 worth of printed circuit boards/year.

What it costs to make

The facility will have to be staffed. Photolab technicians, experienced platers, a chemist and metallurgist are key personnel. Step-by-step inspection is necessary to avoid costly rejections at the end of the line. Mario Lombardi of Circuitron gives a ratio of one inspector to every six operators.

It takes some time to develop the know-how to produce consistently reliable printed-circuit boards. The start-up and learning period is a seemingly never-ending procession of all the maladies that the printed wiring process is susceptible to: improper registration, defective cleaning, spotting, halos, over-etch and under-etch, delamination, and warp.

The return on investment is relatively slow—a minimum of three to four years of printed circuit production. The danger of technical obsolescence is very real in this expanding and technologically effervescent industry. Some processes being used today—such as Photocircuits NT-1 or Du Pont's Riston®—did not exist five years ago. Techniques in the laboratory may some day obsolete present technology.

A premature investment in a small PC facility can lead to restricting the designs to those that can be produced by the facility (very frustrating to design engineers!). All the foregoing ifs, ands, or buts do not mean that in-house production of printed circuits is a stubborn conspiracy to deprive the heroic independent fabricators of their rightful R.F.Qs. But a successful in-house facility is no easy operation to set up. You must know your product and its volume. A rigorous cost-accounting can then determine whether you should do it yourself!

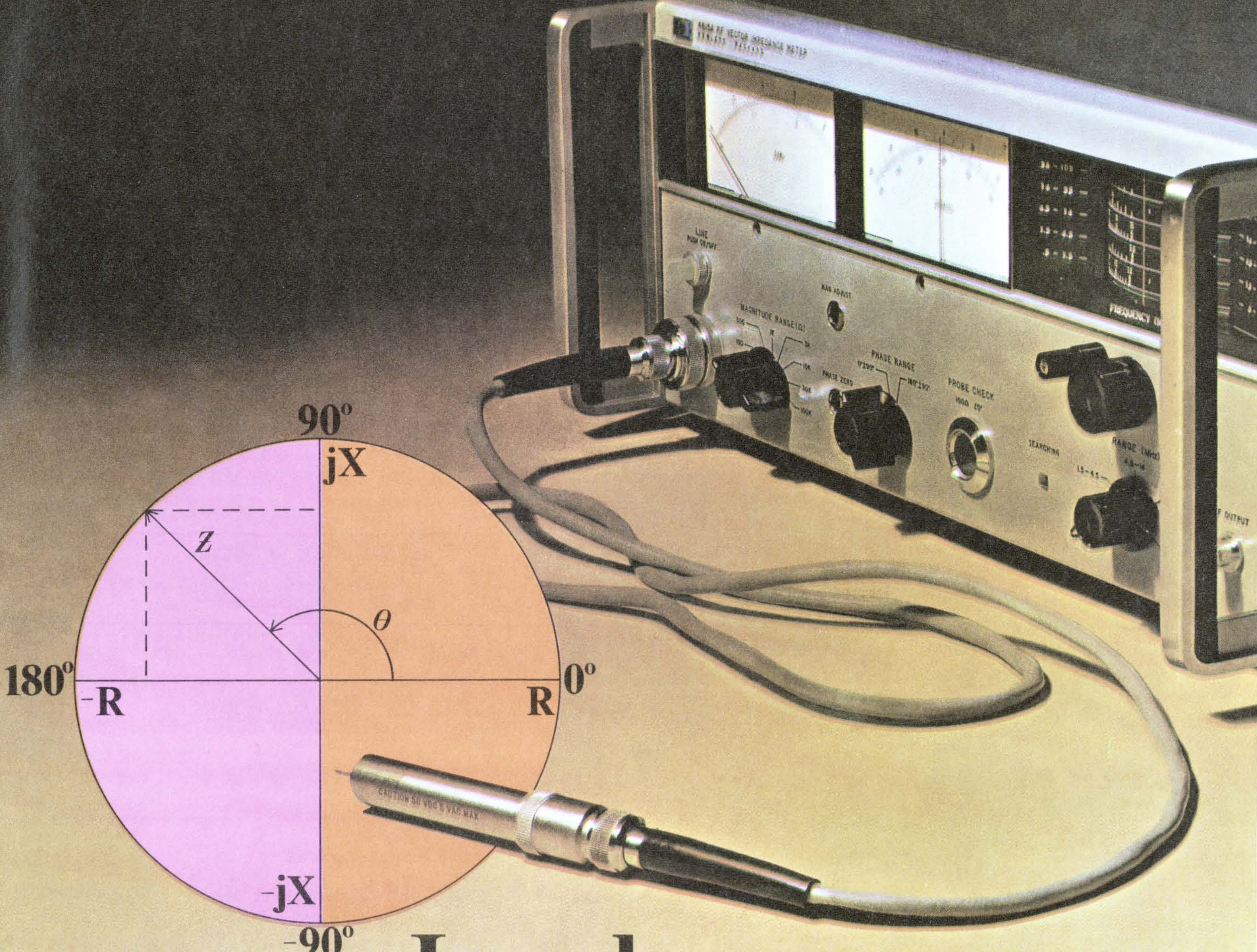
References:

Handbook of Electronic Packaging, Charles A. Harper, Editor. McGraw-Hill, New York, N.Y., 1969. Chapter I.

Clyde F. Coombs, *The printed circuits handbook,* McGraw-Hill, New York, N.Y., 1968.

Dimensional tolerances for printed circuit boards, booklet IPC-D-300. Cost: $1.00. Order from the Institute of Printed Circuits, 3525 W. Patterson Avenue, Chicago, Ill. 60645.

INFORMATION RETRIEVAL
Packaging, Materials



Impedance Measurement goes full circle

The HP 4815A RF Vector Impedance Meter will conveniently measure complex impedance over the entire impedance domain. You get instant, direct readout of impedance magnitude from 1 ohm to 100K ohms and phase angle from 0 to 360°, over a frequency range of 500 kHz to 108 MHz. Now you can easily measure impedances with negative real parts, often present in feedback amplifiers with small phase margin. To measure impedance at multiple frequencies, simply set the frequency, probe, and read. No nulling and balancing, as with conventional bridge measurements.

A convenient probe lets you measure directly in **active** circuits to determine driving point impedance under actual operating conditions, with minimum residual effects. For example, amplifier input or output impedance can be continuously monitored while bias, feedback, load, and frequency are varied. In-circuit measurements for determining loop gain and phase margin can also be made.

The 4815A is also ideal for evaluating **passive** devices, such as components and networks. Use it to characterize transformers, resonant circuits, transmission lines, filters, and crystals. You can measure at actual operating frequencies and make network adjustments while impedance parameters are monitored. For example, antenna/transmission line matching networks can be quickly adjusted. Price: $2650.

To learn more about how easy it is to use impedance for evaluating circuits and components, request Application Note 86 and a special impedance issue of the HP Journal. If you would like to discuss a particular application, call your local HP field engineer or write: **Hewlett-Packard, 100 Locust Ave., Berkeley Heights, N.J. 07922. In Europe: 1217 Meyrin-Geneva, Switzerland.**

21007

HEWLETT hp PACKARD

IMPEDANCE INSTRUMENTS

Speed/power chart for digital ICs

This specifying chart should be an old friend by now. The chart, which first appeared in **The Electronic Engineer** in 1967, is the fourth updating.

The chart shows typical propagation delay in nanoseconds plotted against the average power dissipation (usually for a 50% duty cycle) in milliwatts per gate. All of the over 125 commercial ICs listed are bipolar monolithic devices. The chart does *not* include MOS and hybrid devices.

Each circuit configuration is indicated on the chart by a color dot. The larger dots indicate those popular circuits, made by several manufacturers, that have the same or nearly the same speed/power parameters.

The most apparent difference between last year's chart and this new edition is in the number of listings for each logic type. Four of the five categories include more entries (either new circuits or new second sources) than last year. The biggest gain, as you might expect, was by TTL which lists 62 entries this year as compared to 50 in 1969. The one circuit type which shows no additions to the 1969 listing is RTL.

The following list represents the individual ICs shown on the chart. The number next to the manufacturer corresponds to the number of a circuit configuration shown on the chart. Also shown below is a list of names of circuit classifications and their acronyms, including most of the better known types.

INFORMATION RETRIEVAL

Integrated circuits, Digital design, Charts and nomographs

For a copy of this article circle 202 on Inquiry card.

BIPOLAR DIGITAL LOGIC CHART

DTL

1 Amperex FCJ 111, 201
2 Amperex FCJ 121, 131, 191, 211
3 Amperex FCJ 221
4 Amelco HNIL 300
Continental Device HNIL DTL 330BG, CG
5 Fairchild LPDTL 9040
RCA CD2200
6 Amperex FCJ 101
7 Amperex FCH 231
8 Amelco 6041-6047
9 Amperex FCH 101, 121, 141, 151, 181, 201
10 Texas Instruments MOD-DTL 53, 73
11 Amperex FCH 111, 131, 161, 171, 191, 211
Signetics SE/NE100
12 Fairchild DTμL 930
Hughes HSM 930 J
ITT 930
Motorola MDTL MC 930/830
Philco-Ford DTL 10 MHz PL 9930
Philco-Ford 10 MHz PLR 930 (radiation hardened)
RCA CD2300
Radiation 930 hardened circuits
Raytheon 930
Siliconix S1830, 930
Stewart-Warner SW930
Texas Instruments 15930, 15830
13 Raytheon 200 series
Signetics SP600A
14 National DTL DM930
15 Siliconix A01, A41
16 Radiation 200, 300, 500
17 Fairchild 9950
Philco-Ford 9950
SGS (Varadyne 9950
18 Siliconix SC 126/426

RTL's

1 Texas Instruments 17,900L, 17,800L
2 Fairchild LPRTμL 9910
3 Philco-Ford MWμL-8-MHz PL9908
4 Motorola mW MRTL MC908
5 Motorola mW MRTL MC808/708
6 Motorola mW MRTL MC800P/700P
7 Amelco 100
8 Philco-Ford μL-20 MHz PL9900
9 Fairchild RTμL 900, 9990
10 Motorola MRTL MC900/800
11 Motorola MRTL MC700,MC800P/700P
12 Philco-Ford MW111-15 MHz PL9975
13 Philco-Ford RTL-35 MHz PL9600

TTL's

1 Amelco 500-509
2 Amelco 530-548
3 Fairchild 9400 (low power TTL)
4 Philco-Ford MEL-5 MHz PL9600
5 National 54L
Texas Instruments 54L/74L
6 Amperex FJH 231, 251
7 Amperex FJJ 111, 121, 191
8 Signetics NE/SE400J
9 Amelco 570-587
10 Signetics S/N8400
11 Amperex FJJ 131
12 Amperex FJJ 101
13 Amperex FHJ 101A, 101B
14 Amperex FHJ 121A, 121B
15 Amperex FJH 151, 161, 171, 181, 221
Siemens FLH 100 series
16 Amperex FJH 101, 111, 121, 131, 241
Hughes HSM 5400/7400
ITT 5400/7400
Motorola MC4000
Motorola MTTL MC5400/7400
Nucleonic 7400 series
Philco-Ford 7400
Signetics S5400, N7400
Sprague 54/74
Transitron 54/74
United Aircraft 54/74
17 Amperex FJH 141
18 Amperex FJJ 181
19 Motorola MTTL I, MC500/400
Sylvania SUHL I, 7400 N
Transitron TTL Series I
Raytheon Ray I
20 Stewart-Warner SW 9601
21 Fairchild 9000
ITT 9000
SGS (Varadyne) T100
22 Fairchild LP MSI 9200 MSI 4-bit shift register
23 Philco-Ford 9620
24 Amperex FHH 101A, 101, 121A, 121B, 141A, 141B, 161A, 161B, 181A, 181B
Motorola MTTL II MC-2100/2000, MTTL III MC-3100/3000
Radiation 54HR (hardened TTL family)
Raytheon Ray II
Signetics 8H, 54H/74H
Sprague 54H/74H
Sylvania SUHL II
Texas Instruments 54H/74H
Transitron 54H/74H, Series II
National 74H
25 Fairchild 9300
Philco-Ford 9300 MSI
SGS (Varadyne) T150
26 Raytheon Ray III
27 Texas Instruments 54/74
Signetics TTL S/N 8800
Fairchild 54/74
National 54/74 DM 7000, 8000
Amperex FJJ 211 (7493), FJJ 251 (7492), FJJ 141 (7490), FJL 101 (7441), FJH 191 (7480)
Stewart-Warner SW 5400/7400 series
Sylvania 54/74
28 Amelco 525-529 (TTL ¼ mW/gate, 1 μ sec prop. delay)
29 Texas Instruments 54S/74S

ECL's

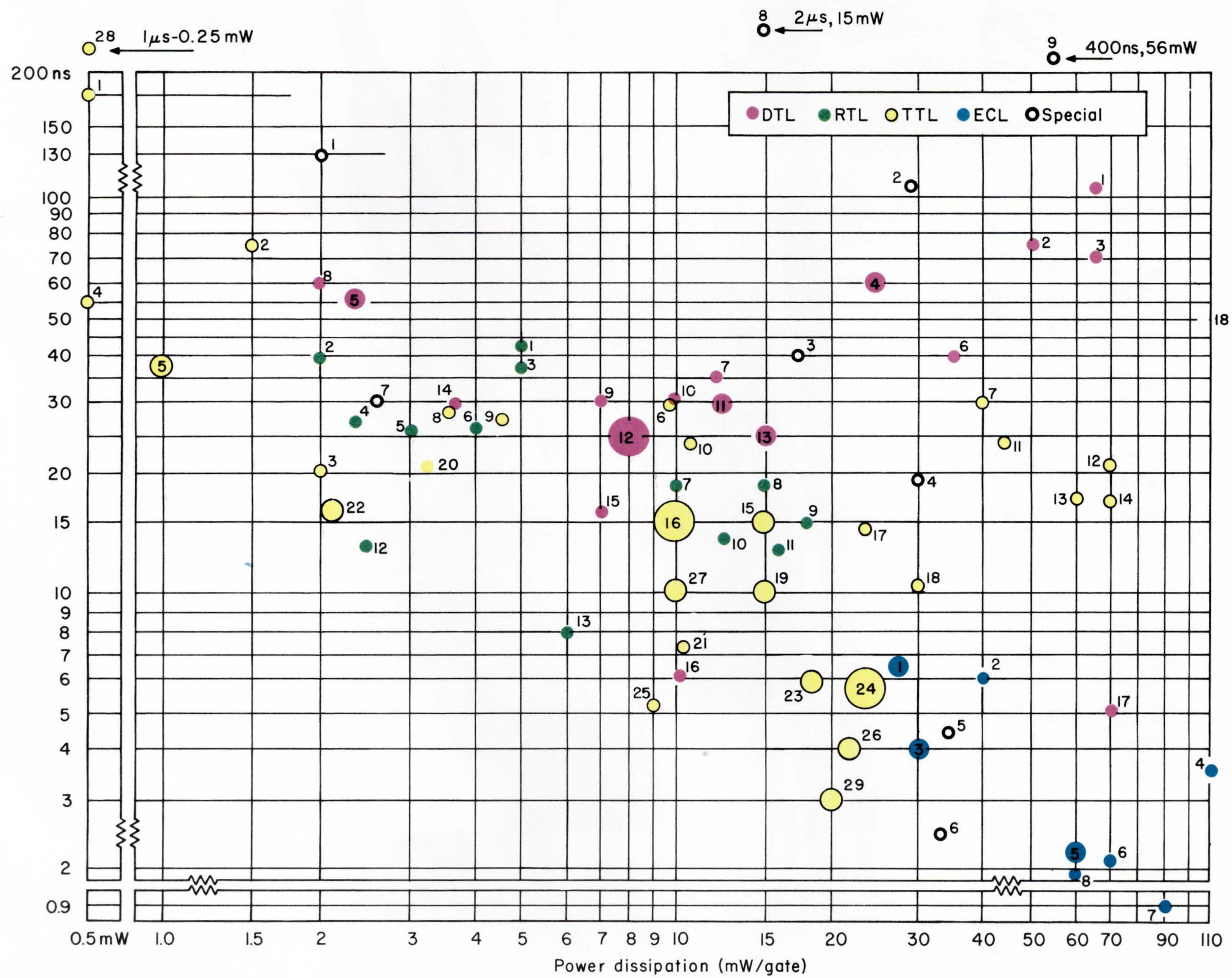
1 Motorola MECL MC300/350
Stewart-Warner SW300, and 350 Series ECL I
2 RCA CD2100
3 Motorola MECL II MC1200/1000
Stewart-Warner SW1000, and 1200 Series ECL II
4 RCA CD2150
5 Fairchild 9500 Series temperature compensated intermediate speed
Texas Instruments 2500
6 Amperex FKH 111
7 Motorola MECL III, MC1660
8 Fairchild 9500 temperature compensated high speed

SPECIALS

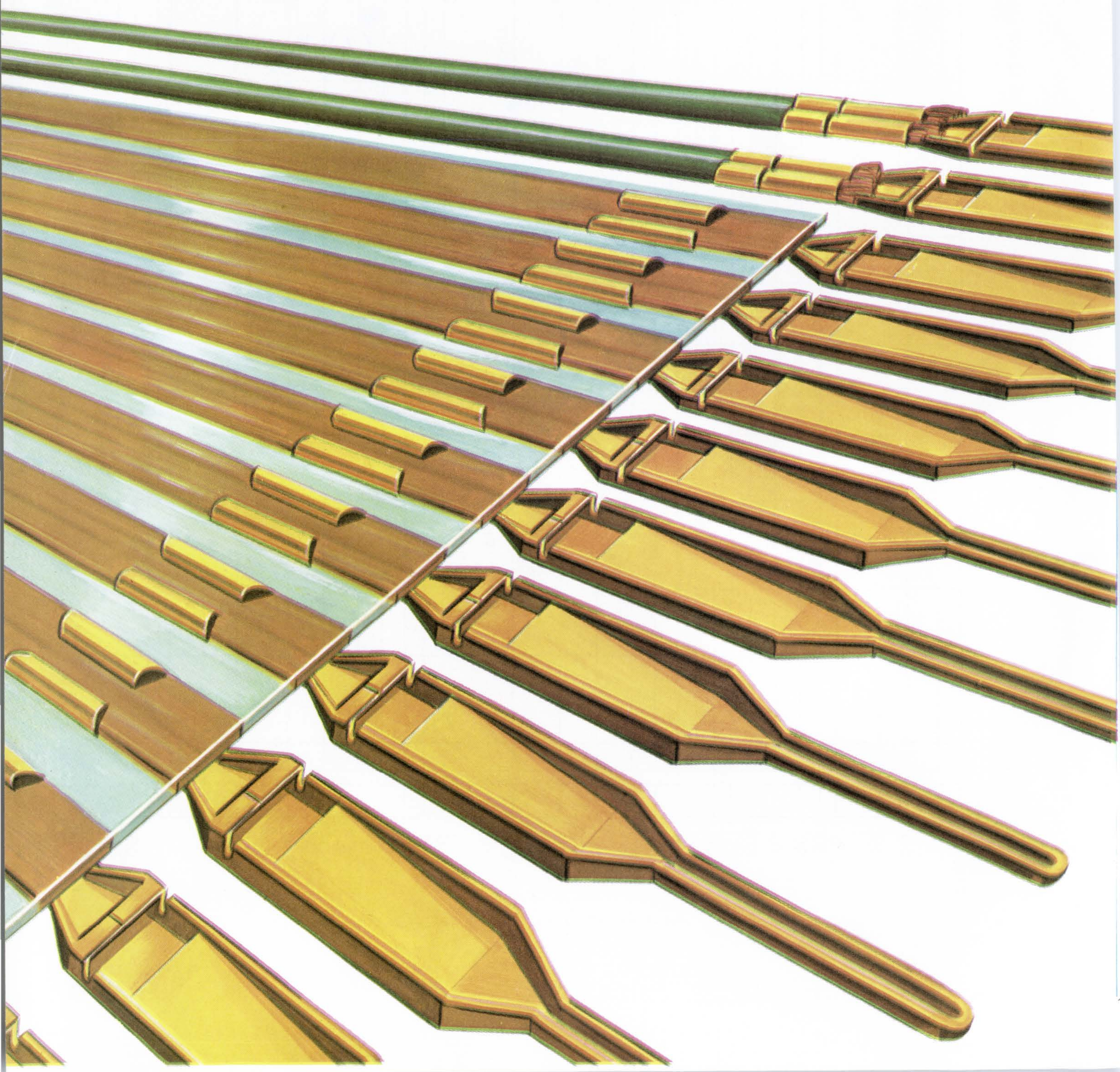
1 Texas Instruments RCTL 51 and 51R (130 ns at 3 V)
2 Motorola MHTL MC660
3 Signetics LU300K, SU300G/K
4 Signetics LU and SP300A
5 Fairchild CTL I
6 Fairchild CTL II
7 Philco-Ford SPO-199A
8 Philco-Ford PLR 980 (radiation hardened)
9 United Aircraft 820

Types of Logic Circuits and Their Acronyms

CCSL	Compatible Current-Sinking Logic
CL	Counting Logic
CML	Current-Mode Logic
CTL	Complimentary Transistor Logic
DCTL	Direct-Coupled Transistor Logic
DTL	Diode-Transistor Logic
DTμL	Diode-Transistor Micrologic
ECCSL (EC^{2}SL)	Emitter-Coupled Current-Steered Logic
ECL	Emitter-Coupled Logic
EECL (E^{2}CL)	Emitter Emitter-Coupled Logic
HLTTL (HLT^{2}L)	High-Level Transistor-Transistor Logic
HNIL	High Noise Immunity Logic
LPDTL	Low-Power Diode-Transistor Logic
LPDTμL	Low-power Diode-Transistor Micrologic
LPRTL	Low-Power Resistor-Transistor Logic
LPRTμL	Low-Power Resistor-Transistor Micrologic
MCML	Motorola Current Mode Logic
MDTL	Motorola Diode-Transistor Logic
MECL	Motorola Emitter-Coupled Logic
MEL	Micro Energy Logic
MHTL	Motorola High-Threshold Logic
MRTL	Motorola Resistor-Transistor Logic
MTTL	Motorola Transistor-Transistor Logic
MVTL	Motorola Variable-Threshold Logic
mWμL	Milliwatt Micrologic
mWMRTL	Milliwatt Motorola Resistor-Transistor Logic
OMIC	Optimized Microcircuits
RCTL	Resistor-Capacitor-Transistor Logic
RTL	Resistor-Transistor Logic
RTμL	Resistor-Transistor Micrologic
SUHL	Sylvania Universal High-Level Logic
TTL (T^{2}L)	Transistor-Transistor Logic
VHL	Variable-Threshold Logic
Utilogic	Utility Logic (with features of DTL, RTL, TTL)


DTL
RTL
TTL
ECL
Special
1µs-0.25 mW
2µs, 15mW
400ns,56mW
Typical propagation delay (ns)
Power dissipation (mW/gate)
200 ns
150
130
100
90
80
70
60
50
40
30
20
15
10
9
8
7
6
5
4
3
2
0.9
0.5 mW
1.0
1.5
2
3
4
5
6
7
8
9
10
15
20
30
40
50
60
70
90
110

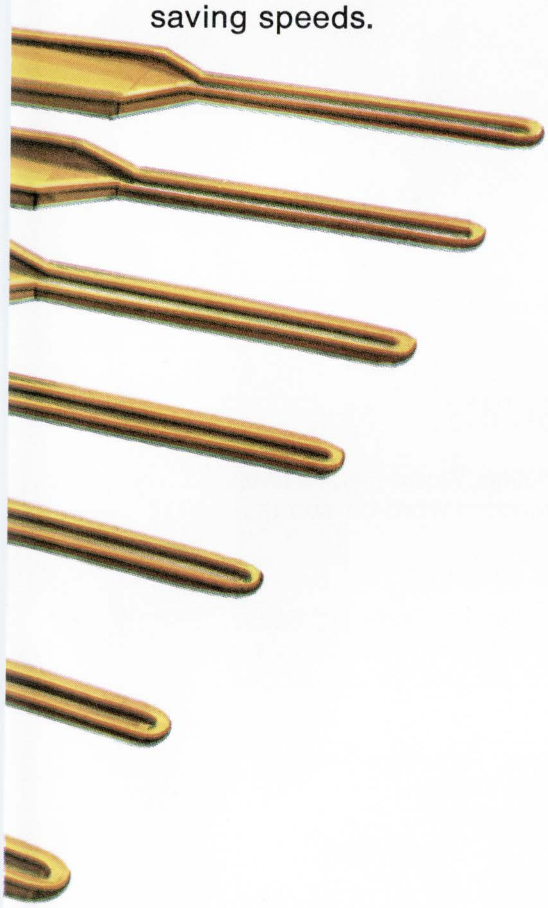
The world's most unpre now has the most reliable terminations.



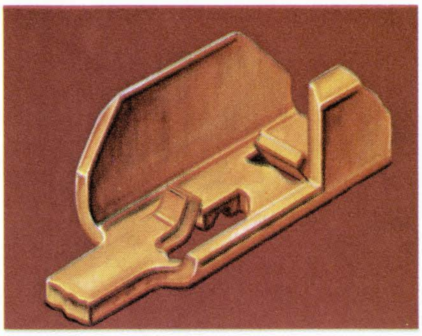
pared flat cable

We completely eliminated all flat cable preparation. And replaced it with a Mechanical Termination Technique.

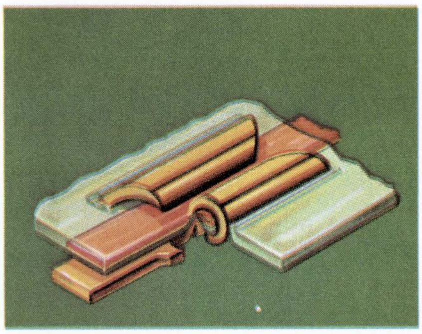
One crimp for each conductor path. That's all it takes to terminate flat cable with our unique method. And it makes absolutely no difference if you crimp on the contacts at the ends of the cable or the middle. Our automatic machine does both. At money-saving speeds.



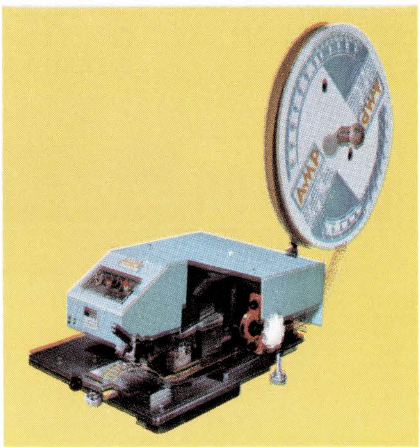
We displace the insulation, then crimp. The contacts we use are "U" shaped. The edges are sharp enough to penetrate the cable insulation.



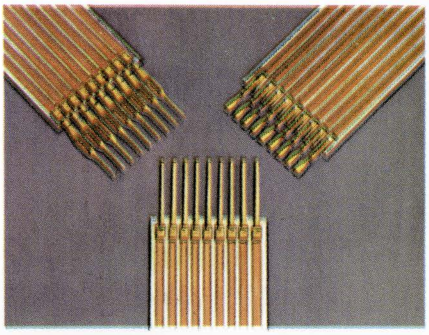
These legs straddle the conductor, and are then rolled 180° to pierce the insulation again. This displacement makes reliable positive contact. Two protruding lances on the under side of the "U" pierce the insulation from the other side. The result is four metal-to-metal-to-metal gastight area contacts in each termination with no deforming effects on the conductor.



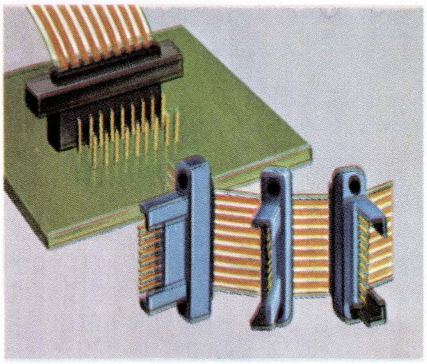
Up to 3,400 terminations an hour. Honest. With a 29 position cable you can really get 3,400 finished terminations an hour. With a 19 position cable you get 2,700. Absolutely no cable preparations — just cut and terminate. It's all done automatically with our precision engineered machine that you can use in your own plant.



Three types of contacts. Crimp snap-in contacts. Square pins .025 inch. And flat tabs for welding or flow soldering to PC boards or components. They can all be crimped to the cable at the ends or any point along its length.



Application. These same pins and sockets can be snapped into housings for the following applications: cable to cable connector, cable to printed circuit board connectors and cable to basic back panel grids commonly used in point-to-point wiring systems. All the above applications can be accomplished with either flat cable or round wire.



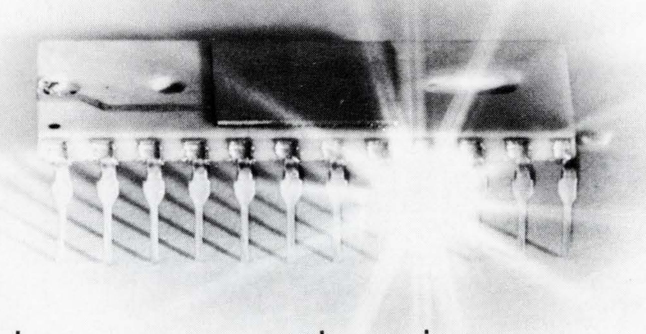
Your costs go down as fast as the crimps. Just let the machine do its job and you'll get the lowest installed costs of any flat cable termination method.

For AMP's Flexible Cable Connector Catalog write **Industrial Division, AMP Incorporated, Harrisburg, Pa. 17105.**

AMP
INCORPORATED

Circle 30 on Inquiry Card

Introducing the first bipolar compatible MOS ROM.



No ifs, ands or external resistors.

A lot of people have said their MOS ROM's were bipolar compatible. For output only. Or just for typical case. Or only if you hung on a resistor.

Solitron's is "worst case" bipolar compatible. Period.

Input can be 0.4v for logic zero. 2.4v for logic one. Any temperature between −55°C and +125°C. Put it with any DTL or T²L and it'll work.

Of course compatibility isn't everything.

Which is why we made our MOS ROM fast and versatile. (And static.)

Typical response 500ns. Worst case, 900ns. 1024 bits in four standard word-bit configurations.

Programmable chip select.

We also made it available. Order UC 6525/7525 now and you'll have it in four to six weeks with your bit pattern. Or contact us for details.

Solitron Devices, Inc., P.O. Box 1416,
San Diego, California 92112
Telephone (714) 278-8780
TWX 910-335-1221

Solitron DEVICES, INC.

For custom designs or standards, contact Solitron, leader in semiconductors:

SAN DIEGO, CAL.
8808 Balboa Avenue
FET & Dual FET Transistors
MOS/FET Devices
MOS Memory Arrays
Shift Resistors
Monolithic IC's

RIVIERA BEACH, FLA.
1177 Blue Heron Blvd.
Hi Rel Power Transistors
Si & Ge. Power Transistors
RF & small Signal Transistors
PNP-NPN Industrial Transistors

TAPPAN, N.Y.
256 Oak Tree Road
Diodes & Rectifiers
Zeners
High Voltage Assemblies
Power Rectifiers
Thick Film Hybrid Circuits

LONG ISLAND CITY, N.Y.
37-11 47th Ave.
Microwave Components
Bolometer Elements
Ferrite & Ferrite Devices
Microwave Semicond.
Plaxial (R) Cable
Precision RF Coax.

PORT SALERNO, FLA.
Cove Road
Precision RF Connectors
Cable Assemblies
Loads & Terminations
Strip Line Launchers
Couplers
Custom Strip Line Assemblies

MOS Course—Part 5
Random access memories

This month, our course on MOS integrated circuits is devoted to random access memories (RAMS). RAMS are the structures in which a computer stores the information that is currently being used. This information, by the way, is not just the data being operated on, but also includes the program that directs the computer's operations

Many ways to remember

There are a number of techniques used to store the information used by a computer. Among the more familiar storage media are magnetic tape, paper tape, punched cards and magnetic discs and drums; all of which are basically mass sequential storage forms. The information they store is organized into fairly large blocks with the information within a block stored sequential—the computer uses storage location #1 first, location #2 second and so on through the block.

However, in the course of all those computations and manipulations that a computer does so quickly, the most efficient organization for data is not necessarily in sequential blocks. A more practical approach with a block of data is to let the computer write-into or read-out-of any storage location at random. Not so surprisingly, this brings us back to our topic at hand—random access memories.

What's in a RAM

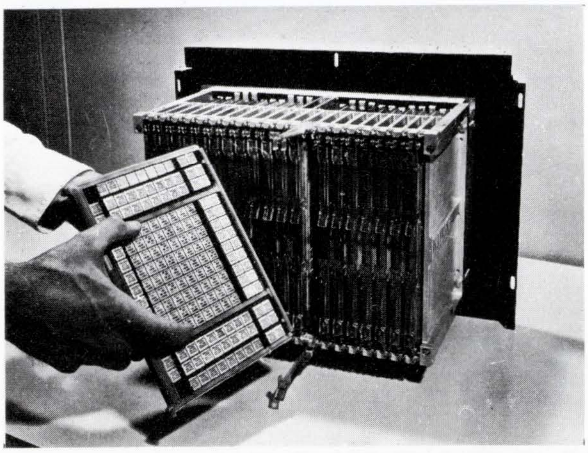
Before we talk about RAMS, let's look at the organization of a memory. All the information in a computer is

Characteristics of Main Memory Systems
(2.5×10^5 bits)

	Ferrite Cores	Plated Wire (film)	Dynamic PMOS	Static PMOS
Cell spacing	25 X 25 mils	50 X 50 mils	2 X 4 mils	6 X 6 mils
Sense signal	50 mV	15 mV	~100 mV	~100 mV
Word drive current	400 mA	600 mA	~100 mA (charging only)	~100 mA (charging only)
Word drive voltage	25 V	25 V	20 V (or 5 V)	20 V (or 5 V)
System cycle time (¼ million bit system)	600 ns	450 ns	700 ns	300 ns
System access time	320 ns	250 ns	600 ns	200 ns
System power	300 W	150 W	50 W	100 W

Here's how a computer manufacturer compares MOS and magnetics in mainframe applications.

(Contributed by Mr. W. F. Jordan, Honeywell Computer Control Div., Framingham, Mass.)



This bipolar IC memory is used as a buffer memory in the IBM 360/85 and 360/195. The memory chips store 64 bits each and have a read time of 7 ns and a write time of 12 ns. The complete memory stores 2048 words of 72 bits each—a total of 147,456 bits—and has an access time of 40 ns. (Courtesy of IBM Corp., Essex Junction, Vt.)

stored as binary 1's and 0's. In a computer, these bits are organized into words, where a word is just a string of bits treated as an entity. Random access memories store each bit individually, but the smallest amount of data that can be written into or read out of the memory is one word.

Because the RAM stores the information that is currently being used by the computer, its most important parameter is speed. How fast you can get the information into and out of the memory significantly affects how fast the computer will operate.

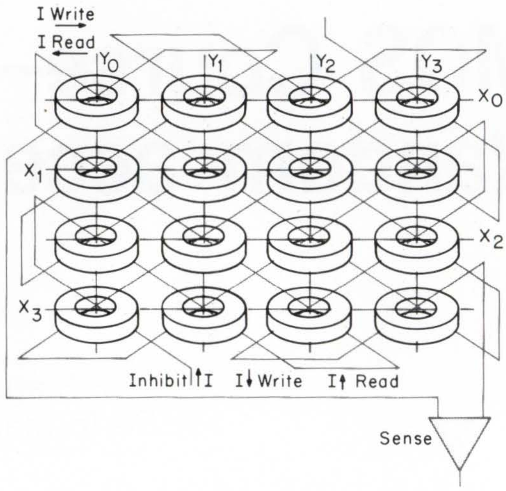
Following speed as a parameter of interest, is a combination of physical size and power dissipation. Computers are becoming faster *and* smaller. The need is to cram more information into the same or less space than is now used. Besides the physical size of the storage device, power dissipation limits the packing density.

Mostly magnetics

By far, the greatest portion of the random access memories in today's computers use the magnetic cores, with a fairly small portion using plated wire. Magnetic core technology has probably played as large a part in the advancement of the computer industry as has the transistor. Magnetic cores have performed more than adequately up to now in the areas of speed, packing density and power dissipation. But there is a new challenger on the scene and this challenger is the integrated semiconductor memory.

Except in specialized applications, bipolar semiconductor memories have not displaced cores to any large extent. Now, however, semiconductor manufacturers are cranking out IC memories that are either all MOS or that combine MOS and bipolar to take advantage of the strong points of each. Read the three articles that comprise this installment of our course. You'll see that the authors are not addressing themselves to the question, "will IC memories replace cores?" Rather they are debating the question, "which configuration will be the one to replace cores?"

The Core Memory



One plane of a 3-D organized random access core memory. Each core in this plane stores the same bit for each word in the memory This plane is repeated for each bit in a word so that the number of planes equals the word length.

To write a 1 in a particular core, currents of I/2 are passed down the appropriate X-select and Y-select lines. The I/2 current is not large enough to reverse the state of a core. However, the core that is located at the intersection of the particular X-select and Y-select lines sees an effective current of 2 (I/2) or I. This current I is large enough to change the state of the core and a 1 is written.

To write a 0, the direction of the current flow is reversed. The selected core then sees an effective current of $-I$ and a 0 is written.

This same procedure is used to read the memory. The $-I/2$ currents cause the core to change states if it contains a 1. When the core changes state, it produces a current pulse on the sense line. Therefore, when reading, a current pulse on the sense line means that particular bit is a 1. If there is no current pulse, the bit is a 0.

Since the read process converts all 1's to 0's, it is necessary to write the 1's back into the memory. To accomplish this, $+I/2$ currents are passed through all the X-select and Y-select lines for the word being addressed. If a particular bit was a 1, the 1 is written back. If the particular bit was a 0, a current of $-I/2$ is passed through the inhibit line for that particular plane. This inhibited line results in the core seeing an effective current of only I/2 and it remains a 0.

MOS course—Part 5

MOS random-access memories

The wait is not over yet, but MOS technology may someday make cores just a memory.

Warren Crews
Motorola Semiconductor Products Inc., Phoenix, Ariz.

One of the most promising applications for MOS circuitry is the construction of random access memories. Not only will MOS memories find application in relatively slow all-MOS systems, but the special suitability of MOS for information storage will result in extensive usage in high-speed applications. The successor to ferrite cores in computer main-frame memories of the future may well be LSI arrays of MOS cells.

What's a RAM?

Basically, a random access memory requires that any location within it can be reached or accessed without regard to any other location. At the selected location, data may be written (stored) in the memory or read (retrieved) from it. Between the time data is written and read, it must be reliably stored.

The basic capacity of the random access memory to store data and retrieve it at will makes the random access memory or RAM a popular system design tool. Categories such as scratch pads, buffers, main memories, and mass storage are all applications for RAMS.

A scratch-pad memory is a small, fast memory normally associated with the central processor of a computer. The scratch pad, which is used for temporary storage of interim calculation results, must operate at speeds comparable to those of the central processor. This speed requirement means that except for all-MOS computers, scratch-pad operation is not an MOS strong point.

Buffer memories may be employed between sections of a computer, between a computer main-frame and peripheral equipment, or in any digital system where temporary storage is required between operating units. The speed of the buffer must be at least equal to that of the input-output rate of the faster of the operating units and its information storage capability is related to the data rates of the units. MOS random access memories are a logical choice for many buffer memory applications, especially in computer peripherals.

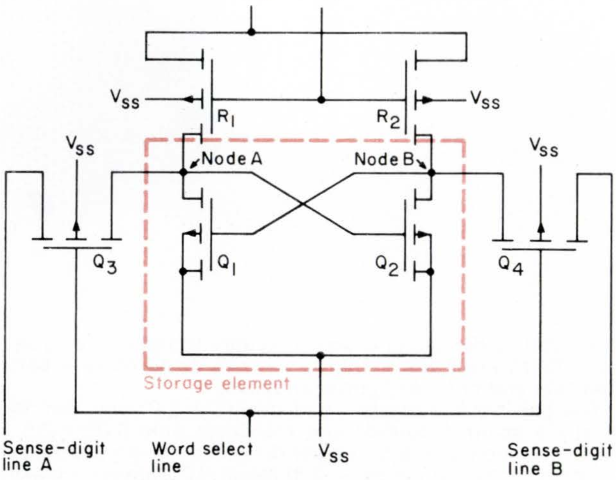


Fig. 1. The basic MOS storage cell. The two p-channel transistors, identified as R_1 and R_2, are biased on by V_{GG} and act as resistors. The cross-coupled combination of Q_1 and Q_2 forms the actual storage element and Q_3 and Q_4 act as switches to connect or isolate the individual cell and the sense-digit lines.

The main memory, or main-frame memory, is the primary operational storage block of a general-purpose computer. In today's computers, this role is filled by magnetic cores almost exclusively. The next generation of computers, however, is expected to use semiconductor main-frame memories. The fastest core memories generally available today operate in the 400- and 500-ns cycle time region. Their semiconductor replacements will operate in the 100- and 500-ns region. Along with this speed requirement, however, is the demand for an enormous number of bits. Main-frame applications start with storage capabilities of about 64,000 bits and many applications demand storage capacities in excess of one million bits.

Mass storage or auxiliary memory is today primarily the province of the magnetic disc. These partially random access and partially sequential magnetic devices store millions of bits at extremely low cost. In order to compete successfully in this market, extremely large LSI arrays must be fabricated at very low cost.

The features that make MOS circuitry so attractive for memory use are very high circuit density, low cost, and low power dissipation. The nature of memories—large regular arrays of identical units—is serving as a spur for LSI development, since memories represent one of the few types of large arrays that can be used in volume by a number of equipment manufacturers.

The MOS RAM

The typical MOS storage cell is a remarkably simple, effective, and low-cost design. The cell consists of only six p-channel, enhancement mode devices. Two of these (R_1 and R_2 in Fig. 1) act as resistors and are biased on by the V_{GG} supply. The two cross-coupled transistors, Q_1 and Q_2, act as a storage element, and Q_3 and Q_4 are switches that selectively connect or isolate the individual storage cell from the sense-digit lines. Two sense-digit lines are used, providing dual rail—signal and complement—drive to the cell. The word-select line drives the gates of Q_3 and Q_4 and operates as a single rail—signal only—input.

With the p-channel devices used, the V_{SS} power supply is the most positive voltage and V_{DD} is negative by 10 V or more. Depending on the particular processing technology used in th construction of the cell and the cell operating constraints, V_{GG} is better equal to, or more negative than, V_{DD}. Since p-channel enhancement mode devices are turned on when the gate is sufficiently negative (relative to the substrate), the substrate is connected to the most positive system voltage, i.e., V_{SS}.

In the storage mode, the cell maintains one of its two stable states. The word select line is in the high logic state (close to V_{SS}) so that transistors Q_3 and Q_4 are off. As a result, the storage cell is isolated from the sense-digit line. One of the possible stable states exists when the gate of Q_2 is low. This means that Q_2 is conducting so that its drain (*node B*) is at a high potential (close to V_{SS}). The difference in potential between V_{DD} and the drain of Q_2 is dissipated across resistor R_2. The high potential on *node B* is coupled to the gate of Q_1. With this high potential on the gate, Q_1 is turned off. As a result, *node A* is at approximately V_{DD} since

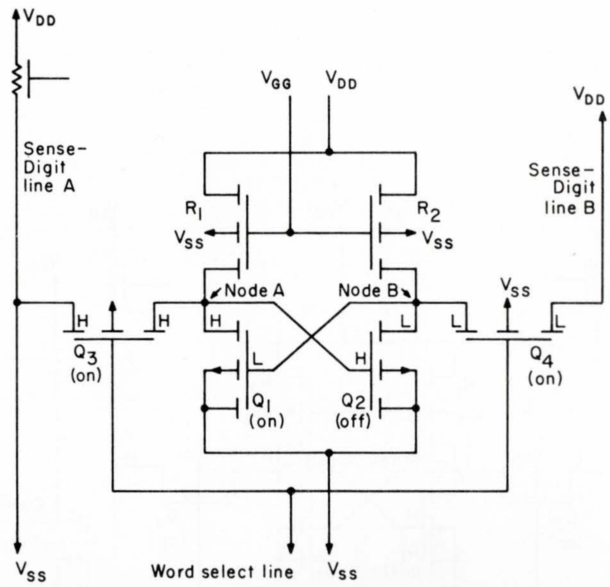


Fig. 2a. Writing into the basic storage cell. When the word-select line is low, Q_3 and Q_4 are turned on and Q_1 and Q_2 are connected to the sense-digit lines. In this case, line A is high (close to V_{SS}) and line B is low (close to V_{DD}). The result is Q_1 is biased on and Q_2 biased off. The H and L designations indicate whether a point is close to V_{SS} (H) or V_{DD}(L).

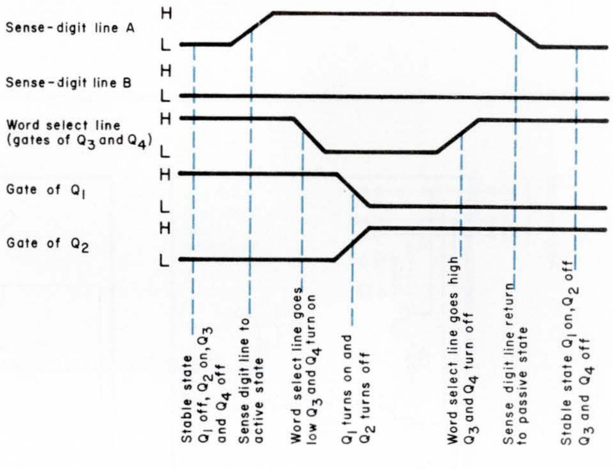


Fig. 2b. Timing diagram for the write operation of Fig. 2a.

there is essentially no current flow through R_1. The drain of Q_1 *(node A)*, which is connected to the gate of Q_2, provides the low or V_{DD} potential that we defined as being stable state 1.

