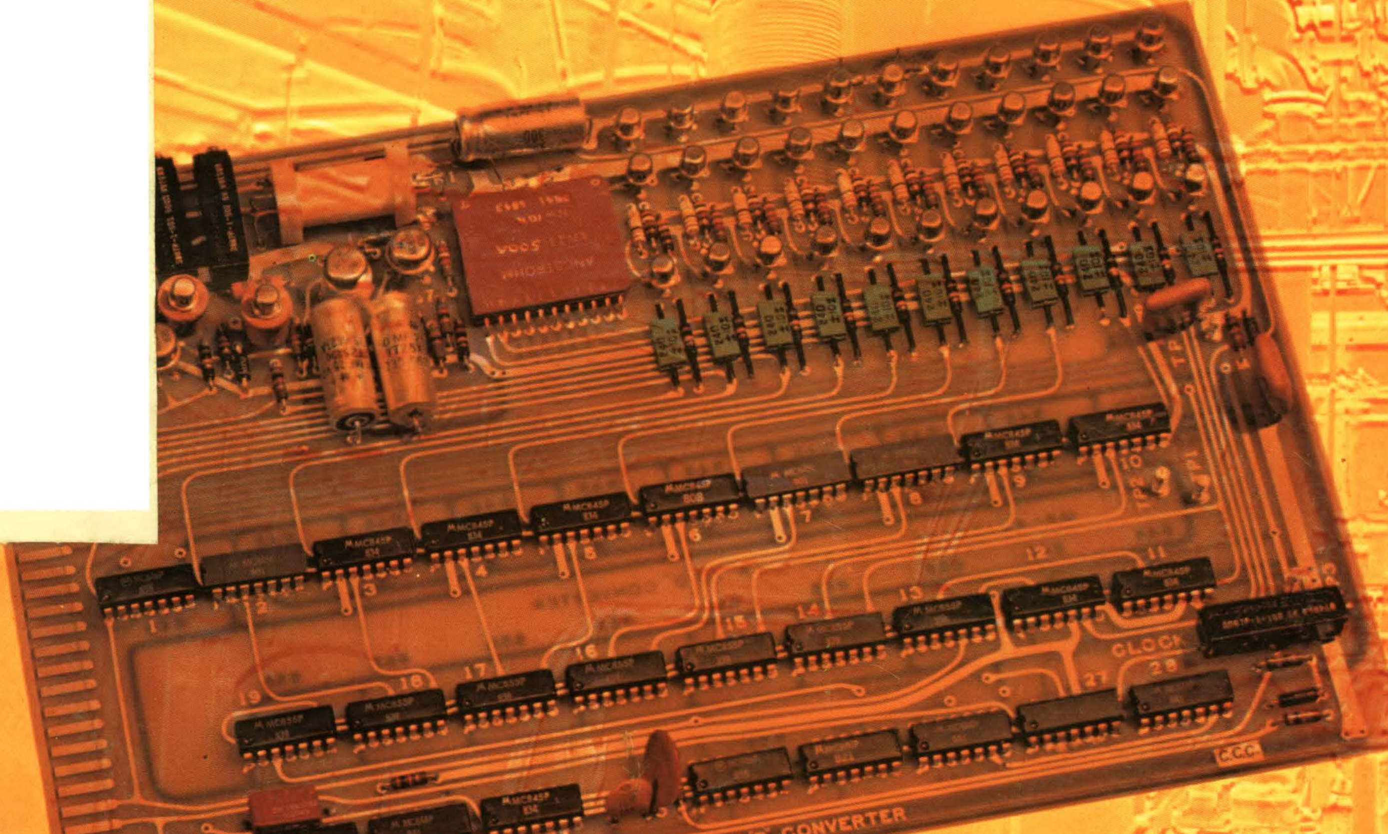
EDN
computer hardware In this Issue

exclusively for designers and design managers in electronics

EEE

Digital ICs tackle tough industrial jobs

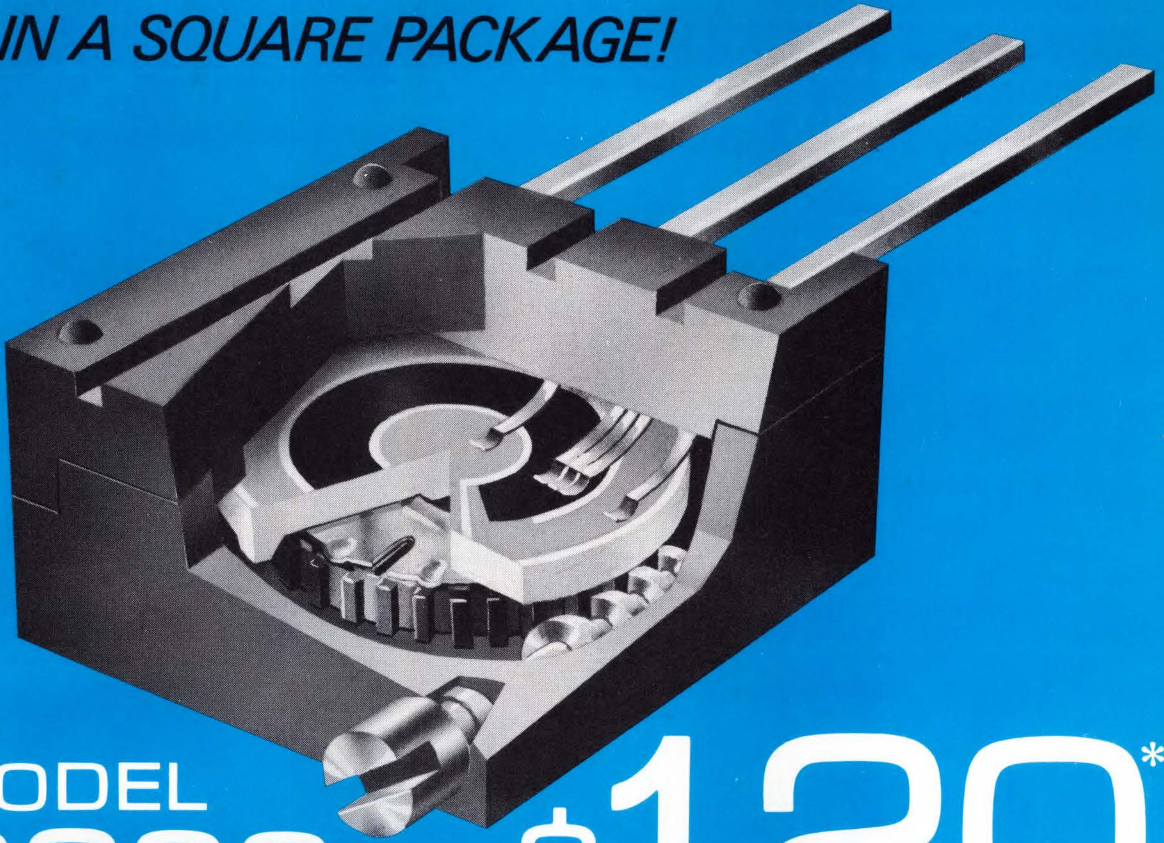


A CAHNERS PUBLICATION

FEBRUARY 15, 1972

MULTI-TURN SETABILITY...
...AT SINGLE-TURN PRICES!

...IN A SQUARE PACKAGE!



MODEL
3299 $1.20*

*500-999 quantity price; U.S. dollars, F.O.B., U.S.A.

NEW CERMET TRIMPOT® POTENTIOMETER

THAT MAKES IT THE LOWEST-PRICED SQUARE MULTI-TURN ON THE MARKET.

In addition to low-cost, Bourns Model 3299 incorporates a number of features usually found only in higher-priced units.

PRECISE SETABILITY
... multi-turn adjustment provides quick, precise setability with infinite resolution.

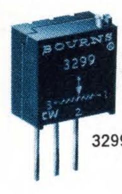
POPULAR ⅜" SQUARE PACKAGE
... it occupies less space on the circuit board.

HIGH POWER RATING:
½ watt at 70°C.

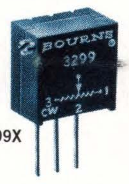
CHOICE OF 3 PIN STYLES
... provides designers with the most popular pin styles for greater design flexibility.

MOLDED-IN TERMINALS