Writing data in

To change the information stored in the basic cell, the sense-digit lines are appropriately biased and the word-selection line placed in the active or low state. Assume the sense-digit line condition shown in Fig. 2. Sense-digit line A is at a high potential. The complementary signal is present on sense-digit line B which is connected to a low potential. When the word select line goes to

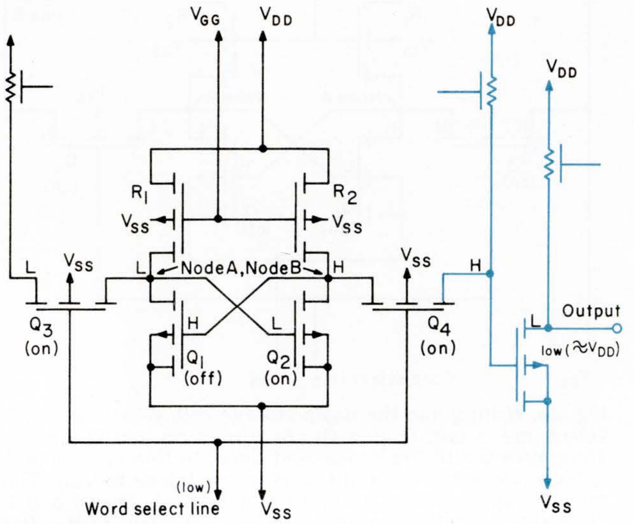


Fig. 3. Reading out of the basic storage cell. The portion of the circuit in color is the simple MOS inverter used as the sense circuit.

a low potential, transistors Q_3 and Q_4 turn on, connecting the sense-digit lines to the cross-coupled transistors Q_1 and Q_2. In the example shown in Fig. 2, Q_3 connects *node A* to the high level on sense-digit line A. This high potential is coupled to the gate of Q_2 and tends to turn Q_2 off. At the same time, because Q_4 is conducting, *node B* is coupled to the low supply. This low voltage is applied to the gate of Q_1 and tends to turn Q_1 on. This provides an additional path from V_{SS} to *node A*, further increasing the potential on the gate Q_2. Therefore, the indicated sense-digit line potentials in Fig. 2 result in transistor Q_1 turning on and transistor Q_2 turning off. This is the alternate stable-state of the storage element. Completing the write operation, raising the word-select line potential, turns off Q_3 and Q_4 and isolates the storage cell from the sense-digit lines.

Connecting sense-digit line B to V_{SS}, sense-digit line A to V_{DD}, and activating the word-select line will reverse the state of the flip-flop, turning Q_2 on and Q_1 off.

Organizations

Applying complementary V_{SS} and V_{DD} signals to the sense-digit lines while the word-select line is activated permits writing into the storage cell. For reading, the word-select line is again activated, but this time both sense-digit lines are terminated with MOS resistors. The read scheme is shown in Fig. 3.

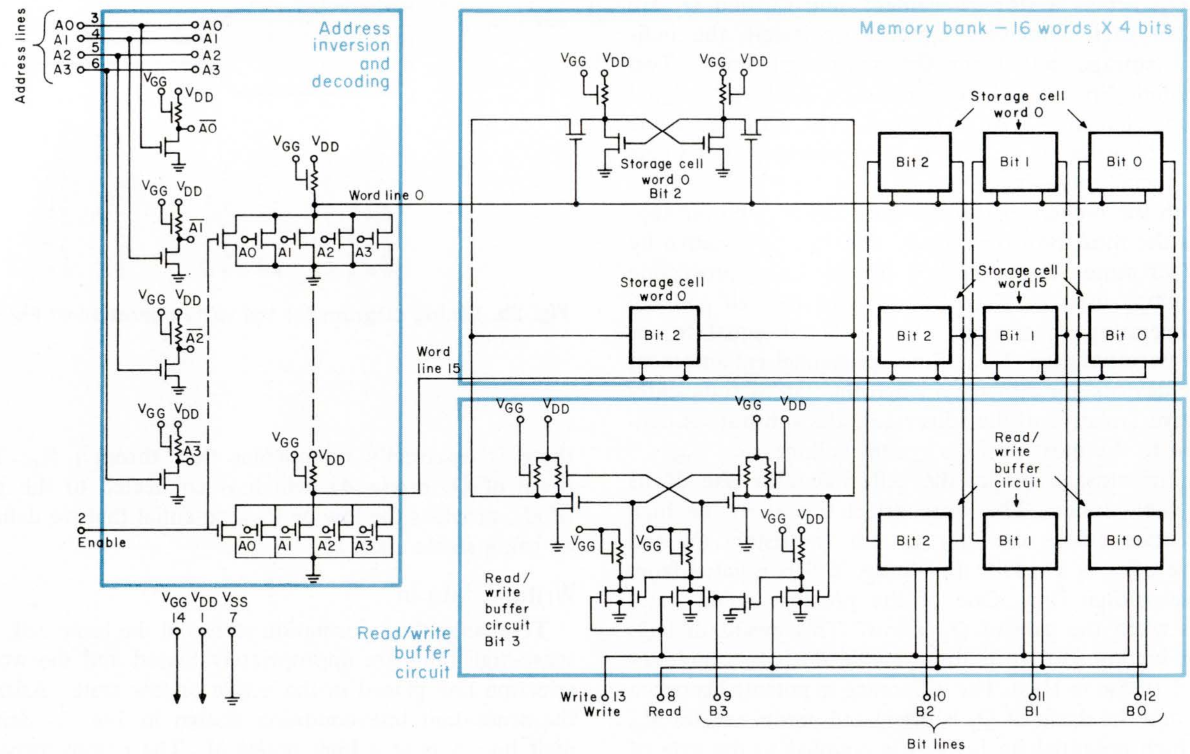


Fig. 4. **Partial schematic** of 64-bit MOS random-access memory (Motorola's MC1170).

The resistive terminations on the sense-digit lines do not change the state of the storage cell when Q_3 and Q_4 conduct the sense-digit lines to the storage cell. For the node that is in the high state, the sense-digit line resistor appears in parallel with the internal resistance (R_1 or R_2). For the drain node of the off storage transistor, the sense-digit line terminating resistance appears as an additional source of V_{DD} potential and through the cross-coupling of Q_1 and Q_2 tends to keep the conducting transistor turned on.

In addition to terminating resistors, at least one of the sense-digit lines must contain sensing circuitry to determine the state of the storage cell. At its simplest, this sense circuitry can be an MOS inverter as shown in Fig. 3.

The cell sensing function is shown as a single rail, or signal only, operation. In an actual memory, sensing may be either single or dual rail. The decision is largely determined by the operating voltages and the processing of the MOS structures. As a generalization, low voltage applications require double rail operation for reliability, while at the higher voltages single rail operation is satisfactory.

Reading out

We have spent a considerable amount of space discussing the basic characteristics and the operation of an MOS storage cell. If this design were limited to a single application, the effort might be unwarranted. This is not the case, however, and the simple storage cell is the basis for a wide variety of MOS random access memories.

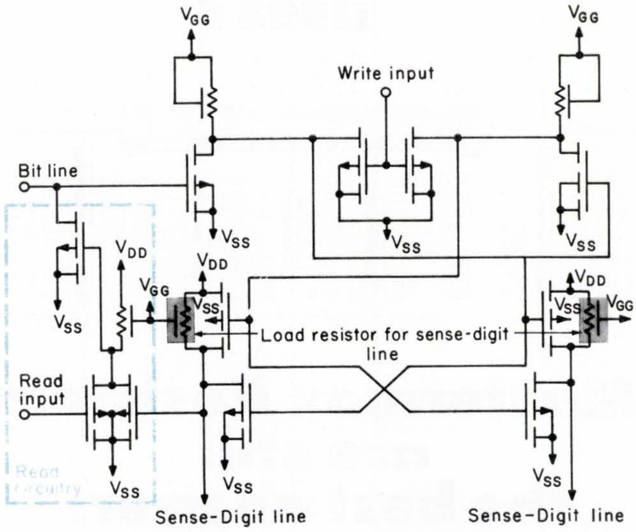
Where relatively few bits of memory are required, a number of storage cells can be combined with read, write, address, decode, and driving circuitry to form a self-contained memory on a single chip of silicon. For example, Fig. 4 shows a partial schematic of Motorola's MC1170L, a 64-bit random access MOS memory. Organized into 16 words of four bits each, a single unit may be used as a buffer in MOS systems or a number of MC1170s can be combined with additional decoding circuitry to build a main memory of substantial size.

Figure 5 is a close-up of the read and write circuitry of the MC1170 that displays an elaboration of the basic concepts shown in Figs. 2 and 3.

Small MOS memories such as the MC1170 are highly useful. The modest amount of information stored in a single 64-bit memory with the 500-ns cycle time, however, is a far cry from the requirements of a practical replacement for magnetic cores in computer main-frame memory applications.

A much more suitable main-frame building block is the random access storage module shown in Fig. 6. This module stores 8192 bits, and has a cycle time of < 150 ns. For all its sophistication, however, the 8-k memory module employs the same basic storage cells as the 64-bit memory considered previously.

The 8-k memory is not contained on a single monolithic chip, but is a hybrid assembly consisting of 42 separate LSI chips. Thirty-two of these chips are MOS storage arrays, each of which contains 256 basic storage cells (Fig. 7). The principal difference in technology,



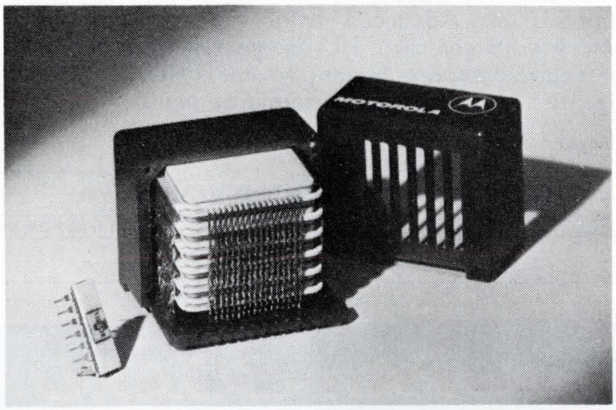


Fig. 6. This random-access memory module stores 8192 bits with an access time of 150 ns. The module combines the high packing density of MOS arrays for the storage function with bipolar read and write circuitry.

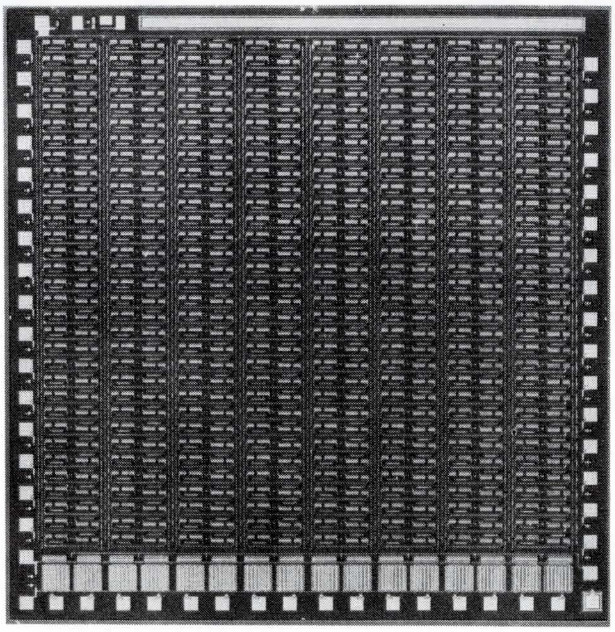


Fig. 7. This 256-bit MOS storage array is one of 32 such chips used in the 8192-bit module.

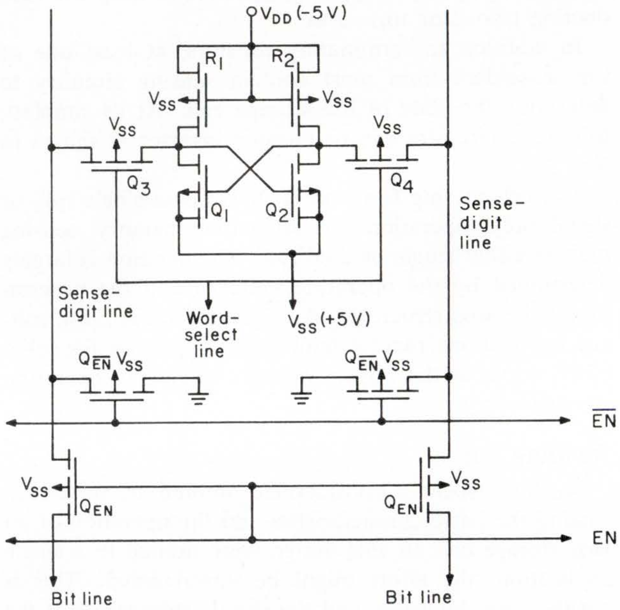


Fig. 8. The storage cell used in the 8-k memory module.

however, is that the relatively slow MOS decoding, driving, and sensing techniques have been replaced by bipolar technology in the 8-k memory module. Figure 8 shows the basic storage cell as adapted to the 8-k memory. The four transistors, labelled Q_{EN} and $Q_{\overline{EN}}$, connect or isolate the chip bit (sense-digit) lines on each storage chip and the memory sub-system bit lines.

The high functional densities, low cost, and low power dissipation of the MOS storage arrays are retained in this concept. The relatively slow operation of MOS circuits does not seriously reduce the operating speed of the module since very few MOS components are involved in any single operation. The complex logic operations, such as decoding and driving, are performed by very high-speed ECL circuits. The interface circuits between the conventional narrow logic swing ECL and the wide logic swing MOS circuits are special bipolar types that provide good driving capability.

For a wide variety of system applications, random access memories and MOS technology are made for each other.

INFORMATION RETRIEVAL
Integrated circuits, Computers and peripherals, Digital design

IMOS:

(THE INDUSTRY'S FIRST ION-IMPLANTED MOS DEVICES)

Because our MOS integrated circuits are ion-implanted, they can handle 20 MHz data. And they're pin compatible with P-channel MOS.

Ion-implantation gives them ultimate automatic gate registration without process complications.

Example: our HDSR2164 dual 64-bit TTL compatible shift register. It's loaded with Tomorrow features. Like greater than 10 MHz operation. Low clock capacitance (typically, 25pf) and low power dissipation (typically 0.1 mW per bit per MHz at operating frequencies over 10 MHz). And it's priced at $24.95 per unit in quantities over 100 pieces.

For literature, data sheets, and name of nearest distributor, please write: Hughes MOS Division, 500 Superior Avenue, Newport Beach, CA 92663.

HUGHES

HUGHES AIRCRAFT COMPANY
MOS DIVISION

HUGHES STANDARD MOSINC DEVICES

COUNTERS

HCTR0107: Reversible Decade Counter with Seven-Segment Decoder and Drivers @ $12.50
HCTR0507: Seven Stage Binary Counter, 7 Outputs, @ $7.00
HCTR0201: RST Flip-Flop @ $1.65
HCTR0102: Commercial/Entertainment Binary Divider @ $0.80

STATIC SHIFT REGISTERS

HSSR2016: Dual-16 Bit @ $5.95
HSSR2064: Dual-64 Bit @ $16.00

DYNAMIC SHIFT REGISTERS

HDSR3066: Triple-66 Bit @ $17.50
HDSR4064: Quad-64 Bit @ $23.50

ION-IMPLANTED MOS (IMOS) SHIFT REGISTERS

HDSR2164: 10 MHz/ Dual-64 Bit Dynamic Shift Register @ $24.95
LISR0064: 20 MHz/ 64 Bit Dynamic Shift Register @ $35.00 (1 up)

MULTIPLEXERS

HMUX1756: 4 Bit D-to-A Converter @ $39.80
HMUX1784: 4 Bit D-to-A Converter @ $39.80
HMUX2542: Dual 2-Bit Commutator @ $29.95
HMUX2641: 4-Bit Commutator @ $29.95

LOGIC ELEMENTS

HLOG2304: Triple 3, Dual 2 NOR Gates @$4.00
HLOG2306: Dual J-K Flip-Flop @ $4.00

MULTIPLES

HMUL 1444: General Purpose Quad @ $10.25
HMUL1445: General Purpose Quad @ $14.75
HMUL1884: Quad Dual-Switch @ $16.25
HMUL2661: Six-Channel Switch @ $15.75

DUALS

HDSW8550: High Level Switch @ $5.60
HDIG8551: Amplifier @ $7.45

DISCRETES

HDGP1000: General Purpose Switch @ $0.70
HDGP1001: General Purpose 30-ohm Switch @ $0.80
HDIG1030: General Purpose @ $3.10
HDIG1886: Electrometer @ $3.55
HDSW2106: Low-Resistance, 20-ohm Switch @ $4.40
HDSW3005: General Purpose Low-Leakage Switch @ $3.30
HDSW8318: General Purpose Switch @ $2.75
HDSW8348: General Purpose 50-ohm Switch @ $4.10

SUBSYSTEMS

HSUB0525: TV Sync Circuit @ $15.00
HSUB5021: Differential Digital Analyzer @ $18.00

COMPLEMENTARY MOS

LCOS4007: Dual Complementary Pair plus Inverter @ $20.00 (1 up)

Note: All prices for 100 and over quantities except as noted.

SAMPLE KITS

#1 Electrometers @ $9.75 each
#2 Switches @ $21.90 each
#3 Multiplexers @ $149.75 each
#4 Counters @ $33.56 each

MOS Course—Part 5

Static or dynamic—two ways to remember

Should the data go round and round or should it just stand still? Here's a look at the two approaches

By Marcian E. Hoff, Jr.
Intel Corp., Mountain View, Calif.

Random access memory devices made with MOS technology use two different techniques to store information. Depending on the type of basic memory cell, MOS RAMs can be categorized as being either static or dynamic. Static MOS memories that usually show poorer performance and higher costs are easier to drive than the dynamic which generally require clock signals in addition to power supplies.

Dynamic MOS circuits make use of the very low leakage associated with the gate circuits and junctions of well made MOS devices. These leakage currents are small enough to permit the circuit's parasitic capacitances to exhibit time constants between milliseconds and seconds. These long time constants may be used to provide temporary storage, which may be made permanent by appropriate cycling or "refreshing" operations.

The static RAM

In the static RAM stage of Fig. 1a, two static inverters are wired together to make a flip-flop. Devices Q_5 and Q_6 are used as (two-way) transmission gates. When reading, the conducting side of the flip-flop pulls the data line toward ground via these gates. Writing is accomplished by forcing the data lines to the value desired in the cell, thereby overriding the contents of the cell. Because of the small current capability of devices Q_3 and Q_4, it is important that neither of the data lines be near ground when the transmission gates are turned on. With grounded data lines, the charge associated with the capacitance of the data lines may flip the cell.

As a vehicle for comparison, let's consider a 256-bit static RAM made with p-channel, silicon gate MOS technology. The memory is organized as one 256-bit plane, with full address decoding, and except for additional power supplies, is fully compatible with TTL logic levels. Typical access time is approximately 1 μs.

The memory chip is easily connected in an array to provide greater memory capacity. Figure 2 shows how the individual packages are connected to realize a 1024-byte memory. Address inputs, write gates (read/write controls), and power leads are common to all packages in the array. Each row in the array corresponds to one plane of a ferrite-core memory, i.e., one row provides storage for one bit of each data word. All data inputs in a given row are connected together. All of the data outputs in a given row are similarly connected. Each memory package realizes one bit from each of 256 bytes. Each column of packages in Fig. 2 corresponds to 256 bytes of memory.

Because it uses silicon gate technology, this static memory provides easy interface to TTL logic levels. The portion of the circuit between the vertical dotted lines in Fig. 3 represents the MOS circuitry on the IC chip interfacing with TTL/DTL levels.

On the output side, a push-pull output stage with input signals D and $\overline{D}$ drives the input to a TTL gate. The output devices are made large enough to draw 2 to 4 mA in the negative direction, sufficient to drive one or two TTL inputs negative. (The TTL should have input diodes so that the TTL input cannot go strongly negative with respect to ground.) Because, in general, it is easier to produce more current in the positive output direction than in the negative, an external resistor R may be used. This resistor draws current from the TTL input, aiding the current drive capacity for the low output. When the MOS output is positive, the upper MOS output device delivers current to the resistor.

The outputs of MOS devices with push-pull outputs of this type may be OR-tied if an enable signal E is used. When E is positive, both D and $\overline{D}$ can drive the output. However, when E is negative, the two devices driven by E conduct and cut off both output devices. The output then appears to float. When no resistor R is used, the TTL gate input resistor will pull the MOS output positive. However, if a suitable value of R is used when E is negative, the output will go negative.

This type of connection is used in the output of the 256-bit memory shown interconnected in Fig. 2. Each package has a chip select signal *(cs)* that is equivalent to the signal *E*. When *cs* is positive, the outputs float. In this way, the OR-tied output connection may be used.

The dynamic RAM

The dynamic memory cell of Fig. 1 may also be used as the basis of an MOS random access memory. Unlike the memories constructed with the static cell, the data of these dynamic memories must be periodically refreshed to maintain its validity. Because of the small size of the cell, many more bits of memory may be produced on a chip of given size than can be made with static cells.

The dynamic cell is used as the basis for random access memory chips of up to 1024-bits. One possible organization of a 1024 bit chip is shown in Fig. 4. With this organization, reading and writing occur for all cells of one row simultaneously. Because only one bit at a time is available for writing, an (internal) read operation must be performed prior to writing. This operation insures that the refresh amplifiers contain data corresponding to the contents of the row into which writing will take place.

There are three clock-like signals associated with the dynamic RAM: *X-enable, Y-enable,* and *precharge*. The *X* and *Y enable* both act as a chip select for both reading and writing. Several chips may have the input-output lead OR-tied to realize larger than 1024-bit planes.

Using silicon-gate MOS technology, the clock signals and addresses are nominally 20 V peak-to-peak. These high voltages are necessary to get high speed performance. The use of TTL compatible levels would add significantly to the memory cycle and access times. Memory cycle times with the high levels are from 300 to 600 ns, depending upon chip organization (several versions are being developed), and drive signal rise and fall times.

To illustrate how the dynamic random-access memory chip of Fig. 4 may be used in a memory, consider the design of 4096 word, 12-bit/word memory. Figure 5 shows how the devices are connected in an array. Each block labeled *L* is a level shifter to convert from logic levels to approximately 20-V levels. The blocks, labeled *W/S,* are word driver/sense amplifiers which sense the memory output currents when reading and perform level shifting when writing.

In the memory of Fig. 5, the inputs to the *X-enable, Y-enable,* and *precharge* leads of the devices are individually decoded to provide chip selection. Decoding *X-enable* is sufficient for this function; however, the use of the extra decoders reduces the power dissipation of the memory. A major portion of the memory power dissipation comes from energy associated with charging the device capacitances. The additional decoding reduces the amount of capacitance charged and discharged in each memory cycle (see below, under Volatility).

Optimum configuration

The memory shown in Fig. 5 realizes a 4096-word-by-12-bit memory witth 22 level shifters. However, given a particular clock driver (level shifter), some other configuration may require fewer peripheral com-

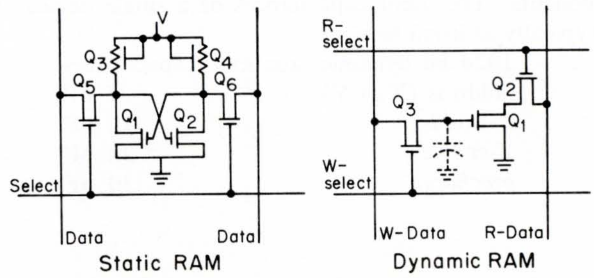


Fig. 1. Storage cells used in MOS RAMs.

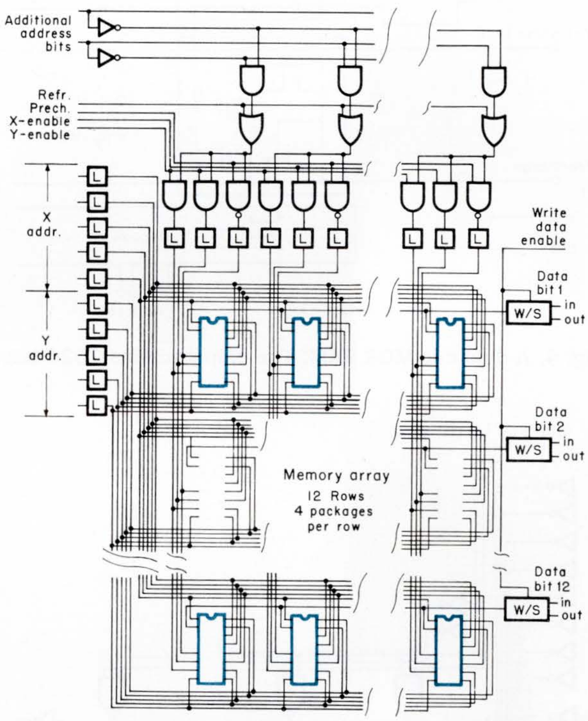


Fig. 2. Using 256-bit static MOS chips to construct a 1024-Byte (1024 x 8) memory.

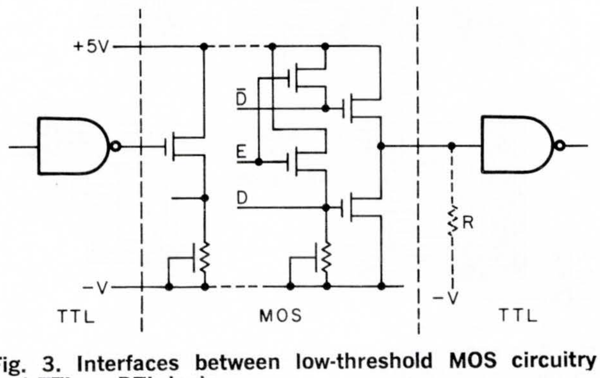


Fig. 3. Interfaces between low-threshold MOS circuitry and TTL or DTL logic.

ponents. The input capacitances of a single device are typically as listed here:

1024 bit dynamic MOS RAM capacitances	
Address (X or Y)	5 pF
X-enable	10 pF
Y-enable	30 pF
precharge	30 pF

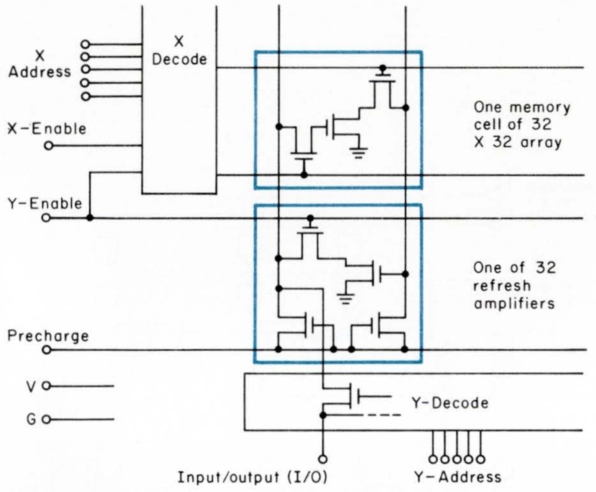


Fig. 4. A dynamic MOS RAM. The chip contains 1024 bits.

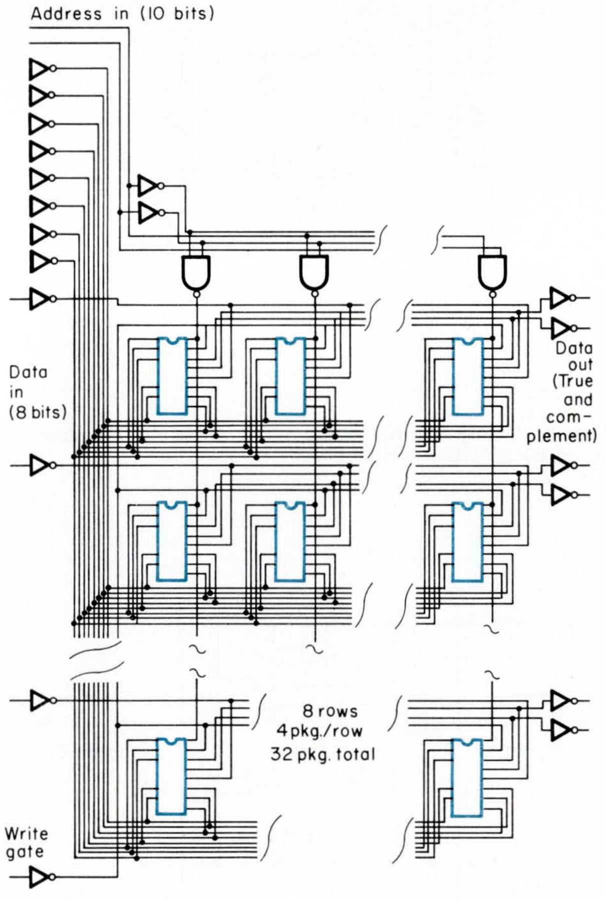


Fig. 5. A 4096 word, 12-bit/word memory using the 1024-bit dynamic MOS RAMs.

In the worst case, each input line must make one 20-V transition in each direction during a memory cycle. If rise and fall times must not exceed 20 ns, each package corresponds to a total current drive requirement of 120 mA. With clock drivers of 1-A capability, at least one clock driver must be used for every eight memory packages. The configuration of Fig. 5 required 22 drivers for 48 memory packages—a much poorer ratio.

In general, the lowest cost configuration of this type of memory will be a relatively large array so that all clock drivers can be fully loaded. In this respect, the dynamic MOS RAM differs from many other types of semiconductor memory, in that there is a significant degree of configuration sensitivity. The effect of this configuration sensitivity is to make larger arrays more economical.

Volatility considerations

All semiconductor memory devices now available (with the exception of ROMs) are volatile storage devices. To retain stored data, power must be applied to the memory. Static MOS and some bipolar memories may have provision for reduced power operation in which no read or write operations may take place, but data is not lost. In general, power levels to retain data are in the order of several hundred mW/bit. However, dynamic MOS memories offer much lower data-retention power requirements.

As outlined above, each 1024-bit package of dynamic MOS RAM has a total capacitance (sum of all input capacitances) of approximately 120 pF. At most, one 20-V transition in each direction must be made per input per memory cycle. To retain the data, 32 memory cycles must be executed in each 2-ms period. To charge the 120-pF capacitance to 20 V, 2400 picocoulombs must be delivered by the power supply. As only one transition draws power from the supply, the approximately 16,000 memory cycles/s draw a total charge of about 38.4 μC from the supply each second. The total power to execute these drive signals averages under 800μW, or 0.8 mW/bit. The dc power used by the cells is a fraction of the clock power, and an allowance must be made for the clock driver bias currents. Nevertheless, using suitably efficient clock drivers, total power requirements to retain data should be in the range of 1 to 2 W/million bits. At these power levels, even a small battery pack may be sufficient for retention of data for several hours or more.

These two types of random access MOS memories are examples of components that are being developed by integrated circuit manufacturers. Static 256-bit MOS memories are already available off-the-shelf and larger dynamic memories should be available soon. Initial experience already shows the static memories should cost less than any of the core memories now available, and yet offer significantly higher operating speeds.

INFORMATION RETRIEVAL

Integrated circuits, Digital design, Computers and peripherals

2240-BIT MOS CHARACTER GENERATOR.

Off the shelf.

Most static ROM's are custom made for special applications. The Philco® pMS2240C static ROM is different. It's mass-produced and preprogrammed to generate 64 alphanumeric display symbols when addressed by the standard ASCII code.

Another big difference . . . it's available right now to fill your digital display circuit requirements.

Bits are organized in 64 groups, in 5 x 7 patterns . . . enough to create all the alphanumeric characters on a conventional teletypewriter.

Access time for first-row bits is 1 μs, and .7 μs for successive bits.

Output buffers drive either MOS or bipolar circuits. A chip-select lead is provided so that the five parallel output bits can be OR-tied. And because the pMS2240C is a static ROM, the output data will remain valid as long as an address is present.

Prices on request, or order from Philco-Ford Corporation, Microelectronics Division, MOS Marketing, Blue Bell, Pa. 19422; (215) 646-9100.

The better idea people in MOS. **PHILCO** Ford

MOS course—Part 5

Performance and cost trade-offs for MOS RAMS

Selecting the right MOS RAM for your application means knowing the design compromises involved.

By Vernon G. McKenny
Mostek Corp., Dallas, Tex.

A number of MOS Random Access Memories (RAMS) are presently on the market. Each has a different combination of speed, power, package, and timing characteristics, and new RAMS, both bigger and faster, will be soon introduced. Some of these new memories will be very easy to use and completely compatible with +5-V bipolar logic. Others will require large input voltage swings, complex timing, refresh cycles, and high-speed sense amps on the outputs. The MOS RAM user can better evaluate all these possibilities if he first gives some thought to the reasons for the different approaches and the trade-offs involved. These trade-offs can be illustrated by examining some of the possibilities for MOS RAMS.

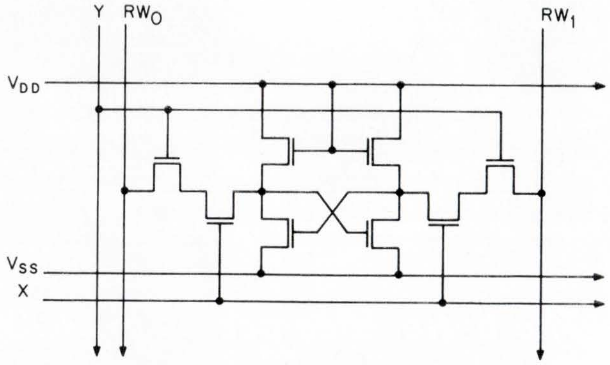
At one extreme, the high-speed RAM aims for high speed and low power resulting in high peripheral complexity. The high-speed RAM with decoding is a compromise between speed and peripheral complexity. On the other end of the spectrum is the RAM with full decoding, output buffering, and read-write control logic. This RAM is by far the simplest to interface with, but speed and power characteristics suffer.

Large dynamic RAMS, although they are subject to the same trade-off considerations as the smaller static memories, are aimed primarily at the low cost market.

The high-speed RAM

The high-speed RAM has its access time specified at 50 ns or less. This so-called access time, however, covers only the delays from the input to the output of the MOS RAM. Since there is no decoding, other than an X-Y matrix, and no output buffering, the memory system must perform these functions in the peripheral circuitry surrounding the MOS memory plane. Decoding, address line buffering, and output sense amps are required. If TTL circuitry performs these functions, a systems speed of 150 to 200 ns is easily attained. The exact speed is dependent on the size of the system. With ECL circuitry, one can expect read or write cycle times in the order of 80 to 100 ns, depending again on both the size of the system and the capability of the address line drivers.

A high-speed RAM can be easily wire-OR'ed with the addressing accomplishing the chip enable function; that is, only the selected chip would have both an X-line and



The memory cell for a high speed RAM is a simple cross-coupled flip-flop.

a Y-line negative. All other outputs would then look like open circuits (except for some transients introduced when switching the X and Y address lines).

This approach can keep the power quite low because V_{DD} can usually be pulsed asynchronously to obtain power duty cycles in the order of 1%. However, V_{DD} can even be continuously held negative without dissipating excessive power.

We can consider a 256-word-by-1-bit, high-speed RAM to be a low complexity chip since it contains only the basic memory cell (a simple cross-coupled flip-flop). The chip size is fairly large because of the large device geometries necessary to deliver the required output current. The package is a large 40-lead DIP because of the large number of address lines which must be brought directly off the chip.

Testing this RAM is difficult. A large and sophisticated tester is required to both drive the inputs over a 16 to 20 V swing while sensing output data in the order of 20 to 100 mV across a termination resistor. It is difficult to measure the 50-ns propagation delay through the chip on an automatic basis.

A high-speed RAM with partial decode

In this case, a RAM with "partial decode," the address lines are actually fully decoded, but each address input requires high amplitude true and complement signals. Thus, for a 256 by 1 RAM, a total of 16 input pins (8 true and 8 false) would be required rather than the 32 input pins on the high-speed RAM without any decoding. Using the same current-sense type outputs as the high-speed unit, access times of about 200 ns through the chip can be obtained with system read or write cycle times in the order of 300 ns.

Since the decoder requires no dc current, the power consumption remains essentially the same as on the high-speed RAM.

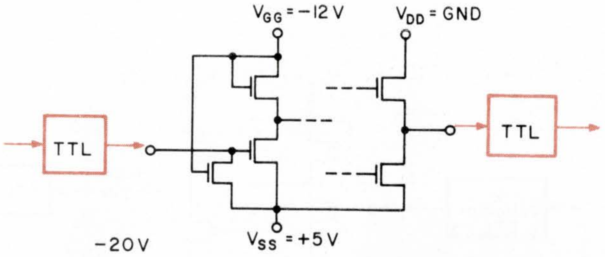
The complexity would be considered medium and the chip could go in a 24-lead DIP. The chip size would be somewhat larger than that of the high-speed RAM, although if the load devices inside the cell were left out, a considerably smaller chip could be obtained. However, a refresh pulse would be required periodically.

The testing problems are similar to that of the high-speed RAM, except that it now becomes easier to measure speed automatically.

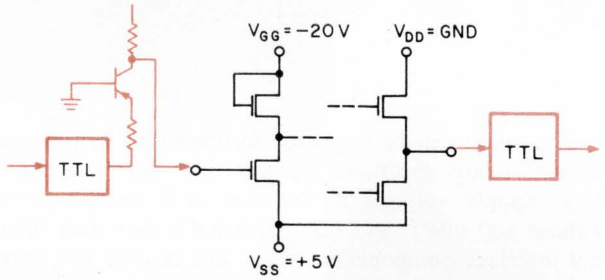
The cost is about the same as the high-speed RAM without decode because the chip is larger but the package is smaller.

RAM with full decode

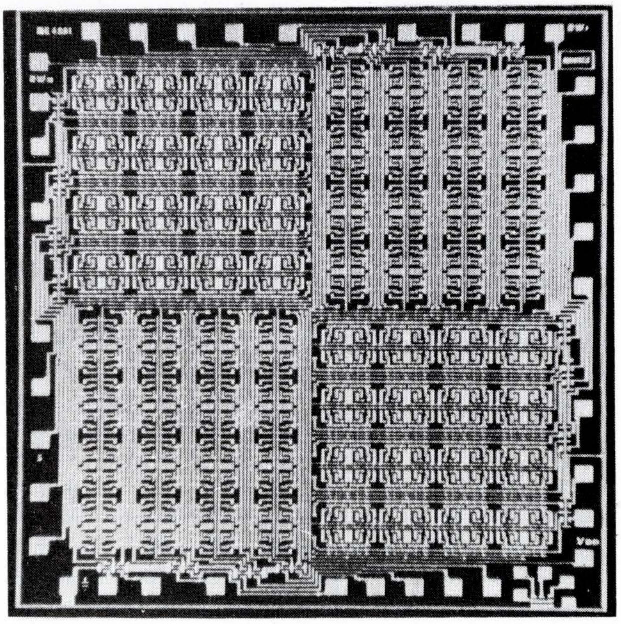
The RAM with full decode has complete address decoding and buffering, data and control input buffering, and output buffering. In addition, it can accept TTL input signals and drive TTL outputs without any external resistors or other components. A static memory system would require no components other than the memory chips themselves. This simplicity of use, unfortunately, is not free. The price to be paid is speed and power. The speed has been reduced to about a 1.0-μs cycle time and 400 to 500 mW of power dissipation for the low-threshold version.



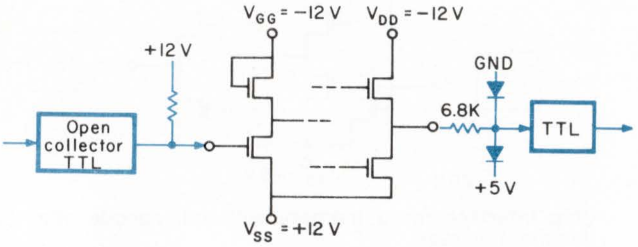
Chip interface for a memory with full decode and low threshold voltage.



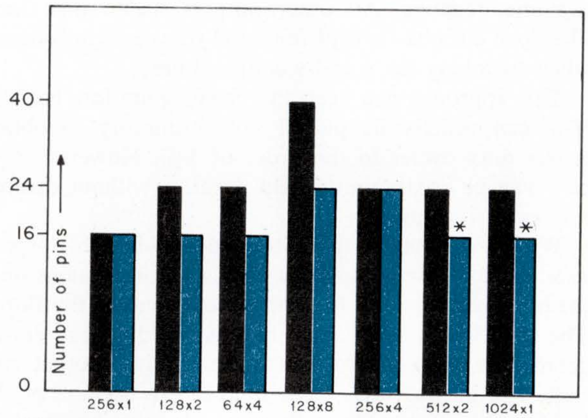
With V_{SS} equal to +5 V, a high threshold MOS RAM chip can drive TTL directly. However, the input does require level shifters.



Microphotograph of a high-speed RAM.



By connecting V_{SS} to +12 or +15 V, you can use an open collector TTL to drive the high threshold MOS RAM. The resistor and diodes on the output protect the TTL from overdrive.



*These can be in a 16-lead DIP if two instead of three supplies are used. The speed-power product would suffer by a ratio of two or three to one.

The speed can be improved to about 0.5 μs by combining a high-threshold process and correspondingly large supply voltages at the cost of increased power (about 600 mW), and using external rather than internal interface components. There are at least two ways to handle the interface problem. First, if the substrate voltage, V_{SS}, is connected to +5 V, then the outputs can drive TTL with no external components. The inputs, however, will require level shifters that can swing between +5 and all least −5 V. A second approach connects V_{SS} to +12 or +15 so that open-collector TTL can drive the inputs. Each MOS output must now have a 6.8-KΩ resistor in series with the output pin with one or two diodes to protect the TTL from overdrive. The best approach depends on the power supplies available and the total number of inputs vs outputs in a given system.

This high complexity chip is only slightly larger than the high-speed RAM because of the smaller cell; it does not have to drive the outside world directly. The organization, 64 words by 4 bits, compromises between package (which is a 24-lead DIP), layout, and speed. A 256 by 1 organization, while offering a smaller package, requires a small MOSFET within the cell to discharge a capacitance almost four times that in the 64 by 4. A 128 by 2 organization is no more attractive as it will not fit into a smaller package. A 32 by 8 organization requires a larger package, probably a 40-lead DIP, with no significant improvement in speed but a significant increase in power due to the number of input and output buffers required. A complex, though less sophisticated, tester than that required for the high-speed RAM would be used that could accomplish 100% testing (including speed), on a completely automatic basis.

Even though this RAM has the same chip size and package size as the high-speed RAM with decode, it costs somewhat less because the thin-oxide area is significantly less.

Large dynamic RAMs

A dynamic RAM would have its input address lines fully decoded, either with or without input buffering depending on the speed desired. Likewise, the outputs could be completely buffered and capable of driving TTL directly. Current sense outputs can provide higher speed, although the output current would probably not come directly from the cell as in the high-speed RAM.

A high-speed version—no input buffering and current sense outputs—would probably have an access time in the order of 0.5 μs and power consumption of <100 mW. A low speed version—full input and output buffering—would probably be no slower than 2.0 μs but would have power consumption in the range of 500 to 600 mW.

The dynamic cell, usually three small MOSFETS, forms half of what amounts to a cross-coupled flip-flop, or half of a clocked, 1-bit shift register recirculating upon itself. In a 1024-bit, dynamic RAM, 32 cells in a column would share the "refresh" circuit at the top of the column. This refresh circuit forms the other half of the 1-bit shift register. Only the cell in the selected *row* can be connected to the refresh and read-write circuitry, and only the cell in the selected *column* is connected to the read-write circuit. The result is that all cells in a selected row are refreshed even though only the cell in the selected column can be read from or written into. Although this means that the RAM can be refreshed in 32 refresh

(*Continued on page* 81)

MOS BRIEF 12

Gene Carter
National Semiconductor

MOS goes bipolar

MOS GOES BIPOLAR

MOS shift registers and read only memories in the National Semiconductor product line have been bipolar compatible since we began manufacturing MOS. Some devices are more compatible than others. It is all a matter of degree. In this brief, we show what voltage levels are required on each pin of the device and what must be done to interface with bipolar circuits.

There have been many questions about applying negative voltages to the input and high voltages (+10 or +12 volts) to the output of a TTL or DTL device. It is true that the bipolar data sheets do not guarantee this operation. Part of the reason being that the situation had not occurred previously. When a negative potential is applied to the input of the TTL/DTL device, it is clamped to one diode drop below ground. The current is limited by the output transistor in the MOS device to about 5 mA or by the external pull-down resistor to 1.6 mA. Since the input clamp diode can handle at least 10 mA this will cause no trouble in the system.

When a high positive potential (+10V to +12V) is applied to the output of a TTL device, two precautions should be taken: either use a series 54/74 device that has a reverse biased diode in the active pull-up, or use an uncommitted collector output. If the maximum breakdown voltage of the device is exceeded (it probably will not be on our TTL devices), the output will go into a non-destructive breakdown mode. The output will assume the LV_{CEO} voltage level of the output transistor as long as the current is limited. For those customers that are still concerned about these operating characteristics, we have two TTL devices guaranteed to have 14 volt breakdown voltage output. They are the DM8810 Quad 2 Input Gate and the DM8812 Hex Inverter Gate.

The voltage required on each pin of our standard product line is shown in this brief. Also included are logic diagrams showing the recommended methods of combining MOS and bipolar circuits in a system. New products will be added as they become available.

DEVICE	CONDITION LOGIC LEVEL	PIN NO. 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	FIGURE NO.
MM400/500, 401/501, 402/502, 403/503, 406/506, 407/507	"0" min	+7.5	+2.5	+10.0		+10.0	+2.5	+7.5																		1 (freq = 1MHz)
	"1" max	+3.0	+0.4	−6.0		−6.0	+0.4	+3.0																		
	Power Supply				+10.0				GND																	
MM400/500, 401/501, 402/502, 403/503, 406/506, 407/507	"0" min	+2.5	+2.5	+5.0		+5.0	+2.5	+2.5																		2 (freq < 750 kHz)
	"1" max	+0.8	+0.4	−12.0		−12.0	+0.4	+0.8																		
	Power Supply				+5.0				−5.0V																	
MM410/510	"0" min	+7.5	GND	+2.5	+10.0		+10.0	+2.5	GND	+7.5																3
	"1" max	+3.0	+3.0	+0.4	−6.0		−6.0	+0.4	+3.0	+3.0																
	Power Supply					+10.0					−6.0															
MM4015/5015	"0" min	+3.0	+3.0	+2.5	+3.0	+3.0	+2.5	+3.0		+3.0	+2.5	+5.0	+5.0	+2.5	+2.5	+2.5										4
	"1" max	+1.0	+1.0	+0.4	+1.0	+1.0	+0.4	+1.0		+1.0	+0.4	−12.0	−12.0	+0.4	+0.4	+0.4										
	Power Supply								+5.0								−12.0									
MM404/504, 405/505	"0" min	+7.5	+2.5	+10.0			+2.5	+7.5																		5
	"1" max	+3.0	+0.4	−6.0			+0.4	+3.0																		
	Power Supply				+10.0	−6.0			GND																	
MM408/508	"0" min	+2.5	+2.5	+2.5	+2.5	+2.5	+2.5		+7.5	+7.5	+10.0	+2.5	+2.5													6
	"1" max	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4		+3.0	+3.0	−6.0	+0.4	+0.4													
	Power Supply							+10.0						−6.0												
MM409/509	"0" min	+2.5	+10.0	+7.5	+7.5	+7.5	+7.5		+7.5	+7.5	+7.5	+7.5	+7.5													7
	"1" max	+0.4	−6.0	+3.0	+3.0	+3.0	+3.0		+3.0	+3.0	+3.0	+3.0	+3.0													
	Power Supply							+10.0						−6.0												
MM421/521	"0" min	+10.0	+10.0	+10.0	+2.5	+2.5	+2.5	+2.5		+10.0	+10.0		+10.0	+10.0	+10.0											8
	"1" max	+4.0	+4.0	+4.0	+0.4	+0.4	+0.4	+0.4		+4.0	+4.0		+4.0	+4.0	+4.0											
	Power Supply								+12.0			−12.0					GND									
MM422/522	"0" min	+10.0	+10.0	+10.0	+2.5	+2.5	+2.5	+2.5	+2.5	+2.5	+2.5	+2.5		NC	+10.0	+10.0	+10.0		+10.0	+10.0	+10.0	+10.0	+10.0	+10.0		9
	"1" max	+4.0	+4.0	+4.0	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4			+4.0	+4.0	+4.0		+4.0	+4.0	+4.0	+4.0	+4.0	+4.0		
	Power Supply												+12.0					−12.0							GND	
MM423/523	"0" min	+10.0	+10.0	+10.0	+2.5	+2.5	+2.5	+2.5	+2.5	+2.5	+2.5	+2.5		+10.0	+10.0	+10.0		+10.0	+10.0	+10.0	+10.0	+10.0	NC	NC		10
	"1" max	+4.0	+4.0	+4.0	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4	+0.4		+4.0	+4.0	+4.0		+4.0	+4.0	+4.0	+4.0	+4.0				
	Power Supply												+12.0				−12.0								GND	

MOS BRIEF 12 MOS GOES BIPOLAR Write: National Semiconductor Corp. 2900 Semiconductor Drive, Santa Clara, California 95051

MOS goes bipolar

MOS/TTL interface connection diagrams

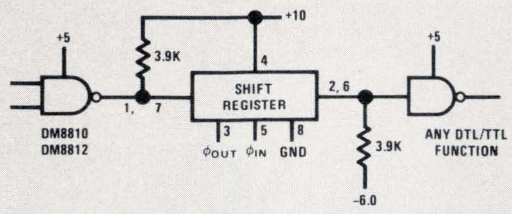
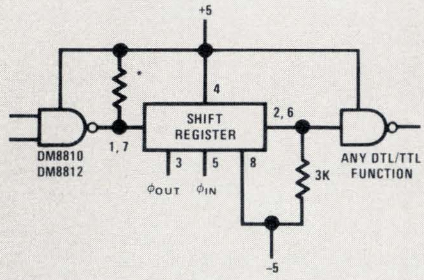


FIGURE 1



*Resistor optional.

FIGURE 2

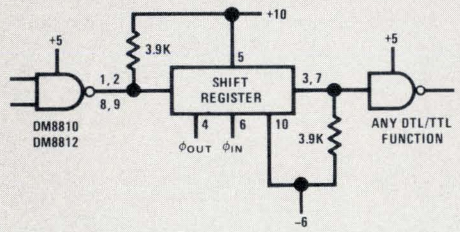
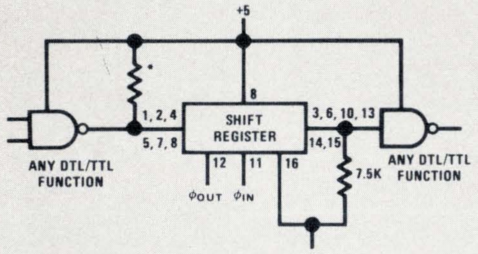


FIGURE 3



*Resistor optional.

FIGURE 4

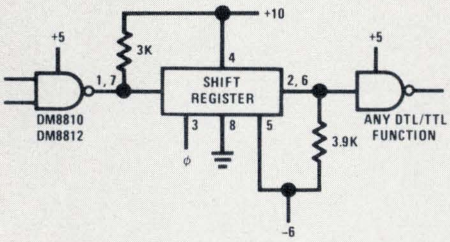


FIGURE 5

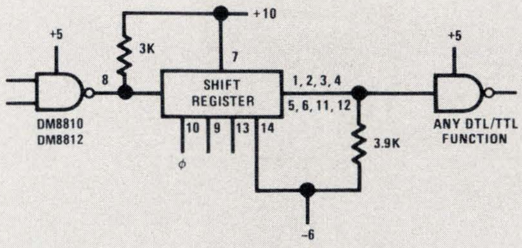


FIGURE 6

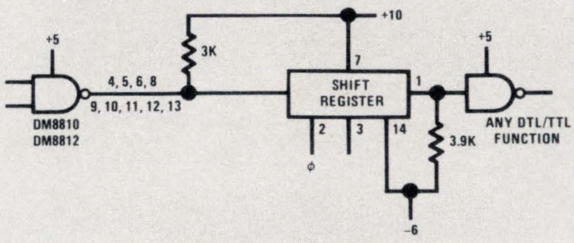


FIGURE 7

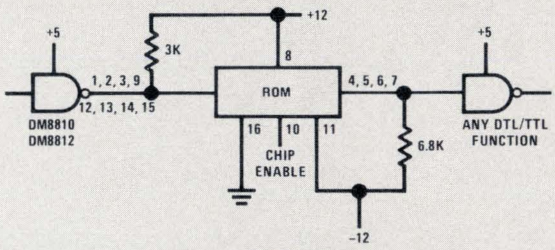


FIGURE 8

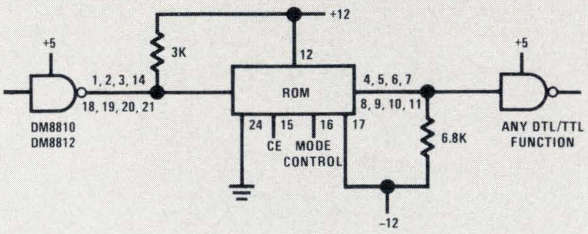


FIGURE 9

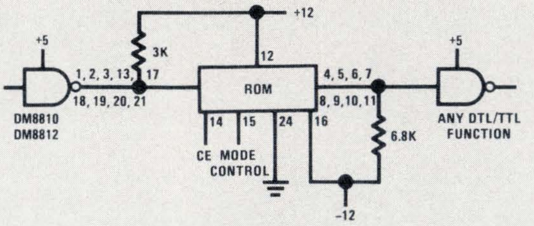


FIGURE 10

National Semiconductor Corporation
2900 Semiconductor Drive, Santa Clara, California 95051
(408) 732-5000 / TWX (910) 339-9240

3-70 PRINTED IN U.S.A.

Comparison of Characteristics

RAM Type	Organization	Speed	Power	Complexity	Package (DIP)	Cost per bit Today	Cost per bit Projection
H.S. RAM	256 x 1	50 -200 ns	500 mw/5mw	Low	40	10-12¢	5¢
H.S. RAM with partial decode	256 x 1	200-300 ns	500 mw/5mw	Medium	24	10-12¢	5¢
RAM with full decode	64 x 4	0.5 μs-1.0 μs	600-400mw	High	24	7-10¢	3¢
Dynamic RAM	1024 x 1	0.5 μs	100 mw	Medium	16	3¢	1¢
	256 x 4	2.0 μs	500 mw	High	24	5¢	2¢

cycles (which may also be read and write cycles), it also means that entire memory cannot be refreshed at once. It is possible to have a refresh cycle going on inside the chip which would function during memory standby time.

The simple cell reduces the high-speed version of the dynamic RAM to a medium complexity chip. The fully buffered, lower speed version, with its automatic refresh feature, would be a high complexity chip. The low-speed version would offer the advantage of a 16-lead DIP if the same pin could be used for both input and output data flow. Even the high-speed version, with its simplified inputs and outputs, would be a large chip. The fully buffered version would probably push the upper limits of practical chip size.

Testing would be difficult. Not only would the input timing and data patterns be complex, but the testing of the automatic refresh feature would involve a large amount of test time for each chip.

A dynamic RAM of 1024 bits would cost more per chip than any of the smaller RAMS. The cost per bit, however, would be significantly less.

Memory organization

The basic organization of most memories usually conforms to binary word and bit lengths. The most convenient, from the users' standpoint, is probably X words by 1 bit for an X-bit RAM. This is also the optimum organization for keeping the pin count to a minimum if the chip is fully decoded. However, circuit layout and performance limitations often dictate other organizations, such as X/2 by 2 or X/4 by 4.

Organizations of X/8 by 8 and beyond usually become impractical due to power (more input and output buffers) and pin count considerations. A change from X by 1 to X/2 by 2 can usually be accomplished without sacrificing too much in terms of pin count (one additional pin). This can mean a significant increase in speed because the small, high resistance devices inside the cell now have about half the capacitance to discharge.

The change from X/2 by 2 to X/4 by 4 will not gain the circuit designer quite as much speed as does the change from X by 1 to X/2 by 2 due to the other propagation delays within address decoder and output buffers. The X/4 by 4 may be necessary to gain the required speed but it will most certainly need a larger (and more expensive) package as a result.

Summary

Of the four RAMs outlined here, the most popular are the "RAM with full decode" and the "large dynamic RAM." The reasons are the simplicity of application and the lower cost per bit, respectively. The "high-speed RAM" is, by far, the fastest and offers the lowest power dissipation, but at the cost of increased complexity of the peripheral circuitry. The "high-speed RAM with partial decode" is a compromise between lower complexity in the surrounding circuitry and speed (although the speed is not much slower than the "high-speed RAM" when TTL decoding and sensing is used).

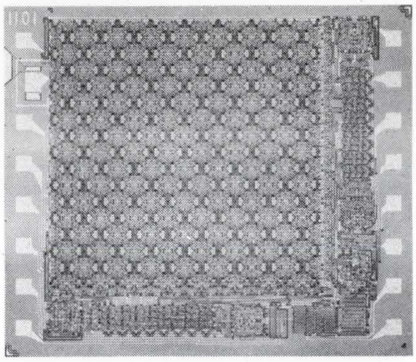
Many combinations of the illustrated trade-offs are possible. In fact the large MOS RAM user can have a RAM chip tailored to fit his system requirements, provided that he is aware of the limitations and advantages of each approach.

INFORMATION RETRIEVAL

Digital design, Integrated circuits, Computers and peripherals

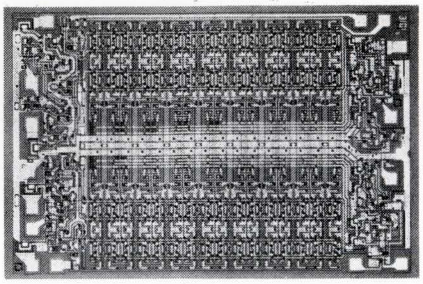
Had enough talk about LSI memories?

Incomparable 256-bit MOS RAMs



In volume production since August 1969. Intel's Model 1101 is a fully-decoded silicon-gate MOS device with 1.5 μsec maximum cycle time. Drives DTL and TTL logic directly. Has OR-Tie capability. Dissipates only 50 μW per bit on standby and 2 mW per bit during access. Packaged in 16-lead DIPs. Intel can begin immediate delivery to you in production volume at a price of about 6¢ per bit.

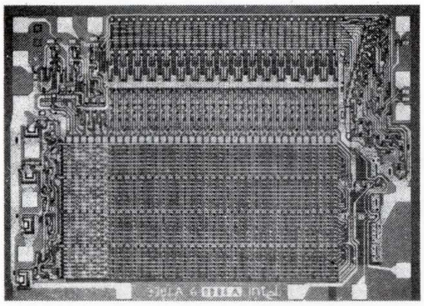
Fast 64-bit bipolar RAMs



Intel's Model 3101 has been in volume production since September 1969. It's a fully-decoded Schottky-process bipolar RAM with fast 60 ns maximum access. Compatible with DTL and TTL logic. Has OR-Tie capability. Dissipates 6 mW per bit. Packaged in 16-lead DIPs. Immediate delivery in production volume at a price of about 25¢ per bit.

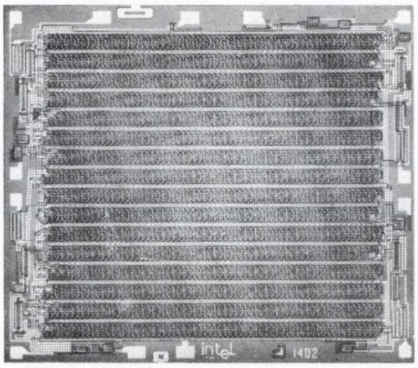
Here's the real thing in volume!

Big 1024-bit bipolar ROMs



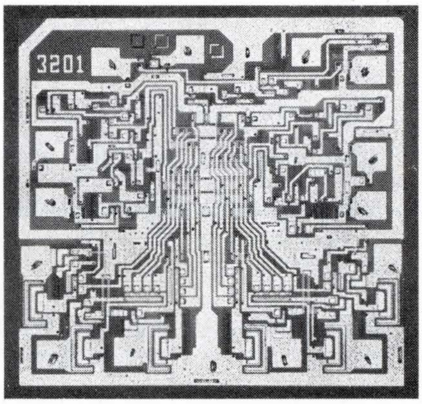
Intel's Model 3301 has been in volume production since December 1969. It's a Schottky-process bipolar ROM with 60 ns maximum access. Supplied in 16-lead DIPs that combine to form memories storing 1024 words of any length. Intel can deliver custom 3301's to match your truth table in 4 to 6 weeks at a price of about 2¢ per bit in production quantities.

Ultra-fast 1024-bit shift registers



In production and in stock right now. They're silicon gate MOS devices with five times the speed (5 MHz) and twice the bit capacity of any others. A single TO-5 holds one long 1024-bit register (Model 1404) or two 512-bit registers (Model 1403). And there's a 16-lead DIP that holds four 256-bit registers on one chip (Model 1402). Clock capacitance is a low 140 pF. Power dissipation is only 500 mW at 5 MHz, dropping to 200 mW at 1 MHz. Input and outputs are DTL and TTL compatible. These registers (plus a dual 100-bit register with similar characteristics) are available immediately in volume for about 1½¢ per bit.

Hard-to-get custom MSI's



Intel's advanced high-yield technologies (like the Schottky process for bipolars and the silicon gate for MOS devices) produce custom MSI's fast and dependably. You can get delivery of parts within 4 to 6 months after you place the order. Intel can meet or beat anyone's specs, and prototype development is free.

intel™ **Phone now.** Call your local Intel distributor: Cramer Electronics or Hamilton Electro-Sales. Or call us collect at (415) 961-8080. Intel Corporation is at 365 Middlefield Rd., Mountain View, Calif. 94040.

intel delivers.

Frequency synthesizing with the Phase Locked Loop

The advancement of IC technology has made phase locked loop circuits feasible. Here the phase locked loop is the basis for a new, somewhat unconventional digital frequency synthesizer design.

By Ed Renschler and Brent Welling,
Motorola Semiconductor Products Inc., Phoenix, Ariz.

Once it is understood, the principle of the phase-locked loop has many applications. An ideal application is a multichannel frequency synthesizer, because many precise frequencies can be generated with only one reference frequency.

With more and more versatility being offered by ICs, we decided to take a fresh look at normal digital frequency synthesizer designs. We chose a portion of an aircraft communications band synthesizer system as a test vehicle for this study. This system, which uses monolithic ICs wherever possible, has the following specifications: freq. range, 116.000-136.000 MHz; channel spacing, 50 kHz (400 channels); ref. freq. sideband level, −66 dB; ref. freq. harmonic sideband level, −70 dB; spurious sideband level, —60 dB; power output (min.), 2mW.

System considerations

The frequency going into the variable counter (Fig. 1) must be N times the frequency at the reference input of the phase detector. To achieve the design goals, the variable counter must be externally programmable over 400 different counting states. We must now consider two things:

- The variable counter must function at a worst case rate of 136.0 MHz.
- Stability of the frequency reference (and phase) at the input of the phase detector is the key to the system's frequency stability.

The first is the real problem area. Making a 9 to 12 bit counter, (depending upon counting method used) operate at a clock rate of 136 MHz is a big problem. To solve it we decided that the VCO's output frequency (116-136 MHz) should be counted down by a high speed decade counter to yield 11.6-13.6 MHz, a less restrictive frequency range.

Stability of the reference is easily solved by using a crystal controlled reference oscillator (Electronic Research Co., Model 800 TS3 703-B-4), which provides a 10 MHz reference frequency with a long term stability of 4 parts in 10^8.

To further reduce clocking requirements of the programmable counter, we mixed the reference frequency with the 11.6-13.6 MHz frequency and used the difference (1.6-3.6 MHz), for the counter clock.

To obtain 400 channels in a frequency spectrum of 1.6-3.6 MHz, the channel spacing must be 5 kHz at the counter, or 50 kHz at the VCO—as desired. It follows that a 5 kHz highly stable frequency reference is needed at the input of the phase detector. This can be obtained by dividing the 10 MHz frequency by 2000.

Another problem with the simplified diagram is that when a new channel is dialed into the counter, the VCO will sweep until it reaches phase lock once again. This could cause considerable interference to be transmitted during sweeping time. Thus when an out-of-lock condition exists, the output rf amplifier is gated off, and remains off until phase-lock is once again established.

One last point of interest is the VCO tuning voltage

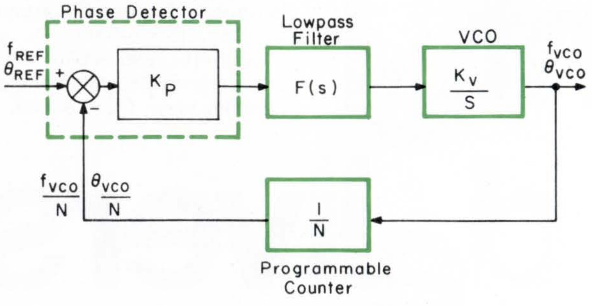


Fig. 1: Linearized phase-locked loop model.

Basic analysis of a phase-locked loop system*

In a basic system, the phase detector will generate a voltage proportional to the phase difference between output and reference frequencies. The detector's output voltage is filtered to remove all time variant components before it is applied to the voltage controlled oscillator (VCO). Since the VCO generates a frequency proportional to its input voltage, any ripple appearing on the control voltage will frequency modulate the VCO.

This system may be analyzed like any feedback control system with the understanding that the phase (θ) is the variable of interest. As was just discussed, the phase detector will generate a control voltage proportional to the phase difference as

$$V_C = K_p\,(\theta_{REF} - \theta_{VCO}) \text{ volts,}$$

where K_p is the proportionality constant in volts/radian, and $(\theta_{REF} - \theta_{VCO})$ is the phase difference in radians.

When f_{VCO} and f_{REF} are not the same, the control voltage produced by the phase detector will cause the VCO to sweep in frequency. While the VCO is sweeping, there will be an instant when

$$f_{VCO} = f_{REF}.$$

When this condition exists, phase lock is established.

The basic system will generate a single (reference) frequency. This is an example of a phase-locked loop used as a very selective, low noise filter. If you want the system to generate more than one stable output frequency without using multiple reference crystals, you can insert a variable counter[1] in the feedback loop.

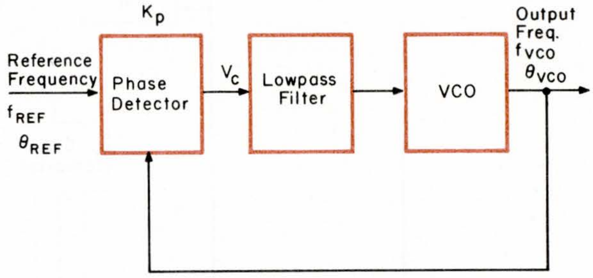
The operation of this modified system is identical to that of the basic system except that the VCO control voltage now is

$$V_C = K_p\,(\theta_{REF} - \frac{\theta_{VCO}}{N}),$$

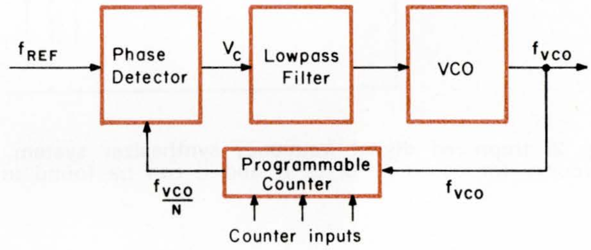
where N is the number programmed into the variable counter[1]. From this last equation the range of allowable numbers in N determines the number of finite control voltages, which in turn specify the number of controlled output frequencies obtainable. Also, each of these frequencies, once phase-locked, will be phase coherent with the reference crystal and thus have the same stability as the reference. From the diagram, for phase lock to occur, we must have:

$$f_{REF} = \frac{f_{VCO}}{N}$$

That is, the VCO frequency must be the divide ratio (N) times the reference frequency:



Basic phase-locked loop system.



Multiple channel phase-locked loop system.

$$f_{VCO} = Nf_{REF}.$$

From this it would appear that we could obtain any output frequency and any desired channel spacing, but practical considerations limit the use of this basic diagram.

The VCO's output frequency is proportional to the control voltage. However, in terms of phase, the VCO functions as an integrator. To illustrate this, consider the case when the phase detector's output $[\theta_{REF}(t) - \theta_{VCO}(t)]$ is a step function of voltage. This voltage drives the VCO, and causes a step change in the VCO's output frequency. Since frequency is the time rate of change of phase, the phase angle of the VCO output with respect to the reference phase will start to increase linearly at time zero and continue indefinitely like a ramp function. This ramp function-step function relationship illustrates the integrating operation of the VCO on phase changes in the system.

The VCO gain constant, K_V, is the sensitivity of the VCO to a change in the control voltage, V_C.

We can show that a phase-locked loop is nonlinear. However, if each subsystem is properly defined in a linear range, reasonably valid results can be predicted from the linearized model[2].

*For a comprehensive analysis of a phase-locked loop see Motorola Application Note AN463.

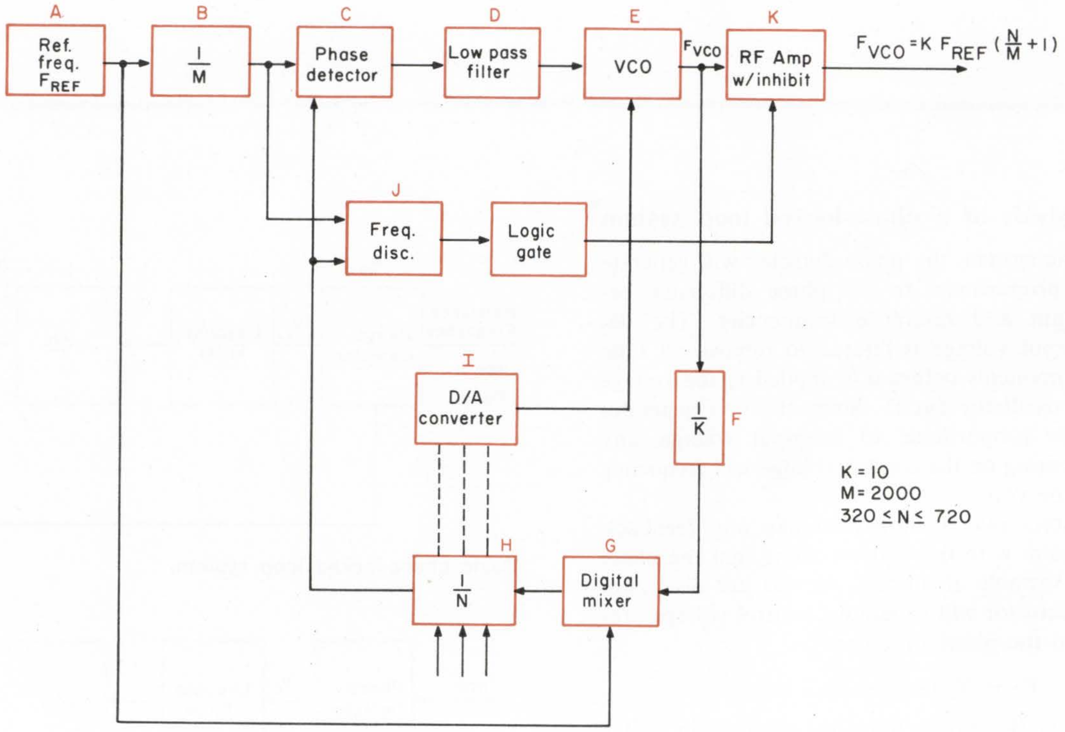
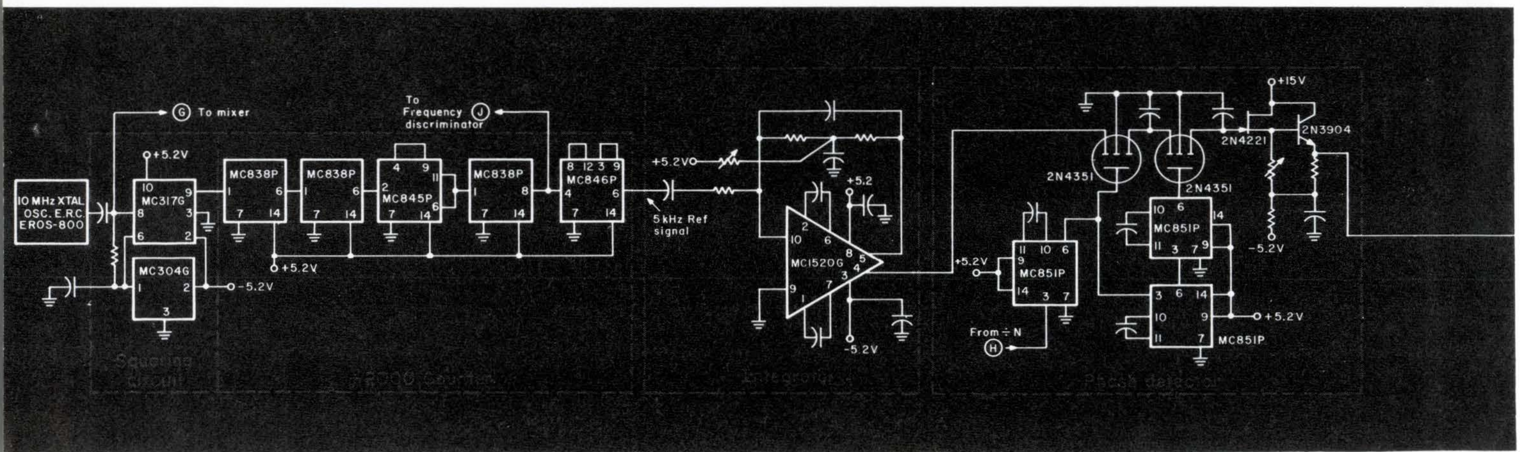


Fig. 2: Improved digital frequency synthesizer system. Circuitry for boxes A, B, C, D and E can be found in Fig. 3: boxes F and G in Fig. 6; box I in Fig. 7; box J in Fig. 8 and box K in Fig. 9.



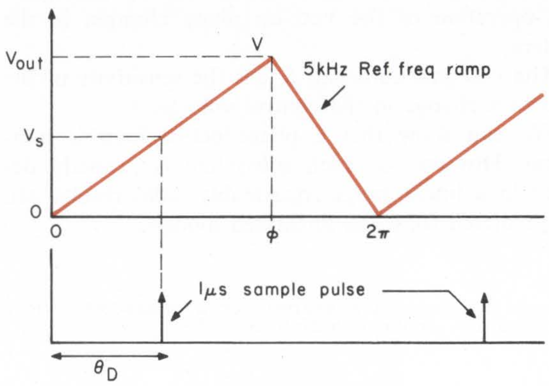


Fig. 4: Sampling timing diagram.

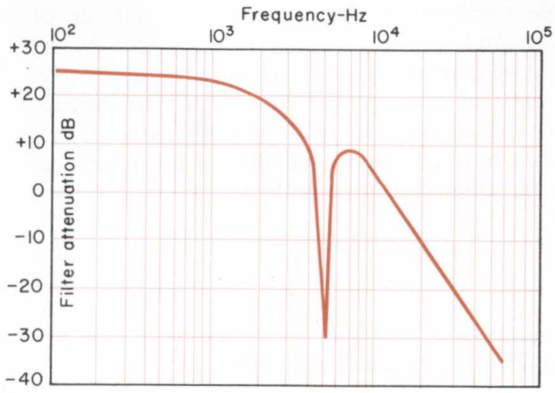


Fig. 5: Loop filter response.

range. The phase detector's output must generate a voltage that will cause the vco to sweep its entire 20 MHz band. This causes the vco sensitivity (K_V) to be very high, making the filter requirements much more severe and the loop stability marginal. In addition, the vco will be susceptible to noise on its control line. To reduce this sensitivity, a D/A converter pretunes the vco to within ±1 MHz of the correct frequency. (The converter obtains its input from the programmable counter control logic.) In this way, the full output of the phase detector is used only to fine-tune and establish phase lock, reducing the sensitivity by a factor of 10.

System design details

A more detailed diagram of the system is shown in Fig. 2. Each block is identified by a letter.

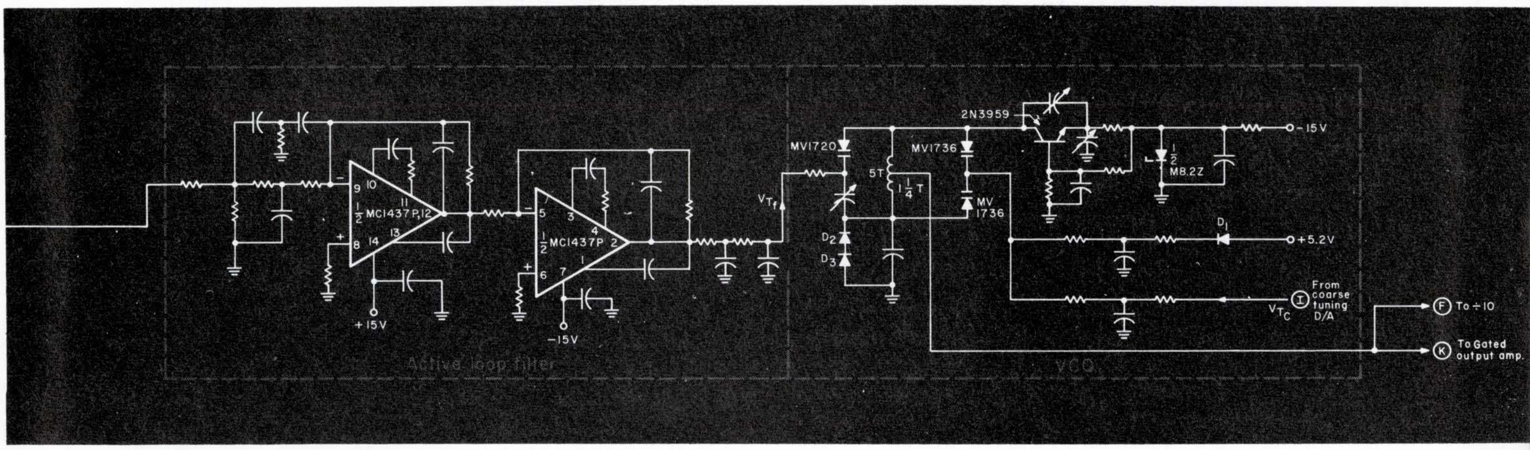
(A) The reference frequency is obtained from a 10 MHz crystal oscillator that is enclosed in a temperature controlled environment.

(B) It is necessary to have a 5 kHz reference frequency, with crystal accuracy, available for the phase detector and frequency discriminator. To obtain this 5 kHz reference, a divide-by-M (M = 2000) counter is needed. Since the frequency of the reference is within the frequency of operation of medium-speed saturated logic, it is convenient to use MC838P packaged decade counters. The divide-by-2000 function is achieved using a MECL level translator to obtain saturated logic levels compatible with standard MDTL. The output from the divide-by-M counter is compatible with the phase detector and the frequency discriminator. Thus, further level translation is not needed.

(C) The phase detector is a sample-hold-delay-sample-hold configuration. One input comes from the op amp (MC1520G) integrator whose input is the 5 kHz reference frequency and whose output is a 5 kHz ramp.

The phase detector consists of two MOS transistors (2N4351), which perform the sampling function, two holding capacitors, a high dc input impedance (JFET) amplifier (2N4221), and three IC one-shots (MC851P) which perform the sample-delay-sample function. The sampled input is the 5 kHz reference ramp and the sampling frequency is the output frequency of the variable divider. Each of the one-shots has been adjusted by means of the 160 pF capacitor to give a period of 1 μs.

The phase detector operates as follows: The input waveform to be sampled is shown in Fig. 4. Assume that the variable divider's output is out of phase with the reference frequency by a phase difference θ_D. Output of the divide-by-N counter triggers the first one-shot. This one-shot samples the reference frequency ramp for 1 μs placing voltage V_S on the first capacitor. At the end of this sample time, the first MOS transistor turns off and holds V_S on the first capacitor. Also, when the one-shot turns off, it triggers the second one-shot to produce a 1 μs delay. At the end of the delay, the third one-shot fires, turning on the second MOS transistor which transfers part of the charge of the first capacitor to the second capacitor. Since the capacitors are equal, the voltage on the second capacitor at the



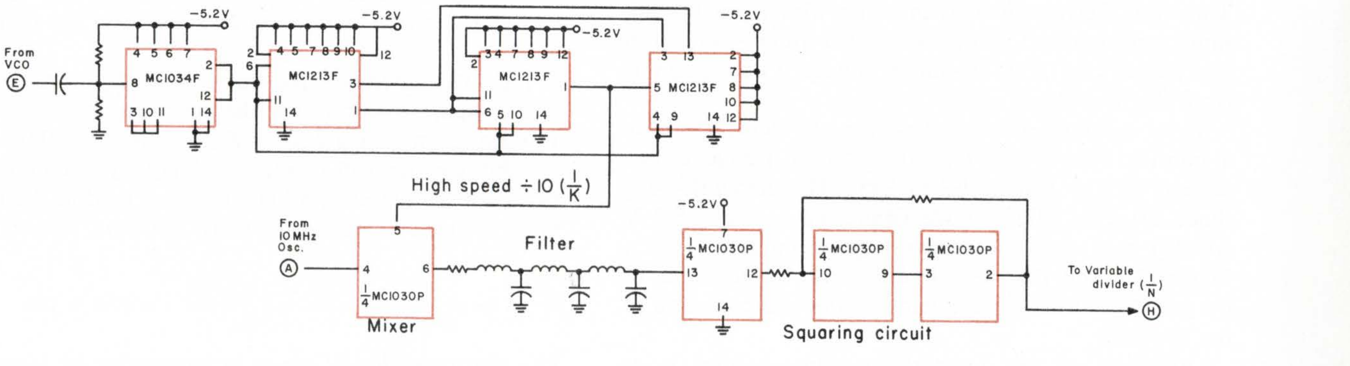


Fig. 6: High-speed divide-by-ten function. Four ceramic flat-pacs were used, with care taken in the layout.

end of this sample time is about $\frac{V_S}{2}$. The sampling process continues step wise until the desired dc voltage is reached. As the phase difference changes, the sampling pulse will ride up and down the reference frequency ramp from 0 to V volts. Phase difference needed to make this excursion is θ radians. The output voltage can be related to the phase difference by the slope of the line from 0 to θ. Thus, as a first order approximation, the static output voltage will be given by

$$V_S = \frac{V}{\phi} \times \theta_D \cdot \tag{1}$$

For this particular system, $V = 1$ V and $\theta = \frac{3\pi}{2}$.

Thus,

$$K_P = \frac{V}{\phi} = \frac{2}{3\pi} \frac{\text{volts}}{\text{radian}} \cdot \tag{2}$$

The combination of the JFET source follower and the emitter follower provides an impedance transformation from about $10^9\ \Omega$ to $200\ \Omega$ to provide a low impedance source to the dc amplifier-filter network. We measured the reference ripple passing through this sample and hold phase detector along with the dc voltage and found it to be 10 μV. This method of phase comparison greatly relaxes the requirements of the low pass filter.

(D) The low-pass filter should provide two functions: (1) a dc gain of 15 (23.5 dB) to increase the VCO tuning voltage range from 0.9 to about 13 V, and (2) to further supress the 5 kHz reference ripple which can frequency modulate the VCO. The active filter[5] shown in Fig. 3 was chosen. Its response is shown in Fig. 5.

The VCO fine tuning voltage has now been increased to a dynamic range of 0 V to 13 V while the 5 kHz ripple has been attenuated 30 dB.

To further improve the system's performance and reduce the sideband levels, we could use a multiple notch filter. An active filter with notches at 5 kHz, 10 kHz, 15 kHz, and 20 kHz would reduce the sideband levels considerably.

(E) The system's VCO is a basic Clapp type using collector-to-emitter feedback in the common base configuration. With this configuration the frequency selective, high Q tank network can be in the collector circuit. An hf 2N3959 transistor is biased to a collector current of 0.7 mA giving a minimum f_T of 400 MHz. Voltage tuning is accomplished with three Epicap diodes in the tank circuit. One set of diodes acts as a course tuning control with the input voltage (V_{T_C}) generated by the D/A converter operating from the counter logic switches. The third Epicap diode is in series with a small trimming capacitor and is used as the fine tuning control in the phase loop with its input voltage (V_{T_F}) coming from the loop filter.

If we assume a linearized system, the VCO must have a constant sensitivity, K_V (the plot of frequency vs. tuning voltage should be linear). The network-using diode D1 (the silicon diode connected to the +5.2 V supply) was used to achieve a good linearity (5%). Diodes D2 and D3, were inserted into the low side of the tank circuit to provide temperature compensation to the oscillator.

Operation of this temperature compensation is as follows: as the temperature increases, the capacitance of the Epicap diodes increases and the frequency of oscillation decreases. However, as the temperature increases, the voltage drop across D2 and D3 in series decreases. Since the tuning voltage remains constant, the total voltage across the tuning diodes goes up, causing the capacitance to go down, ideally causing a zero net change in frequency. When measured over a range from 0° to 85°C, the maximum deviation with temperature was ±200 kHz.

(F) It is desirable to reduce the high-speed clock requirements of the programmable counter. To achieve this, we divided the VCO output (116-136 MHz) by ten (K = 10) and mixed the resulting frequency (11.6-13.6 MHz) with the crystal reference frequency (10 MHz). The difference frequency out of the digital mixer (1.6-3.6 MHz) is then used to clock the variable counter.

The first step in reduction of the VCO frequency requires a high-speed decade counter compatible with the VCO output. Two things point to use of an emitter-coupled current-mode counter:

- It is reasonably compatible with the VCO output signal.
- It must clock at about 140 MHz worst case.

We decided that the optimum arrangement would be to have one high-speed current-mode flip-flop (MC-1034F) operating in the toggle mode which will divide the 116-136 MHz down to 58-68 MHz, followed by a divide-by-five circuit, again using the MECL emitter coupled ICs. In this way, the clocking requirement of the divide-by-five counter is only 70 MHz instead of 140 MHz.

(G) The digital mixer circuit takes the output from the high speed decade counter ($\frac{F_{VCO}}{10}$ = 11.6-13.6 MHz) and mixes it with the crystal reference (F_R = 10 MHz) to obtain a difference frequency F_D as

$$F_D = \frac{F_{VCO}}{10} - F_R$$

$$F_D = (11.6 - 13.6\text{ MHz}) - 10\text{ MHz} \tag{3}$$

$$F_D = 1.6 - 3.6\text{ MHz}$$

which is suitable for clocking the programmable counter. There are several ways to perform this mixing action. One which seems to be satisfactory is the use of an exclusive-OR gate. When this function is analyzed it is found that the sum, difference, and a spectrum of harmonics are available at the output for two different frequency inputs. Hence, the difference frequency can be extracted by inserting a bandpass filter. The exclusive-OR digital mixer is simple, accepts digital inputs, and provides a digital output suitable to drive the variable counter.

(H) The difference frequency out of the digital mixer is the input frequency for the programmable counter. For Eq. 3, we have $F_{in} = F_D$ = 1.6-3.6 MHz. The variable counter will divide this input by a number N such that the output is 5 kHz, which is used as the sampling frequency input to the phase detector. Hence,

$$N = \frac{F_D}{5\text{ kHz}} = \frac{1.6 - 3.6\text{ MHz}}{5\text{ kHz}} = 320 - 720 \tag{4}$$

This illustrates that N varies in increments of 1 over a range of 400, which accounts for the 400 possible chan-

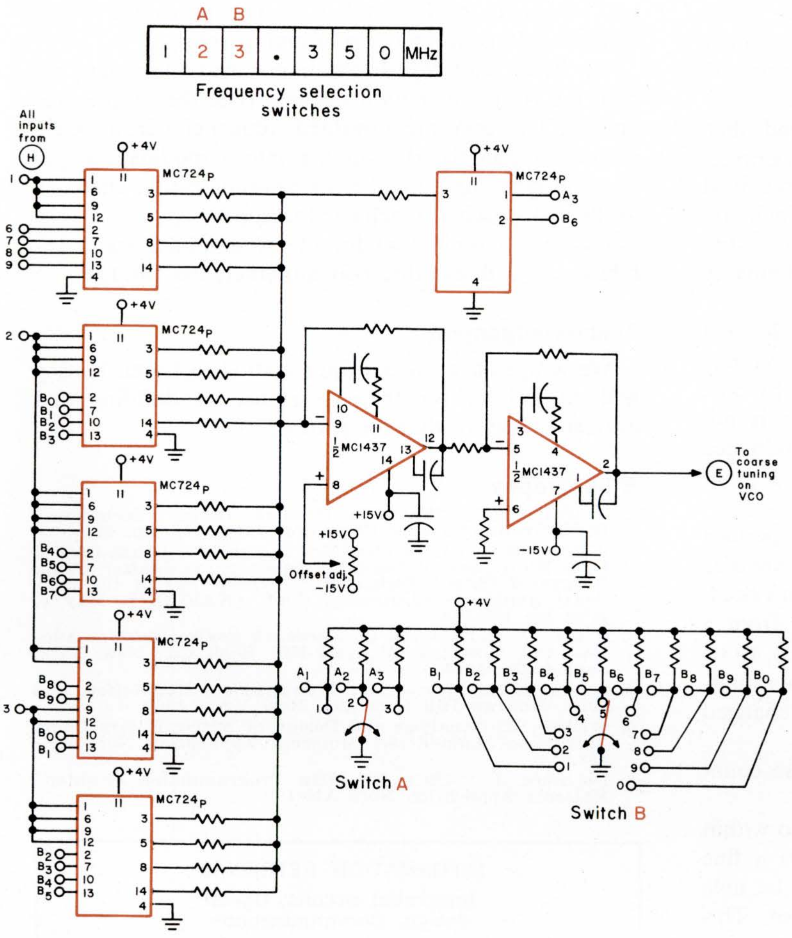


Fig. 7: **D/A converter** is a weighted resistor configuration. The input is obtained from the selector switches that program the variable counter.

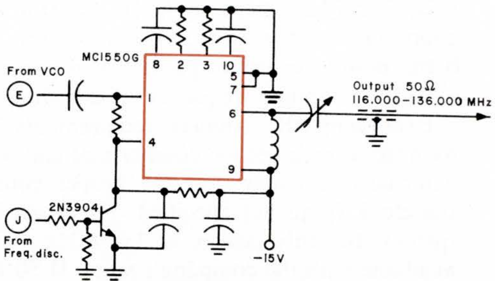


Fig. 9: Gated amplifier. This stage serves as a buffer between the output of the synthesizer and the system into which it feeds. It also lowers the output of the synthesizer at least 40 dB when the synthesizer is out of frequency lock. This is done by applying the logical output from the window detector to the 2N3904 transistor, as shown. When this transistor is turned on, it removes the dc bias from the amplifier, which causes the 40 dB reduction in output.

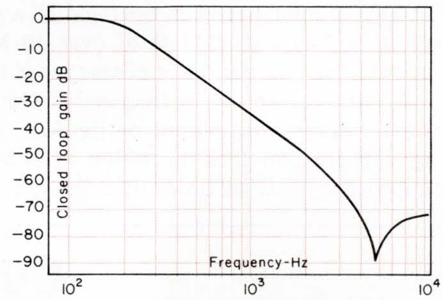


Fig. 10: Actual measured closed loop response. The measured damping coefficient of 0.55 indicates that very little overshoot is present, giving rise to a stable system with excellent transient response. Lock-up time is about 2 ms.