... enhance ruggedness of construction. Of course the unit is sealed to withstand printed circuit board cleaning processes.

3299P



3299W



3299X

SPECIFICATIONS

Dimensions	.375" x .395" x .250"
Standard Resistance Range	100 to 1,000,000 ohms
Resistance Tolerance	±10% Standard
Power Rating	0.5 Watts at 70°C
Operating Temperature Range	−55 to +125°C
Temperature Coefficient	±150 ppm/°C

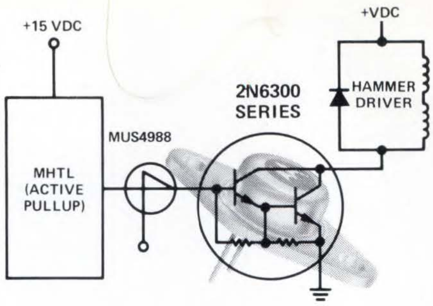
Delivery is off-the-shelf. Get full details on this new Cermet unit today by contacting your local Bourns Field Office, Representative, or the Factory direct.

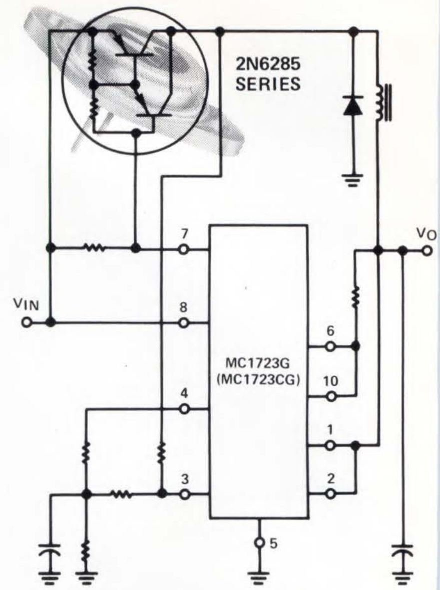
BOURNS

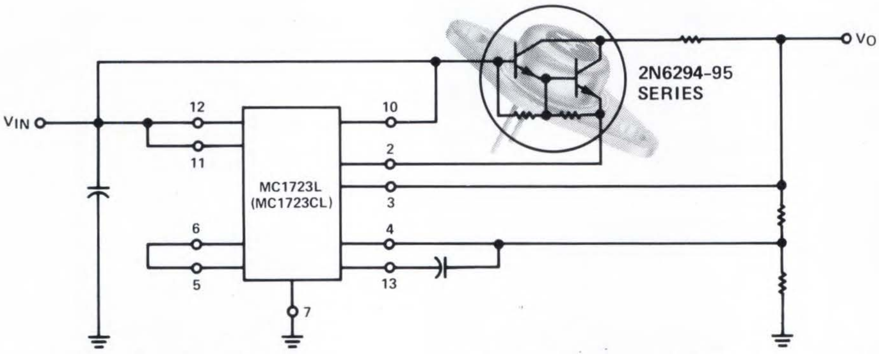
BOURNS, INC., TRIMPOT PRODUCTS DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF. 92507

CIRCLE NO. 2

. . . In Space-Limited Applications
Hammer Driver Darlingtons are now available in compact, TO-66 packaging! The new, 2 and 4 A types offer 3,000 typical gain for space-critical switching applications such as hammer drivers. This design provides one-stage interface between MHTL logic drive and printout in minimum space.



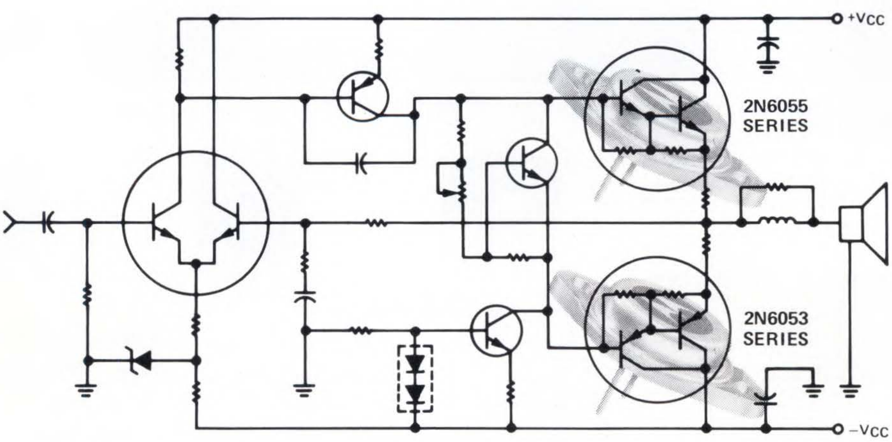


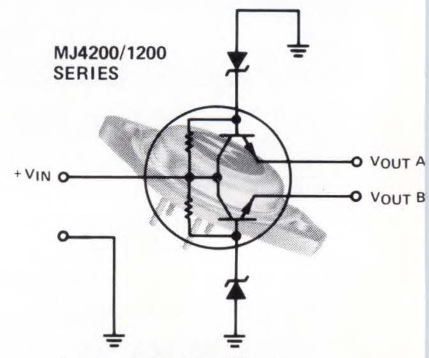


. . . In IC-Driven Applications
High-Performance Series Pass Regulator-Better than 0.03% performance is realized with this 2 A Darlington/MC1723 hookup. The capacitor between pins 4 and 13 provides frequency compensation for the MC1723. The new 2N6294-95 series Darlingtons, with typical gain specs of 3,000 at 2 A I_C, greatly boost load current since the regulator will only source up to 150 mA. Go from milliamperes to amperes directly, compatibly, easily.

. . . In High-Power Applications
High-Performance Switching Regulator-The new 2N6282/6284 Darlingtons can be used in this regulator to furnish 2,400 typical gain at 10 A. Switching regulators are especially useful in reducing power dissipation in a circuit requiring a large input voltage and producing a small output voltage. Darlingtons simplify!

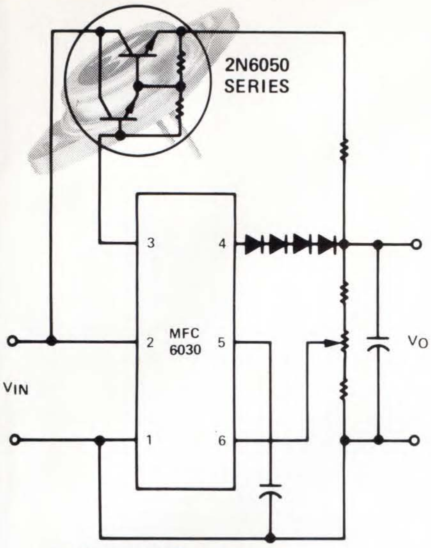
Gain Command With





. . . In Complementary Applications
15 to 60 W Power Amplifier-Typical gain of 3,000 at 4 A with the new 2N6053-55 NPN/PNP Darlington complements ensures significant simplification and cost savings in complementary power amps. The circuit features zero center voltage for maximum signal swing, 100% dc feedback, automatic offset voltage correction and noise and hum filtering. Amplify your gain specs with Darlingtons.

. . . In Dual Applications
Split Voltage Power Supply- Simpler, lower-cost, split power supplies using just one 4-lead discrete power package containing two drivers, two output devices and emitter-base resistors are easy with the new 2 and 4 A MJ4200/1200 Darlingtons. Providing 3,000 typical gain, the units are common-collector-connected to give 2 separate output voltages.



. . . In General-Purpose, "2N3055" Applications

Short-Circuit Protected Power Supply- For this economical functional circuit supply, load regulation is 0.08% when used as a 5 V regulator. The 4 and 6 A 2N6057/6059 series Darlingtons provide 4,000 typical gain figures and include the new 2N6055 Darlington — a direct, plug-in replacement for the industry-standard, general-purpose 2N-3055 and its driver!

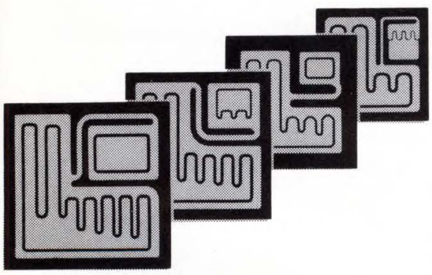
New Darlingtons . . .

NPN	PNP	Package	$V_{CEO(sus)}$ V Max.	P_D W	h_{FE} @ I_C Min	Price Range 100-999	
						NPN	PNP
2N6294-95	2N6296-97	TO-66	60-80	50	750 @ 2 A	$1.30-$1.65	$1.80-$2.25
MJ4200-01 Dual	MJ4210-11 Dual	4-Lead TO-3	60-80	50	750 @ 2 A	3.50- 4.30	3.90- 4.80
MJ1200-01 Dual	MJ920-21 Dual	4-Lead TO-3	60-80	90	750 @ 4 A	4.90- 5.80	5.90- 6.80
2N6055-56	2N6053-54	TO-3	60-80	100	750 @ 4 A	1.72- 2.07	2.43- 2.88
2N6300-01	2N6298-99	TO-66	60-80	75	750 @ 4 A	1.67- 2.02	2.38- 2.83
2N6057-9	2N6050-52	TO-3	60-100	150	750 @ 6 A	2.54- 3.54	3.25- 4.36
2N6282-84	2N6285-87	TO-3	60-100	160	750 @ 10 A	4.30- 5.20	4.55- 5.65

Darlingtons Introduced . . .