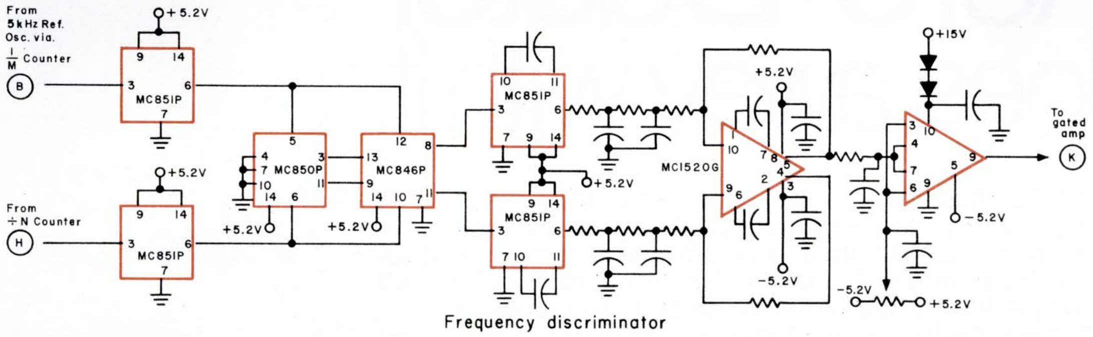


Fig. 8: Frequency discriminator. The criterion for determining out-of-frequency-lock is when the output of the variable-counter waveform crosses a reference point, going negative, more than once since the reference waveform has crossed a similar point going negative. Since only negative going transitions are of interest, the input MC851 one-shots are used which generate a 100 ns pulse to indicate each negative transition. When an out-of-frequency exists, a pulse is generated in the second MC851 which produces a 100 μs pulse. This pulse is filtered and applied to the input of a differential output op amp (MC1520). Output of the op amp drives a dual voltage comparator (MC1711) operating as a window detector. As long as the output from the op amp is zero plus or minus a small amount, it lies within the input window of the detector and the detector output is a logical "0". However, if the output of the op amp deviates from this window, as it will in an out-of-frequency condition, the detector output will be a logical "1". The logic output from the window detector is used to drive the inhibit gate of the output rf amplifier.

nels. For 5 kHz steps in F_D (K = 10 in the high speed counter), the steps in the vco output are 50 kHz, which is the desired channel spacing. This explains the use of a 5 kHz reference frequency in the phase detector.

Examining the counter requirements, we find that we need a three decade counter that can be programmed externally to count over the proper counting range at the clock frequency specified. The worst case clock frequency for this design is 3.6 MHz. The logic setup available with the company's MECL II 50 MHz divide-by N counter easily meets these counting needs.[6]

With this counter, a BCD equivalent of the decimal number N is initially preset into a three stage counter. Each clock pulse that arrives reduces the count by one. When a count of one is reached, a reset cycle is initiated, and at the zero count the number N is reloaded into the counter stages so that when the next clock pulse arrives, the counting sequence can begin again.

The counter, as designed, required two clock periods to achieve reloading, therefore, its counting capabilities are $2 \leq N \leq 999$ which well satisfies this system's need. The counter can also be programmed directly from a computer. It can allow its divide number input, N, to be changed while counting is in process, without miscounting, as long as the input number is not being changed during a reload period.

The counter has been operated in a worst case count of N = 2 at a clock rate of over 50 MHz.

(I) The D/A converter coarse tunes the vco to within ± 1 MHz of the final frequency. This requires a fine tune voltage—the output of the low filter—to be able to capture and lock-up within a 2 MHz range. This approach yields an order of magnitude improvement in vco sensitivity over a system that requires the phase detector voltage to be the sole tuning voltage.

(J) The frequency discriminator and logic gate inhibit the rf amplifier until the vco is at the proper frequency. This prevents unwanted frequencies from being passed through the rf amplifier into a modulating section and jamming a number of communication channels as the vco searches to achieve lock-up.

(K) The circuit used for the rf amplifier (with inhibit) uses a monolithic rf-if amplifier, the MC1550.

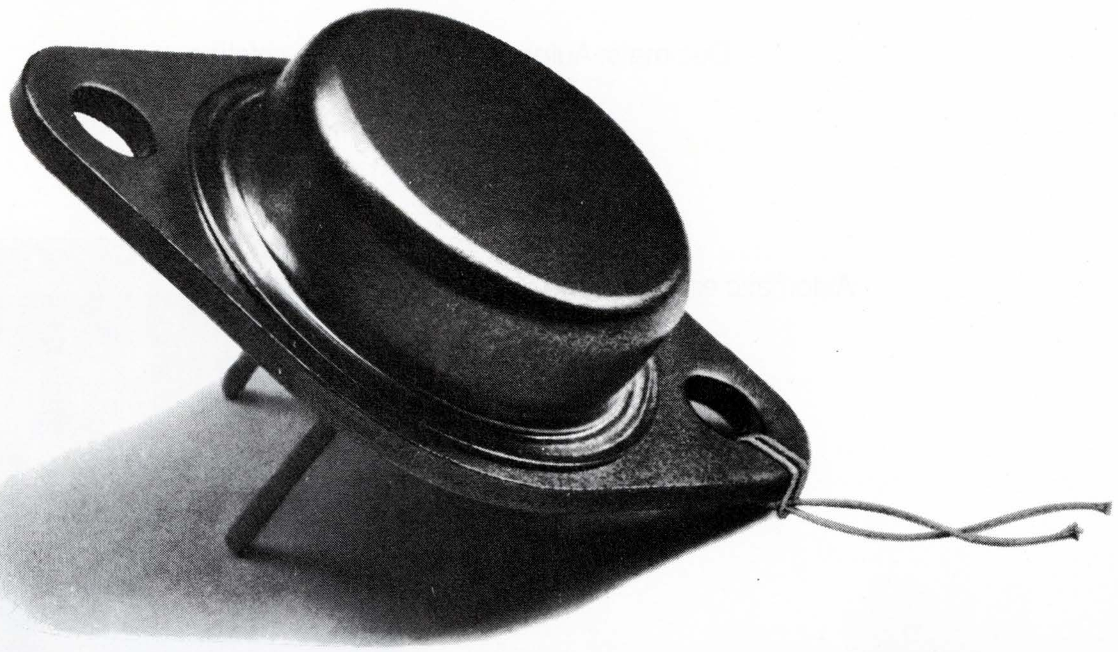
Acknowledgement

We wish to express our appreciation to Loren Kinsey and Al Collum for their assistance in building and evaluating the synthesizer system.

Bibliography

1. Renschler, E., "Variable Counter Design Technique", IEEE Transactions on Computer, July 1968, pp. 694.
2. Welling, B. and Renschler, E., "Design of a Phase-Locked Loop Multi-Channel Digital Frequency Synthesizer Using Integrated Circuit Technology", Proceedings of the National Aerospace Electronics Conf. (NAECON), May 6, 1968, pp. 123-129.
3. D'Azzo, J. and Houpis, C., *Feedback Control System Analysis and Synthesis*, McGraw-Hill Book Co., New York, Second Ed., 1966.
4. Schwartz, M., *Information Transmission, Modulation, and Noise*, McGraw-Hill Book Co., New York, 1969.
5. Welling, B., "Analysis and Design of Active Filters Using Operational Amplifiers," Motorola Application Note AN-438.
6. DeLaune, J. "MECL 50 MHz Programmable Counter", Motorola Application Note AN-456.

INFORMATION RETRIEVAL
Integrated circuits, Digital design, Communications



RCA's ESP (Exceptional Switching Performance) type 2N5805 and its companion 2N5804 are veritable "switch hitters" through an unusual combination of capabilities: *both transistor types have excellent current handling—at high voltage — in economic TO-3 packages.* For example, the 2N5805 can switch 375 volts and 5 amperes in less than 2 μs.

You'll find that for efficient and economical power conversions, these two new triple-diffused n-p-n units will excel for use in military and industrial applications.

Rounding out a transistor line that already makes RCA the industry leader in silicon power, these ESP devices—the 2N5804 (formerly TA7130) and 2N5805 (formerly TA7130A)—feature:

□ Current capability to 8 A
□ Controlled beta at 5 A
□ V_{CEX} — 375 V (2N5805); 300 V (2N5804)
□ V_{CEO} — 300 V (2N5805); 225 V (2N5804)
□ Fall time — 2 μs @ 5 A
□ Full safe area operating protection

If your requirements are for a high-voltage transistor family that has more than ordinary power, try RCA's new 2N5804 and 2N5805. As switch hitters, they're ideally suitable for such applications as: switching inverters, switching regulators, converters, solenoid and relay drivers, modulators, deflection amplifiers, and motor controls.

For more information on these and other RCA silicon power transistors, just contact your local RCA Representative or RCA Distributor. For technical information, write: RCA Electronic Components, Commercial Engineering, Section No. 65F/UT6, Harrison, N. J. 07029. In Europe: RCA International Marketing, S. A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

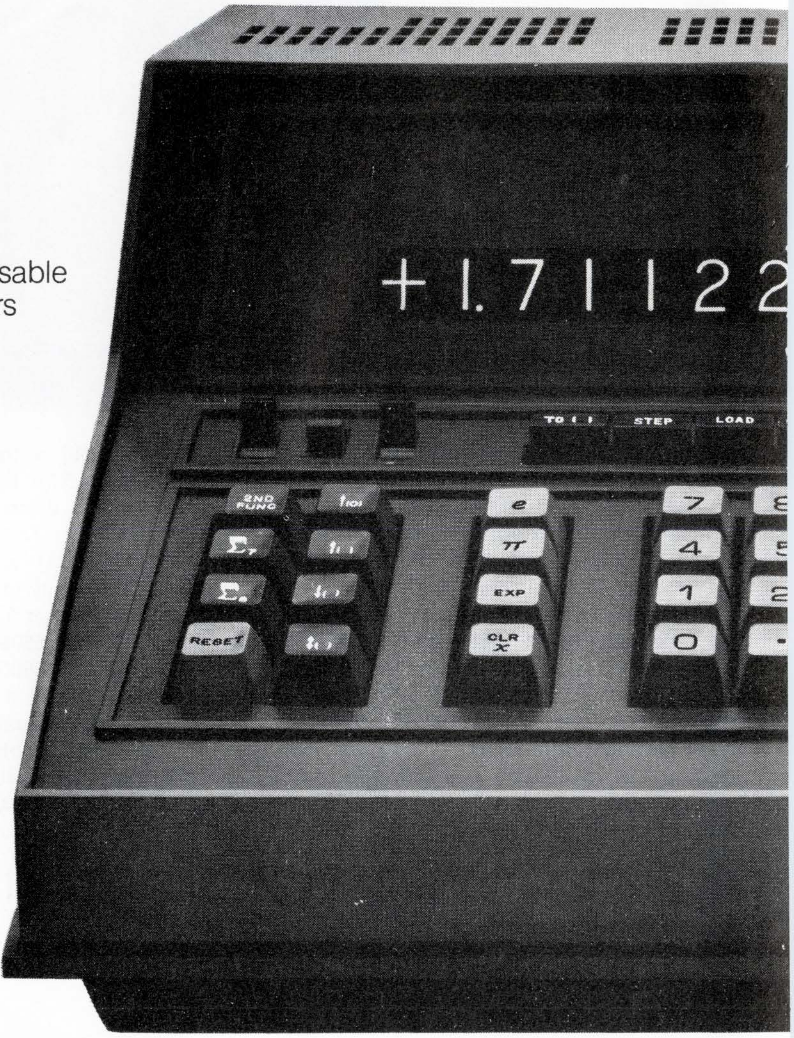
RCA

Decimals: Autopoint and scientific notation.

Automatic entry of e and π.

Ten directly addressable storage registers

Programming: Up to 128 steps. Conditional branching and automatic entry of programs with card reader.



Model 1655. Size: 13″ x 13½″ x 6½″.

Announcing an important breakthrough for engineers and scientists. Calculators based on the latest MOS/LSI technology. In both printing and display models. Available in over 350 cities coast to coast. And supported by more than 3,300 sales and service technicians.

Dynamic range: 10^{-99} to 10^{+99}

Automatic special functions:
a^x, Log_{10}/Log_e, SIN/COS,
SIN^{-1}/COS^{-1}, $\times!$, $\frac{1}{x}$,
Radians to Degrees,
Single key Σx, Σx^2, N,
Rectangular to Polar Conversion.

Just plug in
and put it to work.

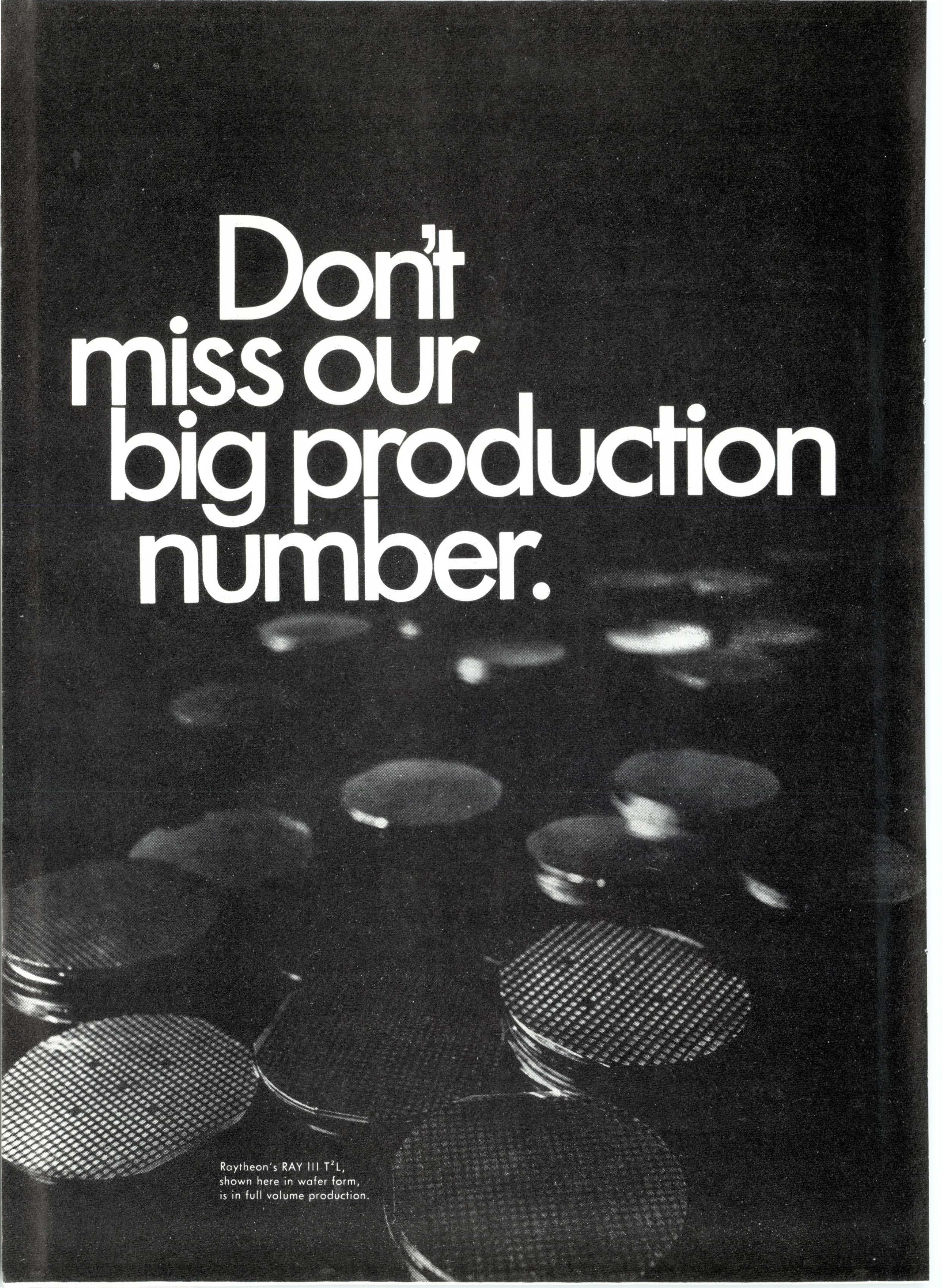
Weight: Twelve pounds.

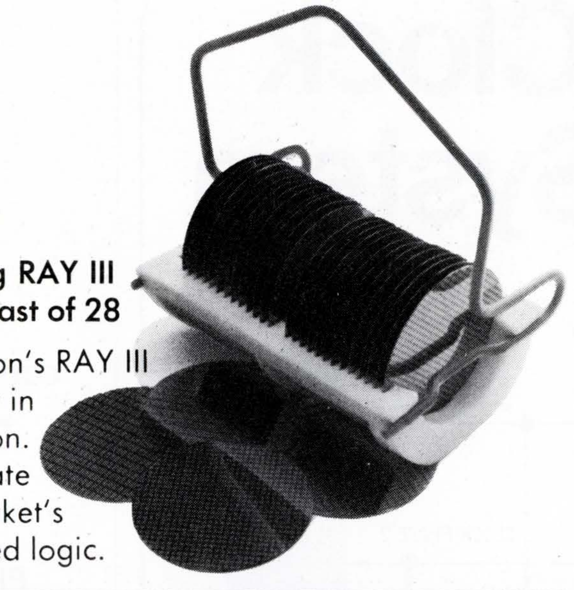
**Monroe men who provide
the most complete technical
hardware and software support.
Because calculators are their only business.
And our only business too.
That's how we got our name.
Monroe. The Calculator Company**

A DIVISION OF LITTON INDUSTRIES

550 Central Avenue, Orange, New Jersey 07050

Circle 42 on Inquiry Card


Don't miss our big production number.
Raytheon's RAY III T^2L,
shown here in wafer form,
is in full volume production.



Starring RAY III and a cast of 28

Raytheon's RAY III T^2L is now in volume production. With 28 separate functions, it's the market's fastest saturated logic.

RG3180	Dual 4-Input NAND Expander	RG3440	2-Wide 2-Input AOI Gate, Split Outputs
RG3200	Expandable Single 8-Input NAND Gate	RG3450	4-Wide 2-2-3-4 Input AOI Gate
RG3240	Dual 4-Input NAND Gate	RG3380	Hex Inverter
RG3260	Single 8-Input NAND Gate	RG3390	Dual 4-Input AND Gate, Split Outputs
RG3220	Quadruple 2-Input NAND Gate	RG3400	Quad 2-Input AND Gate
RG3320	Triple 3-Input NAND Gate	RG3410	Quad 2-Input NOR Gate
RG3420	Dual 4-Input NAND Gate, Split Outputs	RF3200	AND-Input JK Flip Flop
RG3430	Single 8-Input NAND Gate, Split Outputs	RF3210	OR-Input JK Flip Flop
RG3210	Expandable 2-wide, 4-Input AOI Gate	RF3120	Dual JK Flip Flop (Separate Clocks)
RG3230	4-Wide 2-2-3-3 Input AOI Expander	RF3130	Dual JK Flip Flop (Common Clock)
RG3250	Expandable 4-Wide, 2-2-2-3 Input AOI Gate	RF3220	Triple Flip Flop, Sep. Neg. Edge Clocks
RG3270	2-Wide, 4-Input AOI Expander	RF3230	60 MHz Dual-D Flip Flop
RG3300	Expandable 3-Wide, 3-Input AOI Gate	RF3240	Triple Flip Flop, Com. Pos. Edge Clock
RG3310	Dual 2-Wide, 2-Input AOI Gate, One Side Expandable	RF3250	5 Channel Selector Flip Flop

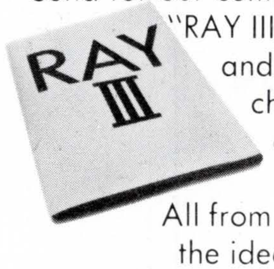
Catch the main feature

This third-generation T^2L is designed for new sockets needing higher logic speeds, or for upgrading existing systems. Either way you pay no design penalties.

At all temperatures it's nearly twice as fast (with 5 nanosecond gate delays, 9 ns flip flops) as 54H/74H, SUHL II and RAY II. But it takes no more power. Still only 22 mW per gate from a 5 volt supply.

And RAY III is function-compatible with all second-generation logic, pin-compatible with most. It gives you improved noise immunity, plus input clamping diodes. All types come in hermetic or plastic DIP's, or in flatpacks, and operate from −55° to +125°C. (Also available from 0° to +75°C.)

We wrote the script



Send for our comprehensive data book, "RAY III," with logic diagrams and schematics, electrical characteristics, test data and application notes on the whole line.

All from the company that gets the ideas and produces them. Raytheon Semiconductor, Mountain View, California. (415) 968-9211.

See it now at your neighborhood Raytheon distributor

Alabama
Huntsville
Cramer/Huntsville, Inc.
(205) 536-4493

Arizona
Phoenix
Avnet
(602) 272-6821

California
Culver City
Avnet
(213) 836-7200

Inglewood
Liberty Electronics
(213) 776-6252

Los Angeles
Kierulff Electronics
(213) 685-5511

Mountain View
Avnet
(415) 961-7700

Mountain View
Elmar Electronics
(415) 961-3611

Palo Alto
Kierulff Electronics
(415) 968-6292

San Carlos
Intermark Electronics
(415) 961-5222

San Diego
Avnet
(714) 279-1550

Colorado
Denver
Avnet
(303) 623-6255

Connecticut
North Haven
Cramer Electronics
(203) 239-5641

Florida
Fort Lauderdale
Cramer/Florida, Inc.
(305) 566-7511

Fort Lauderdale
Hallmark of
Ft. Lauderdale
(305) 563-3271

Orlando
Hallmark
Electronics Corp.
(305) 855-4020

Palm Beach Gardens
Industrial Electronics Assoc.
(305) 848-8686

Georgia
Atlanta
Cramer/Atlanta, Inc.
(404) 451-5421

Illinois
Rosemont
Hallmark Electronics
(312) 299-6602

Schiller Park
Pace/Avnet
(312) 678-6310

Kansas
Prairie Village
Avnet
(913) 362-3250

Maryland
Baltimore
Cramer/Baltimore, Inc.
(301) 354-0100

Baltimore
Radio Electric Service
Company of Baltimore
(301) 823-0070

Rockville
Cramer/Washington, Inc.
(301) 424-2700

Rockville
Pioneer Washington
Electronics
(301) 427-3300

Silver Springs
Radio Electric
Service Company
(301) 588-5140

Massachusetts
Burlington
Avnet
(617) 272-3060

Newton
Cramer Electronics
(617) 969-7700

Michigan
Detroit
Avnet
(313) 538-1000

Minnesota
Bloomington
Cramer Electronics
(612) 881-8678

Minneapolis
Avnet
(612) 920-5866

Missouri
St. Louis
Hallmark Electronics
(314) 521-3800

New Jersey
Jersey City
KRS Electronics, Inc.
(201) 435-3600

Pennsauken
Cramer Pennsylvania
(215) 923-5950

New Mexico
Albuquerque
Avnet
(505) 265-7926

Albuquerque
Century Electronics
(505) 265-7837

New York
Baldwin, L.I.
Hamilton Electro Sales
(516) 223-8000

East Syracuse
Cramer/Eastern, Inc.
(315) 437-6671

Elmhurst
Cramer/Esco, Inc.
(212) 478-4000

Great Neck, L.I.
Time Electronics Sales
(516) 487-0100

South Rochester
Cramer/Rochester
(716) 275-0300

Westbury, L.I.
Avnet
(516) 333-5800

North Carolina
Raleigh
Cramer/Raleigh, Inc.
(919) 876-2371

Ohio
Cincinnati
Cramer/Tri-States, Inc.
(513) 771-6441

Cleveland
W. M. Pattison
Supply Co.
(216) 441-3000

Pennsylvania
Hatboro
Avnet
(215) 052-6900

Pittsburgh
Cameradio Company
(412) 391-4000

Texas
Dallas
Avnet/Contact Electronics
(214) 638-2850

Utah
Salt Lake City
Cramer/Hyer
(801) 487-3681

Washington
Seattle
Avnet
(206) 623-8824

Seattle
Kierulff Electronics
(206) 763-1550

Wisconsin
Milwaukee
Hallmark Electronics
(414) 476-1270

Canada
Montreal
Avnet Electronics
of Canada, Ltd.
(514) 381-9127

Ottawa
Wackid Radio & Television
Labs, Ltd.
(613) 728-1821

Toronto
Avnet Electronics
of Canada, Ltd.
(416) 789-1838

RAYTHEON

Circle 44 on Inquiry Card

Here is your copy of a brand new reference chart sponsored by TELEDYNE PHILBRICK NEXUS

Guide to NONLINEAR MODULES

Tear it out,

NOW

. . . and mount it on your wall

If the chart has been removed, Circle Number 41 on the Inquiry Card for a copy.

READ THESE BOOKS

Management Information Systems Handbook: Analysis, Requirements Determination, Design and Development, Implementation and Evaluation

By W. Hartman, H. Matthes, and A. Proeme. Published 1968 by McGraw-Hill Book Company, 330 W. 42 St., New York, N. Y. 10036. Price $29.50.

Extremely detailed in scope, this large handbook, which calls for a large hand, details the processes involved in any systems effort. Aimed at managerial and technical personnel in the computer field, this book follows the acronym derived from the book's subtitle: ARDI or Analysis, Requirements determination, Design and development, Implementation and Evaluation.

Functionally, the book is divided into six volumes or sections: Introduction; Project management; Feasibility study, System analysis and design; System development; System implementation and evaluation; and Techniques and standards. Illustrated with flow charts, the book stresses the balance that must be maintained between a company's strategic goals and its managerial and operational control requirements.

Extremely meticulous, this book should be a welcome addition to the library of any manager or engineer involved in the implementation of new applications for the computer.

Modern Control Theory and Computing

By D. Bell and A. W. J. Griffin. Published 1970 by McGraw-Hill Book Company, 330 W. 42 St., New York, N. Y. 10036. Price $16.50. 221 pages.

Conduction of Electricity Through Gases

By J. J. Thomson and G. P. Thomson. Republished 1969 by Dover Publications, Inc., 180 Varick St., New York, N. Y. 10014. Price $3.75 each volume for paperback. Volume I: 491 pages; Volume II: 608 pages.

Sound, Noise and Vibration Control

By Lyle F. Yerges. Published 1969 by Van Nostrand Reinhold Publishing Inc., 450 W. 33 St., New York, N. Y. 10001. Price $9.95. 194 pages plus index.

The Production of Printed Circuits and Electronics Assemblies With Particular Reference to Metal Deposition and Related Processes

Edited by C. R. Draper. Published 1969 by Robert Draper Ltd., Kerbihan House, 85 Udney Park Rd., Teddington, Middlesex, England. Price 155/($22.00). 468 pages.

Introduction to Nonlinear Network Theory

By Leon O. Chua. Published 1969 by McGraw-Hill Book Company, 330 W. 42 St., New York, N. Y. 10036. Price $22.50. 987 pages including index.

Electric Circuits Part 1, Direct Current

By J. Richard Johnson. Published 1970 by Holt, Rinehart and Winston, Inc., 338 Madison Ave., New York, N. Y. 10017. Price $9.95 cloth; $6.50 paperback. 511 pages.

Electric Circuits Part 2, Alternating Current

By J. Richard Johnson. Published 1970 by Holt, Rinehart and Winston, Inc., 338 Madison Ave., New York, N. Y. 10017. Price $9.95 cloth; $6.50 paperback. 339 pages.

IC IDEAS

This month's Ideas

Vote **for the one you like best.**

Write the number of the Idea you like best in the box on the Inquiry Card, and send to us.

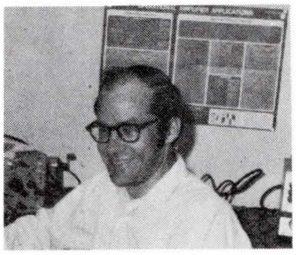
Send us practical, reproducible ideas that are original with you and have been implemented with linear or digital ICs.

- If we publish your idea you win a check for $25.00.
- If our readers vote yours the best of the issue in which it appears, you have your choice of a Simpson 270 or a Triplett 600 multitester.
- After 12 issues our readers will vote on the best idea for all 12 issues. The winner gets his choice of either a Hewlett-Packard 1206A or a Tektronix 310A oscilloscope.

Submit your IC Ideas to:
Alberto Socolovsky
Editor
THE ELECTRONIC ENGINEER
Chestnut & 56th Sts.
Philadelphia, Pa. 19139

Here's how you voted

The winning Idea for the December 1969 issue is, "Function generator has variable polarity exponents"



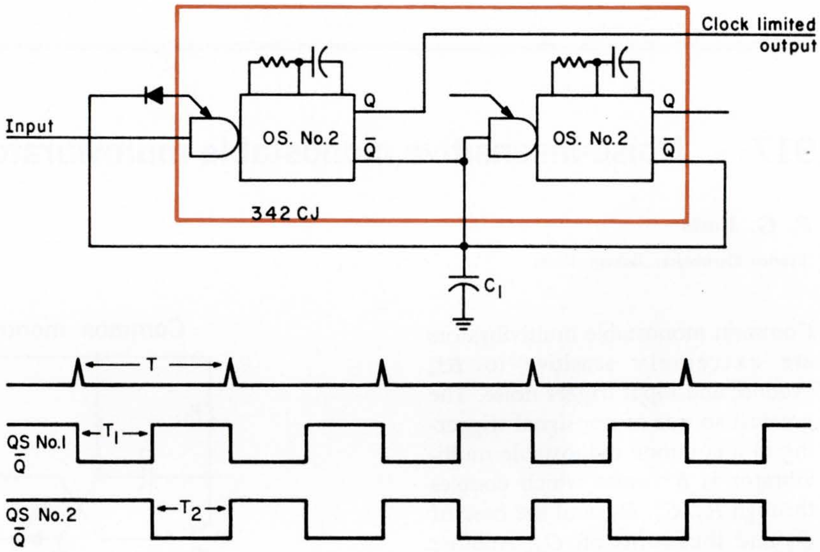
William Neeland, our prize-winning author for December, is a design engineer at Morvue Electronic Systems in Tigard, Ore. For his prize, Mr. Neeland has selected the Triplett Model 600 TVO multitester.

915 Clock rate limit circuit

Stephen Faris
Honeywell Co., Waltham, Mass.

When working with pulse circuitry, it is often desirable to limit the maximum clock rate that can be applied to a system.

One simple way of accomplishing this clock rate limiting is with a dual one-shot such as the Amelco 342CJ, in the circuit shown here.



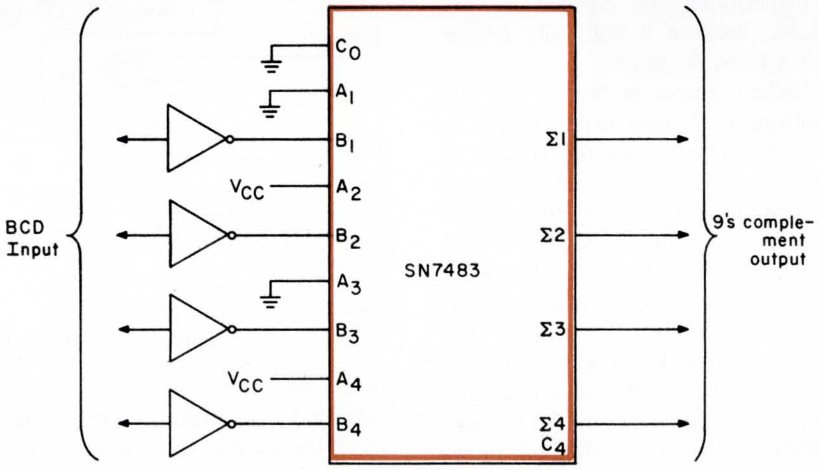
The output from the first one-shot blanks its own input by means of the diode expander gate on the 342. You should choose T_1 and T_2 slightly less than $T/2$. In this way, any repetition rate higher than $1/T$ will not pass because of the diode expander which forms a NAND gate.

Since each one-shot has a recovery time, you cannot use just one. With a single circuit, excess pulses could sneak through during the recovery interval. With the connection shown, the only problem would occur when control is transferred from the first to the second one-shot. You can prevent this by slowing down the rise of the first one-shot output with capacitor C_1.

916 BCD to 9's complement converter

Ken Erickson
Interstate Electronics Corp., Anaheim, Calif.

The 9's complement of binary coded decimal numbers is often used in programming BCD frequency dividers or in performing decimal subtraction. This circuit easily accomplishes the transformation from BCD to 9's complement.



The circuit uses a 4-bit binary adder and four inverters. Conversion is accomplished because of the fact that the 9's complement of a BCD number is formed by first deriving the l's complement and then adding 10 (binary 1010) to it. The inverters in the circuit form the l's complement which is then fed to the binary adder where 10 is added. The carry output C_4, is not used.

The circuit shown would be repeated for each decimal digit. If the inverted BCD inputs are already available, as is often the case, then of course the inverters are not needed.

Carry input C_0 can be grounded as shown if only the 9's compliment is desired. You may, however, use the input to add an end-around carry in subtraction applications. Also, the 10's compliment of the input can be formed by applying logic 1 to C_0.

917 Noise-insensitive monostable multivibrators

E. G. Faris
Sparton Electronics, Jackson, Mich.

Common monostable multivibrators are extremely sensitive to B^+, ground, and input trigger noise. The greatest source of nonsignal triggering in a common monostable multivibrator is B^+ noise which couples through R_1, C_1, D_1, and the base of Q_2 and thus turns off Q_2. Another problem is that at power turn-on, there is no assurance that the circuit will start in its stable state (i.e., Q_1 is cut off).

You can eliminate the inadvertent triggering problem with this circuit. It combines a modified unijunction transistor oscillator with a flip-flop and two inverters. The combination of R_1, and C_1, effectively filters B^+ noise to ground. Furthermore, the flip-flop is very stable because it will only trigger on a large B^+ noise.

When power is turned on, the voltage at C_2 rises exponentially to +5 V. This causes the voltage at A to go high and remain high until an input signal reverses the state of the flip-flop (high = logic 1 = +5 V; low = logic 0 = 0.2 V). Since V_A is high, the unijunction oscillator is shut off and V_E is high; that is, the output V_E is a logic 1.

When the flip-flop changes state, V_B goes high, V_A and V_E go low. With V_A low, Q_1 is shut off allowing C_1 to charge through R_1 to η B^+ with a time constant of

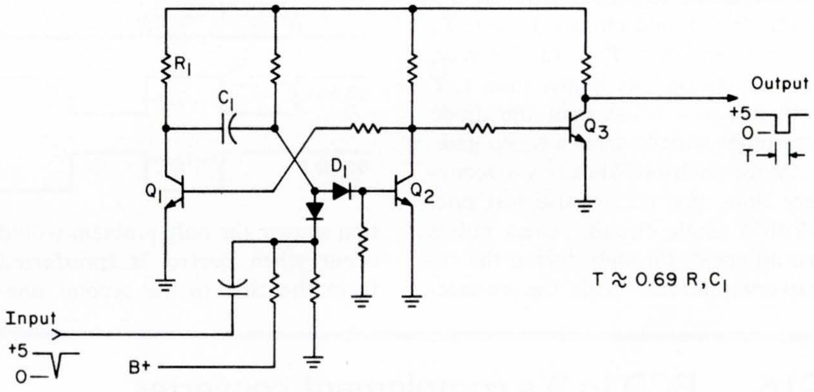
$$T \cong R_1 C_1 \ln \frac{1}{1-\eta}.$$

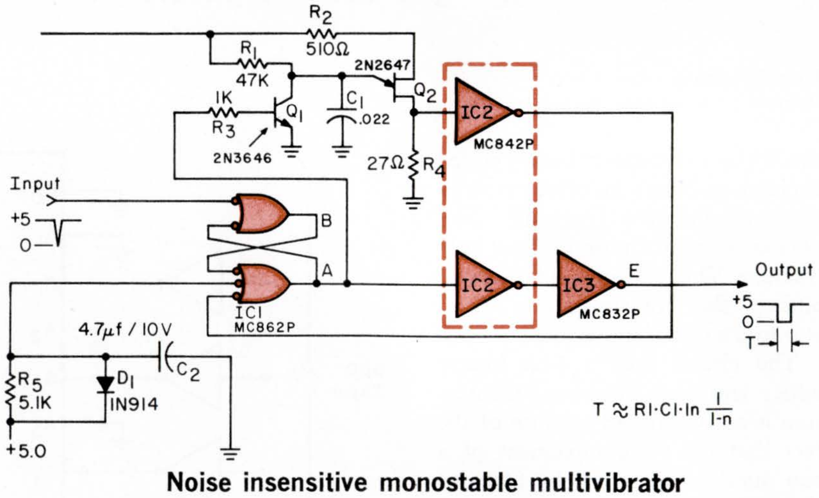
When Q_2 fires, V_D goes low and resets the flip-flop. This turns on Q_1 and shuts off the oscillator causing V_E to become high again. Thus, the output pulse width is determined by T and is free of the effects of erroneous trigger noise.

Note that if at power turn-on the input signal is low, both inputs of the flip-flop are high. Therefore, to prevent an erroneous output signal, the output is derived from point A.

Resistor R_4 must be of sufficient value that the output pulse of Q_2 exceeds the maximum threshold voltage needed to turn on the inverter. Resistor R_3 must be of sufficient value that it does not prevent the regenerative action of the flip-flop.

Common monostable multivibrator





Noise insensitive monostable multivibrator

Clary's new LP321 Digital Printer prints 21 columns in 1 or 2 colors at 180 lpm and costs $995...about the same as everybody else's.

It's also backed by 1000-hour MTBF reliability, a 1-year warranty and nationwide service ...like nobody else's.

Once you've sorted out the specs on digital printers, you'll find they're all pretty much the same. Then what do you look for?

Consider this: A 1000-hour MTBF because Clary's been making printers for 25 years, so they really know what they're doing. A one-year warranty, backed by 14 service offices throughout the country. Factory stocking of certain critical components that other manufacturers may wait weeks for.

Clary's pricing has some extra benefits. For example, compare the LP321's 21 columns at $995 with the 7 columns offered by competitive printers priced as high as $1295. Or maybe a basic 5-column LP321 at $770 fills your need. All models are substantially less in quantities.

Floating decimal point, dual inputs and all DC operation can be added for just a few dollars each. You don't have to buy them, if you don't need them. Of course, you can have zero suppression and desk mount if you want them . . . at no extra cost.

Write or call today for Data File LP-T-6.

Clary...the printer people

CLARY CORPORATION • PRECISION INSTRUMENT DIVISION
320 W. Clary Avenue, San Gabriel,
California 91776 • (213) 287-6111

Circle 48 on Inquiry Card

New Snap-in panel mount Snap-action switches. From Cherry.

If you're in a hurry to go places on your production line, try one of these fellows. You'll save time, money, and aggravation every time you snap one of these new Cherry switches into a panel. And, they'll stay put because of molded-in serrated spring lock clips that hold tight. No extra mounting brackets needed.

Cherry's large overtravel helps you eliminate extra adjustments from unit to unit. You won't be sticking your neck out either when you pick a sure winner from Cherry, because Cherry switches keep right on going without stopping along the way.

Cherry "snappers" are sturdy, too—the cases are molded of durable nylon for strength. Cherry's exclusive long-life coil spring mechanism assures trouble free performance. Rating? 10 amps., 125 VAC. Ideal for refrigerator doors, television interlock, business equipment, vending machines . . . anywhere you would use more expensive, hard-to-install screw mounted assemblies.

Another Winner . . . Cherry "snappers" come in Gold Crosspoint Contact versions for low energy switching applications, too. Write for complete details or give us a call (312) 831-2100. We'll get to your place fast.

CHERRY®

CHERRY ELECTRICAL PRODUCTS CORP.
1655 Old Deerfield Road, Highland Park, Illinois 60035

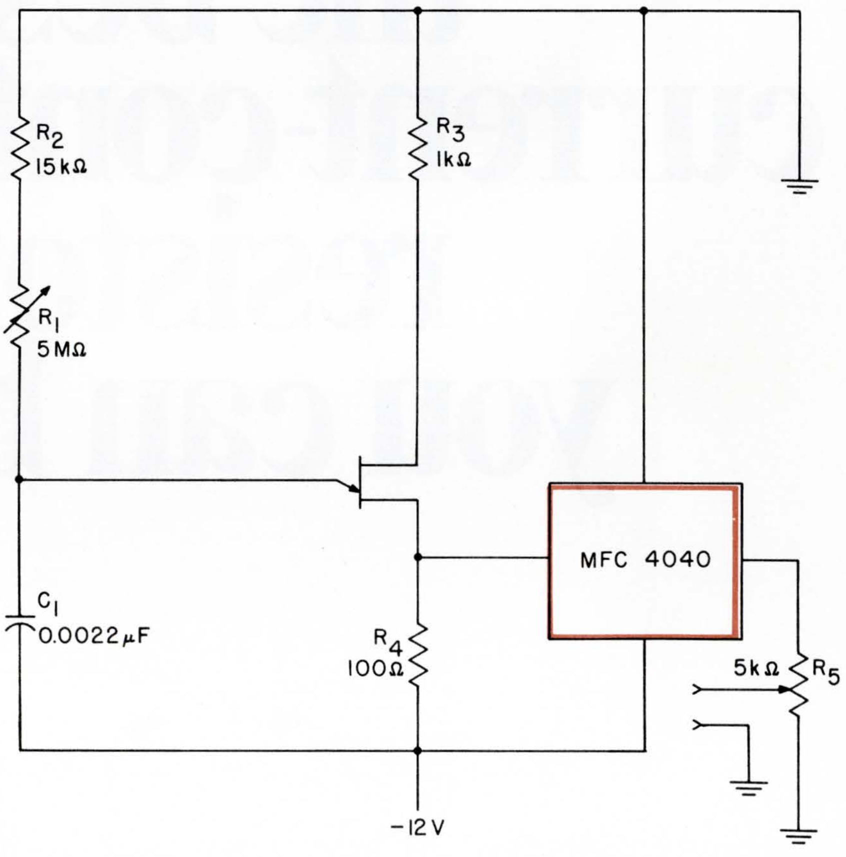
Makers of patented Snap-Action, Leverwheel/Thumbwheel and Matrix Selector Switches.

Circle 49 on Inquiry Card

VOTE: for the one you like best.

918 Super-simple square-wave generator

Paul Franson
Teradyne Inc., Boston, Mass.



This simple circuit generates excellent square waves over a wide frequency range with a minimum number of components and with a convenient 12-V supply. With the component values shown, the circuit produces 42 Hz to 13 kHz square waves with only one tuning control.

The circuit consists of a unijunction transistor pulse generator operating from about 84 Hz to 26 kHz, followed by a new high-voltage RTL frequency divider.

The UJT circuit is a conventional relaxation oscillator. The capacitance of C_1 can be increased for a lower frequency range, or decreased for higher frequencies. A Mylar, mica or other stable capacitor should be used since many disc ceramics are very temperature sensitive. The circuit easily oscillates to 1 MHz with an Annular UJT; the plastic 2N4871 at 68 cents is recommended. The combination of R_1 and R_2, along with C_1, determines pulse rate:

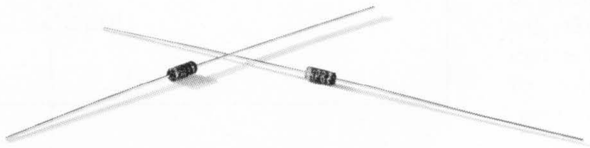
$$f \approx 2/C_1(R_1+R_2)$$

The maximum tuning ratio is equivalent to $(R_{1(MAX)}+R_2)/R_2$. In this case it is about 5 MΩ/15kΩ or 333. Resistor R_2, which determines the maximum frequency, must be at least 15 kΩ to ensure oscillation, while 5 MΩ is about the maximum useful value for R_1. A log taper potentiometer used for R_1 minimizes scale crowding. You may have to trim R_4 to provide reliable triggering of the following stage at the extremes of the frequency range, especially if C_1 is changed.

The MFC4040 is a low-cost, divide by two IC. It is basically a high-voltage RTL flip-flop with only four terminals (input, output, positive supply and ground). The output is through an internal buffer stage. The circuit operates reliably from 4 to 16 V and draws about 12 mA at 12 V. instead of the 45 mA at 3.6 V required by conventional RTL. It seems to trigger reliably to at least 5 MHz.

Output of the circuit is a peak-to-peak voltage slightly less than the supply voltage (about 11 V with a 12 V supply). The output level can be adjusted with potentiometer R_5.

Two simple facts make this diode the best current-controlled resistor you can buy.



Performance. HP's PIN diode offers better cross-modulation and second order distortion performance than FETs or other conventional techniques. Our current-controlled resistors have an effective minority carrier lifetime of 1.3 μs with extremely low distortion over the 1 MHz to 1 GHz range. They also have tight resistance tracking between units, and the RF resistance limits are fully specified.

Price. You get all this for 99¢ each in 10,000 lots, the lowest priced PIN diode anywhere! Even lower costs in larger quantities. Which now moves true high performance within the price range of low-frequency designers.

Before you design your next equipment with current-controlled attenuators, constant-impedance AGC, levelling and switching circuits, talk to us about specs and prices and immediate delivery on the 5082-3080 PIN diodes.

HEWLETT hp PACKARD

SOLID STATE DEVICES

01009

NEW PRODUCTS

New keyboard simplifies electronics

Many of the keyboards presently on the market use reed switches because of their proven reliability. However, contact bounce can be a problem. The problem has been solved in a variety of ways, but each of these approaches has added to unit cost and complexity and has decreased reliability.

Now Cherry Electrical Products Corp. has developed a new concept in keyboard design that simplifies the electronics. It works by continuously scanning all possible codes every 256 μs. When you depress a key the scanning process is stopped at the selected code.

The new keyboard uses a single PC board, a magnet actuated hermetically sealed dry reed switch in each key module and off-the-shelf components. Contact bounce isn't a factor since the code doesn't come from the key.

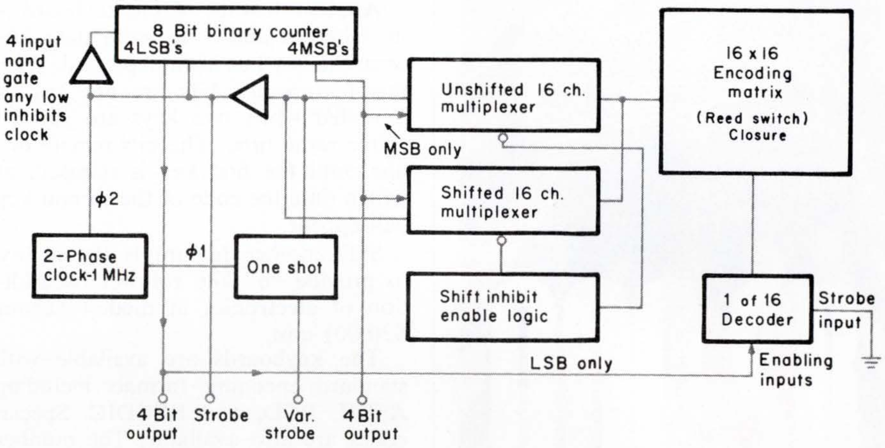
The new keyboard does not rely on analog or current sensing devices to detect two key rollover. It uses a new approach that eliminates the need for steering diodes, diode encoding, delayed strobe, two key rollover detection circuitry, second level PC board and having to interconnect two PC boards. The entire encoding and keyboard in the new system is limited to a single PCB in most applications, thereby contributing to increased reliability.