Complementary Series	Package	h_{FE} @ I_C Min.	Pair Price (60 V) 100-999
MJE700/800	Plastic THERMOPAD	750 @ 1.5, 2 A	$2.62
MJ4000/4001	TO-3	1,000 @ 1.5	3.20
MJ900/1000	TO-3	1,000 @ 3 A	3.85
MJE1090/1100	Plastic THERMOPAD	750 @ 3, 4 A	3.45
MJ2500/3000	TO-3	1,000 @ 5 A	5.40
MJ4030/4033	TO-3	1,000 @ 10 A	8.50

More Power Darlingtons



Special Offer!

Get a $1.72 2N6055 NPN Darlington for $1.05 . . . the same 100-up price as a 2N3055! Get 750 minimum gain at 4 A . . . plus all the space, time and money-saving advantages inherent in Darlington design for your prototype relay and solenoid drivers, audio/servo amplifiers, power supply and series pass regulators. Fill in and send the coupon to your Motorola distributor . . . he'll respond with your 2N6055 Darlington in a hurry!

EpiBase* Makes It Possible . . .

Only EpiBase technology possesses inherent capability to yield complementary Darlingtons — all possessing higher gain with better linearity, more chip sizes, higher frequency, lower saturation voltages and lower cost than other processes.

Select from 33 complementary, metal and plastic, Motorola Darlington pairs now. And write us at Box 20912, Phoenix, AZ 85036 for complete Darlington data.

To: (distributor)____________________________

I want to gain Darlington command in my power circuits — send me a 2N6055 for the price of a 2N3055 today . . . only $1.05!

Name____________________ Title________________

Company____________________________________

Address____________________________________

City________________ State__________ Zip_______

(Offer expires April 30, 1972)

MOTOROLA POWER

— Complements Of A Friend

CIRCLE NO. 3

*Trademark of Motorola Inc.

Get our problem-solving package: good products, prices, availability and design assistance—all from one source.

Digital-to-Analog Converters

Model 845: Complete 8-bit binary DAC. 4 preset output ranges. Slew rate: 0.2V/μsec min. Settling time: 5.0 μsec/volt + 1 μsec. Price (1-9) $39.75.

Model 846: Complete 8-bit binary DAC. 4 preset output ranges. Slew rate: 4V/μsec min. Settling time: 0.25 μsec/volt + 2 μsec. Price (1-9) $49.75.

Model 848: Complete 11-bit binary DAC. Guaranteed monotonicity and accuracy levels. 4 preset output ratings. Slew rate: 4.0V/ μsec min. Settling time: 0.25 μsec/volt + 2.0 μsec. Hermetically sealed Kovar case. MIL-STD-883. Price (1-9) $95-$155 depending on accuracy code.

Model 849: 13-bit resolution binary DAC. Four quadrant operation (AC reference). Accepts serial data input. MOS compatible (high threshold). Low power dissipation. Price (1-9) $155-$185 depending on accuracy code.

Ladder Networks

Model No.	Standard "R" Values	R_{sw} Compensation	Best Standard Accuracy	Pricing 1-9	
811 (Binary)	5K, 10K, 20K	5Ω Bits 1-4	±122 ppm −55°C to +125°C	811-B12	$40.00
812 (Binary)	50K, 100K	500Ω All Bits	±122 ppm −55°C to +125°C	812-B12	40.00
814 (Binary)	10K	5Ω Bits 1-5	±30 ppm @ +25°C and +61 ppm −20°C to +85°C	814-D14	90.00
815 (Binary)	10K	None	±1952 ppm −55°C to +125°C	815	6.95
862 (BCD)	50K, 100K	500Ω All Bits	±300 ppm −55°C to +125°C	862-B	45.00

Miniature Power Amplifiers

Model	± Supply Range	Output Max. Range	Minimum Load Resistance	Price (1-9)
821	10 — 20V	±16V	100Ω	$30.00
822	10 — 20V	±16V	50Ω	35.00
823	10 — 30V	±26V	$\frac{30\ (E_o \text{ max.})}{E_{cc} - E_o \text{ max.} - 1}$	8.95
824	18 — 30V	±27V	140Ω	40.00
866	10 — 20V	±16V	50Ω	40.00

Call your local Helipot Sales Representative today.

Model 841 Ladder Switch

Features: 0 to 2 mV switch offset. 5 (±3) ohms "on" resistance. 200 ns rise and fall time. 0 to 5 mA load range. R_{OFF} and V_{OFFSET} independent of reference voltage used. Model 841-1 Price (1-9) $100.