A "flying magnet motion" mechanism provides more reliable reed switch operation and improved sensory and audible feedback to the operator. The key module and mechanism is shown in the accompanying illustration.

The key module consists of a molded key button, a plunger with keeper plate that holds the magnet, upper and lower springs, hermetically sealed dry reed switch (Form A) and nylon housing.

As the key is depressed to the operate position, the upper spring stores energy until it has enongh to overcome the magnet-to-keeper plate seal force of 70 grams. The magnet is suddenly released from its captive position against the keeper plate and flies down the tube to the region of the reed switch contacts, coming to rest against the lower spring. The reed switch contacts close with a sharp,

(*Continued on page* 116)



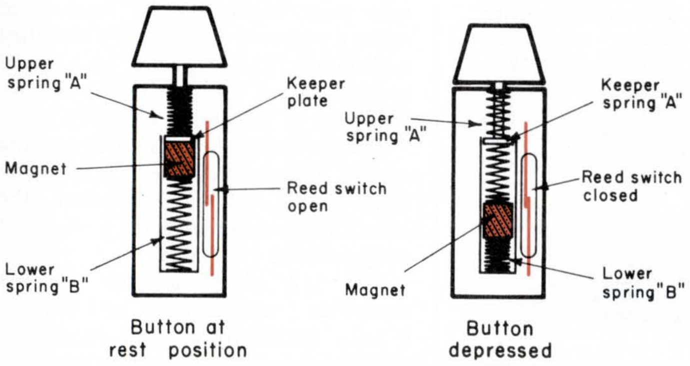
Keyboard encoding is based on this circuitry. The binary counter operates continuously. Any Low input to the 4 input NAND gate feeding it (other than the clock input) will inhibit the clock and effectively stop the counter at a particular 8-bit code.

The two multiplexers have a strobe input which only allows them to become active if the input is Low. By using two multiplexers, an unshifted and a shifted code can be generated by strobing one in the unshifted mode and the other in the shifted mode. The strobe input of the decoder is connected to ground to allow for continuous actuation. The decoder provides a Low output on one of the 16 lines for any binary code generated from 2° to 2^8.

When a key is depressed to the operating point, the matrix connection between the decoder and the multiplexer will be made. Since the decoder output is a Low, it will be represented as a Low at the corresponding connection to the multiplexer. When the counter reaches the code specified for the key, a cross matrix continuity is sensed and the multiplexer provides a High output to the "one-shot" which operates from a phase of the 2-phase clock, 90° out of phase with the counter clock. The "one-shot" generates a 1 ms pulse to inhibit the clock to the counter, stopping the clock at the desired code.

At the end of the 1 ms pulse, any effects of contact bounce are eliminated and an alternate path from the multiplexer to one of the 4 NAND gate inputs to the clock will inhibit the clock which holds the bits at the selected code until the key is released.

Clock rate is 1 MHz. The counter completes a count every 256 μs. Since clock pulses occur every microsecond, there is a 0.5 μs for signal acknowledgement. Delay through gate chain is (40 + 40 + 40 + 25) ns =145 max.

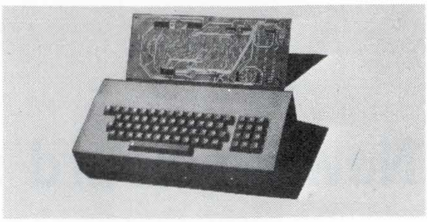


positive action. The magnet presses downward against the lower spring until the energy stored in it overcomes the upper spring force and returns the magnet to the captive keeper plate position. Reed switch contact closure is the result of the dynamic action of the magnet which contributes to more reliable reed switch operation.

Another feature of the keyboard is its inherent ability to store data bits once the key has been depressed. With this feature the bits are not lost or inhibited when two keys are pressed at the same time. The bits remain online until the first key is released, at which time the code of the second key will appear.

Still another feature is the ability to provide "n" key rollover by addition of electronics at modest (about $20.00) cost.

The keyboards are available with standard encoding formats including ASCII, BCD, and EBCDIC. Special codes are also available. The number of bits in a code is not limited to eight as with most conventional keyboards. Up to 16 bits in a code can be provided with little difficulty.



Keyboard performance meets or exceeds Mil. Std. 188C. Operating environment for commercial applications is 0°C to 70°C, and −55°C to +125°C at 90% relative humidity for military applications. Prices for a standard 52 key ASCII coded keyboard (not including metal housing) range from $250 for one to $140 for 1000. The keys (not including buttons) range from $2.60 for one to $1.40 for 1,000 to $0.87 for 50,000. Cherry Electrical Products Corp., 1650 Old Deerfield Rd., Highland Park, Ill. 60035. (312) 831-2100.

Circle 293 on Inquiry Card

Automated network analyzer

Here's an example of how to tie your lab instruments to a computer for automatic data reduction. The system is packaged and sold by Wiltron, and called the Model 312 vector network analyzer.

The heart of the 312 is a device made not by Wiltron, but by Pacific Radionics: the Model LP-1000 coupler.

Couplers such as this convert the digitized, parallel-line outputs of the various instruments into serial-coded, teletype-compatible ASCII data. And the teletype is the "open sesame" to automatic processing by computer.

Wiltron combined their Model 310 phase, level, and impedance indicator with their Model 311 rf resolver to make a network analyzer. To this they added their 610B sweeper as a signal source, and a Tektronix 503 oscilloscope for a Smith-chart display.

Pacific Radionics's LP-1000 ties the system together because it acts as the input/output adapter between the measuring instruments and a standard ASCII teletype (included).

The 312 system controls the test equipment, records data, and reduces it to a usable form. And because it operates through a timeshare terminal, you can use the large computer central to control as many of these automated analysis stations as you may need.

Wiltron's system measures and displays transmission phase-shift and insertion-loss or -gain, and reflected signal amplitude and phase. It operates in the range of 1 to 20 GHz, depending on the units you select.

Significant characteristics of the 312 include standards lab accuracy in both coax and waveguide, and automatic adjustment to the calibration curves of the reference standards; automatic error correction on both the teletype print-out and the Smith-chart display; and instant data analyses and computations via automatic reference to built-up, test data files.

The system comes with all software routines for calibration, operation, and print-out in engineering units (dB gain or loss, and phase). And note that once you're plugged in, you have access to all the routines provided by your timeshare service.

The Model 312 is expandable and easily adaptable to pulsed-signal analysis. For more information, contact Wiltron Company, 930 E. Meadow Dr., Palo Alto, Calif. 94303.

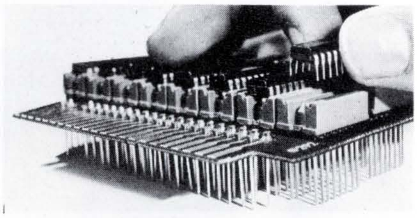
Circle 294 on Inquiry Card

New concept simplifies logic design

The standard back-plane approach to logic-card system design requires complex interconnections if you want to use function cards such as digital comparators or shift registers. And, complex interconnections mean extensive run lists and many hours of engineering design time.

Now, however, with the "Wrap-X" logic card system recently announced by Datascan, Inc., you can select the complex function card you need and then do the simple logic yourself. You merely plug standard ICs into a Wrap-X printed circuit board and interconnect them (with Wrap-X most of the interconnect is plated). Then you make the connections to function cards.

The new Wrap-X board contains 16 solderless-wrap sockets for either 14-pin ICs and/or 16-pin MSI chips. It is mechanically compatible with over 100 DTL, HTL and TTL standard off-the-shelf "function" logic cards such as comparators, decimals converters and shift registers.



Competing with the large scale back-plane approach, Wrap-X has an economic advantage in small systems and prototype quantities of large systems because complex function cards can't be economically duplicated with the back-plane approach. With the back-plane, complex solderless-wrap interconnections are needed to replace the function cards. Thus, the extensive run list. Also, in the back-plane, you must house discrete components and semiconductors on plug-in platforms, and each of these requires a physical design before you can generate the run list. This also means that you will spend many hours of design and drafting time that are not necessary with the Wrap-X and standard card approach, where function cards have already been designed, and laid out.

Another important plus is that both the Wrap-X and standard card approach include the company's Dynamic Decoupling circuit which greatly reduces a system's susceptibility to noise on the power supply lines.

Wiring for the large back-plane is much more extensive than for the Wrap-X system because all of the plated interconnect on the function cards must be hard wired. Thus, there is a greater chance of noise problems because summing junctions and other low level signal points must be run over some distance, and may be mixed with digital wiring.

Datascan, Inc., 1111 Paulison Ave., Clifton, N.J. 07013. (201) 478-2800.

Circle 289 on Inquiry Card

NEW PRODUCTS

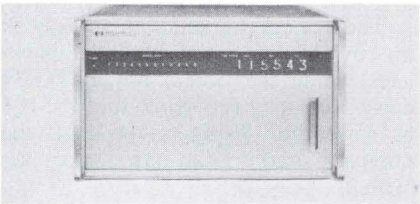
Controller/coupler interfaces with computer

This new instrument gives you a programmable, bidirectional link among up to eight digital equipments (DVMS, counters, power supplies, and so forth). With it, you can coordinate and control these equipments to build a stand-alone test and measurement system, or one that is controllable by a computer.

Hewlett-Packard's 2570A consists of a mainframe assembly that holds a power supply, and control and clocking circuits. Input/output slots hold up to eight interface cards corresponding to the eight digital equipments that you choose to control.

Among the interface cards available, one lets you interface the 2570A to a computer. This means that you can use the unit to automatically transfer data from a group of instruments to a central computer for on-line data analysis. (You can also record data on punched tape for off-line analysis.)

Now, remember that the 2570A can communicate in two directions.



So, with the computer interface card installed, you can use the computer program not only to control the process under study, but also to reduce the data, print a report, and plot the results. Furthermore, a number of instrumentation terminals, each with its own 2570A, can simultaneously access the central computer.

The operational concept of the controller/coupler is straightforward. The input/output interface cards provide a standard language for the controller/coupler: the cards convert BCD inputs from various digital instruments to ASCII code. The input cards gather and insert measured data onto a data bus. The output cards, in effect, gather the data from the bus, and output it. Both input and output cards are interconnected through, and under the command of, a mainframe control card.

You can control the 2570A by diode pin positions on a control-card matrix. Or, you can program the control card to shift control to any ASCII-generating unit such as a teletype or punched-tape reader.

The Model 2570A controller/coupler costs $1625. This price doesn't include interface cards, but does include the standard controller panel, control card, and so forth. The various interface cards cost from $450 to $700 each, depending on function and options selected. Interface cards include a 16-bit relay register, an 8-bit duplex register, a TTY interface, and, of course, 10-digit-BCD to ASCII (and vice versa) conversion cards. Inquiries Mgr. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94303.

Circle 290 on Inquiry Card

Microwave transistors: new supplier enters lists

There's a new source to be reckoned with in the rf and microwave power transistor field. Raytheon Semiconductor—not previously known for power devices—has jumped into the swim in a big way with an announcement of 11 overlay transistor types. And that's just for starters.

To create an image as a supplier of state of the art microwave power packages, Raytheon launched a development program some time back to make use of those advantages which discrete devices have over monolithics: power, voltage, frequency, and current. The first results of the program are shown below.

Device	Freq./Pwr./Min. Gain
LS4976 (*)	2GHz/1W/5dB
LS5110 (*)	1GHz/10W/5dB
LS5108A (*)	1GHz/1W/7dB
2N5108A	1GHz/1W/5dB
LS7101 (*)	1GHz/1W/7dB
2N5108	1GHz/1W/5dB
2N5109	1GHz/0.5W/3dB
LS4429 (*)	1GHz/1W/5dB
LS4428 (*)	500MHz/0.75W/10dB
2N3886	400MHz/1W/10dB
2N3553	175MHz/2.5W/10dB

The devices marked with an asterisk are in stripline, stud mounted packages, while the others are in TO-39 cans. You may recognize the 2N5108 as an earlier Raytheon product; the company used it as an introductory vehicle.

All the 2N-numbered devices are second-source items except for the 2N5108A, which is a premium version of the 2N5108. It has a leakage current two orders of magnitude less than that of the original, unlettered version, plus higher reliability and efficiency. Raytheon sole-sources the stripline items.

Although this semiconductor house has never been known as a price leader, the new line offers value at industry-competitive prices. For one thing, the stripline devices are in hermetically-sealed packages, not, as is common, in epoxy cases. For another, Raytheon is aiming at the high-reliability market (airborne radars, and so forth), and so you can expect a quality product. In fact, their 2N3886 and 2N3553 will soon appear on the JAN-qualified lists.

And finally the company plans to beam-lead as much of their product line as is possible (this should occur later in the year). Beam-leading, you know, generally gives a more reliable device and is a popular technique among microwave people. Interestingly, the beam-lead units will be housed in plastic packages, because the chip itself will be hermetically sealed.

Raytheon expects to expand its base in the Fall, with a much broader line of 2-GHz transistors. Beam-leaded chips, too, will be available for microwave hybrids. And by the end of the year, Raytheon expects to have a 3-GHz, coaxially packaged transistor on the market.

The company is already offering its new line in custom packages to meet the varied needs of users, and you can have any of the devices in either a common-base package (for oscillator circuits), or a common-emitter package (for amplifier circuits). Limited production lots—100 to 500 pcs.—will be available next month. For more information, contact Raytheon Corp., Semiconductor Div., 350 Ellis St., Mountain View, Calif. 94040. (415) 968-9211.

Circle 291 on Inquiry Card

Word generator operates to 100 MHz

Here's an example of a test instrument manufactured by a firm that is normally a user of instruments.

Advanced Memory Systems, Inc. needed a word generator to test their high-speed IC memories. The company felt that the right combination of word patterning, clock rate, and rise/fall times it needed were not available from any instrument on the market, so they designed their own unit. And because logic card and MSI/LSI memory users have test requirements similar to those of AMS, the company decided to offer the generator as a standard product.

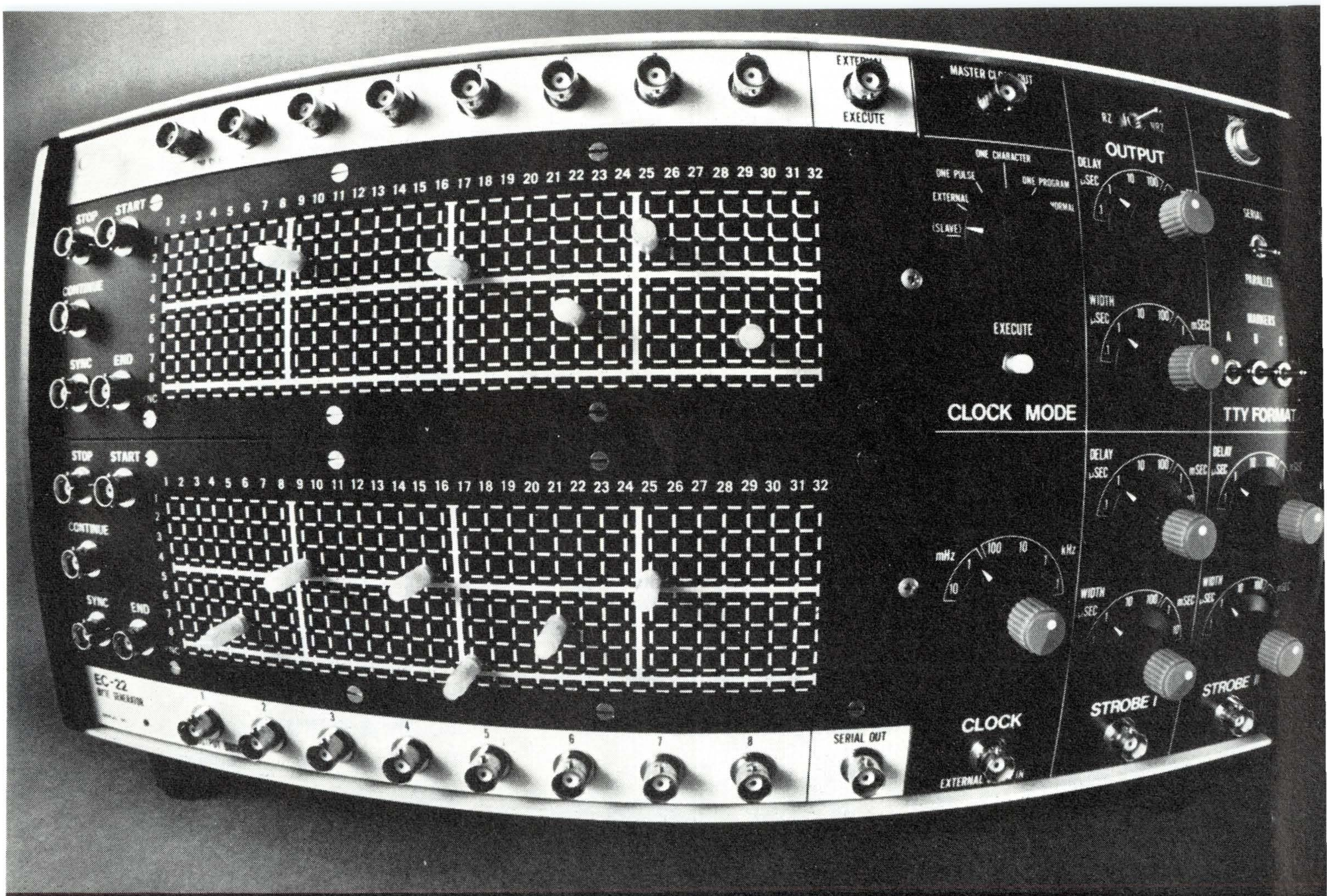
[For a discussion of such instruments see **The Electronic Engineer**, Vol. 29, No. 1, January 1970, pp. 42-45, "All word generators are not women," by Jerry Heyer. And for a survey of instruments on the market see the same issue, pp. 47-48, "Commercially available word generators," by Stephen A. Thompson.]

Some key features of the Model PPG-1 are:

- *Manual/remote programming* — you can use the word generator as a stand-alone instrument in the lab (manual operation), or you can incorporate it into an automated test system in which a computer or other digital equipment (remotely) controls address selection and data pattern generation.
- *Precise data positioning*—there are eight data-channel outputs with 64 bits/channel. This means that there are 64 time slots—one for each address in the generator's storage—in each channel. At the maximum clock rate of 100 MHz, each of these time slots is only 10 ns long. In other words, when you operate the PPG-1 at its highest rate, you can vary each channel's pulse widths from 10 to 640 ns, in 10-ns intervals. And the time relationships among the pulses on the eight channels are similarly varible in 10-ns increments.
- *High-rate clocking*—you can vary the frequency of the PPG-1's internal clock from 100 MHz down to 1MHz, while an external clock (minimum pulse width, 3 ns) will take you down to dc. Address changes occur on the positive-going edges of the clock pulses. Typical delay from clock signal to data output is 20 ns, and all changes in the output data take place within ± 1 ns of this delay. Cycle length is 1 to 64 words external, and 8, 16, 32, or 64 words internal.
- *Fast rise/fall times*—the output data signal is in the NRZ (non-return to-zero) format, and rise/fall times are $<$ 1.5 ns into a 50-Ω load. These specs are for the ECL version, which has a minimum output signal swing of -0.85 to -1.55 V.

The standard version of the PPG-1 has ECL-compatible programming inputs and data outputs, costs $5995, and has a 90-day delivery time. Option 02 gives you DTL/TTL-compatible outputs, and costs an extra $500. There is no charge either for Option 01, which gives you DTL/TTL-compatible inputs, or for Option 03, which matches the PPG-1 input levels to your particular needs. Advanced Memory Systems, Inc., 1276 Hammerwood Lane, Sunnyvale, Calif. 94086. (408) 734-4330.

Circle 292 on Inquiry Card



The $2500 Necessity.

If you use an oscilloscope at your lab or production facility, then you need our EC-22 Byte Generator™. This compact, versatile electronic marvel is designed for simulation and testing of all digital equipment.

It features 32 or 64 eight-bit bytes; serial or parallel output; variable program length; automatic ASCII code formatting; expandable pattern in length and width by stacking units; and up to 8MHz bit or byte rate.

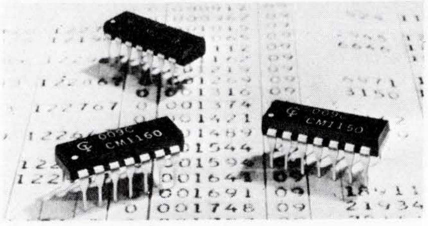
The EC-22 is perfect for – Testing of peripherals, data terminals, CRT displays, IC's, LSI's, and PC's – Simulation of computer output, Telemetry, and Teletype – Generation of analog functions.

Considering what the EC-22 does for only $2,500, it's a steal. Get in touch with us today, and we'll tell you how the EC-22 can help make your job a whole lot easier. It's nice to be needed. Call Bill Noren, collect.

Adar Associates, Inc., 85 Bolton St., Cambridge, Mass. 02140. (617) 492-7110.

I/O CIRCUITS

In 14-lead TO-116 DIPS.

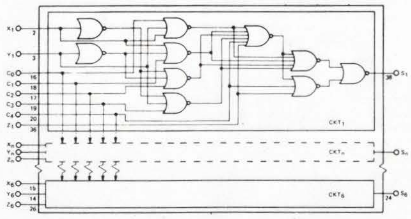


The CM1150 dual transmitter and CM1160 dual receiver meet EIA RS232B/C and Mil-STD-188B specifications. The ±1.25 V noise margin at the inputs of the CM1160 receiver is the highest currently available. Price for both devices is $8.45 ea. in 100 pc. quantities. Cermetek, Inc., 660 National Ave., Mountain View, Calif. 94040. (415) 969-9433.

Circle 235 on Inquiry Card

MOS LOGIC CIRCUITS

For off-the-shelf design.

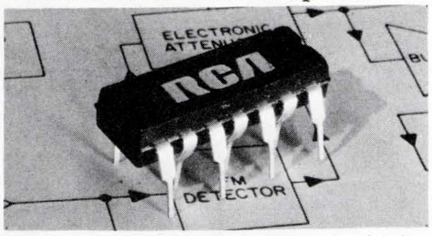


This family consists of the EA 1800 universal logic array, EA 1801 control array, EA 1802 register array and EA 1803 carry array. Features include power dissipations ranging from 180 to 200 mW/package and typical propagation delays of 150 to 500 ns. Electronic Arrays, Inc., 501 Ellis St., Mountain View, Calif. 94040. (415) 964-4321.

Circle 238 on Inquiry Card

TV SOUND SYSTEM

Needs fewer external components.



The CA3065 offers high sensitivity and high-level output for direct drive of an n-p-n audio transistor or a high transconductance tube. An electronic attenuator eliminates shielding of volume control leads and allows simplified remote control design. $1.40 ea. in 1000 pc. lots. Commercial Engineering, RCA/Electronic Components, Harrison, N.J. 07029.

Circle 241 on Inquiry Card

ACTIVE FILTERS

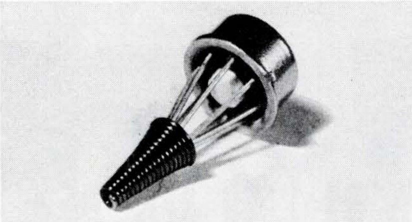
With low freq. response to 1 mHz.

Key features of the Series 700 filters include 0.001 Hz to 20 kHz cutoff frequency, 2% f_c tolerance and 50 μV noise level. Extensive use of CAD allows standard units to be adjusted to specific f_c with standard component values. Prices start at $22 ea. in 100 lots quan. Analog Devices, Inc., 221 Fifth St., Cambridge, Mass. 02142. (617) 492-6000.

Circle 236 on Inquiry Card

DUAL SHIFT REGISTERS

Both 50- and 64-bit lengths.

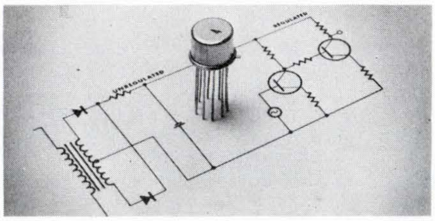


These static registers give you the choice of interfacing directly with TTL/DTL or MOS. Both the 50-bit (SL-6-2050) and the 64-bit (SL-6-2064) come in 8-lead, TO-77 packages and have Zener clamp protection. Prices in quantities of 100 are: SL-6-2050, $13 ea.; SL-6-2064, $16.75. General Instrument Corp., 600 W. John St., Hicksville, N.Y. 11802.

Circle 239 on Inquiry Card

VOLTAGE REGULATOR

Hybrid unit is in a 10-lead TO-5.

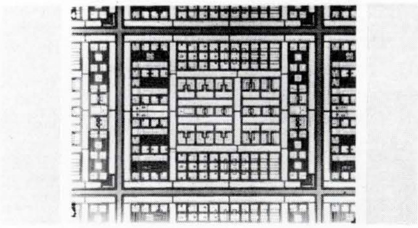


The DVR100 provides an output voltage of 12 V ±5% (or ±1%) and load currents up to 100 mA with internal over-current protection. By adding external components, you can get voltages of 12 to 40 V and load currents up to 3 A. Prices range $23 to $28 (100-999 quan.). Dickson Electronics Corp., Box 1390, Scottsdale, Ariz. 85252. (602) 947-2231.

Circle 242 on Inquiry Card

MONOLITHIC BREADBOARD

For custom IC fabrication.

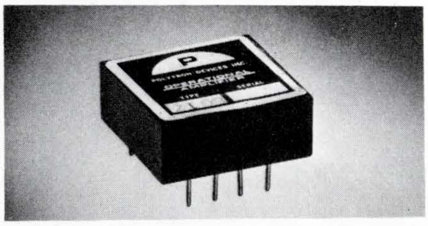


The SG3801 QuikChip contains over 50 separate components. A wire bonding machine lets you construct prototypes as needed. They come in chip form or mounted on TO-100, 10-pin headers with pressed-on caps. Prices: (100 pieces) $5.30 ($4.50 in chip form). Silicon General, Inc., 7382 Bolsa Ave., Westminster, Calif. 92683. (714) 839-6200.

Circle 237 on Inquiry Card

POWER OP AMP

Gives you 500 mA at ±10 V.



These op amps, Series 210, feature an input impedance of $10^{12}\Omega$, and voltage drifts from 2 μv/°C. They are especially useful in instrumentation where the recording device (galvanometer) requires dc stability and a high current drive or in applications as a power buffer. Polytron Devices, Inc., 844 E. 25th St., Paterson, N.J. 07513. (201) 523-5000.

Circle 240 on Inquiry Card

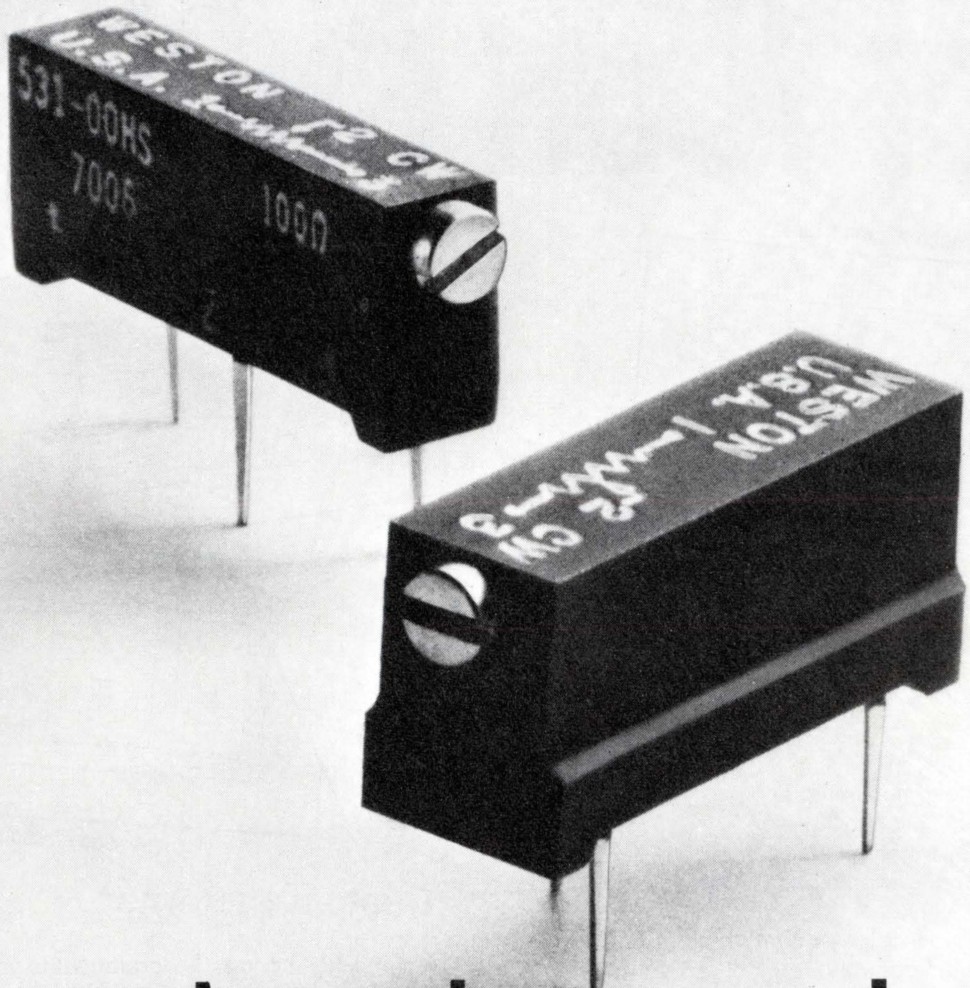
DC CURRENT REGULATORS

Both plus and minus models.

Models 868 and 878 feature an adjustable current range from 1 to 400 mA, ±0.5% output current setting tolerance and stability and a ±0.01% output current TO. The two units are completely complementary in circuit design, internal layout and terminal designation. Helipot Div., Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634.

Circle 243 on Inquiry Card

Look who has the popular new size at a popular price.



Cermet or wirewound.

Now it's no longer necessary to settle for less than the best.

These popular new Weston ¾″ rectangular series 530-533 combine the famous features of our Squaretrim® potentiometer line—high quality, wide temperature range, precision tolerance, low noise, 15 turn adjustability with slip clutch protection—in a case size that's rapidly becoming industry's number one choice. In addition to standard models, sealed equivalents are available for protection against water, cleaning solvents, flux and encapsulating compounds. Units are priced as low as $1.30*.

Cermet series 532 and 533 come in standard resistance values to one megohm. Those who prefer wirewounds may order series 530 and 531 in standard values from 10 ohms to 35K. Both cermet and wirewound models are available with tab mounting centers of either .10″ or .20″.

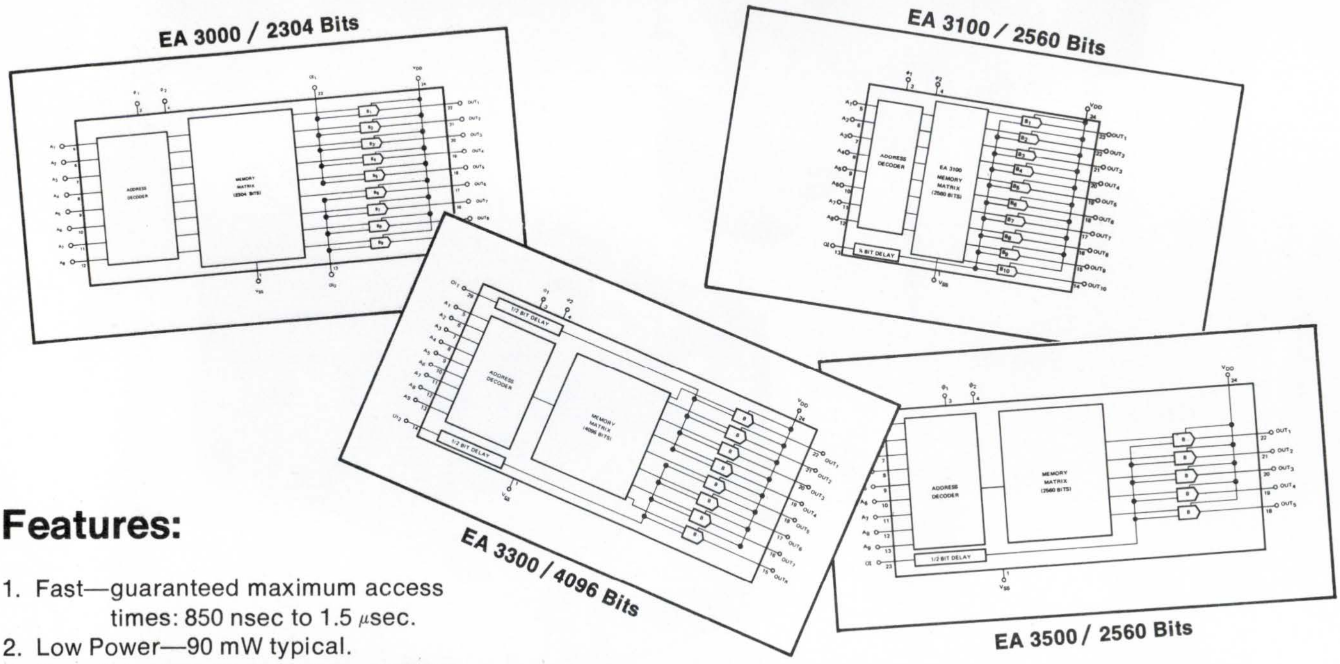
However you choose, you're clearly a winner with Weston's 530-533 rectangular trimmers. Write or phone today for sample units and complete data.

WESTON COMPONENTS DIVISION, Archbald, Pennsylvania 18403, Weston Instruments, Inc.
a Schlumberger Company

WESTON®

*100 quantity unit price for standard models.
100 quantity unit price for sealed models is $1.63.

For ≈ 1¢/bit – production quantities of YOUR CHOICE



EA 3000 / 2304 Bits

EA 3100 / 2560 Bits

EA 3300 / 4096 Bits

EA 3500 / 2560 Bits

Features:

1. Fast—guaranteed maximum access times: 850 nsec to 1.5 μsec.
2. Low Power—90 mW typical.
3. Complete decoding within each ROM.
4. Wire-OR capability.
5. May be biased to be bipolar compatible.
6. Synchronous and compatible.
7. 24-pin dual-in-line packages.

Standard Patterns

available *today* at EA distributors

1. **EA 3001**—Starburst character generator and Selectric bail to ASCII code converter.
2. **EA 3101**—ASCII to Selectric Line Code and Selectric Line Code to ASCII code converter.
3. **EA 3307**—ASCII to EBCDIC and EBCDIC to ASCII code converter.
4. **EA 3501**—Row Scan Dot Code Matrix Character Generator.
5. **EA 3701**—Column Scan Dot Code Matrix Character Generator.

Custom Patterns

Any EA ROM can be programmed to your specialized bit patterns. Allow 6 to 8 week delivery.

For data sheets and forms for submitting your specialized bit patterns, contact your local representative or write Electronic Arrays, Inc., 501 Ellis Street, Mountain View, California 94040. (415) 964-4321.

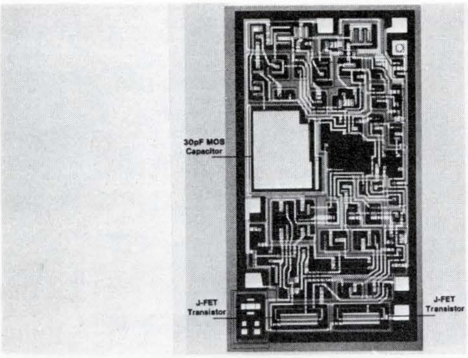
electronic arrays, inc.

PROVEN MOS PRODUCTS DELIVERED IN VOLUME

NEW MICROWORLD PRODUCTS

J-FET INPUT OP AMP

Draws 200 pA max. input current.



This monolithic circuit, the μA740, differs in design from the super beta or "punch-through" operational amplifiers. While punch-through devices provide current gains of 1000, this device features equivalent betas of more than 15,000. Other key parameters include a unity gain slew rate of 6 V/μs, a 120 dB voltage gain, a typical, 20 pA input offset current, and an input offset voltage of 20 mV maximum (all at 25°C). Because of the FET input, you get an input impedance of 10^{12} Ω. The package is a TO-99 can and unit prices are $73.50 (military) and $37.50 (industrial). Fairchild Semiconductor, 464 Ellis St., Mountain View, Calif. 94040. (415) 962-3563.

Circle 231 on Inquiry Card

TTL CIRCUIT

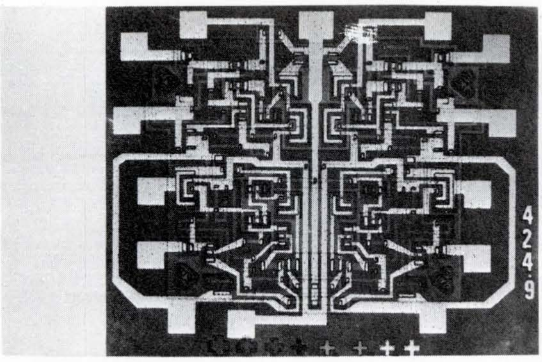
Can be wire-OR'ed

The DM7551/8551 is a quad D flip-flop for use with common data lines in small computers. To get the wire-OR capability, this circuit has a third logic state, a high impedance state in which both output transistors are off. You can also use the circuit without worrying about clock control because input enable circuitry blocks data from entering the circuit unless it is specifically addressed. If the incoming data is blocked, the flip-flop sees only its own output, which is fed back. In effect, the circuit samples itself until new data is entered. $14.50 ea. (1-24 pcs), available from stock. National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051.

Circle 233 on Inquiry Card

LINE DRIVER/RECEIVER CIRCUITS

For digital transmission in high noise environments.

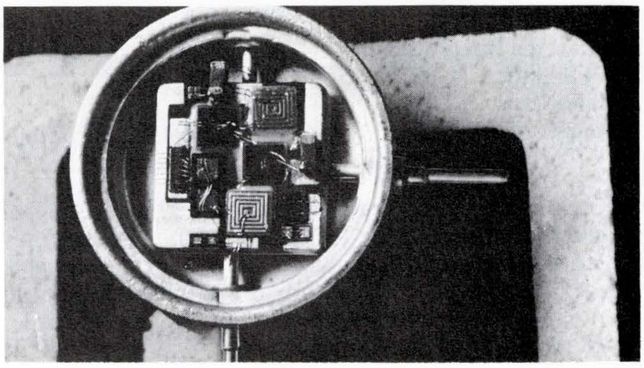


The SS334 series consists of a quad, logic-level driver for digital transmission and two types of receivers. One receiver is a quad single-ended device and the other is a dual differential receiver. These units perform interface functions between standard TTL or DTL and interconnecting lines. As an example of noise protection offered, the series show common mode noise rejection of ±5 V with worst case power supplies of ±5%. The circuits are packaged in a TO-85 ceramic, 14-lead flat pack with a metal lid. In quantities of 100 and over, the cost of these circuits ranges from $5.90 ea. for industrial grade to $12.45 ea. for military grade. Semiconductor Div., Sylvania Electric Products Inc., Woburn Mass. 01801.

Circle 232 on Inquiry Card

MICROWAVE INTEGRATED CIRCUITS

UHF devices use hybrid technology.



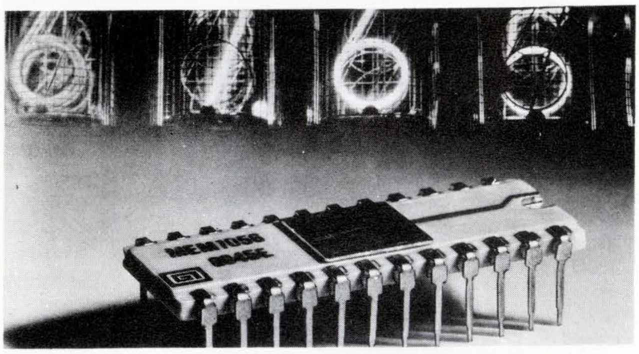
These new devices are the TA7702/7703 wideband UHF power amplifiers and TA7747/7748 UHF three-port hybrid power combiner/dividers. The amplifier typically delivers 16 W at 350 MHz with 6 dB gain. The gain variation across the band (225 to 400 MHz) is ±0.5 dB and the efficiency varies between 50% and 75%. The TA7747/7748 is an equiphase, equiamplitude three-port hybrid that you can use as a power combiner or divider. When used as a divider, the output ports are isolated. The loss of the unit across the 225 to 400 MHz band is $<$ 0.25 dB and the isolation varies between 10 and 40 dB. Commercial Engineering, RCA/Electronic Components, 415 S. Fifth St., Harrison, N.J. 07029 (201) 485-3900

Circle 234 on Inquiry Card

NEW MICROWORLD PRODUCTS

COUNTER/DISPLAY DRIVER

For seven-segment indicators.

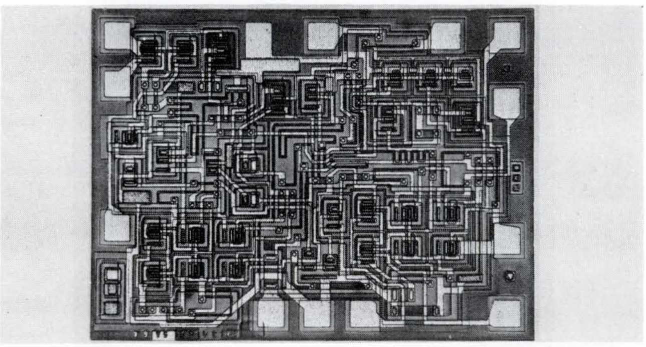


The MEM 1056 is an MTOS (metal-thick oxide silicon) monolithic integrated circuit and contains a one decade up-down BCD counter, a storage register, a BCD-to-seven segment decoding matrix and display drivers. The device features low power consumption, count zero indication, decimal point indication, false code indication, and blanking input. You can cascade the up-down counter sections to form synchronous counting chains. You can achieve asynchronous, 1 MHz, up-down counting irrespective of the number of counter stages cascaded by using external elements. $20 ea. in 100 piece lots. General Instrument Corp., 600 W. John St., Hicksville, N.Y. 11802. (516) 733-3333.

Circle 227 on Inquiry Card

IF AMPLIFIER HAS AGC

Unit minimizes detuning.

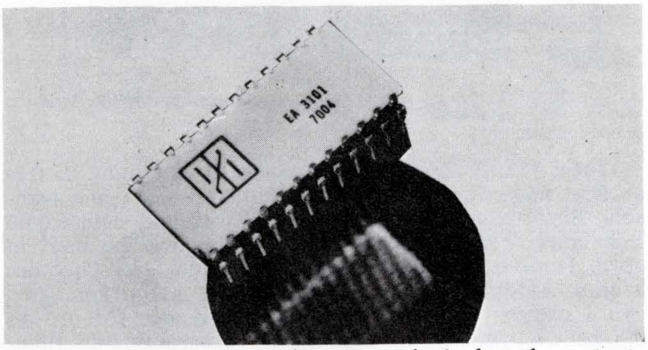


The μA757C is designed for use in am and fm communications receivers, where it provides high-gain amplification without detuning the external filter circuits. The amplifier has two gain-controlled sections that you can operate independently or in cascade. The device has an AGC sensitivity of 50 dB/V, with a 70 dB AGC range at 10.7 MHz. The voltage gain at this frequency is 70 dB, while the power gain is 78 dB. Input signal handling capability is 300 mV and the unit operates with an intermodulation distortion of −50 dB. The output current is 5.5 mA peak to peak. It costs $4.85 ea. in quantities of 100 to 999. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 94040. (415) 962-3563.

Circle 228 on Inquiry Card

READ ONLY MEMORY

With 256 words, 10 bits/word.

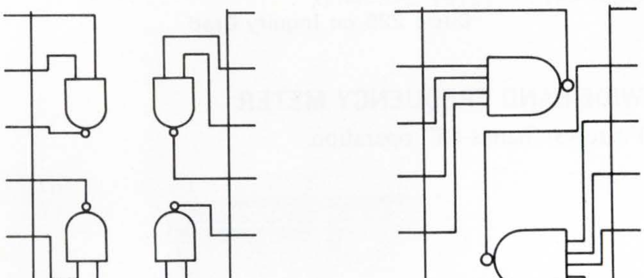


The EA 3100 uses a two-phase clock, but the outputs appear as steady-state signals as long as the address remains unchanged. An output inhibit control allows the use of multiple memories in a wire-OR'd configuration. One custom mask accomplishes the programming of the memory matrix during fabrication of the device. The only dc supply required is the output buffer supply, which is variable and can be biased to drive bipolar output loads directly. Also available off-the shelf is the EA3101 with both the ASCII to Selectric line code and Selectric line code to ASCII code conversions. $83.50 ea. in 100 lot quantities. Electronic Arrays, Inc., 501 Ellis St., Mountain View, Calif. 94040.

Circle 229 on Inquiry Card

POSITIVE LOGIC NAND GATES

Complementary MOS construction.