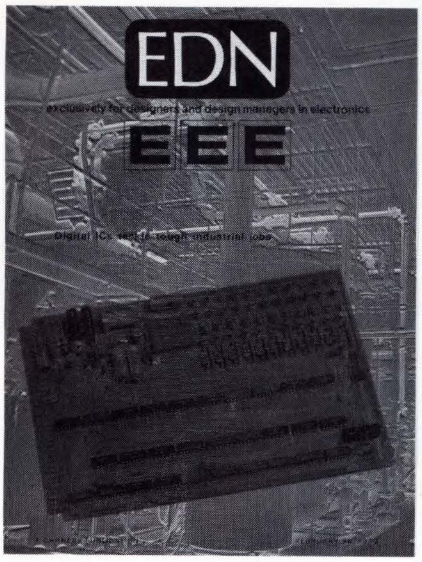
Beckman®
INSTRUMENTS, INC.
HELIPOT DIVISION
2500 Harbor Blvd., Fullerton, Calif. 92634

CIRCLE NO. 4

FEBRUARY 15, 1972
VOLUME 17, NUMBER 4

EDN/EEE

EXCLUSIVELY
FOR DESIGNERS
AND DESIGN MANAGERS
IN ELECTRONICS



COVER

Photo, courtesy of Motorola, Inc., Semiconductor Products Div., shows 10-bit analog-to-digital converter used as part of a positioning control for a precision X-Y table. For a report on ICs in industrial uses, see p. 20.

DESIGN NEWS

DESIGN FEATURES

PROGRESS IN PRODUCTS

DESIGN PRODUCTS

DESIGN DEPARTMENTS

International Business Press Associates
DESIGN ELECTRONICS
ELECTRONICS WEEKLY
EDN/EEE
ELEKTRONIK
ELEKTRONIK-ZEITUNG
INTER ELECTRONIQUE

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

Editorial

Engineering has social responsibilities

It has been brought to our attention that a committee, called the "Committee for Social Responsibility in Engineering," has been circulating a petition requesting that the Executive Board of the IEEE authorize the formation of an IEEE Professional Group on Social Implications of Technology.

The purpose of this Group would be ". . . pursued by encouraging research and study, by the publication of the resulting reports and treatises, by the holding of meetings for the reading and discussion of papers, and by any other activities necessary, suitable and proper for the fulfillment of these objectives."

Pertinent topics to be considered by the Group would be ". . . the application of electronics to the alleviation of pollution problems, the effects of energy consumption on the biosphere, effects of data banks and electronic surveillance techniques on privacy, the application of engineering talent to urban problems and transportation, and the role of government in technological research and development."

Stated in these terms and with such purposes, the establishment of such a Group within the IEEE is a desirable goal and something we concur in and are whole-heartedly for.

We would question, though, how representative of the engineering community the Committee promoting the establishment of such a Group actually is. On their official letterhead, 18 of the 32 members of the working committee are academicians, either teaching at, or associated with, various universities. It's possible, and quite probable, of course, that these people possess the best balance of conviction, dedication, and credentials to form such a working committee whose purpose is to promote initial action.

But the vast bulk of engineers in the United States, whether inside IEEE or out, are associated with industry. And it is these engineers who can, and should, be most concerned with social responsibility in engineering.

We feel, therefore, that if the Committee for Social Responsibility in Engineering is to be a viable and useful organization, it should concentrate its efforts on the typical working engineer who is intimately involved in, and whose livelihood could be affected by, the social implications of engineering.

(The Committee for Social Responsibility in Engineering can be contacted at 137a West 14th Street, New York, NY 10011.)

Frank Egan
Editor

Staff

Publisher
E. Patrick Wiesner

Editorial Staff
Frank Egan, *Editor*
Steve Erenburg, *Managing Editor*
Earle Dilatush, *Western Field Editor*
Bob Cushman, *New York Editor*
Roy Forsberg, *Boston Editor*
Roger Allan, *Associate Editor*
Bill Furlow, *Associate Editor*

Art Staff
Dan Kicilinski, *Director*
Roy Nelson, *Illustrator*
Beverly Lembo, *Illustrator*
Patricia Rawlins, *Illustrator*

Production Manager
Wayne Hulitzky

Production Assistant
Susan Grober

Circulation Manager
Ron Kinnes

Editorial Consultant
John Peter

Editorial Office Addresses
Executive *(617) 536-7780*
221 Columbus Ave.
Boston, Mass. 02116

New York (212) 689-3250
205 E. 42nd St.
New York, N.Y. 10017

Denver (303) 388-4511
270 St. Paul St.
Denver, Colo. 80206

New bi-polar power-dac* solves five major system problems in automatic test equipment

*TM

A new programmable power source from the John Fluke Company solves several big system problems. Appropriately called a Power-DAC, the Models 4250A and 4265A provide up to ±65 volts at 1 amp, with a 100 micro-second settling time to 0.01% accuracy. A full complement of options provide needed flexibility in both price and performance.

1. Parallel or series operation — just like batteries

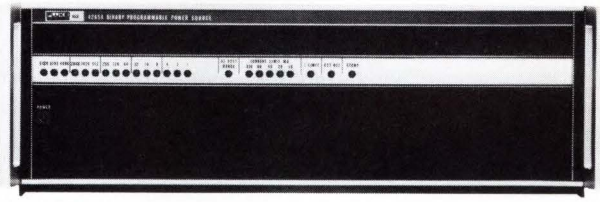
Have you ever needed just a little more current or voltage to test a new device? (Probably this slight extra capability is only needed for a very few tests.) With the 4200 Series Power-DAC, you can double, triple or quadruple your current or voltage capability by a simple parallel or series connection with external relays. No special hardware or software protection features are required. With several Power-DACs in your system you have both single unit control and unlimited power configuration at the discretion of the programmer.

2. AC or DC outputs provide versatility

In addition to the standard internal dc reference, an external reference option allows any external ac or dc signal to be used as the reference for the bi-polar D-to-A ladder network. The Power-DAC can perform many different functions within the test system. Operate it as a programmable amplifier, attenuator or multiplying DAC for either ac or dc signals up to 30 kHz. Amplitude of fixed level function generators and special purpose signal sources can be precisely controlled from microvolt levels up to 50v rms at 0.7 amp rms. By accurately controlling the level of the external reference, programming resolution can be varied from 1 millivolt to several microvolts. Either the internal or external reference is selected by a 1-bit control line. The 100 μsec settling time includes polarity change, range change and selecting either the internal or external reference.

3. Fast programmable current limiting protects circuits under test

Standard models provide a gross 1.2 amp current limit as an overload protection feature. One option provides a programmable current limit in two ranges, 100 ma and 1 amp. Each range is programmable in 10 percent steps, yielding 10 ma or 100 ma resolution. When the overload occurs, transition from the constant voltage mode to the current mode requires less



Model 4265A

than 20 microseconds, the crossover time being a function of the load. The larger the overload, the faster the transition. This fast crossover capability minimizes the energy transients to the circuits under test.

4. Programming glitch reduction

A unique track-and-hold technique during the programming interval reduces the peak glitch and transient excursions to less than 50 mv in the 16 volt range, and less than 100 mv in the 65 volt range. Transitions from computer generated waveforms or incremental slewing operations take place smoothly.

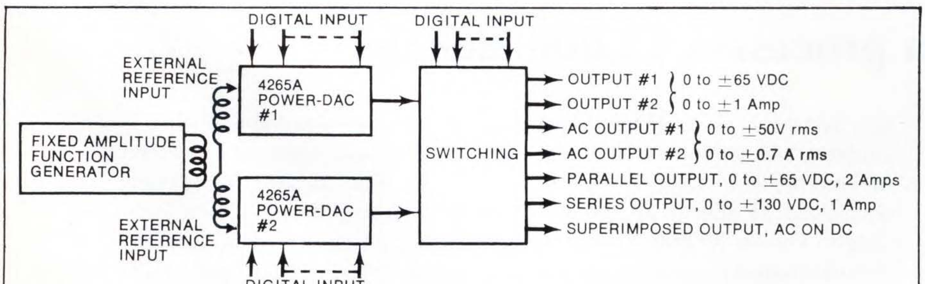
5. Isolation and guarding reduces noise and ground loops

Digital and analog portions of the 4200s are separated by a metal guard to eliminate both ground loops and digital noise which severely affect the system performance of conventional power supplies and D-to-A converters. With the isolated control logic option, impedance between the digital control logic and the analog circuits is 10^9 ohms in parallel with 3 picofarads. This isolation provides significant rejection of system noise on the analog output. Up to 1000 volts of common mode voltage can be applied between chassis ground and the guard terminal without harming the instrument, or causing severe common mode errors.

Prices and options

For $1295, the basic 4250A and 4265A are equipped with direct coupled control logic and blank front panel. The isolated control logic option which also contains a memory register for storing the program command is $300. The external reference, programmable current limit and front panel digital display options are priced at $200 each. Delivery is 30 days. For complete specifications on all 4200 Series Power-DACs, write Fluke, P. O. Box 7428, Seattle, WA 98133.

FLUKE®



The 4200 Series POWER-DACs provide a wide range of automatic test system capability. With the equipment shown above, note the different types of output obtainable.

Implanted heart pacemaker is recharged without surgery

A Columbia University professor and a team of Israeli researchers have come up with an electronic heart pacemaker powered by batteries that can be recharged through the patient's skin, without removal by surgery.

Electronic heart pacemakers—implanted devices that keep hearts beating at life-sustaining rhythms—are keeping some 50,000 Americans alive, with 10,000 more joining this list annually. The pacemaker takes the place of the heart's own biological pacemaker, which is either nonfunctioning or unreliable due to heart disease. Approximately once every two years, however, expensive and possibly risky surgery is needed to replace conventional pacemakers' mercury batteries.

Developed last year in Israel, the 3.6V pacemaker is powered by three Ni-Cd batteries which are recharged by transmitting RF power through the patient's skin, without any surgery. The pacemaker is triangular in shape (about 2-1/4-inch long per side and 5/8-inch thick) and weighs about 3-1/2 oz.

According to its inventor, Dr. Robert Bernstein, professor of electrical engineering at Columbia University, the new cardiac pacemaker's batteries are expected to last 25 years before replacement is necessary.

To recharge the Ni-Cd batteries, which is necessary every 4 to 6 months, a small transmitter is strapped to the patient's chest. The transmitter sends out RF waves to a receiving coil implanted in the pacemaker. The received power is rectified and regulated by circuitry built into the device.

A full recharge takes approximately 8 to 10 hours. "There is no discomfort in this recharging procedure," says Bernstein, "which can take place overnight even while the patient is sleeping at home."

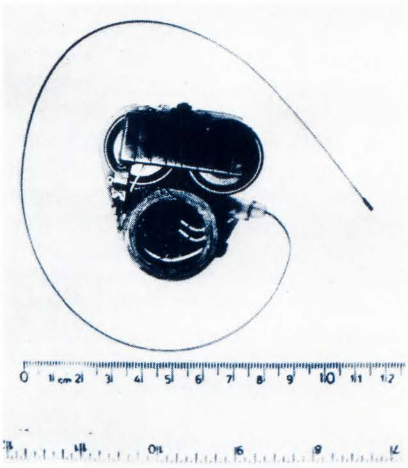
The device has so far been tested only in dogs, with three more animal tests scheduled within the next few weeks. Clinical testing with human beings is expected to start by early 1972 at Israel's Tel Hashomer Institute.

Electro-Catheter Corp. of Rahway, N. J. will be the American manufacturer of the pacemaker. Although its cost is not yet fixed, the company will probably begin selling the pacemaker for under $1000, says Bernstein, which is about the same as for the non-rechargeable types. They cost about $850.

Another possible long-term development is the "atomic" pacemaker which will be powered by a radioactive device. It is expected, however, to cost from $5000 to $10,000.

One of the features planned for the new pacemaker is so-called "demand" circuitry. Many pacemakers are inserted in humans on a temporary basis, until the heart begins its own natural pacemaking. However, a problem is presented with current pacemakers in that when the heart's own natural pacemaker gets healthy, it begins to compete with the implanted device.