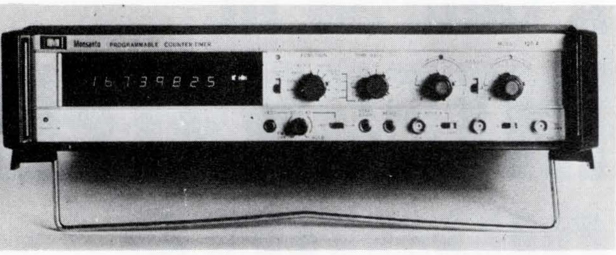


The CD4011 is a quad two-input NAND gate and the CD4012 is a dual four-input NAND gate. Both offer medium speed operation ($t_{pd} = 50$ ns typical with $C_L = 15$ pF) and an input impedance of 10^9 Ω (typical). Output impedance for the CD4012 is 400Ω in the 1 level and 1000Ω in the 0 level (V_{DD}-10 V). For the CD4011 the figures are 400Ω and 700Ω respectively. The devices operate over the full military temp. range and are immediately available in quantity. They come in both flat-pack and ceramic DIP's. Prices range from $4.50 to $5.75 ea. in 1000pc. lots. Commercial Engineering, RCA/Electronic Components, 415 S. Fifth St., Harrison, N.J. 07029. (201) 485-3900.

Circle 230 on Inquiry Card

AUTOMATIC COUNTER/TIMER

Features solid state display.



The Model 120A is a 150 MHz universal counter/timer. More than 60% of its components are MSI circuits and the eight-digit readout consists of solid state light-emitting numerics. The instrument incorporates automatic ranging so that all frequency and period measurements are automatically displayed with maximum resolution. Functions include totalizing from dc to 150 MHz, or 0 to 10^7, measuring frequency ratios from 10^{-7} to 10^7, period averaging from 0.1 μs to 1 s, period measurements from 1 μs to 10^8 s and measuring time intervals from 0.1 μs to 10^8 s. $1775. Monsanto Electronic Instruments, 620 Passaic Ave., W. Caldwell, N.J. 07006. (201) 228-3800.

Circle 221 on Inquiry Card

MICROWAVE SWEEPER

All rf elements are hybrid microcircuits.

Model 8620A uses plug-in modules to determine its frequency range. Presently, modules up to 4 GHz are available using YIG-tuned transistor oscillators and heterodyne techniques. YIG-tuned bulk effect devices will be used in up to 18 GHz modules which are scheduled for later deliveries. Modular circuit boards for the mainframe give you a sweeper that's optimum in convenience for use on the bench, without the expense of programmable functions. With other options, the instrument can be wholly or partly programmable for automatic operation. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 326-7000.

Circle 224 on Inquiry Card

BATTERY OPERATED X-Y RECORDER

Gives 75 h of operation on D-cells.

This self-contained recorder, the Model 2745, features low current drain, virtually no drift, and high input impedance (greater than 15 MΩ at 20 mV sensitivity). The unit gives you ±1.0% accuracy and has a response time of 0.5 s for a full scale change on the Y axis and 0.7 s for a full scale X-axis change. Range selection on the two axis is totally independent. A built-in time sweep for the X axis lets you operate it as a Y vs time strip chart recorder. Available for both ink and inkless recording, it is priced at less than $750. Simpson Electric Co., div. of American Gage & Machine Co., 5200 W. Kinzie St., Chicago, Ill. 60644.

Circle 222 on Inquiry Card

DIGITAL ELECTROMETER MULTIMETER

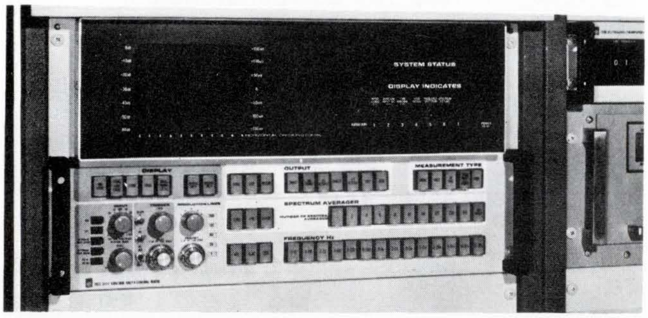
Has 3½ digit display with 100% overrange.

Model 615 gives you 4 voltage ranges, 12 current ranges, 11 linear resistance ranges and 7 charge ranges. Measurement capabilities are 100 μV to 100 V, 10^{-15} to 0.1 A, 100 to 10^{14} Ω and 10^{-14} to 10^{-5} coulomb. You can adjust the display rate from 24 readings/s to 2 readings/m and the decimal point is automatically positioned when changing ranges. The unit operates up to 100 V off ground, and it recovers almost immediately from overloads up to 500 V. Prices start at $1195 for the basic rack-mounted unit. Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, Ohio 44139. (216) 248-0400.

Circle 225 on Inquiry Crad

REAL-TIME ANALYZER

From dc to 20 kHz.

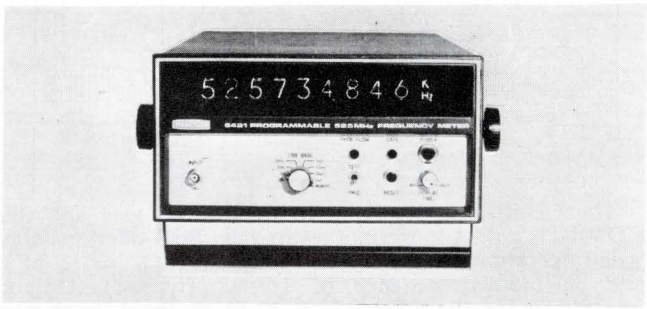


Model 1922 provides high-resolution constant-bandwidth frequency analysis. Pushbutton operation provides a series of oscilloscope displays that guide the user to make the proper instrument adjustments. The successive displays are input signal, input signal after low-pass filter with measurement trigger point intensified, input signal intensified over the portion of the signal to be analyzed, recorded signal, amplitude-vs-spectrum (single and averages), a band of frequency components vs time, and an alphanumeric output of the measurement parameters. The basic single-bay version (shown) is $32,000. General Radio Co., 300 Baker Ave., West Concord, Mass. 01781. (617) 369-4400.

Circle 223 on Inquiry Card

WIDE-BAND FREQUENCY METER

Features "hands-off" operation.

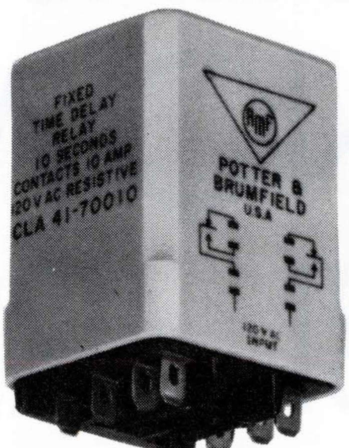


The Model 6421 has a sensitivity of −10 dBm (50 mV rms) and a dynamic range to +33 dBm (10 V rms). Because it can count directly across the entire band, the meter provides the most accurate method of measurement in the shortest time. Time base factors for frequency measurements range from 1 μs to 10 s in decade steps. A front panel which allows the instrument to count its own internal 1 MHz reference, to assure that all counter dividing circuits are operating properly. Price is $1575 with delivery in 90 days. Technical Information Section, Electronic Instruments Div., Beckman Instruments, Inc., 2200 Wright Ave., Richmond, Calif. 94804.

Circle 226 on Inquiry Card

WHERE

can you get a time delay relay that won't false operate, that will give you ±3% repeatability, will switch 10 amperes and costs only $16.50?



HERE

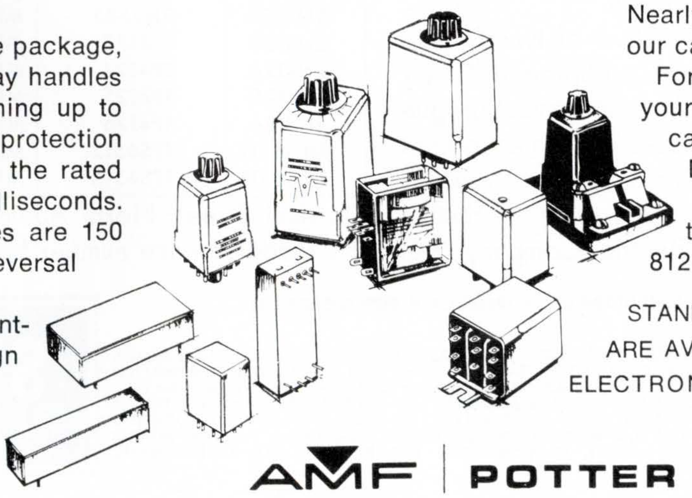
This compact time delay, our CL Series, provides a delay on operate. Its reliable solid state circuit will time as little as 0.1 second and as much as 120 seconds. Three types are offered in AC or DC versions: fixed delay on operate, resistor adjustable and knob adjustable.

An integral part of the package, our field-proven KU relay handles the DPDT output switching up to 10 amperes. Transient protection is provided up to twice the rated input voltage for 8 milliseconds. Reset and recycle times are 150 milliseconds. Polarity reversal protection is provided.

A wide variety of mountings give you many design options. Nylon sockets are available with solder, quick-connect or printed circuit terminals. Also, cases with brackets for mounting the CL time delays directly to a chassis can be provided. Manual push-to-test buttons are also available. The plain case measures 1.53" x 1.40" x 1.90" high.

The CL Series is but one in a large family of solid state/relay time delays. Some have screw terminals and will switch 30 amperes. Others are combined with dry reed relays in an exceptionally compact package. Delays on operate, on release, or "interval on" may be ordered. Nearly 1300 listings are shown in our catalog.

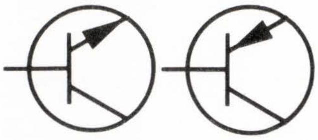
For complete information, call your local P&B sales engineer. Or, call or write Potter & Brumfield Division of American Machine & Foundry Company, Princeton, Indiana 47570. Telephone 812/385-5251.

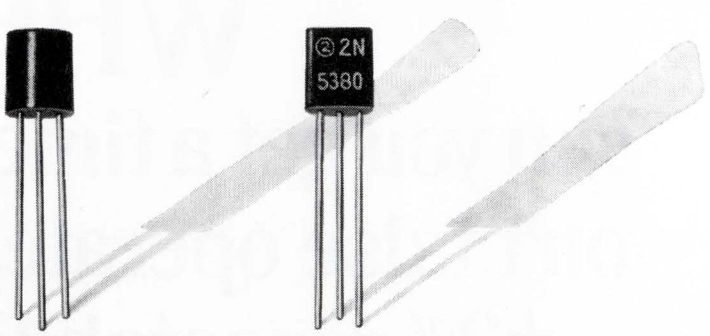


STANDARD P&B TIME DELAYS ARE AVAILABLE FROM LEADING ELECTRONIC PARTS DISTRIBUTORS.

AMF | POTTER & BRUMFIELD

Circle 57 on Inquiry Card





GOOD NUMBERS TO KNOW: 2N5381 2N5383

REPLACE OLD 2N3904 and 2N3906 PLASTIC TRANSISTORS AND GAIN 3 WAYS. 360 mW P_D vs 310. T_J (max) =150°C vs 135. TO-18 PINNING.

These two new Sprague plastic transistors give you 20% more power dissipation, 15° C higher junction temperature, and industry standard TO-18 pinning when used as direct electrically interchangeable replacements for 2N3904 and 2N3906.

The 2N5381 and 2N5383 are two of twenty new TO-18 pinned plastic transistors from Sprague. Check the replacement chart, then make your move. Sprague industrial distributors have stock. The sales offices listed below can supply samples. Call them now. Or get complete specifications by writing Technical Literature Service, Sprague Electric Company, 233 Marshall Street, North Adams, Mass. 01247, or use the reader service number below.

OLD NUMBERS	NEW SPRAGUE TYPES	OLD NUMBERS	NEW SPRAGUE TYPES
2N3903	2N5380	MPS6514	TPS6514
2N3904	2N5381	MPS6515	TPS6515
2N3905	2N5382	MPS6516	TPS6516
2N3906	2N5383	MPS6517	TPS6517
2N4123	TP4123	MPS6518	TPS6518
2N4124	TP4124	MPS6519	TPS6519
2N4125	TP4125	MPS6520	TPS6520
2N4126	TP4126	MPS6521	TPS6521
MPS6512	TPS6512	MPS6522	TPS6522
MPS6513	TPS6513	MPS6523	TPS6523

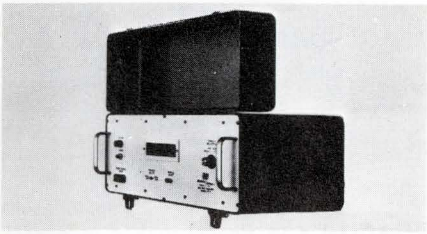
SPRAGUE ELECTRIC CO., SEMICONDUCTOR DIV., CONCORD, N.H. 03301 (603) 224-1961

ALA. Huntsville, no charge call operator, WX4000 **ARIZ.** Phoenix (602) 279-5435 **CALIF.** Burlingame (415) 347-7701 Los Angeles, Bell Tel., (213) 870-0161, Gen. Tel., (213) 391-0611 San Diego (714) 278-7640 **COLO.** Denver (303) 756-3611 **CONN.** Trumbull (203) 261-2551 **DC.** Washington (202) 244-6006 **FLA.** Orlando (305) 831-3636 **ILL.** Schiller Park (312) 678-2262 **IND.** Indianapolis (317) 253-4247 **MASS.** Newton (617) 969-2520 North Adams (413) 664-4411 **MICH.** Jackson (517) 787-3934 **MINN.** Minneapolis (612) 335-7734 **MO.** St. Ann (314) 291-2500 **N.J.** Cherry Hill (609) 667-4444/(215) 467-5252 Wayne (201) 696-8200 **N.M.** Albuquerque (505) 265-1579 **N.Y.** Melville (516) 549-4141 Syracuse (315) 437-7311 **N.C.** Winston-Salem (919) 722-5151 **OHIO** Chagrin Falls (216) 247-6488 Dayton (513) 223-9187 Cincinnati, no charge call operator, Enterprise 3-8805 **TEX.** Richardson (214) 235-1256 **WASH.** Seattle (206) 632-7761.

SPRAGUE®
THE MARK OF RELIABILITY

15S-0133

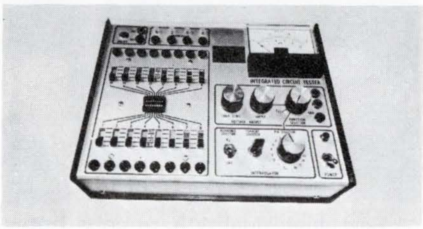
LOGARITHMIC TIMER
Uses digital techniques.



Model DLT-1 accepts start/stop signals and measures the time interval between them logarithmically. The basic unit reads in 0.1 dB steps up to a max. reading of 60 dB, with the reference (0 dB interval) selected as 10 μs, 100 μs, 1 ms, 10 ms, 100 ms, or 1s. Microwave/Systems, 1 Adler Dr., East Syracuse, N.Y. 13057.

Circle 212 on Inquiry Card

IC TESTER
With 4 x 16 program matrix.



Model 101 performs dc and functional testing of most digital IC's. Panel layout follows typical data sheets for fast programming. Model 101A has a test socket for TO-5s and flat packs as well as 14- and 16-pin DIPs. $295 (Model 101) and $315 (101A). Spectrum Dynamics, 2300 E. Oakland Park Blvd., Ft. Lauderdale, Fla. 33306. (305) 566-4467.

Circle 213 on Inquiry Card

DIFFERENTIAL VOLTMETER
Has accuracy of 0.01% of reading.

The DC 110C has a 6-digit readout and a guarded 100 μV null detector. The voltmeter gives you a recorder output of 0 to 1 V at ½ mA. Also included is a voltage reference source (from 0 to 11 V) that has an accuracy of 0.01% of setting. $675. Precision Standards Corp., 1701 Reynolds (Irvine Industrial Complex) Santa Ana, Calif. (714) 546-0431.

Circle 214 on Inquiry Card

RF NOISE SOURCE
From 1 to 500 MHz.

Model NS-C has a stabilized white noise output that is continually variable from 0-16 dB excess noise in two ranges. A resonant line output-coupling circuit ensures low vswr and gives you high accuracy over the full range. Available from stock, it costs $495. Aerospace Research, Inc., 130 Lincoln St., Boston, Mass. 02135.

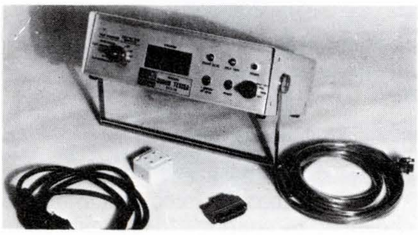
Circle 215 on Inquiry Card

DIGITAL VOLTMETER
with 3½ digits.

Features of the VT 300 include automatic zero, overrange indicator, internal calibration voltage, BCD output, end of measurement signal output, and an external trigger input. Accuracy is ±0.1% of reading, ±0.1% of full scale. $199 with delivery from stock. Dixson, Inc., Box 1449, Dept. 227, Grand Junction, Colo. 81501. (303) 242-8863.

Circle 216 on Inquiry Card

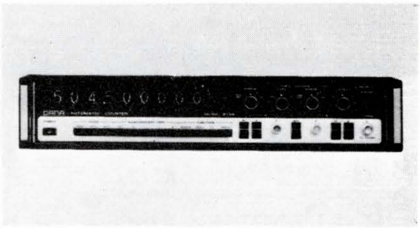
MODEM TESTER
Provides direct error readout.



This pre-set, bit-count modem tester determines error rates on asynchronous modems to 240 bps and synchronous modems to 200,000 bps. Designed for both local and remote looped, full duplex modems, it is compatible with all RS232B interfaced modems. Sanders Associates, Inc., Daniel Webster Hwy, So., Nashua, N.H. 03060. (603) 885-2816.

Circle 217 on Inquiry Card

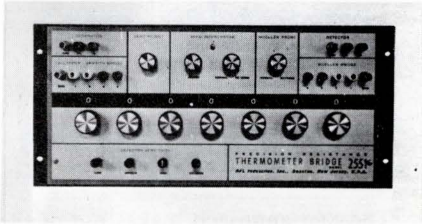
COUNTER/TIMER
Completely programmable.



Model 8134 is an 8-digit counter that measures frequencies to 500 MHz (with 500 μV sensitivity) and time intervals with 100 ns resolution. All front panel controls can be programmed with TTL-compatible BCD codes. Dana Laboratories, Inc., High Frequency Div., 2401 Campus Dr., Irvine, Calif. 92664. (714) 833-1234.

Circle 218 on Inquiry Card

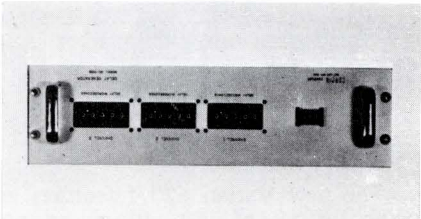
RESISTANCE BRIDGE
With calibration traceable to NBS.



This instrument, Model 2551, can measure temperature or temperature difference (with resistance thermometer probes) to within ±0.005% ±0.0015Ω. Potentiometers on the bridge panel give you ratio equality and residual resistance balance to within 0.0001Ω. Price is $1400 with delivery 30 to 60 days. RFL Industries, Inc., Boonton, N.J. 07005.

Circle 219 on Inquiry Card

TIME DELAY GENERATOR
With ±0.1 μs accuracy.

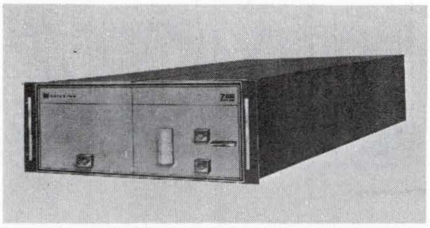


Model 413, gives you three independently delayed output pulses (from 1.0 to 9,999.9 μs). You can vary input pulse sensitivity from +10 to +1200 V, and the generator produces a pulse of +100 V into 50Ω with a rise time of 100 ns (10-90% points) and with a duration of 100 μs. Cordin Co., 2230 So. 3270 W, Salt Lake City, Utah 84119.

Circle 220 on Inquiry Card

DIGITAL PRINTER

Fed with 4, 5 or 6-line BCD data.

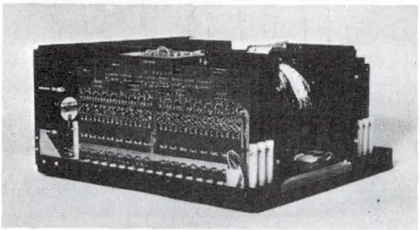


Model AN72 digital printer can be fed with 4-, 5-, or 6-line BCD data. With a 6-line input, a full complement of 64 alphanumeric characters as well as all std. signs, symbols and punctuation marks can be printed. For standardization, input follows an ASCII format. Datadyne Corp., Bldg. 37A, Valley Forge Ctr., King of Prussia, Pa. 19406.

Circle 203 on Inquiry Card

READ ONLY MEMORY

Electrically alterable.



The MSI approach makes use of the inherent fast NDRO properties of plated wire to achieve a 200 ns Read cycle. The EAROM is organized in such a way to make the write function very tolerant of timing, drive current variations, and line recovery, as a tradeoff for high read speed. Even so, it has a 1 µs write cycle. Memory Systems, Inc., 3341 W. El Segundo Blvd., Hawthorne, Calif. 90250. (213) 772-4220.

Circle 204 on Inquiry Card

MINI-COMPUTER

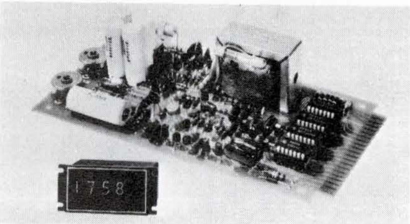
750 ns cycle time.

The new Varian 620/f features an extended set of instructions, an optional 300 ns ROM, for an effective processor time of 500 ns, a Priority Memory Access (PMA) mode that permits data transfers asynchronously to and from memory at rates to 1.3 MHz, and a compact packaging design that allows up to 8 k of memory. Varian Data Machines, 2722 Michelson Dr., Irvine, Calif. 92664. (714) 833-2400.

Circle 205 on Inquiry Card

A/D CONVERTER

With optional numeric display.

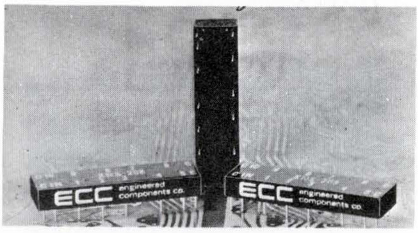


Model 281 is a self-contained converter that operates on 115 Vac. Basic input sens. is 199.9 mV with conversion made at 0.1% of signal ±1 digit. Model 282 Numeric Display is usable with the 281 where visual readout is needed. It displays 3 full digits, decimal point, overrange and error indicators. United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403.

Circle 206 on Inquiry Card

DELAY LINES

Two lumped constant units.



The XNS-208 is a 50 ns unit tapped at 5 ns increments with a rise time of 5 ns and a Z of 50 Ω. The XNS-209 is a 100 ns unit tapped at 10 ns increments with a rise time of 10 ns and a Z of 100 Ω. Delay to rise-time ratios of both units is 10:1; attenuation is < 2% and max. distortion is 3%. Engineered Components Co., 2134 Rosecrans Ave., Gardena, Calif. 90249. (213) 321-6565.

Circle 207 on Inquiry Card

MINIATURE RECORDER

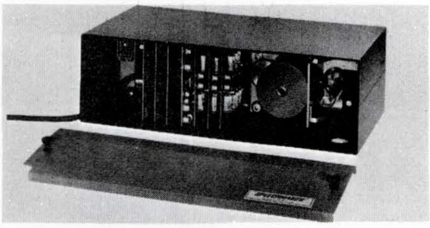
It's inkless.

The Minigraph recorder offers a choice of 14 chart speeds ranging from ⅛ in. to 60 in./h. Accuracy is ±2% and full scale response is 1 s. Sensitivity is 10 µA full scale. The Minigraph has four basic movements—from 0 to 10 µA, 50 µA, 100 µA and 1 mA. The six dc ranges range from 1 to 500 V. The ac ranges are 150, 300 or 600 V. $99.50 and up. Esterline Angus, div. of Esterline Corp., Box 24000, Indianapolis, Ind. 46224.

Circle 208 on Inquiry Card

AUDIO RESPONSE SYSTEM

It's IC compatible.



Model 636 Speechmaker is a real-time system that interfaces with computers to give spoken answers in words, phrases or numbers to a request for information. Up to 31 words are stored and, on command, are spoken back singularly or in any group sequence. Cognitronics Corp., Speechmaker Div., 333 N. Bedford Rd., Mt. Kisco, N.Y. 10549.

Circle 209 on Inquiry Card

DATA TERMINAL

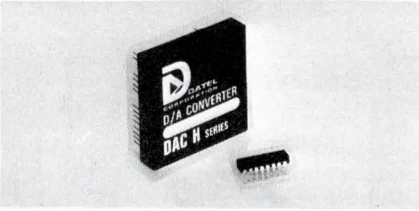
Hard copy output available.

Fast, high quality hard copy output for CRT terminals is available as an integral feature of the '45' desk-top CRT Data Terminal. The electro-optical printout process produces a 5 x 5 in. photoprint of the data displayed on the CRT in < 7 s after pressing the print button, with additional copies at 2 s intervals. $15,000. Photophysics Data Systems, 1255 Terra Bella Ave., Mountain View, Calif. 94040.

Circle 210 on Inquiry Card

D/A CONVERTER

Output settling time is 25 ns.



The 25 ns settling time to within 0.1% of the final value in these DAC-H converters allows for an update word rate of 40 MHz. Full scale output is ±2.5 mA with a max. voltage compliance of ±1.2 V. Output linearity is ±2.5 µA with a current resolution of 5 µA. Overall accuracy is ±0.005% with a TC of ±15 ppm/°C. Total volume is only 1.6 in.^{3} Datel Systems Corp., 943 Turnpike St., Canton, Mass. 02021.

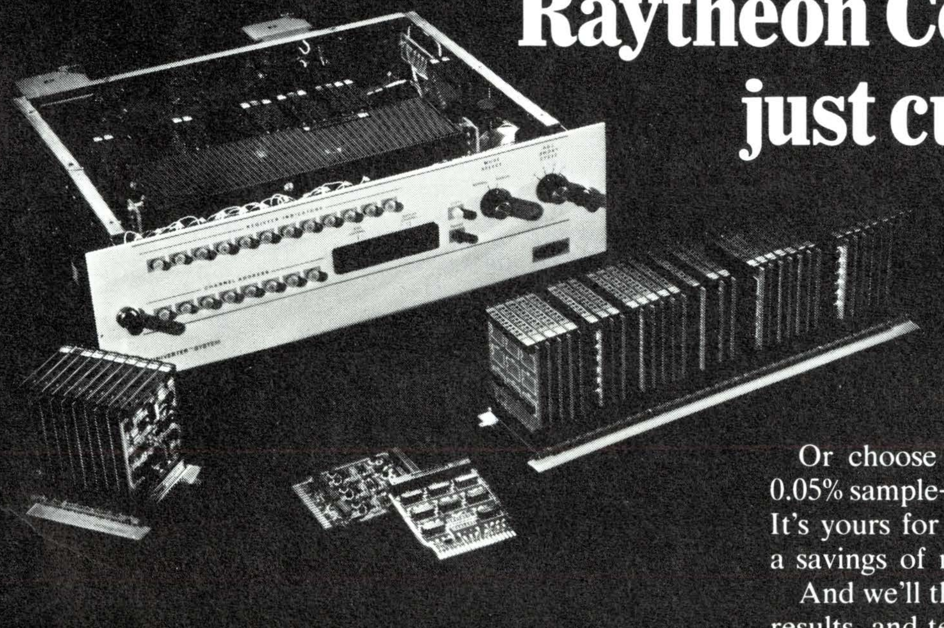
Circle 211 on Inquiry Card

Circle 59 on Inquiry Card ⟶

Trading off performance for cost in conversion equipment?

Stop!

Raytheon Computer just cut prices 33%



Now you don't have to make any cost/performance trade-offs in A-to-D and D-to-A conversion or interface equipment. We've taken the best price/performance ratio in the industry and made it even better. With price reductions from 15% to 50%.

So now you can pick from the industry's broadest line of conversion equipment. With ADC's. DAC's. Multiplexers. Sample-and-holds. All at new low prices. All available now. Off-the-shelf.

Take our 12-bit, multiplexed ADC. Case-mounted with 32 channels, this unit was a good buy for $3,640. The new price is only $2,300. Want more capacity? It's available with up to 256 channels. With savings to match.

Or choose our high performance 0.05% sample-and-hold amplifier card. It's yours for only $125. And That's a savings of more than 33%.

And we'll throw in wiring lists, test results, and technical manuals. Free. We'll deliver your conversion equipment and documentation cheaper and faster than you could do it yourself.

And, if your systems need computer power, try one of ours. Choose from a family of 16-bit machines. With cycle times from 900ns to 1.75μs, including our new 1.0μs 704 mini for under $10,000. All are software compatible with over 400 proven off-the-shelf programs.

Get the best price/performance bargain in the industry for your system, today. Call or write and ask for Data File E-188.

RAYTHEON

Raytheon Computer, 2700 S. Fairview Street, Santa Ana, California 92704. Phone (714) 546-7160.

The only thing Raytheon Computer does is your job. Cheaper.

MATCH

With an optimization feature.

With MATCH you specify a desired frequency response, giving either the magnitude or phase. It will then take a "ballpark" design and vary its element values to fit the response to that desired. The optimization feature makes it easier to solve broadbanding, equalization, and synthesis problems. This feature is also useful for correcting designs to account for parasitics.

This interactive program is applicable to any practical cascade circuit, including a wide variety of active filters. It will calculate Z, Y, G, H, ABCD and scattering parameters. It also calculates group delay and lets you describe sections with either empirical frequency response data or rational functions. You can also compute a variety of exact sensitivities and partial derivatives.

You can plot results against linear or logarithmic frequency, as well as on normal or expanded Smith charts.

Applicon Incorporated, 83 Second Ave., Burlington, Mass. 01803. (617) 272-7070.

Circle 262 on Inquiry Card

LOGIC

Digital system simulation.

This program simulates digital systems containing logic gates. Flip-flops, clocks, registers and other special purpose modules. Give it a description of your logic block diagram and it will produce tables showing the logical state of selected modules at designated points in time. You can use this printout as a timing diagram.

The printout, in addition to being keyed to specified periods of time, can also be keyed to the state changes of various modules, giving you considerable latitude in your design analysis.

This program has a conversational data input model for the experienced user. It will simulate a digital system having up to 500 logic modules. Propagation delays can be specified for each module.

General Electric, Information Service Dept., 7735 Old Georgetown Rd., Bethesda, Md. 20014.

Circle 263 on Inquiry Card

MICRONET

For designing microwave circuits.

MICRONET is used on a remote interactive basis. It provides a program for frequency domain analysis of distributed parameter circuits and includes modeling and analysis flexibility. Applicon Incorporated, 83 Second Ave., Burlington, Mass. 01803. (617) 272-7070.

Circle 264 on Inquiry Card

ACNET and DCNET

For linear circuit analysis.

These two programs perform ac and dc linear network analysis, respectively. By building a data file describing the circuit you can "breadboard" your circuit on the computer. The programs then perform analysis and tests on the "bread-board" circuit so that you can evaluate circuit performance. The programs' interactive conversational mode lets you direct the course of analysis and alter circuit parameters "on-line" during the run.

A useful feature of these programs is their ability to produce a sensitivity analysis.

ACNET and DCNET also have the capability to provide information on the production yield in circuit manufacturing. This is done through a Monte Carlo analysis. General Electric, Information Service Dept., 7735 Old Georgetown Rd., Bethesda, Md. 20014.

Circle 265 on Inquiry Card

NLNET

For non-linear circuit analysis.

NLNET is an on-line application program for analyzing electronic circuits. It quickly performs non-linear dc analysis with non-linear models for transistors and diodes. With it you can create a file of stored transistor models for referencing. Thus, you need to model a specific transistor only once. It not only readily calculates steady-state voltages, currents, and powers, but also produces statistical analysis of your circuit's performance.

It also has the capability to provide information on the production yield in circuit manufacture. This is done through a Monte Carlo analysis. General Electric, Information Service Dept., 7735 Old Georgetown Rd., Bethesda, Md. 20014.

Circle 266 on Inquiry Card

ALICE

Logic simulation for digital analysis.

This program simulates the behavior of asynchronous and synchronous digital logic networks as well as verifying the behavior of a logic net. It is particularly useful for designing MSI or LSI circuits where bread-boarding is difficult. Rise and fall can be specified for each logic element. Clock logic elements are also allowed.

This three-value (logic simulators are typically bistable) look ahead simulator allows undefined inputs, checks result sequences and allows undefined inputs, checks result sequences and allows several types of timing analysis to be performed. Applicon Incorporated, 83 Second Ave., Burlington, Mass. 01803. (617) 272-7070.

Circle 267 on Inquiry Card

MOFACS

Calculate feedback parameters.

MOFACS (Multi Order Feedback and Compensation Synthesis) is a digital computer program for synthesizing the linear and/or non-linear feedback parameters needed to achieve a desired transient response. With it you can calculate the best possible feedback parameters and compensation time constants in one pass. This differs from the analysis and CAD programs where you must continually re-select hardware and parameters and analyze them to get the desired performance.

Because MOFACS input is in the form of a transient response, it can be used as an off-line adaptive controller. It can be applied to R&D designs. And, it can be applied to applications, instrumentation, process control and DDC engineering. Compro Associates Inc., 825 N. Church St., Room 201, Rockford, Ill. 61103. (815) 964-7224.

Circle 268 on Inquiry Card

ANALG

Dynamic system simulation.

ANALG simulates the operation of an analog computer. Thus, it can be used to produce the transient response of a system which has been modeled using linear or non-linear differential equations. With it you can store system descriptions in a data file instead of having to build a patchboard. Once the simulated "patchboard" has been created, the program will determine the time-domain response at any point within your system over any interval of time.

ANALG has 31 different types of functional blocks which allow you to build all types of function generators and also allow you to describe system non-linearities. Another feature is that configuration and parameter changes can be made on-line. General Electric, Information Service Dept., 7735 Old Georgetown Rd., Bethesda, Md.

Circle 269 on Inquiry Card

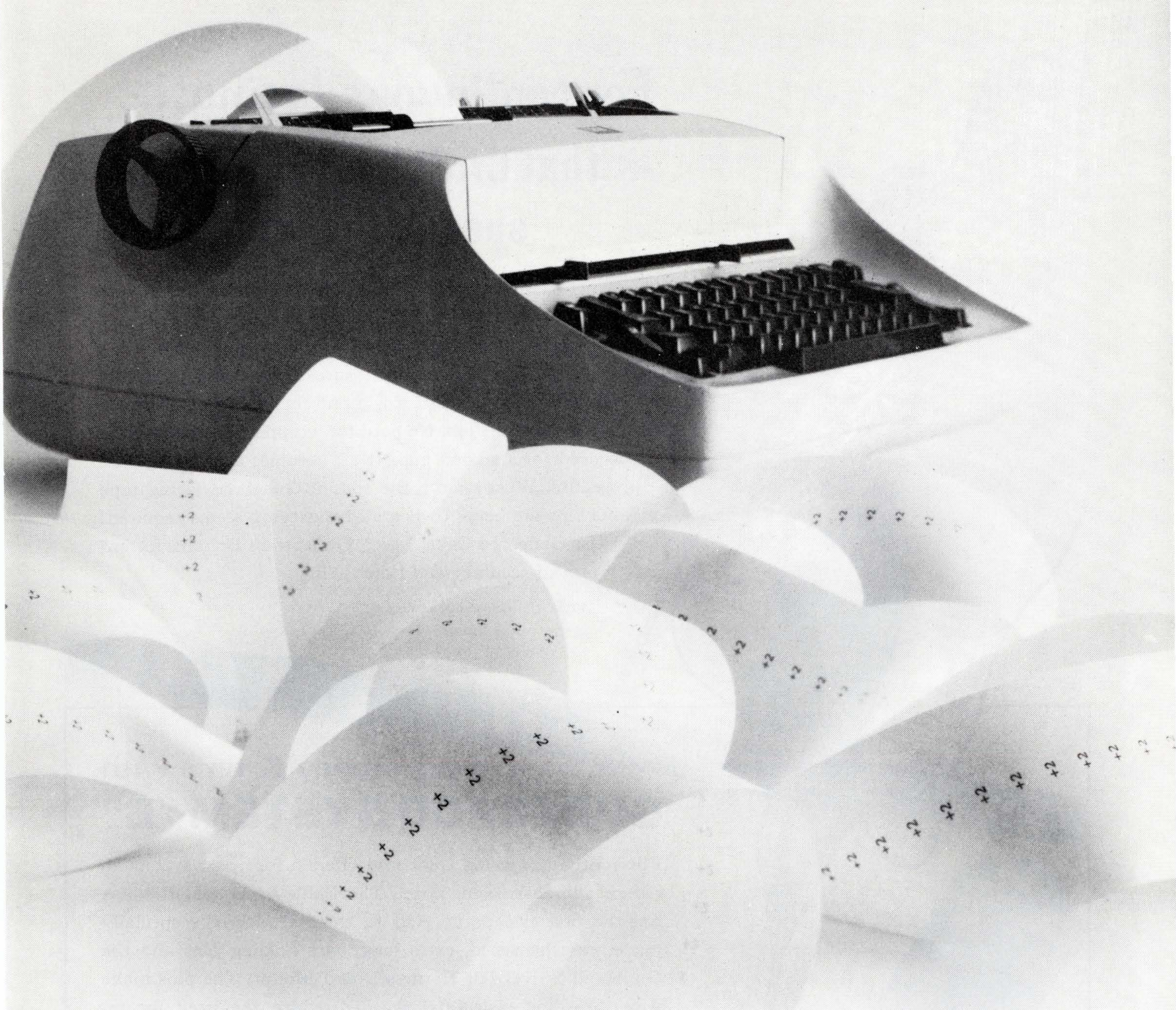
TRANS

Dynamic system simulation.

TRANS is used to quickly and easily invert Laplace transforms to obtain either numerical or plotted transient response of dynamic systems. You merely enter the coefficients of the transform into the program, and the transient response is produced. It provides you with an accurate method to study the performance of a proposed system and investigate differences in existing systems. General Electric, Information Service Dept., 7735 Old Georgetown Rd., Bethesda, Md.

Circle 270 on Inquiry Card

Circle 60 on Inquiry Card ⟶



Time-sharing is like trying to add 2+2 on a typewriter.

Most service bureaus give you a teleprinter terminal and expect you to solve your problems with a computer many miles away. So when their computer gets busy, your teleprinter goes dead.

And a dead teleprinter is just another typewriter.

But now there's a different kind of time-sharing that only you can use.

It's called the Interplex System I. It's an in-house system with a 12K general-purpose computer, hard-wired to as many as 16 specially designed terminals. So you don't need phone lines.

And because it's your own in-house system, you can use it as much as you want without paying an extra cent for it.

It's easy.

Our new time-sharing terminal is the first to combine BASIC language programming with an electronic calculator in a single desk-top unit. So you can do up to 90% of your time-sharing jobs in BASIC without leaving your desk. And for a lot less than you're paying now.

You won't need any more equipment, because the terminal's also an electronic calculator. So you can even stop in the middle of your own program to run your calculations. And you don't have to wait for anybody else.

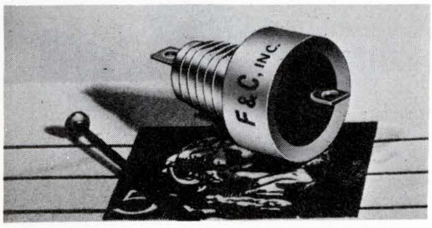
The Interplex System I. It's a different kind of time-sharing. You share it with yourself.

interplex

Interplex Corporation
400 Totten Pond Road
Waltham, Mass. 02154

NEW PRODUCTS

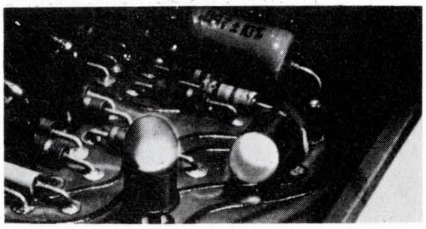
CERAMIC FILTERS
For broad use.



Series 800 units filter ac and dc lines in aircraft, aerospace and industrial avionic systems, power supplies, communication, navigation and guidance equipment. Models are available with ratings from 50 Vdc to 120 Vac, 400 Hz., and from 40 mA to 15 A. A typ. 50 Vdc, 40 mA unit would display an insertion loss of over 80 dB at 1 MHz. About $12 ea. Filters & Capacitors, Inc., 425 N. Fox St., Box 1272, San Fernando, Calif. 91341.

Circle 244 on Inquiry Card

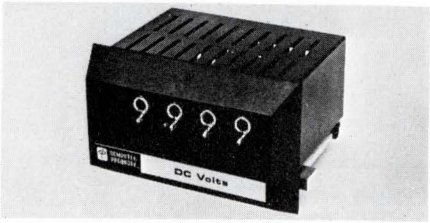
SOLID-STATE LAMP
Only $0.50 in quantity.



New HP 5082-4403 red light-emitting diode (LED) is designed to displace miniature incandescent and glow lamps in indicator applications. The GaAsP lamp is for self-mounting in panels or PC boards, and has a rugged lead-frame and plastic construction. It has a typ. life of 1,000,000 hrs. Operating on 1.8 V at 20 mA, it is compatible with ICs. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 326-7000.

Circle 247 on Inquiry Card

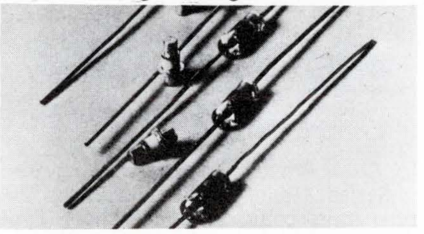
DIGITAL PANEL METER
Accurate 10,000 count resolution.



DP400 Series 10,000 count meters are high-accuracy (±0.02%, ±1 count) dc voltage measuring devices that provide direct digital readout of the value of the applied input voltage. Three models are available with full-scale input ranges of 1.0, 10.0 or 100.0 V. Range is 30°F to 140°F, and TC is 0.003%/°F. $273.00 and up. Computer Products, 2709 Dixie Hwy, Box 23849, Ft. Lauderdale, Fla. 33307. (305) 565-9565.

Circle 250 on Inquiry Card

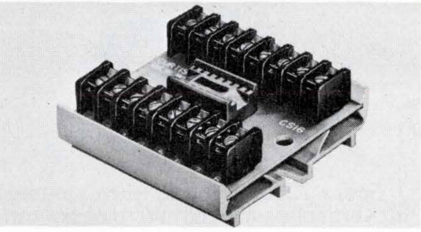
LOW POWER PIN DIODES
Fast switching and high dynamic Q.



These PIN diodes provide up to 1.0 kW peak power with 5 ns switching time and dynamic Q of 300. Minimum breakdown of 100 V and lifetime of 75 ns are other characteristics. These diodes, characterized at 1 GHz, are for use in fast switches and modulators in waveguide, stripline or coaxial circuits. Microwave Associates, Burlington, Mass. 01803. (617) 272-3000.

Circle 245 on Inquiry Card

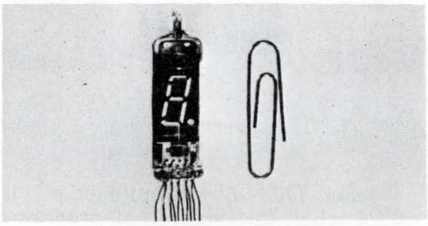
IC SOCKET ASSEMBLIES
Track-mounted.



New CS16 assemblies are for testing, breadboarding and packaging 16-pin DIL modules. They feature a PC design, a 16-pin DIL socket, and SE Series barrier terminal blocks. Up to 21 sockets can be mounted to a 48 in. length of prepunched track. $2.85/assembly, including track, in lots of 1000. Curtis Development & Mfg. Co., 3250 N. 33rd St., Milwaukee, Wis. 53216.

Circle 248 on Inquiry Card

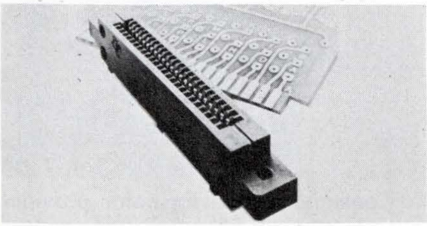
DIGITAL INDICATOR
Wide spectral bandwidth.



DG-12H seven segment indicator is a low voltage, low current drain, planar readout device. Digits, symbols, and letters are composed of highly efficient phosphor coated segments providing clarity between digits up to 40 ft. distances. Wide spectral BW makes available different color outputs using proper filtering. Legitron Corp., 3118 W. Jefferson Blvd., Los Angeles, Calif. 90018. (213) 733-9105.

Circle 251 on Inquiry Card

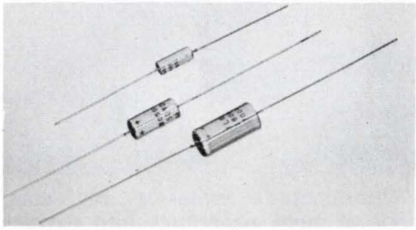
EDGEBOARD CONNECTOR
Matched impedance for h-f uses.



This connector offers you an inexpensive system mechanically similar to std. edgeboard connectors, yet electrically equivalent to coaxial connectors. It has quick connect-disconnect capability, and costs about 80% less than traditional coaxial connector systems. Texas Instruments Incorporated, 34 Forest St., Attleboro, Mass. 02703.

Circle 246 on Inquiry Card

TANTALUM CAPACITOR
Seal prevents leakage.



A positive hermetic glass-to-metal seal on this wet anode tantalum electrolytic capacitor prevents electrolyte leakage. The new TLW capacitor has voltage ratings of from 6 to 125 V and a capacitance of 560 μF at 6 V to 25 μF at 125 V. P.R. Mallory & Co. Inc., 3029 E. Washington St., Indianapolis, Ind. 46206. (317) 636-5353.

Circle 249 on Inquiry Card

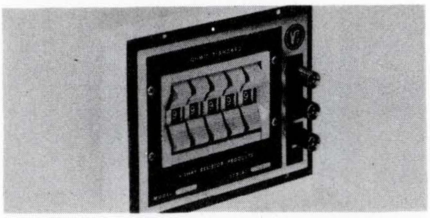
MULTI-PURPOSE EPOXY
Cures in < 1 min.