The new pacemaker will have built-in sensing devices that monitor and analyze the heart's natural electrical activity, and send out battery powered impulses only when needed.



New implantable pacemaker is powered by three Ni-Cd batteries which are recharged by transmitting RF power through the patient's skin.

Multiplexing system processes 13,000 signals

How to lay out and interconnect an aircraft's power distribution system with over 33 miles of wire that must be absolutely reliable was a problem that engineers at North American Rockwell Corp. faced in designing the B-1 bomber—America's next generation of supersonic SAC aircraft.

The answer was provided by Radiation Systems, Div. of Harris-Intertype. Under a $44 million subcontract, the Melbourne, Fla. based company has developed an electrical multiplexing system, known as EMUX, which can provide control processing and routing for nearly 13,000 signals through a single coaxial cable. The system will handle the B-1's landing gear, flaps, hydraulic pumps, lights, heaters, engine controls and flight instrumentation.

The time-division-multiplexing system is composed of remote input and output black-box data terminals for signal transmission and reception, working in conjunction with a master unit to process and route the multiplexed information.

Commercial airliners at present use multiplexing for passenger entertainment consoles. However, this is done on a much smaller and less sophisticated level, and not for power distribution control.

A significant feature of the EMUX system is its multiple redundancy. Even though one cable is all that is required, each B-1 bomber will use two main redundant cables for each of two redundant systems to provide, in effect, two double-redundant systems. If a cable is opened or shorted for any reason the other cable takes over automatically, and the system continues to function. Even if an entire system should fail—a highly unlikely event—the other one takes over.

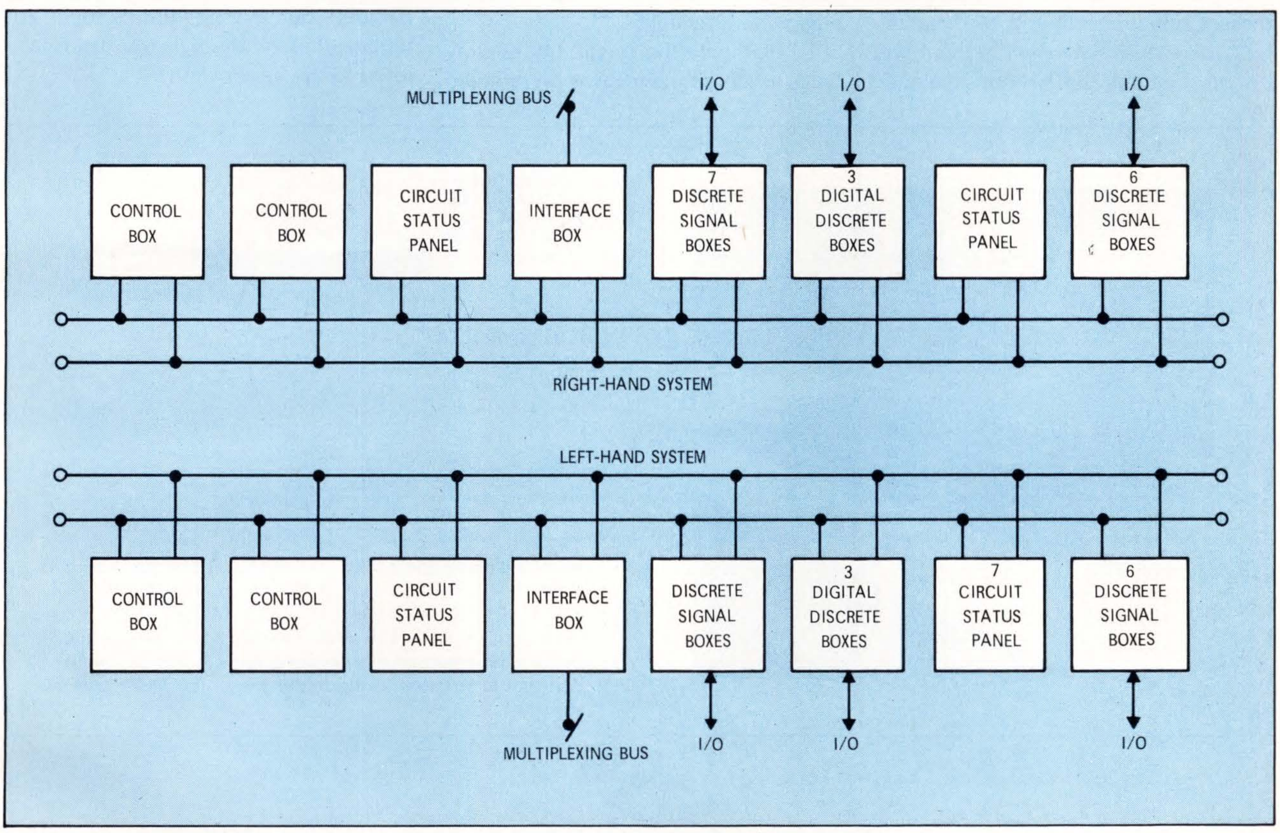
According to Radiation, an aircraft with such a system has a probability of mission success of 0.99992. On each bomber, forty-two nuclear-hardened black boxes (21 per system) will be used, with a total weight of less than 400 pounds (less interconnecting cables)—a 40 to 60% weight reduction over a non-multiplexing approach.

The single-balanced twisted-pair cable operates in a lossless terminated mode and handles two-way Manchester-coded data at a 1-megabit/sec rate. Built-in LED indicators in the master unit are available to immediately indicate the status of an open or shorted control point.

A special-purpose 210,000-bit processor is used in the system. The processor is made up of 1024-bit PROMs supplied by Radiation's sister company, Harris Semiconductor. The total system cycle time is quite fast—less than 30 msec.