Minit-Cure epoxy is well suited for jobs that require fast curing time at room temp. (75°F). It bonds metals, woods, plastics, rubber and glass. Almost instantaneous use can be obtained from the item being bonded. Its tensile strength is 2900 psi. Tescom Corp., Instrument Div., 2633 S.E. 4th St., Minneapolis, Minn. 55414.

Circle 252 on Inquiry Card

NEW PRODUCTS

DECADE MODULES
For mounting in test panels.

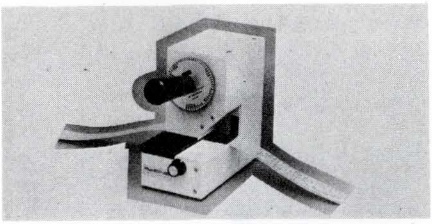


These resistance decades are very accurate (±0.005% at the terminals) with a long-term stability up to 5 ppm/yr. They can be used at incoming inspection stations, in the stds. lab. and for component evaluation.

Their TC is 2 ppm/°C, and they are usable to 100 MHz. Set point resolution is available up to 0.01 Ω over the 100,000 Ω range. Vishay Resistor Products, 63 Lincoln Highway, Malvern, Pa.

Circle 253 on Inquiry Card

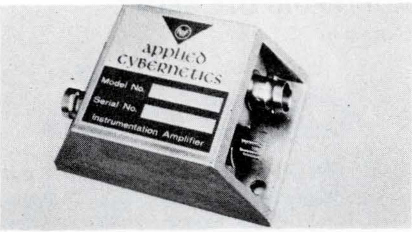
HAND ENCODER
Simplified, lower cost.



Model DCN-64 "Commander" is useful where the volume of programs or messages is small or sporadic, for backup in case of major equipment downtime, and for making corrections. It can be programmed with up to 64 individual codes in eight channels, plus feed holes, providing capability for virtually any hole-punch system. Robins Industries Corp., 15-58 127th St., College Point, N.Y. 11356

Circle 254 on Inquiry Card

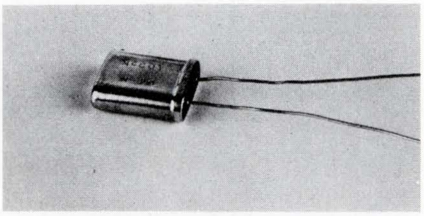
VIDEO AMPLIFIERS
Low noise, broadband.



These video preamplifiers are suitable for use in CCTV and CATV as well as high resolution video detection, low light level TV, pulse studies, and general lab use. Features include 1 V pk-pk into 50 Ω, 50 MHz bandwidth, 0-40 dB gain, Z_0: 50 or 75 Ω, Zi: 50 Ω to 1 kMΩ, and a rugged aluminum case. AMF Alexandria Div., 1025 N. Royal St., Alexandria, Va. 22314. (703) 548-7221.

Circle 255 on Inquiry Card

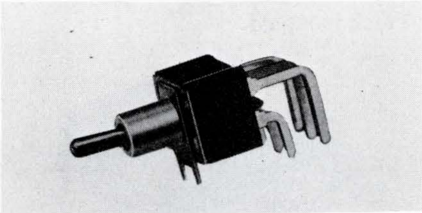
QUARTZ CRYSTAL
With 2.0 to 4.0 MHz freq. range.



New, series resonance AT precision cut crystal is available in small HC-18/U or HC-25/U holders. The fundamental mode crystal holds tolerances as low as ±0.003% over a range of −55 through 105°C. Rs max. varies from 500 Ω at 2.0 MHz to 75 Ω at 4.0 MHz. Drive level is 1 mW with a Co of 4.0 pF. McCoy Electronics Co., a subsidiary of Oak Electro/Netics Corp., Mt. Holly Springs, Pa. 17065.

Circle 256 on Inquiry Card

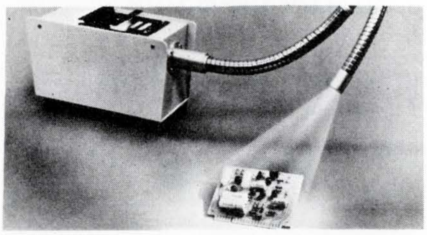
DPDT TOGGLE SWITCH
Right-angle mounting.



Series 7200A switch, when mounted in vertically stacked PC panels, protrudes outward, making the toggle easily accessible. The 7200A measures only 1.250 +0.015 in. from end-of-toggle to end-of-deepest-pole (absolute length). Contacts are made on the opposite side to which the toggle is thrown. C&K Components, Inc., 103 Morse St., Watertown, Mass. 02172. (617) 926-0800.

Circle 257 on Inquiry Card

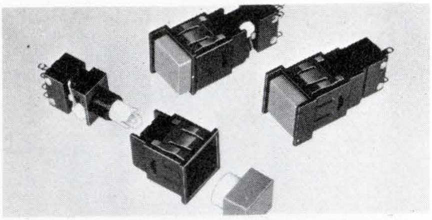
FIBER OPTICS ILLUMINATOR
Provides light for difficult areas.



Illuminator's intensive, but cool, spot of light penetrates into cavities and other hard-to-illuminate areas. It provides 800 ft. candles of non-glare illumination within a 7 in. dia. circle up to 6 in. from the end of its fiber optics probe. The optical system is housed completely in the light box source. Under $300. Bausch & Lomb, 635 St. Paul St., Rochester, N.Y. 14602. (716) 232-6000.

Circle 258 on Inquiry Card

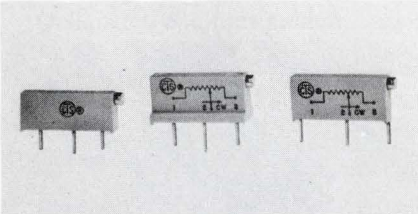
SINGLE LITE SWITCH
With snap-in housing.



Snap-in housing of the 01-600 series switches is available in bezel, single barrier or double barrier design. Indicator, momentary and alternate action units are available, also 1 or 2-pole switch packages using the 10 A Butterfly® double break switch mechanism. Lamp does not move during switch operation. Licon Div., Illinois Tool Works Inc., 6615 W. Irving Park Rd., Chicago, Ill. 60645. (312) AV 2-4040.

Circle 259 on Inquiry Card

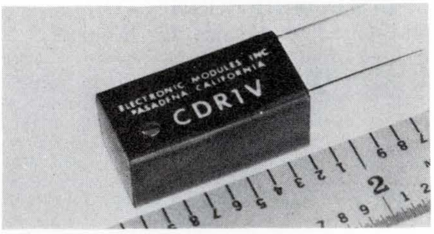
CERMET TRIMMERS
Low TC and sealed construction.



Series 190 ¾ inch rectilinear 20-turn units come in three types: Type 190, 0.100 in. wide and 0.500 in. length pin spacing; Type 191, 0.200 and 0.500 in., and Type 192, 0.100 and 0.700 in. All have low ±150 ppm/°C TC for most values, ½ W rating at 85°C and clutch stops. Standard range is from 50 Ω to 500 kΩ. Under $1.00 (in quan.). CTS of Berne, Ind. 46711. (219) 589-3111.

Circle 260 on Inquiry Card

CURRENT REGULATOR
Screw driver adjustable.

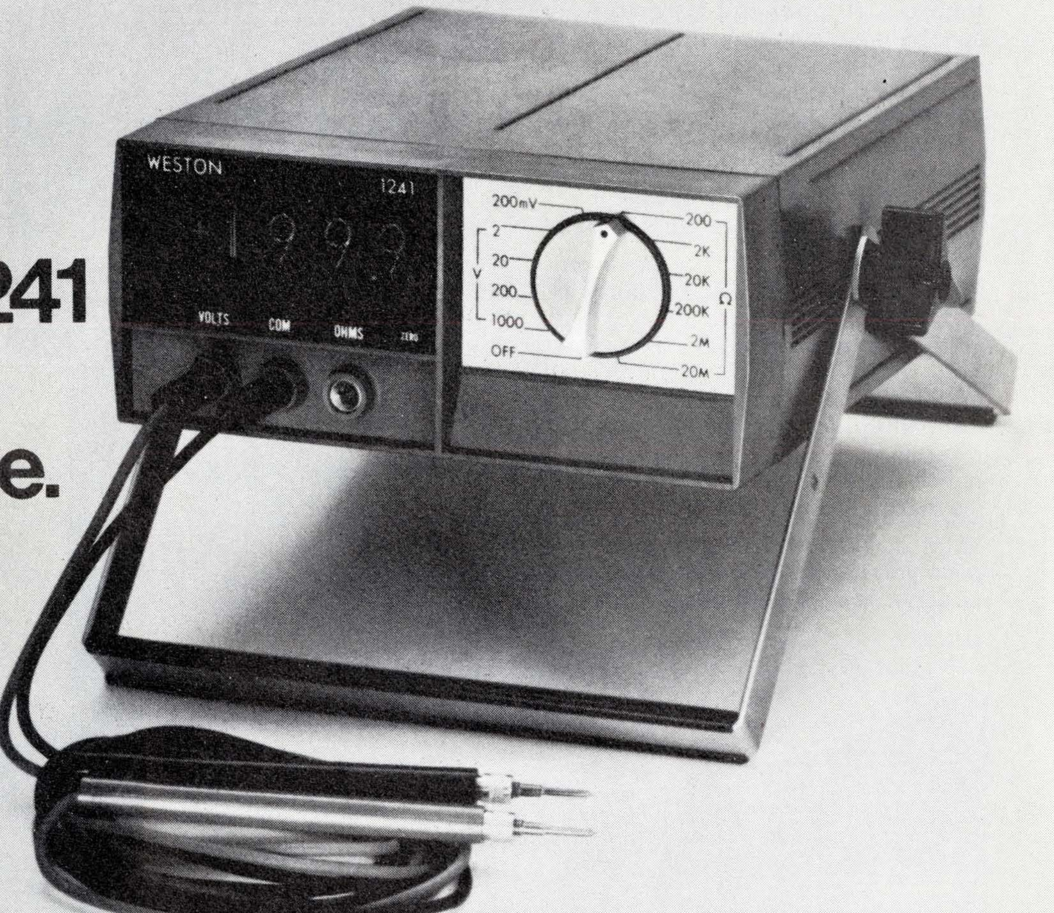


Constant current regulator provides current reg. of 1% over wide ranges of input voltage and temp. A two terminal regulator, it can be used in series with the current line and needs no ref. to ground. TC is 0.03%/° c. Current stab. with voltage 1%. Maximum power diss. ranges from 1 to 3 W at 25°C case. Electronic Modules Inc., 2560 East Foothill Blvd., Pasadena, Calif. 91107

Circle 261 on Inquiry Card

Circle 62 on Inquiry Card ⟶

Any DC VOM with 0.1% accuracy should cost more.



Model 1241 $289 complete.

We wanted the price low enough that anyone taking DC voltage or resistance readings wouldn't have to think twice about choosing our new Model 1241. As it turned out, we can give you an even bigger break. Because most of the circuitry, as well as the rugged housing and many convenience features, had been developed previously for the Weston 1240 DMM which we introduced last November.

Here's a proprietary-designed Weston instrument you can pack in your tote case, use on the bench, or mount in a standard 3½" panel. The only "extra" you may ever need is an optional battery pack for remote field applications. Model 1241 gives you high-impedance measuring capability to 3½ digits on five voltage and six ohm ranges.

In addition to its outstanding accuracy of 0.1% of reading ±.05% F.S. on Volts (0.5% ±1 digit on Ohms), this advanced meter features complete circuit overload protection. Fuses are replaceable without opening the rugged, glass-filled thermoplastic case. And, of course, there's Weston's patented dual slope* integration, automatic decimal positioning, and non-blinking display.

If you want to see how much quality a dollar will buy today, contact your Weston Distributor. He also has in stock our 1240 DMM, with 26 AC-DC ranges plus all the above features. Or write today for complete specifications.

WESTON INSTRUMENTS DIVISION, Weston Instruments, Inc., Newark, N.J. 07114, a Schlumberger company

WESTON®

*U.S. Pat. #3,051,939

Unitek Bonders Stack Up Best

Build your bonding line with the source that's proven best in the field . . . take UNITEK

In case after case of tough on-line comparison testing, more leading firms take UNITEK because they've proved that when the chips are down you get the Best Chance for the Best Choice . . . here's why . . . flexibility, repeatability, and service in-depth.

First, you get wider work-choice options. Each UNITEK bonder is built for production-versatility . . . handles all package types by simply interchanging optional accessories. Single units, rack-feed or automatic strip-feed handling of conventional packages . . . hybrids, too, all available on virtually every bonder. Take exactly the options you need now . . . add later when you need to . . . the closest thing yet to custom making your production line.

Pinpoint repeatability is another very big reason. Prototype work or line work, it's guaranteed by exclusive rugged, durable UNITEK construction, perfect process controllability and ultra-simple operation. Training and maintenance stay low . . . rates and yields stay up . . . lot-run after lot-run.

Third . . . service . . . expert guidance you can count on; after you specify as well as before. Your UNITEK man and the entire UNITEK Applications Laboratory team of bonding specialists can make life a lot easier out there on the line.

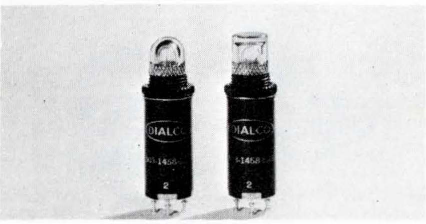
UNITEK stacks-up best . . . has for over twenty years . . . there's bound to be a proven UNITEK bonder for you . . . get more facts by contacting your nearby UNITEK man or UNITEK/Weldmatic Division, 1820 So. Myrtle Avenue, Monrovia, California 91016. Telephone: (213) 358-0123; TWX: 910 585-3236.

The Best Chance for the Best Choice

UNITEK

INDICATOR LIGHTS

For integrated circuits.

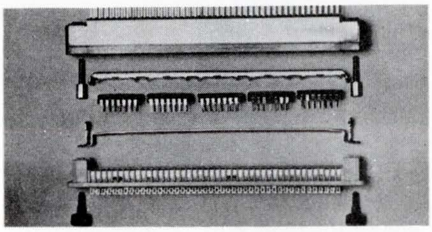


This subminiature transistorized light, specially designed for ICs, needs no power supply and interface circuitry. It operates directly from std. TTL, DTL, and RTL micrologic modules. Signal level requirements and power supply voltage for these units are completely compatible with ICs. All driving circuitry is within the indicator light itself. Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237. (212) 497-7600

Cricle 271 on Inquiry Card

IC PACKAGING SYSTEM

Low cost, solderless.

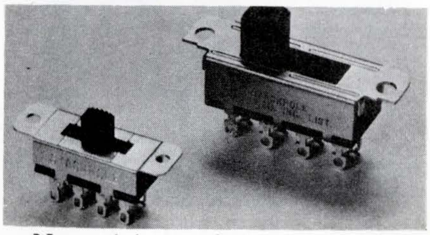


New packaging system, DipStik II, provides high capacitance and low impedance ground and power planes. With it you can mount DILs, remove or replace them and change logic circuitry, all in a few seconds—without the use of solder. Its high density packaging capability allows 1000 DILs to be mounted in a 5¼ in. rack. ACS Industries, 13726 Saticoy St., Van Nuys, Calif. 91402. (213) 988-5310.

Circle 272 on Inquiry Card

SLIDE SWITCH

Smaller mass.

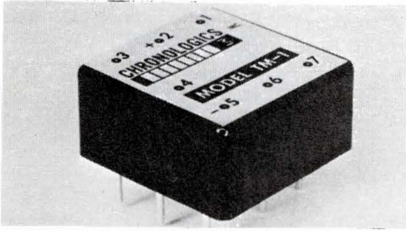


New miniature slide switch is about half the mass of a regular slide switch. Typical overall length is reduced from 1⅜ in. for a std. sized switch to 1 in. for a comparable miniature switch. The multi-purpose switch is available in all combinations from SPST to double pole—three position. Initial ratings are 1 A at 125 Vac (ind. load). Stackpole Components Co., Box 14466, Raleigh, N.C. 27610.

Circle 273 on Inquiry Card

TIMING MODULES

From milliseconds to hours.

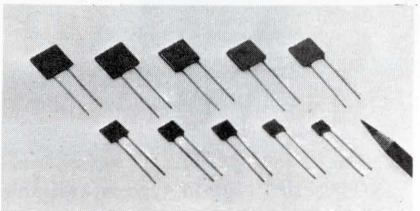


By adding ext. resistors and capacitors to the TM series modules, you can obtain timing ranges from milliseconds to hours. Timing is fixed or adjustable with delay or interval modes of operation. Outputs are pulse, continuous, or complementary. Repeat accuracy is ±1% at constant temp. Series also features on/off voltage level control. Chronologics Inc., 24 Martin St., Webster, N.Y. 14580. (716) 782-1470.

Circle 274 on Inquiry Card

MICA CAPACITORS

For improved circuit stability.

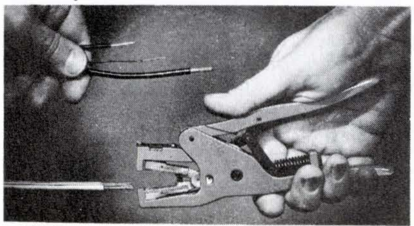


Lead spacings of these single-film silvered mica capacitors are interchangeable with those of normal ceramic disc capacitors. Thus you can have the advantages of silvered mica dielectric without having to completely revise PC boards. Type 91M capacitors come in 45 ratings ranging from 10 pF to 68 pF at 500 V. Sprague Electric Co., 233 Marshall St., North Adams. Mass. 01247.

Circle 275 on Inquiry Card

WIRE STRIPPER

Self-adjusts to different wire sizes.

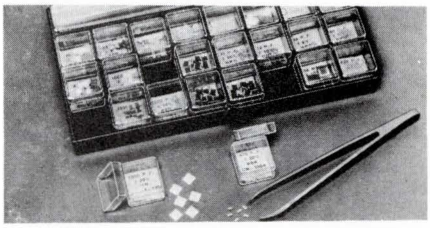


This new tool (ABMK-1) is completely self-adjusting to the point where it is not necessary to know the wire size. Different diameter wires can be stripped consecutively without changing or adjusting the stripping jaws. The tool takes wire dia. from AWG #30 through #12, both copper and aluminum. $28.00. The Thomas & Betts Co., 36 Butler St., Elizabeth, N.J. 07207. (201) 354-4321.

Circle 276 on Inquiry Card

CAPACITOR KIT

Contains over 400 ceramics.

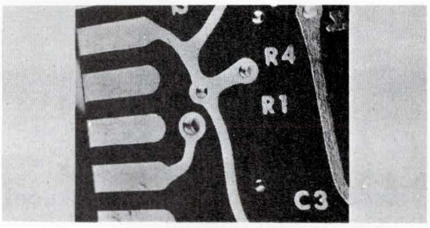


AlSiMag® kit contains both single layer and multi-layer capacitors. Diced chip capacitors range from 18 pF to 1500 pF in sizes from 0.020 in.^{2} to 0.350 in.^{2} Multi-Cap® capacitors range from 10 pF to 0.085 μF in sizes from 0.085 x 0.055 in. to 0.220 x 0.250 in. Materials range from TC to high K. Tolerances are ±5%, ±10% and ±20%. $50. American Lava Corp., Chattanooga, Tenn. 37405. (615) 265-3411.

Circle 277 on Inquiry Card

COPPER-CLAD LAMINATE

For PC boards.

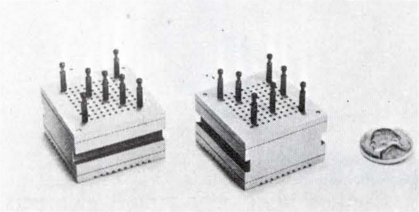


Insulstruc® copper clad X2FR-PG glass polyester sheet is for applications requiring superior toughness at low cost. High density Insulstruc has Izod impact strength of 7 ft. lbs., solder dip resistance of 20 s (Mil-P-13949D), and other excellent mechanical and electrical characteristics typical of glass polyester. Cincinnati Development & Mfg. Co., 5614 Wooster Pike, Cincinnati, Ohio 45227.

Circle 278 on Inquiry Card

MATRIX BOARDS

Grooved for modular assembly.

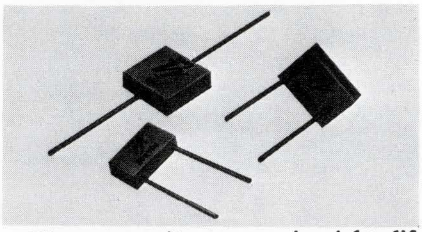


Miniature 10 x 10 solderless boards, grooved for lock-in assembly, provide any number of groupings consisting of 100 terminal holes on 0.100 in. centers. Each "Miniboard" module is 0.147 in.^{2} and 27/32 in. thick. Units mount on aluminum framing rails. Contact rating is 3 A. Voltage rating is 300 Vdc max. Programming Devices Div., Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543.

Circle 279 on Inquiry Card

PORCELAIN CAPACITORS

With tight tolerance.

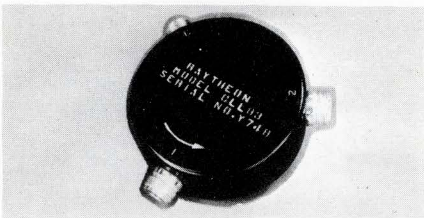


These capacitors come in eight different series which include 22 styles. Available in a range of 0.24 pF through 10,000 pF, they have tolerances of either ±0.1 pF or ±1%. All styles have failure rates of < 0.15%/1000 h at a 90% confidence level at rated temp. and voltage conditions. Vitramon, Inc., Box 544, Bridgeport, Conn. 06601. (203) 268-6261.

Circle 280 on Inquiry Card

COAXIAL CIRCULATOR

For low power applications.

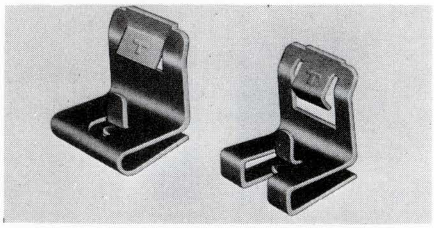


Three-port L-band, Model CLL 83 operates in freq. range of 1200-1400 MHz, with a max. input VSWR of 1:20. Maximum insertion loss is 0.3 dB, and min. isolation is 20 dB over the band. It is 3⅛ in. in dia. and 1-5/32 in. long, excluding connectors. It comes in either Y- or T-configurations. Raytheon Co., 190 Willow St., Waltham, Mass. 02154.

Circle 283 on Inquiry Card

FASTENERS

For PC boards.

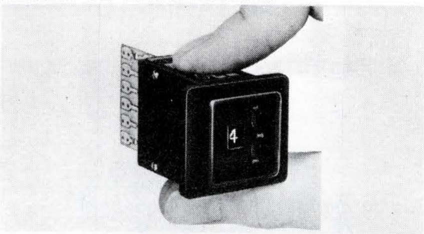


Eight variations of this Speed Clip® fastener accommodate the full range of hardware uses in PCB rack applications. The clips snap to the board rack flanges without tools. Tabs on the clips engage mounting holes in the flanges, and, once installed, the clips remain in place if the connectors must later be removed. Tinnerman Products, Inc., Box 6688, Cleveland, Ohio 44101.

Circle 286 on Inquiry Card

THUMBWHEEL SWITCHES

Mount on ½ in. centers.

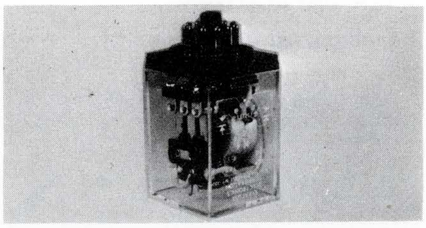


Series RSM mini thumbwheel switches retrofit most miniature thumbwheel switch openings. They can be furnished with decimal, binary, and binary with complement outputs as well as specially specified codes. They have large, easily read numerals, positive detent, and 10 and 12 positions. \$6 to \$8/module. Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversey Blvd., Chicago, Ill. 60614. (312) WE 5-4600.

Circle 281 on Inquiry Card

GENERAL PURPOSE RELAYS

Three series available.

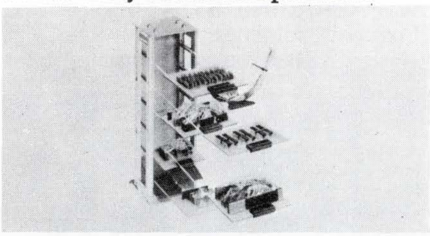


RGP series plug-in type is available in SPDT, DPDT, TPDT with coil voltages of 6 to 230 V. The RGO is the open type. Both series have contact ratings of 10 A resistive with silver cadmium oxide contacts for a min. of 1 million operations at rated load. RMC series min. relay is for PCB mounting. It comes with SPDT, 3 A contacts and coil voltages from 6 to 48 Vdc. Syracuse Electronics Corp., Box 566, Syracuse, N.Y. 13201. (305) 488-4911.

Circle 284 on Inquiry Card

INTERCONNECTION SYSTEM

Solves many connection problems.

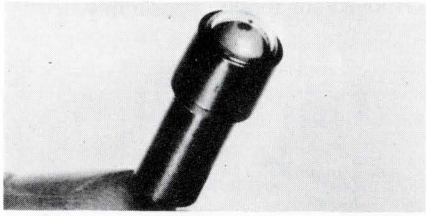


BergCon interconnection system includes the male and female connectors, removable crimp-to-wire housing assemblies, card connectors and headers for direct board mounting. It offers an infinite variety of interconnections between staked 0.025 $in.^2$ pins (Berg-Post) and PV connectors, min-PV connectors, molded connector housings, card connectors and headers. Berg Electronics, Inc., New Cumberland, Pa. 17070. (717) 938-6711.

Circle 287 on Inquiry Card

FAULT INDICATOR

Only 0.320 in. max. dia.

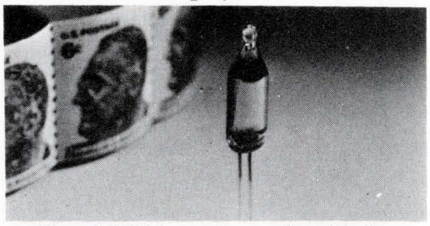


Connected to key circuit elements, these microminiature fault isolation indicators respond to a fault signal—transient or continuous—by a color transfer of its display mode. The display latches into place magnetically until reset. Reset is accomplished by momentarily energizing a reset coil. They are for pulse operation and do not require continuous power. The A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720.

Circle 282 on Inquiry Card

LONG LIFE NEON

For numeric displays.

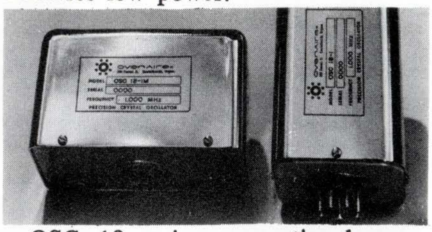


The A297 lamp is made with 7mm electrodes enclosed in a glass envelope which is much longer than necessary for an ordinary neon lamp. The long envelope with shorter electrodes eliminates the possibility of a change in characteristics of the device due to sputtering. Breakdown rating is 215 V max. and a maintaining voltage 128 to 148 V. Design current is 5 mA. Signalite Inc., 1933 Heck Ave., Neptune, N.J. 07753. (201) 775-2490.

Circle 285 on Inquiry Card

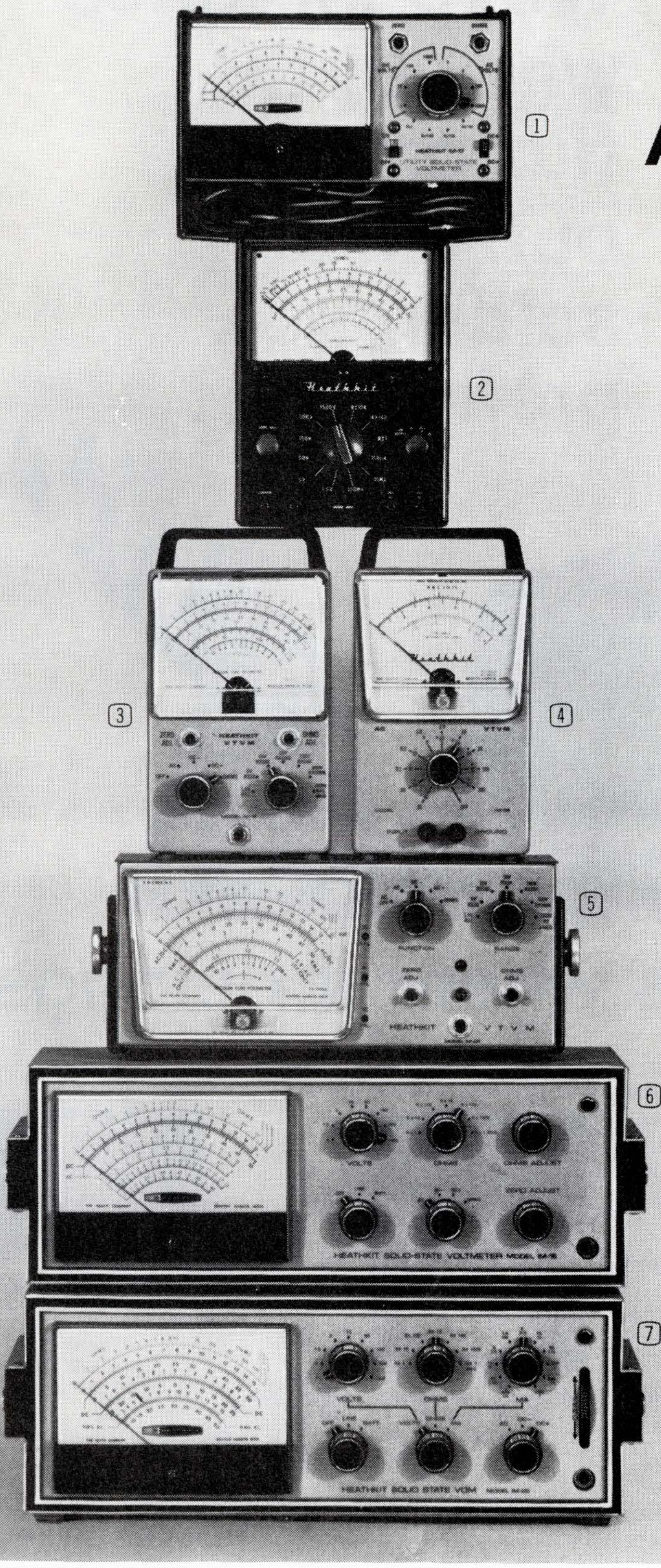
CRYSTAL OSCILLATOR

Features low power.



OSC 18 series proportional oven controlled oscillators range in stability from 1 x 10^{-9}/day through 1 x 10^{-8}/day. Oscillator and oven together need only 3 W power (12 Vdc or 24 Vdc) in steady state condition, at +25°C. Available with <2 x 10^{-10} change in freq./°C amb. change. Frequencies from 500 kHz to 30 MHz. Plug-in or PCB mounting. Ovenaire, Inc., Charlottesville, Va. 22902. (703) 293-5148.

Circle 288 on Inquiry Card



Stack These Up Against The Others

your best buys in meters come from Heath

For over 20 years, Heath has been the first choice in meters for tens of thousands of service technicians, schools and home labs. There's a reason for this continued popularity — Heath meters are designed to have that balance of versatility, needed features and low cost that make them your best buy. For the price of just a couple of meters from others, you can buy every meter Heath makes. We believe that you should still be able to get a stack of meters without spending a pile of money. When you need a meter, look to Heath. For performance, versatility and top dollar value, the others just don't stack up.

1 **$21.95* Buys A Portable Solid-State Volt-Ohm-Meter.** Four ranges on AC & DC volts measure 1-1000 volts full scale. Four resistance ranges measure 0.1 ohm to 1000 megohms. Features convenient battery operation . . . zero & ohms adj. controls . . . DC polarity reversing switch . . . spare jack for HV & RF probes . . . rugged polypropylene carrying case. IM-17, 4 lbs.

2 **$31.95* Buys A Portable Volt-Ohm Milliammeter.** Measures AC & DC volts 1.5-5000 full scale. DC current from 150 uA to 15A. Resistance midscale from 15-150,000 ohms. Large 4½" 50 uA movement meter for extra accuracy. MM-1, 5 lbs.

3 **$29.95* Buys An Accurate VTVM.** 7 AC & DC ranges measure RMS volts from 1.5-15000 full scale . . . AC P-P from 4.0-4000 . . . 7 resistance ranges from 0.1 ohms to 1000 megohms. 25 Hz — 1 MHz response. Single probe makes all measurements. IM-18, 5 lbs. Assembled IMW-18, 5 lbs. . . . $49.95*

4 **$41.95* Buys A Laboratory AC VTVM.** Especially useful for low-level AC & audio work. Ten RMS ranges from 0.01—300 V full scale . . . measures dB from −52 to +58. ±1 dB response from 10 Hz—500 kHz. 10 megs. input impedance. IM-38, 4 lbs. Assembled IMW-38, 5 lbs. . . $49.95*

5 **$39.95* Buys A Big Service Bench VTVM.** Has the same high performance as the IM-18 above, plus added features to make it more useful for service work . . . separate 1.5 & 5 VAC scales . . . calibration controls that are adjustable from the front panel . . . versatile gimbal mounting . . . large 7" meter. IM-28, 7 lbs. Assembled IMW-28, 7 lbs. . . . $59.95*

6 **$46.95* Buys A Big Solid-State Volt-Ohm Meter.** Battery-powered portability plus built-in AC supply. 8 AC & DC ranges 0.5-1500 full scale . . . 7 resistance ranges (10 ohm center scale) x1-x1 meg. High input impedance & 6" meter for greater accuracy. IM-16, 10 lbs. Assembled IMW-16, 11 lbs. . . . $69.95*

7 **$85.00* Buys A Deluxe Solid-State Volt-Ohm Milliammeter.** 9 AC & DC ranges from 150 mV-1500 V full scale . . . 7 resistance ranges measure from 1 ohm to 1000 megohms . . . 11 current ranges from 15 uA-1.5 A full scale. 100 kHz response . . . high input impedance . . . large 6" meter with zero center. IM-25, 10 lbs. Assembled IMW-25, 10 lbs. . . . $120.00*

NEW
FREE 1970 CATALOG!

Now with more kits, more color. Fully describes these along with over 300 kits for stereo/hi-fi, color TV, electronic organs, guitar amplifiers, amateur radio, marine, educational, CB, home & hobby. Mail coupon or write Heath Company, Benton Harbor, Michigan 49022.

HEATHKIT
a Schlumberger company

HEATH COMPANY, Dept. 520-25
Benton Harbor, Michigan 49022

☐ Enclosed is $__________, plus shipping.

Please send model (s)__________
☐ Please send FREE Heathkit Catalog. ☐ Please send Credit Application.

Name__________

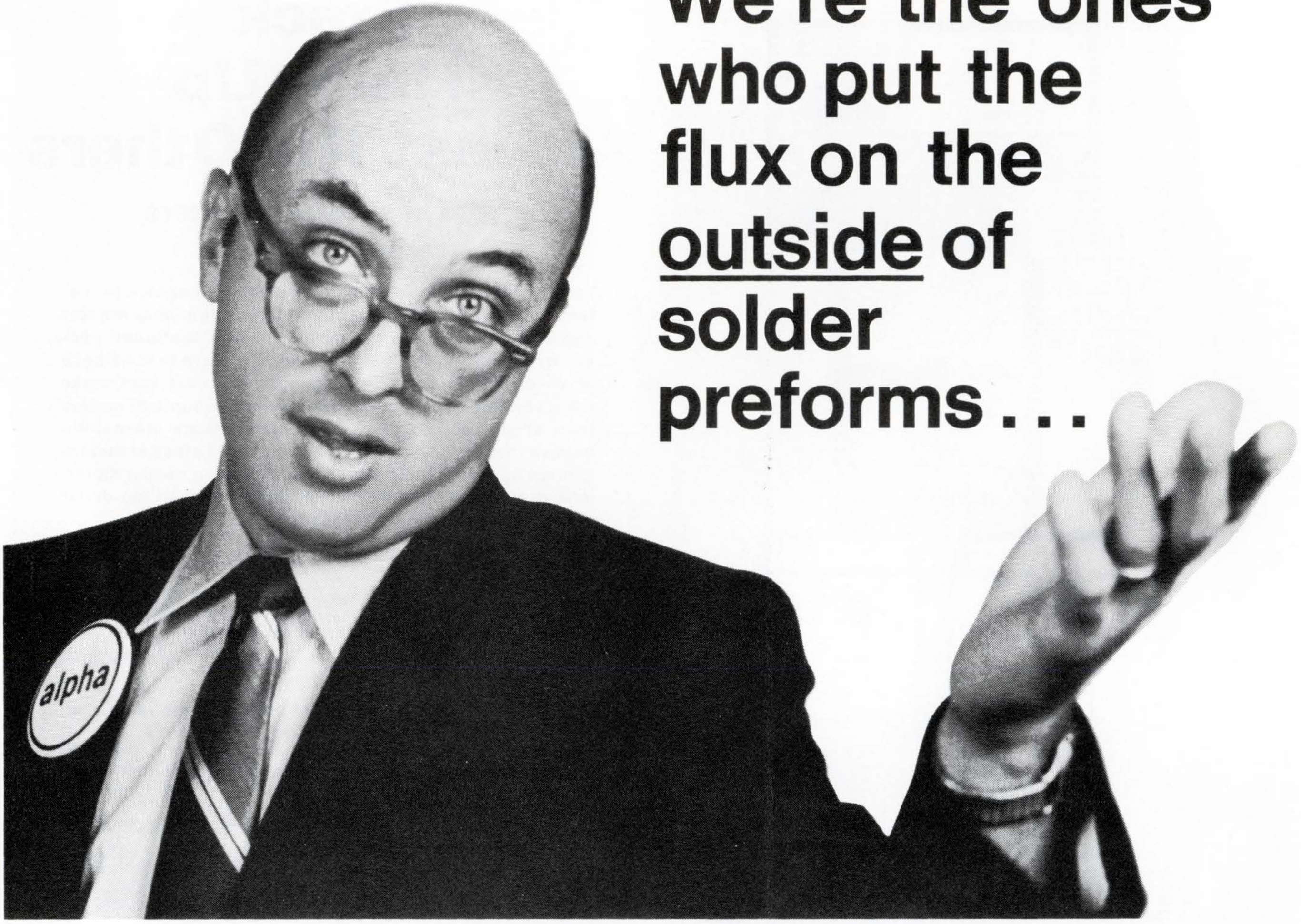
Address__________

City__________State__________Zip__________

*Mail order prices; F.O.B. factory. Prices & specifications subject to change without notice. TE-221R

Circle 64 on Inquiry Card

We're the ones who put the flux on the <u>outside</u> of solder preforms . . .



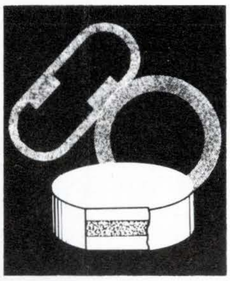
. . . because that's where it belongs

The advantages are obvious. Flux on the outer surface of the preform liquefies first and flows onto the base metal before the solder melts. With flux-filled preforms, the solder must melt before the flux can escape and there's a good chance liquid solder will come in contact with the metal surface before it has been properly cleaned.

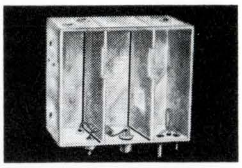
Flux-coated preforms also provide other advantages over solid solder or flux filled solid preforms: a quicker, more even spread rate, 100% flux coverage and consistently reproducible dimensional control upon melting. You can choose from a wide variety of standard and special shapes, coated with the finest grade of water-white rosin flux in all degrees of activation.

Flux-coated preforms join a long list of Alpha product innovations for better soldering, including oxide-free, Vaculoy® processed bar solders and anodes, a foam flux that meets MIL-F-14256, Type A specification, a complete line of neutral pH, electronic grade cleaners and a host of others.

Back these with our full range of quality industrial solders, fluxes and soldering chemicals, the largest research staff and the most proficient technical service and assistance in the industry, and you have a supplier you can really rely on. Call or write for full information today.



Alpha flux-coated solder preforms in standard configurations as well as multilayers and spheres. Flux-filled and solid solder preforms are also available.



Alpha Solder Creams cut costs in mass production operations. (Ill: attaching feed throughs and dividers in tuner box.)

Alpha bar solders and solder and tin anodes are Vaculoy® processed to be oxide-free.

ALPHA METALS, INC.

alpha®

56 WATER STREET, JERSEY CITY, N. J. 07304 • 201 • 434-6778
Alpha Metals, Inc., Los Angeles, Calif.
Alphaloy Corp. (Div.) Chicago, Ill.
Alpha Metals, Inc. (U.K.), Ltd., London, England

10658-E

Feature article abstracts

Published information is vital to your job.
To save time in finding this information,
we have abstracted the important technical features
from eight electronic engineering publications.
Should any of these articles interest you, contact the magazine—
names and addresses are listed below.
Reprints of articles with an asterisk are available free.
Save this section for future reference.

Charts and Nomographs

***Guide to nonlinear circuits,** a wall chart prepared in cooperation by Philbrick-Nexus and the editors of The Electronic Engineer. "The Electronic Engineer," Vo. 29, No. 6, June 1970, pp. 97-104. The chart describes types of nonlinear circuits, the mathematical functions they implement, and their applications.

Guide to CAD, "Electronics," Vol. 43, No. 8, April 13, 1970, pp. 109-112. This is a full color, 4-page chart listing first and second generation Computer-Aided Design programs known today. Each is compared on a table to aid in the selection of one for your requirements.

Circuit Design

***Three-pole active filter,** Russell Kincaid, Sanders Associates Inc., "The Electronic Engineer," Vol. 29, No. 6, p. 46. Here is a circuit that gives you six different filter responses with just three capacitor changes. Included is a graph of all six responses.

Top performance from analog multipliers? Much depends on errors gauged in your circuit, Tom Cate, Burr-Brown, "Electronics," Vol. 43, No. 8, April 13, 1970, pp. 114-117. At one time analog multipliers were only for analog computers. Today they are used in signal processing and telemetry. Correct selection and application of these devices is based on your signal requirements. The author guides you through some of the methods used to decide your requirements.

Choose magnetic deflection, William Peterson, ITL Research Corp., "Electronic Design," Vol. 18, No. 9, April 26, 1970, pp. 80-82. Circuit diagrams accompany a discussion of the advantages of magnetic deflection over electrostatic deflection in CRT displays. Small spot size and large deflection angles are the biggest benefits. Magnetic deflection is current-controlled, which gives higher system reliability and matches solid-state amplifiers better. It works up to 5MHz with little trouble. Distortion due to series resistance is overcome with feedback techniques.

Communications

Transmission delay and echo suppression, Richard G. Gould, Office of Telecommunications Management, and George K. Helder, Bell Telephone Laboratories, "Spectrum," Vol. 7, No. 4, April 1970, pp. 47-54. Although the promise of satellite communication is great, the authors point out the inherent problems of transmission delay and echo in telephony. Advances in echo control are presented with proposed standards for acceptable and unacceptable delays for telephone circuits.

Bell's money is riding on millimeter waves for future communications, Laurence Altman, "Electronics," Vol. 43, No. 8, April 13, 1970, pp. 96-105. Waveguides and solid state microwave devices are what Bell is working with to increase circuit requirements. Their system designs rest on dielectric-clad wavequides. Impatt and pin diodes. This article describes the decisions that were and still have to be made along with some of the technical problems and some solutions.

Computers and Peripherals

There's a better way to design a character generator, Gene Carter and Dale Mrazek, National Semiconductor, "Electronics," Vol. 43, No. 9, April 27, 1970, pp. 107-112. With the increased need of computer terminal equipment, all kinds of methods are being tried to get better, cheaper readout displays. This article describes a display which uses MOS read-only memories and shift registers. Through these devices alphanumeric displays are generated that are simple and inexpensive.

Four-phase LSI logic offers new approach to computer designer, Lee Boysel and Joseph Murphy, Four Phase Systems, Inc., "Computer Design," Vol. 9, No. 4, April 1970, pp. 141-146. According to the authors, the development of MOS/LSI calls for a new four-phase logic that focused attention on areas that were not previously critical. Thus, they discuss both circuit design and the strategy of partitioning system architecture to minimize cost. They also describe the main LSI block of a low-cost fourth-generation computer currently in pilot production.

Magazine publishers and their addresses

Computer Design
Computer Design Publishing Corp.
Prof. Bldg., Baker Ave.
W. Concord, Mass. 01781

EDN
Cahners Publishing Company
270 St. Paul Street
Denver, Colo. 80206

EEE
Mactier Publishing Co.
820 Second Avenue
New York, N. Y. 10017

Electronic Design
Hayden Publishing Co.
850 Third Avenue
New York, N. Y. 10022

Electronic Products
United Technical Publications
645 Stewart Avenue
Garden City, N. Y. 11530

Electronics
McGraw-Hill, Inc.
330 W. 42nd Stıeet
New York, N. Y. 10036

IEEE Spectrum
Institute of Electrical & Electronics Engineers
345 East 47th Street
New York, N. Y. 10017

The Electronic Engineer
Chilton Company
56th & Chestnut Streets
Philadelphia, Pa. 19139

*Reprints available free. Request them on your company letterhead.

Small computer design using microprogramming and multifunction LSI arrays, Frank J. Langley, Raytheon Co., "Computer Design," Vol. 9, No. 4, April 1970, pp. 151-157. Although not new in basic concept, microprogram control in digital computers presents new challenges. The result is an LSI-MSI computer design with currently available circuits. Advantages are simplicity, orderliness, and modular flexibility in instruction repertoire and register length and complement. Another big advantage of microprogram control was that the computer prototype model was designed, built and checked out in only five months.

Speed up the fast Fourier transform, Peter Bice, Hewlett-Packard Co., "Electronic Design," Vol. 18, No. 9, April 26, 1970, pp. 66-69. The frequency domain is the most convenient for linear analysis, and the time domain for nonlinear analysis. Direct and inverse Fourier transformations can be speeded up so that frequency and time domain analysis can be used simultaneously. The basis of the method is the fast Fourier transform, which is a version of the Cooley-Tukey algorithm. A BASIC program for the algorithm is given as a starting point. Flow charts are given to get the specialized fast Fourier transform. Memory requirements are reduced so that a minicomputer can do the job.

Digital Design

Synchro-to-digital converters, Part 3. Adapted from Electronic Analog/Digital Conversion by Hermann Schmid, Van Nostrand Reinhold Co., 1970. "Electronic Design," Vol. 18, No. 8, April 12, 1970, pp. 76-79. The type three synchro/resolver-to-digital angle converters can be easily made from existing hardware. The three converter types in this category are the general, low-speed, and highspeed. The general type III converter contains an octant selector, two ac-to-dc converters, a dc encoder, and an arc-tangent function generator. The digital output signal is equal to the tangent of the resolver shaft angular position, and conversion to the angle is accomplished with a linear-segment function generator. Block diagrams are included.

Synchro-to-digital converters, Part 4. Adapted from Electronic Analog/Digital Conversion by Hermann Schmid, Van Nostrand Reinhold Co., 1970. "Electronic Design," Vol. 18, No. 9, April 26, 1970, pp. 72-77. Type IV and V converters are discussed. Type IV converters do not require linear-segment generators. A simple resolver-to-digital-angle converter is used. The circuit contains an octant selector, analog-to-digital converter, and a special reference voltage generator. Low precision and temperature sensitivity are limitations of these circuits. The type V converter uses a harmonic oscillator for encoding resolver output signals. The oscillator provides shaft angle information in proportion to angle magnitude. It is simple, but has significant accuracy limitations. Several schematics are provided.

Boost your DTL efficiency with wired-OR, Gilbert Starr, QED Systems Inc., "Electronic Design," Vol. 18, No. 8, April 12, 1970, pp. 89-91. NAND gates are the most widely available type, though many two-stage functions can be reduced to one-stage logic by other types. Decreased propagation delay is an immediate benefit. If you sacrifice fan-out capability, wired-OR is a way out. The method is to express functions in Boolean algebra and manipulate them into a form suited to AND/NOR implementation. On the logic diagram, substitute NAND gates for AND gates and wired-OR connections for NOR gates to get an equivalent NAND/wired-OR circuit. Examples are given.

Phase state diagrams and hardware equations for sequential logic design, A. Alfred Pestone, and Stephan M. Koenig, Information Displays Inc., "Computer Design," Vol. 9, No. 4, April 1970, pp. 161-164. This design approach broadens the application of the design engineer's mapping and equation tools, making them more useful than in the past. Thus, modification of the Karnaugh map and Boolean equations has resulted in a reduction in design and documentation costs and time.

Integrated Circuits

***Static or dynamic—two ways to remember,** Marcian E. Hoff, Jr., Intel Corp., "The Electronic Engineer," Vol. 29, No. 6, pp. 72-74. MOS RAMs use two different techniques to store information. The first, static storage, uses flip-flops as storage elements just as bipolar memories do. The other technique, dynamic storage, uses a unique characteristic of the MOS device to gain some definite advantages. In this article, Dr. Hoff looks at the two techniques and describes the advantages and disadvantages of both.

***MOS random access memories,** Warren Crews, Motorola Semiconductor, "The Electronic Engineer," Vol. 29, No. 6, pp. 66-70. One of the most promising areas for the application of MOS integrated circuits is in the construction of random access memories. Mr. Crews discusses the different types of RAMs used today and describes the MOS RAM and its special features.

***Performance and cost trade-offs for MOS RAMs,** Vernon G. McKenny, Mostek Corp., "The Electronic Engineer," Vol. 29, No. 6, pp. 76-78. The characteristics of MOS RAMs depend to a large extent on the configuration of the memory. In this article, Mr. McKenny looks at some of the most popular configurations and describes just what trade-offs are required.

***Frequency synthesizing with the phase locked loop,** Ed Renschler and Brent Welling, Motorola Semiconductor Products Inc., "The Electronic Engineer," Vol. 29, No. 6, pp. 84-90. The advancement of IC technology has made the phase locked loop circuit feasible. And, an ideal application of this circuit is as a multichannel frequency synthesizer because many precise frequencies can be generated with only one reference frequency. In this article the PLL is the basis for a new, somewhat unconventional digital frequency synthesizer design.

***Speed/power chart for digital ICs,** Staff Report, "The Electronic Engineer," Vol. 29, No. 6, June 1970, pp. 58-59. This chart allows the reader to make a "ballpark" selection of those digital integrated circuits that are best suited for his application. The chart shows in graph form the two most important parameters—power dissipation and propagation delay.

Packaging

***Printed circuits, make or buy?** Jack Froelich, Contributing Editor. "The Electronic Engineer," Vol. 29, No. 6, June 1970, pp. 51-56. If you want to make printed circuits, you will have to be familiar with all the physical sciences—electronics, mechanics, optics, chemistry, metallurgy and even computer-aided design. If you want to buy them, you should still be familiar with the new manufacturing processes for PCs, described in this article.

Semiconductors

Watt-megahertz ratings run second to high reliability in foreign r-f power transistors, Leon M. Magill, "Electronics," Vol. 43, No. 9, April 27, 1970, pp. 80-89. Here is a chance to learn where the overseas companies stand in the rf power transistor field. The state-of-the-art in various countries is described.

Three ways to build low-threshold MOS, Warner Bridwell, American Microsystems, "Electronics," Vol. 43, No. 8, April 13, 1970, pp. 118-123. Low threshold MOS is important for interfacing with bipolar ICs, and is being so used. There are three methods of obtaining low-threshold MOS described in this article, along with the trade-offs that you must make in selecting one of the methods.

Systems

System design means trade-offs, Jaak Jurison, North American Rockwell Corp., "Electronic Design," Vol. 18, No. 7, April 1, 1970, pp. 60-64. A master computer for the Short Range Attack Missile (SRAM) is used as the system design example. It performs aircraft navigation and missile fire-control computations. The author treats the basic tradeoffs of number of modules vs volume, memory capacity vs physical size, arithmetic operations vs computation speed, and word length vs precision and efficient use of memory. The memory is the most important cost and complexity factor. Several considerations lead to a choice of a 3D, coincident current, core memory with a cycle time of 3.6 microseconds. Other aircraft design considerations are also described.

Test and Measurement

Check flip-flops automatically, Kenneth C. Waine, Honeywell, "Electronic Design," Vol. 18, No. 7, April 1, 1970, pp. 66-68. Rapid, accurate testing must be done to obtain repeatable, reliable IC flip-flop preset times, clock thresholds, and input gate thresholds. The problem to overcome is performance change as a function of time-dependent temperature changes. Schematics and descriptions are given for an integrator and a voltage-controlled one-shot, which are arranged in a closed-loop system with the flip-flop under test to perform the required measurements.

Functional test philosophy for a limited funded digital computer, M. Bruce Hack, IBM Electronics Systems Ctr., "Computer Design," Vol. 9, No. 4, April 1970, pp. 179-183. If your funding is limited, you can keep test hardware and software to a minimum without sacrificing reliable performance. A properly designed, single, external test program can meet all test environment needs.

Techniques for true-rms conversion in DVMs, Kenneth Jessen, Hewlett-Packard. "EEE," Vol. 18, No. 4, April 1970, pp. 50-52. The author discusses two methods—both using thermocouples—to obtain the rms value of a waveform: the dual (differential) thermocouple method, and the single thermocouple technique. It compares the performance and range of application of both methods. Most of the discussion is on the single-thermocouple method, since it is the one used in H-P's 3450A digital voltmeter. The article does not mention, however, the method employed in H-P's newest DVM, the 3480, which uses a thermopile (a multiple-element thermocouple) connected as a differential thermocouple. Nor does it mention explicitly the slow response of thermocouples, which has prompted the development of other methods to approximate rms measurements.

What you hear about our new dry test bath is true.

The tape recorder is operating in a dry bath of Fluorinert® Brand Electronic Liquids. Just as your electronic and microelectronic units will.

Fluorinert Liquids give you an accurate method of temperature testing or testing for gross leaks. They keep their efficiency over a wide range of temperatures. They do not react with even the most sensitive of materials. They won't deteriorate with use.

And you can ship or use parts directly out of the test bath without cleaning because Fluorinert Liquids evaporate, leaving no residue.

If you've been listening, you know that Fluorinert Electronic Liquids are specified for Mil-Standard 883 and Mil-Standard 750A gross leak tests for microcircuits.

The coupon will bring you copies of both Mil-Standards and a lot of good solid information about test baths. Send it or call your local 3M man.

Fluorinert® Electronic Liquids 3M
BRAND

3M Company, Chemical Division, 3M Center
St. Paul, Minn. 55101
KAZ 6-70

Send me all the details about Fluorinert Brand Electronic Liquids.

Name____________________

Company__________ Title__________

Address____________________

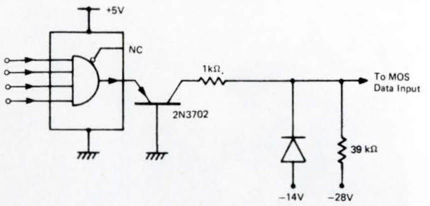
City__________ State______ Zip______

Circle 66 on Inquiry Card

LITERATURE

MOS applications

Two application reports discussing the use of MOS ICs bring you important information on "MOS circulating memories" and "MOS character generators." More specifically, the first report discusses how MOS shift registers can be combined with TTL ICs to form economical data memories (16 pages), and the second describes TI's



Data interface

MOS RAM character generators, indicating the advantages of their use in display systems (12 pages). Other topics covered include internal circuitry and construction, power supply requirements, inputs and dc output characteristics. Texas Intsruments Inc., Box 5012, M/S 308, Dallas, Tex. 75222.

Circle 361 on Inquiry Card

Capacitors

Application notes providing practical considerations for selecting and using monolithic chip capacitors are yours with this 28-page manual. Answers are given for electrical and environmental considerations, such as combined voltage and temperature effects and dielectrics. Mounting, handling, chip attachment and testing are also discussed. U.S. Capacitor Corp., 2151 N. Lincoln St., Burbank, Calif. 91504.

Circle 362 on Inquiry Card

Application note

This application note introduces you to a system that provides accurate calibration of bolometer mounts with leveled rf power. If you follow the procedures in the note, you'll find that easy and direct transferring of calibration factors from primary to secondary standards and power meters can be accomplished with less than 1% error. Helpful extras in the note include calibration setup diagram, procedures for both terminating and feed-through bolometer mounts and descriptions of each instrument in the system. Weinschel Engineering, Gaithersburg, Md. 20760.

Circle 363 on Inquiry Card

Relay information

Ohmite Manufacturing Co. has been running a series of seminars which they call "Think-ins," devoted to the proper application of relays and related devices. Copies of the papers from all three "Think-ins" are now available to our readers. The booklets contain the complete text of the papers delivered and a transcript of the question and answer periods which followed the presentations of papers. For copies of these booklets write on company letterhead to Mr. H. J. Roeser, Ohmite Manufacturing Co., 3662 Howard St., Skokie, Ill. 60076.

Anti-Tohubohu

International Rectifier has organized (perpetrated, they say) a society of users intended to promote their products. If you agree to join the society IR will send you a copy of the above cartoon, a handy calendar and the first in a series of conversion tables. The company calls this the

Anti-Tohubohu society, which we guess is based on the Hebrew word for chaos, mentioned in the first chapter of Genesis. If you want to join this society, circle the number below or write to Bill Wagner at International Rectifier, 233 Kansas St., El Segundo, Calif. 90245 at your own risk.

Circle 364 on Inquiry Card

Digital printers

Complete specs, illustrations and prices are provided for you in this 4-page data sheet on 10 and 20 lines/s alphanumeric printers. The printers, which are all solid state with TTL logic, include a full 64-character ASCII code. Reliability at low cost? See for yourself by reading spec sheet 3070 on the 722 series of digital printers. Datadyne Corp., Bldg. 37A, Valley Forge Center, King of Prussia, Pa. 19406.

Circle 365 on Inquiry Card

Computerized design

"Computerized Design — Photomasks and Documentation for Printed Circuit Board Layout" is the title of a brochure describing this company's expanded facilities. Preceded by a two-year software development program, they are now ready to offer the consumer a five-part package including computerized design complying with given requirements, translation into photomask production graphics, numerical control tapes for automated machining, computer printouts of necessary documentation and component assembly drawings. Electronic Graphics Inc., 2834 W. Kingsley Rd., Garland, Tex. 75040.

Circle 366 on Inquiry Card

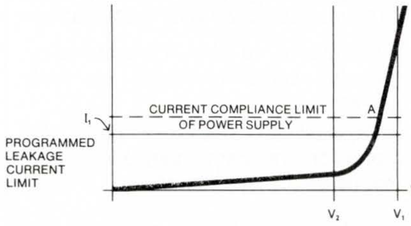
Engineers and cities

"The Engineer and the City" is the title of the feature article in this issue of "Tomorrow Through Research." It acquaints you with the the projects Southwest Research Institute sponsors and participates in, and keeps you abreast of their experience in the field of engineering research. The publication brings you 8 pages of interesting and informative news and ideas. Southwest Research Institute, 8500 Culebra Rd., San Antonio, Tex. 78228.

Circle 367 on Inquiry Card

Transistor test system

A thorough introduction to the T241 computer-operated transistor test system is offered to you in this 20-page brochure. A brief background of the company's experience in the field encourages you to read on to a description of the test instrument and its



Breakdown voltage testing

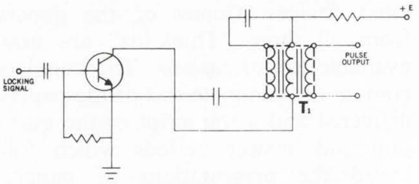
features. Next, the testing procedure is explained and you learn of available software and peripheral equipment. This is followed by applications, options and accessories, and all necessary specs. Teradyne, 183 Essex St., Boston, Mass. 02111.

Circle 368 on Inquiry Card

LITERATURE

Component design

A double ring binder opens into an "applications" and a "configurations" division so you can see the featured component in its entirety. Within the ten sections you'll find the capabilities and limitations of each design type. The catalog is carefully divided so you can easily specify those parameters that are pertinent to your application. Line drawings show actual internal construction as well as external dimensions. Aladdin Electronics, 703 Murfreesboro Rd., Nashville, Tenn. 37210.



Blocking oscillator circuit

Circle 369 on Inquiry Card

Packaging equipment

A line of packaging equipment, materials and services is featured in a 48-page catalog. It includes samples of materials offered as well as descriptions of products and services. Sections cover barrier bags, poly bags, packing list envelopes, tapes, cartons, containers and sealers. Packaging equipment includes automatic pouch handling machines, shrink tunnels and film. R. M. Bracamonte Co. Inc., Dept. CP, 1331 San Mateo Ave., S. San Francisco, Calif. 94080.

Circle 370 on Inquiry Card

IC Chart

"A Guide to the Selection of Integrated Circuits" is available to you from the Barnes Corporation. It includes a guide to the selection of sockets, carriers and contactors for ICS as well. Digital IC and op amp manufacturers are listed and typical circuits are illustrated. For your copy of this colorful, fold-out wall chart,

Circle 371 on Inquiry Card

Photodetector design

Practical discussions on design characteristics such as uniformity, linearity, spectral response and sensitivity are offered in this 12-page manual. You'll find a new insight on trade-offs that will help you select the right detector for specific applications. For a copy of this manual, write on company letterhead to Detector Technology, 1732 21st St., Santa Monica, Calif. 90404.

LITERATURE

Thermal impedance of IMPATTs

Engineering bulletin AEB-103, "Measuring thermal impedance of IMPATT diodes," discusses a new method for measuring that parameter. The technique makes use of the reverse-bias characteristics of the diode's I-V curve. Thermal impedance values determined in this way are both more reliable and useful than those obtained in the conventional way, which uses forward-bias characteristics. Varian, Solid State Div., Salem Rd., Beverly, Mass. 01915.

Circle 372 on Inquiry Card

Optoelectronics

Optically coupled isolators are the subject here, and the 6-page brochure offers you details and diagrams of their significant features. Tables provide current ratios and switching characteristics; diagrams show construction, terminal connections and mechanical data. Texas Instruments Inc., Box 5012, Dallas, Tex. 75222.

Circle 373 on Inquiry Card

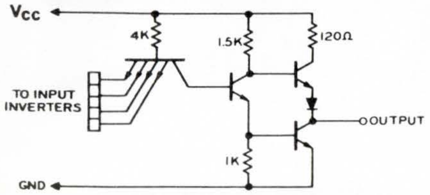
EMI/RFI filters

Four standard filters are covered in this technical brochure: the "L" section filter, the "Pi" capacitive input filter, the "T" inductive input filter, and the "2L" filter. The complete line of subminiature interference control filters are supplemented with diagrams and "insertion loss" chart information. Genisco Technology Corp., 18435 Susana Rd., Compton, Calif. 90221.

Circle 374 on Inquiry Card

MSI complex arrays

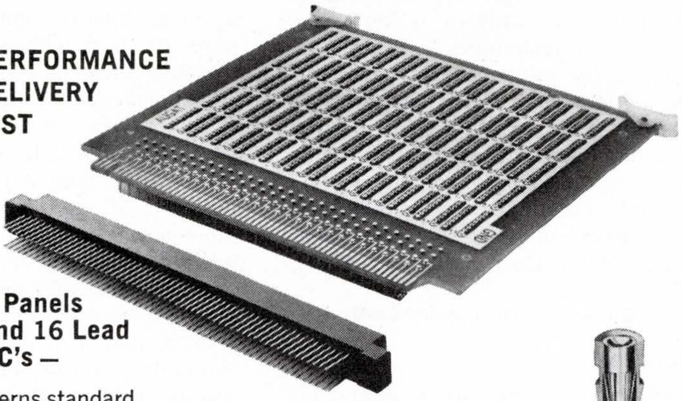
The intent of this 60-page handbook is to provide the systems and logic designer with descriptive information on the company's series 54/74 complex arrays logic family. You'll find the book divided into three sec-



Decoder gate

tions for easy reference: general design characteristics, electrical characteristics (includes test limit and test condition information for use in device evaluation), and parameter measurement information. Sprague Electric Co., North Adams, Mass. 02147.

Circle 375 on Inquiry Card



Circle 70 on Inquiry Card

Circle 71 on Inquiry Card

Logic handbook

This 448-page logic handbook is your guide to logic applications, capabilities and hardware. You'll find material on techniques and products available for implementing your electronic logic designs for instrumentation, computer interfacing, data gathering or control. If you're involved in specifying, designing, manufacturing or using solid-state logic, you'll find this an excellent basic reference. Digital Equipment Corp., Maynard, Mass. 01754.

Circle 376 on Inquiry Card

Rectifiers

All the necessary specs, characteristics, parameters and ratings to select and apply IR's line of selenium rectifiers, Klip-Sel transient voltage suppressors and contact protectors are listed for you in this 40-page brochure. It catalogs many of the assemblies and configurations currently available and covers the coding and characteristics for all popular and typical series. International Rectifier, Semiconductor Div., Dept. 781, 233 Kansas St., El Segundo, Calif. 90245.

Circle 377 on Inquiry Card

Operational amplifiers

This 32-page reference guide describes the maker's complete line of discrete, hybrid, and monolithic op amps. It starts with a six-page section that lists important specifying parameters, and definitions (with test circuits) of many others. The bulk of the brochure's first half is a detailed spec listing for about 80 op amps. The last half of the brochure consists of dimensional drawings, electrical connection diagrams, and some information on accessories such as power supplies, IC regulators, booster amps, sockets, and trimming potentiometers. Fairchild Controls, 423 National Ave., Mountain View, Calif. 94040.

Circle 378 on Inquiry Card

Hybrid circuit chart

A wall chart, summarizing hybrid circuit design considerations, contains design guidelines, packaging information and data on active devices, substrate materials and capacitors. Typical parameters of key hybrid materials are provided. Sylvania Electric Products Inc., 1100 Main St., Buffalo, N.Y. 14902.

Circle 379 on Inquiry Card

New professional publication

The Society of Aerospace Materials and Process Engineers (SAMPE) offers you the SAMPE Quarterly, a collection of technical papers you'll find useful for up-to-date information or for technical reference. The first volume (75 pages) contains eight papers on topics of value to research, development and engineering. If you're interested in a subscription to this publication, write directly to Bill Long, SAMPE Quarterly, Box 613, Azuza, Calif. 91702.

Power supplies

A 32-page catalog details a line of standard power supplies, including modular types, system supplies, laboratory units, and special purpose types for op amps and ICs. A locator chart which requires that the reader know only the type of supply needed and desired voltage and current rating is included in the manual. Also provided are electrical and mechanical specs and schematics. Deltron, Inc., Wissahickon Ave., N. Wales, Pa. 19454.

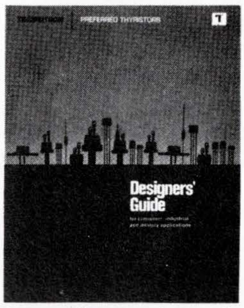
Circle 380 on Inquiry Card

Circle 72 on Inquiry Card

Circle 73 on Inquiry Card

Thyristor guide

A 20-page designer's guide to industry preferred thyristor types lists triacs, SCRS, GTOS, photosensitive devices, and chips. Also covered are thyristor symbology and definitions, applications, and packaging considerations.



The products discussed are for use in ac power control, computers, optoelectronics, display systems, power conversion, and microwave equipment. Transitron Electronic Corp., 168 Albion St., Wakefield, Mass. 01880.

Circle 381 on Inquiry Card

Terminals and splices

Descriptions and specs for a line of straight and flag-type terminals, splices, and quick disconnects are provided in a 20-page catalog. The products discussed can be crimped individually or applied with semiautomatic machinery at production rates. Performance characteristics are included, as is a numerical index. AMP Inc., Harrisburg, Pa. 17105.

Circle 382 on Inquiry Card

Data conversion modules

Data conversion modules, designed for mounting on PC boards and "system engineered" to interface with systems, are available in three operating temperature ranges — −55°C to +85°C, −25°C to +70°C, and 0°C to +50°C. Encapsulated modular D/A, A/D, digital-synchro, and synchro-digital converters are described, and operating features are listed for each. Data Device Corp., 100 Tec St., Hicksville, N. Y. 11801.

Circle 383 on Inquiry Card

Rotational power transducers

Non-contact torque transducers and RPM pick-ups are the subject of a 5-page catalog. A description of the operation of transducers is provided, as are application information and physical specs. Ametek Instruments & Controls, 880 Pennsylvania Blvd., Feasterville, Pa. 19047.

Circle 384 on Inquiry Card

Design considerations

Two application papers are now available, one discussing design considerations for the EA 1200 and EA 1201 dynamic shift registers, and one discussing MOS/TTL interfacing. The first helps you with the selection, testing and proper electrical implementation of dynamic registers and discusses clock options, power dissipation, interfacing considerations and test circuits. The second discusses single phase vs two phase clock registers, noise margins, TTL-to-MOS and MOS-to-TTL interface. Electronic Arrays Inc., 501 Ellis St., Mountain View, Calif. 94040.

Circle 385 on Inquiry Card

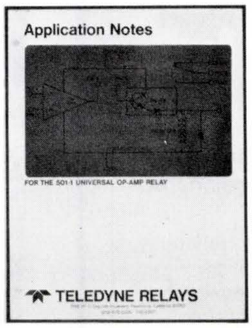
High-power silicon transistor

The highest power silicon transistor available, designated the 1401, has been designed for regulation, amplification, and power switching applications. The transistor, described in a 4-page bulletin, exhibits low saturation voltage, fast switching time and high current and power capabilities. The high power rating (625 watts at T_C = 75°C) is achieved by a compression bonded encapsulation proccess. Ac and dc characteristics of the 1401 are included in the brochure, as is temperature capability (up to 200°C). Westinghouse Electric Corp., Box 868, Pittsburgh, Pa. 15230.

Circle 386 on Inquiry Card

Application notes

The use of the 501-1 universal op amp relay in time-delay, level-detector, free-running pulse generator and one-shot applications is outlined in a 14-page brochure. It contains eight schematic diagrams illustrating spe-



cific applications and provides design equations for each circuit. Detailed technical notes accompany each application description. Teledyne Relays, 3155 W. El Segundo Blvd., Hawthorne, Calif. 90250.

Circle 387 on Inquiry Card

LITERATURE

Electro-optics

Electro-optic programs, capabilities, and products emerging from the imaging systems department of Raytheon are outlined in a 12-page booklet. The programs described are intended for commercial and military applications and encompass passive and active night-viewing techniques. Imaging products described include a miniature night vision device, a low-light-level TV system, and a ruby laser range-finder. Raytheon Co., Special Microwave Devices Operation, 130 Second Ave., Waltham, Mass. 02154.

Circle 388 on Inquiry Card

Micro sampling

Infrared micro-sampling techniques, for use in such areas as air pollution, bio-medical studies, criminology, or any research where sample quantities are minute, are contained in an 8-page booklet. Also listed are a line of micro-sampling accessories, including mirror beam condensers, microcells, ultra-micro-cavity cells and variable beam attenuators. Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn. 06902.

Circle 389 on Inquiry Card

Hybrid circuits

This 36-page catalog is filled with diagrams and schematics illustrating hybrid semiconductor circuits. Absolute maximum ratings and electrical characteristics are included, and towards the end of the catalog you'll find drawings illustrating test configurations and typical applications. There's also room for any notes you might like to make. Teledyne Amelco Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94040.

Circle 390 on Inquiry Card

Tweezers for ICs

A complete line of tweezers designed for use in IC, computer, semiconductor and aerospace assembly applications is described in this bulletin. Special design helps to eliminate breakage and damage to wafers used in IC manufacture. In addition you'll receive a 2-page bulletin describing the custom design and manufacturing facility which offers 48-72 hour service on hand tools made to individual requirements. Swiss American Precision Imports, Dept. TWP, 505 S. Douglas St., El Segundo, Calif. 90245.

Circle 391 on Inquiry Card

Dc servo amps

Dc servo amplifiers, designed to meet MIL-E-5400 specs (including MIL-STD-704), but differing in size and output, are discussed in three separate data sheets. The amplifiers described are suggested for such applications as driving dc torque motors, due to their wide bandwidths and adjustable current limiting features. They can be utilized as voltage or current amplifiers by terminal selection and their gain can be varied by the addition of external resistors. Working schematics are provided in the sheets, as are typical performance curves and specs. Inland Controls Inc., 250 Alpha Dr., Pittsburgh, Pa. 15238.

Circle 392 on Inquiry Card

Analog multipliers

A high-speed analog multiplier for use in modulation and demodulation, computation, signal conditioning, and/or multiplexer switching, is described in a 14-page application note. The different types of available multipliers are discussed and schematics are provided. GPS Corp., 14 Burr St., Framingham, Mass. 01701.

Circle 393 on Inquiry Card

Applications manual

A multiplier applications manual (12 pages) offers data on the operation and applications of multipliers. It includes basic multiplier operation, block diagrams, error curves and details of connecting multipliers for multi-quadrant operations. Application data includes operation of multipliers in squaring, voltage-controlled function generators, suppressed-carrier modulation, frequency doubling, resolution and voltage-controlled time constant configurations. Zeltex Inc., 1000 Chalomar Rd., Concord, Calif. 94520.

Circle 394 on Inquiry Card

Design guide

Four steps are all that are required on your part for leaf switches custom-designed for particular applications. You provide information such as number and type of circuits and actuation required. If you want to do your own designing, you specify the prototype and the company will supply the samples for your approval and handle the production runs. Look over the standard, already-tooled parts, draw a sketch of the prototypes you want made and you're ready to go (6 pages). Chicago Switch Inc., 2035 Wabansia Ave., Chicago, Ill. 60647.

Circle 395 on Inquiry Card

LITERATURE

Master/slave system can scan up to 1000 channels, and multiplexes low-level signals into a single measuring system. Bulletin 141—4 pages. Vidar Corp., 77 Ortega Ave., Mountain View, Calif. 94040.
Circle 396 on Inquiry Card

Byte generator, designated EC-22, is low in cost, plugboard-loaded, and easily programmable, and has been designed for simulation and testing of digital equipment—2-page data sheet. Adar Associates Inc., 85 Bolton St., Cambridge, Mass. 02140.
Circle 397 on Inquiry Card

Rf voltmeter handles frequency range of 20 kHz to 500 MHz over a potential range from 200 mV to 15 V (2 pages). High Frequency Engineering, 2626 Frontage Rd., Mountain View, Calif. 94040.
Circle 398 on Inquiry Card

Solid state time delay relays in an 8-page brochure with circuit applications and definitions of terms. Midtex/Aemco, 10 State St., Mankato, Minn. 56001.
Circle 399 on Inquiry Card

Power amplifier can drive low impedance loads to within 4 V of either supply voltage (2 pages). Beckman Instruments Inc., Fullerton, Calif. 92634.
Circle 400 on Inquiry Card

Op amp will operate with supply voltages from ±6 V to ±28 V, and over a temp. range of −55° C to +125° C (2 pages). CTS Microelectronics Inc., West Lafayette, Ind. 47906.
Circle 401 on Inquiry Card

400 controller features mA output, adjustable proportional band and manual reset. Applications include batch processes and valve positioning processes —2 pages. Thermo Electric, Saddle Brook, N.J. 07662.
Circle 402 on Inquiry Card

Pressure transducers, designed for use under extreme pressure and temperature ranges for a variety of applications, weigh 2.75 oz. and have a maximum diameter of 0.875″—bulletin P692210. Taber Teledyne, 455 Bryant St., North Tonawanda, N.Y. 14120.
Circle 403 on Inquiry Card

Miniature broadband transformers feature transmission line techniques and frequency ranges to beyond 500 MHz— pages. Vanguard Electronics, 930 West Hyde Park, Inglewood, Calif. 90302.
Circle 404 on Inquiry Card

Sample and hold module, compatible with DTL and TTL, has an output of ±10 V at ±10 mA and meets environmental specs of Mil-Std-202C. Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801.
Circle 405 on Inquiry Card

Mixer/modulators (17 models) with complete technical specs and graphs showing isolation, VSWR, noise figure and conversion loss—4 pages. Aertech Ind., 825 Stewart Dr., Sunnyvale, Calif. 94086.
Circle 406 on Inquiry Card

RFI equipment filters, 1-, 2-, 3-, 5-, and 10-A versions are graphically illustrated with complete attenuation characteristics. Components Corporation, 2857 N. Halsted St., Chicago, Ill. 60657.
Circle 407 on Inquiry Card

Digit impulse counters with transfer contacts, zero and reset contacts, and predetermining switches are of the plug-in type and are interchangeable —bulletin 102. Landis & Gyr, Inc., 4 Westchester Plaza, Elmsford, N.Y. 10523.
Circle 408 on Inquiry Card

Strain gage and differential data amplifier with gain ranges of 1 to 1000 in a 1, 2, 5 sequence at 0.05% accuracy — 4 pages. Century-Detroit, 6101 Concord Ave., Detroit, Mich. 48211.
Circle 409 on Inquiry Card

Miniature card-edge connector meets all standards for automatic solderless wrap connections—2 pages. Hugh H. Eby Co., 4701 Germantown Ave., Phila., Pa. 19144.
Circle 410 on Inquiry Card

Conductive carriers for MOS IC devices are aluminum-plated to prevent voltage differential between leads (1 page). Barnes Corp., 24 N. Lansdowne Ave., Lansdowne, Pa. 19050.
Circle 411 on Inquiry Card

Waveform generators and test oscillators are described with features and applications, illustrations and specs—4 pages. Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif. 91030.
Circle 412 on Inquiry Card

Relay/contactor fact sheet provides load rating tables, mounting selections, kW ratings, typical coil data and ordering information—2 pages. Mack Electric Devices Inc., Wyncote, Pa. 19095.
Circle 413 on Inquiry Card

Subminiature lever lock switches are available in 1, 2, 3 and 4 pole models —2 pages data sheet with schematics and specs. C & K Components Inc., 103 Morse St., Watertown, Mass. 02172.
Circle 414 on Inquiry Card

Dielectric capacitors are 50 Vdc metallized polycarbonate capacitors for PC applications (6 pages). Gudeman, Div. of Gulton Industries Inc., 340 W. Huron St., Chicago, Ill. 60610.
Circle 415 on Inquiry Card

Wideband amplifier described in 4-page brochure giving specs, schematics (15) and applications. Halex Inc., 3500 W. Torrance Blvd., Torrance, Calif. 90509.
Circle 416 on Inquiry Card

Scanner will transmit signals from 1 μV to 300 V and can scan up to 100 channels in data-acquisition systems. Vidar Corp., 77 Ortega Ave., Mountain View, Calif. 94040.
Circle 417 on Inquiry Card

Semiconductor research microscope with illuminating systems for transmitted, reflected, and mixed light built into its base—12-pager. Hacker Instruments, Inc., Box 646, West Caldwell, N.J. 07006.
Circle 418 on Inquiry Card

Binary/angular values, in wallet-sized form, are intended for engineers working with the conversion of data, as in synchro-digital applications. Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801.
Circle 419 on Inquiry Card

Communications option for key-to-tape data recorder features error detection, data compression, and binary synchronous communications techniques that increase throughput and reduce costs. Potter Instrument Company, Inc., East Bethpage Rd., Plainview, N.Y. 11803.
Circle 420 on Inquiry Card

Instruments and accessories for the measurement of parameters and electronic components—8 pages, Boonton Electronics Corp., Route 287 at Smith Rd., Parsippany, N.J. 07054.
Circle 421 on Inquiry Card

Resistor stop-and-test instruments are described with full information, diagrams and specs. Teradyne, 183 Essex St., Boston, Mass. 02111.
Circle 422 on Inquiry Card

Amplifiers, converters and power supplies are among the products discussed in this 4-page short form catalog. Newport Laboratories Inc., 630 E. Young St., Santa Ana, Calif. 92705.
Circle 423 on Inquiry Card

EMI shielding materials for protecting electronic equipment from stray electromagnetic or radio frequency fields —4 pages. Radcon Corp., 246 Columbus Ave., Roselle, N.J. 07203.
Circle 424 on Inquiry Card

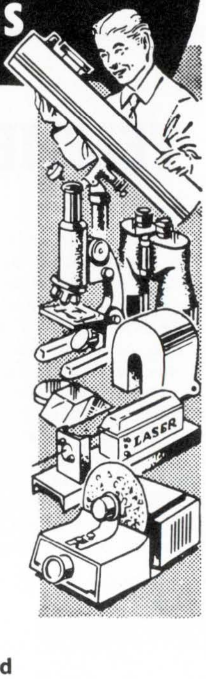
Programming modules and matrices offer high panel area, volumetric density and visual presentation of circuit linkages (4 pages). Interswitch, 770 Airport Blvd., Burlingame, Calif. 94010.
Circle 425 on Inquiry Card

Multimeter, 3-digit, with information as to accuracy, stability, input resistance, noise rejection, capability, resolution, etc.—8 pages. Dana Labs. Inc., 2401 Campus Dr., Irvine; Calif. 92664.
Circle 426 on Inquiry Card

C-band balanced mixer with self test circuit which, when interrogated, provides an i-f output—2 pages. Electronic Resources Inc., 4561 Colorado Blvd., Los Angeles, Calif. 90039.
Circle 427 on Inquiry Card

Data communications system, 520/DC, is described in an 8-page brochure giving specs, available software packages and major system components descriptions. Varian Data Machines, 2722 Michelson Dr., Irvine, Calif. 92664.
Circle 428 on Inquiry Card

Digital-to-synchro converter-on-a-card features single standard PC card mounted package accepting 12-bit binary information and converting it to 3-wire synchro—2 pages. Astrosystems Inc., 6 Nevada Dr., Lake Success, N.Y. 11040.
Circle 429 on Inquiry Card



 Circle 82 on Inquiry Card

Circle 83 on Inquiry Card

Advertisers—June 1970

No liability is assumed for errors or omissions.
This index is published for a convenience.

THE ELECTRONIC ENGINEER

DISTRICT SALES MANAGERS

EDWARD G. SHAUD
BALA-CYNWYD, (Pa.) 19004
One Decker Square
(Area Code 215) SHerwood 8-2000

JOSEPH DRUCKER
NEW YORK 10017—100 East 42nd St.
(Area Code 212) OXford 7-3400

JOHN W. BERNHARDT
CHICAGO 60606—120 S. Riverside Plaza
(Area Code 312) 782-1400

G. T. ALFANO
NEEDHAM HEIGHTS, MASS. 02194—
570 Hillside Ave.
(Area Code 617) 444-0010

TERRENCE D. BUCKLEY
THOMAS R. BORIS
LOS ANGELES 90005 3727 W. Sixth St. #202
(Area Code 213) DUnkirk 7-1271

RALPH PETERSEN
LOS ALTOS (San Francisco) 94022
199 First St., Room 335
(Area Code 415) 941-6655

RICHARD DUTE
CLEVELAND 44114—601 Rockwell Ave.
(Area Code 216) SUperior 1-2860

FRANK A. SMITH
HOLLYWOOD, FLA. 33020—
2419 Hollywood Blvd.
(Area Code 305) 927-7829

NEWTON B. COLLINSON
ATLANTA 30309—1776 Peachtree St. N.W.
(Area Code 404) 872-4723

HAROLD E. MOTT
WAYNE L. LOVING
DALLAS 75206—Meadows Bldg.
Expressway at Milton
(Area Code 214) EMerson 3-6426

BRENT GILBERT
BELLAIRE, (Texas) 77401
P.O. Box 160
(Area Code 713) 621-7550

INTERNATIONAL BUSINESS OFFICES

London, S W 1 .... Max F Holsinger
67 68 Jermyn St , St James's — Dir European Sales
TRA 6318 9 — Roy V C Hall, A Berg
Cables — WHIP LONDON S.W. 1

Manchester 22 .... D I Goulden
Haletop, Wythenshawe Civic Centre — MERcury 3292

4 Dusseldorf-Rath ... E Hillerbrand, R Schomburg,
Eitelstrasse 32 — W Heckelmann
Dusseldorf 632031
Cables — WHIP DUSSELDORF

Paris, 8e .... S Brown-Joussard
70 Rue de Ponthieu — ELYsees 65-77
Cables — UIIP PARIS 16e

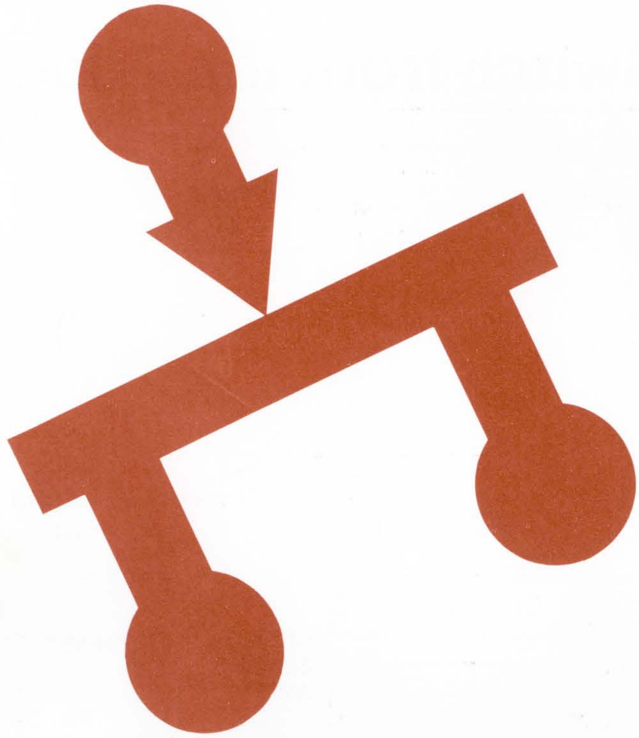
Tokyo .... C T Sakaguchi
Room 814, Togin Bldg Marunouchi
CPO Box No 1572 — Tel: 211-3506-3509
Cables — CLARENCESAKA TOKYO

BUSINESS STAFF

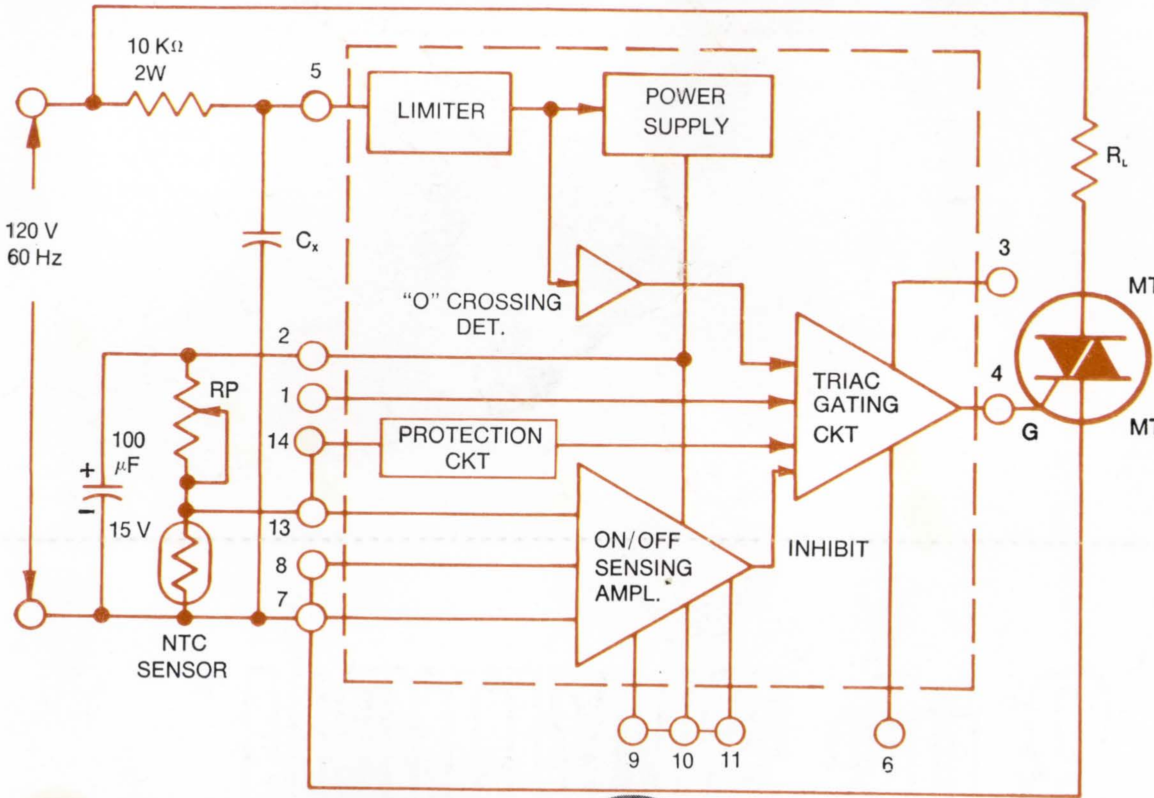
K. ROBERT BRINK
Publisher
STEPHEN A. FARKAS
Sales/Service Director
DENNIS J. PERKINS
Promotion Manager
MARK R. WERTH
Marketing Services Manager
JOHN E. JAENISCH
Advertising Sales Manager
PAT KAUFFMAN
Production Manager
WILLIAM M. COFFEY
Circulation Director
JAMES F. NAGY
Circulation Manager
JOSEPH P. BABCOCK
Reader Service Manager
JOHN H. KOFRON
Chilton Research Services
C. R. WILHIDE
Washington Vice-President

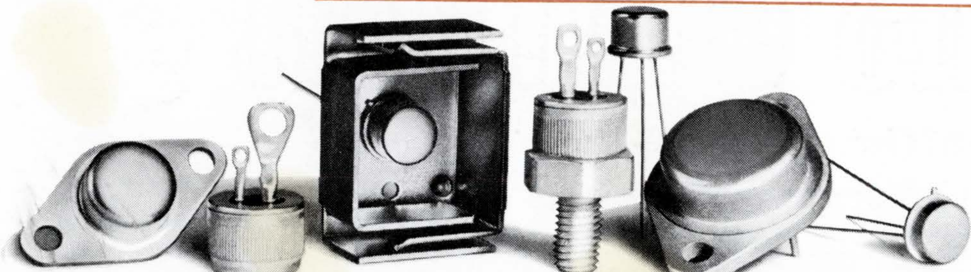
Index to Product Information

Listed below are all products and new literature that appear in this issue, along with the page number they appear on and their Reader Service Numbers (RSN). For more information, see the appropriate page and circle the corresponding number on the reader service card.



New IC Switch from the Triac Leader





RCA-CA3059 Zero-Voltage Switch for New Economy, New Simplicity in Thyristor Trigger Circuits $1.95 (1000-unit level)

Here's RCA's economical, new approach to Thyristor triggering—the CA3059 monolithic zero-voltage switch, at $1.95 (1000 units). For efficient triggering of Triacs and SCR's with current ratings to 40 amperes—in applications such as electric heating, motor on/off controls, one-shot controls, and light-flashing systems—CA3059 offers these important new design advantages:

- Triggers Thyristors at zero-voltage crossing for minimum RFI in applications at 50, 60, 400 Hz.
- Self-contained DC power supply with provision for supply of DC bias current to external components.
- Built-in protection against sensor failure.
- Flexible connection arrangement for adding hysteresis control or proportional control.
- External provisions for zero-current switching with inductive loads.
- On/off accuracy typically 1% with 5 kΩ sensor; 3% with 100 kΩ sensor.
- Triacs in RCA's 2.5—40 Amp, 100—600 Volt series, Types 40693—40734, are selected to operate over the entire CA3059 temperature range.
- 14-lead DIP pkg. for —40°C to +85°C operation.

For further details, check your local RCA Representative or your RCA Distributor. For technical data bulletin, file no. 397, and Application Note ICAN4158, write RCA Electronic Components, Commercial Engineering, Section 55F/CA0014, Harrison, N.J. 07029. In Europe, contact: RCA International Marketing S.A. 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

RCA Integrated Circuits

Circle 3 on Inquiry Card