Since each EMUX system is built with spare capacity for reprogramming, it can be expanded easily by having terminals added (or deleted). Up to 24 black boxes per system will be possible. The system is capable of handling video, analog and digital data in a time-division multiplexing mode.

According to Radiation spokesmen, talks are presently being conducted with the Boeing Aircraft Co., Seattle, Wash., for the possible use of EMUX in the upcoming Space Shuttle. Radiation also foresees EMUX applications in automobile, ship and train electrical systems, as well as many commercial applications.



•**A single coaxial cable is all that is used to process 13,000 signals** in the new EMUX electrical multiplexing system built by Radiation Systems Div. of Harris-Intertype Corp., Melbourne, Fla. The system was designed to handle the electrical power distribution aboard the Air Force's upcoming strategic B-1 bomber. Each EMUX system is composed of 21 black-box terminals.

Kitchen stove uses solid-state oscillator

New York—Westinghouse engineers have developed an electric home range that heats cooking utensils directly by low-frequency induction rather than indirectly by the usual resistance elements. This, they say, gives the housewife the same speed of response as gas, plus a countertop so smooth and cool that unused portions can be used as additional work surface.

The main drawback of the new range is that because of the cost of the semiconductors used in the oscillator circuit, the induction range will cost almost an order of magnitude more than conventional resistive electrical ranges. Westinghouse's first product based on this principle—a four "burner" range, will sell for $2500, rather than the several hundred dollars of a conventional surface unit. But Westinghouse expects that continued decreases in power semiconductor costs will bring the price down to less than $1000.

The 23kHz magnetic field is generated by flat, pancake-shaped coils located underneath a non-magnetic counter top (made of a ceramic material). These coils are part of a transistor oscillator that runs off dc rectified from the regular 220V ac line used for large appliances.

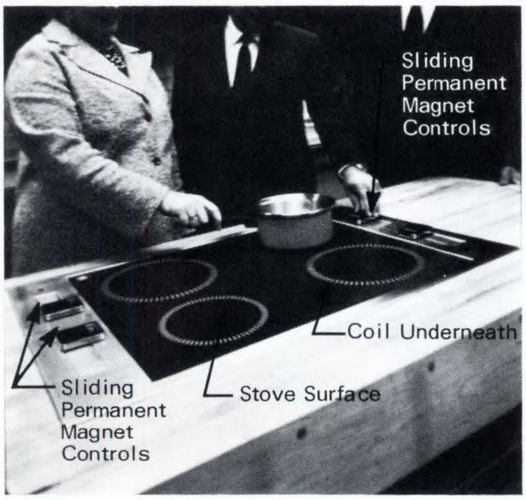
The 23 kHz flux emanating from these coils induces high circulation currents in any metal pan or kettle sitting on top of the cooking surface. If the pan is made of the proper material—only iron and steel utensils should be used—the eddy-current losses from these circulating currents will rapidly heat the utensil. Meanwhile there will be no heating of the non-magnetic countertop, except from the cooking utensil. Westinghouse demonstrated that it is possible to put a paper towel between the pan and the surface. The oscillators consume about 1900 W and because of the efficiency of this method of applying the heat are said to be equivalent to 2400 W resistive units.

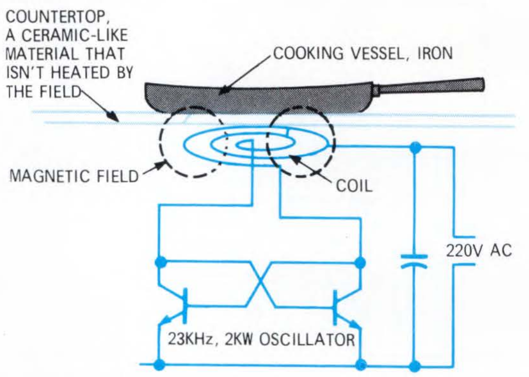
Westinghouse has been working with the U.L. to ensure that the process—which hitherto has only been used in industry—is safe for household use. The engineers were especially concerned that stray 23 kHz radiations might falsely trigger or swamp certain types of heart pacers. But their tests have shown that as long as a cooking utensil is in place, it will "grab" most of the radiated flux and there will be negligible stray field.

To eliminate the possibility of stray fields when no utensil was on the unit, the engineers incorporated a sensor that notes the absense of a utensil and turns off the oscillator.

Special controls were developed to maintain the clean, smooth styling of the counter top. These consist of permanent-magnets the size of a pack of cards, which are slid back and forth in shallow grooves. They operate linear potentiometers. The housewife can lift them off to clean the surface of the unit. Just how the power of the oscillators is varied was not disclosed by Westinghouse.

The reason for the expense of the semiconductors is that each oscillator must have transistors capable of handling over 10A at high voltages. Right now, large numbers of TV deflction system transistors are being used in parallel, but Westinghouse hopes to replace these with single transistors tailored to the application.





Induction-principle range boasts a cool, smooth work-top surface. It is said to appeal to housewives because it is easily cleaned and has the speed of gas. The circuit (sketched by EDN/EEE after talking with the designers) consists of a transistor oscillator driving a pancake-shaped coil that is fastened to the underside of the non-magnetic surface.

Fingerprint transmission via satellite proves feasible

The first television transmission of fingerprint records via satellite link, from California to Florida, has been successfully achieved. The transmission system uses microwave communications and Ampex Corp. Videofile system equipment as part of experiments by project SEARCH (System for Electronic Analysis and Retrieval of Criminal Histories).

In the experiment, fingerprints and photographs filed by videofile system equipment at Sacramento, California were transmitted as video signals via NASA's Hughes ATS-1 satellite to a complete videofile system at Tallahassee, Florida. There they were converted to video recordings and retrieved by "instant replay" as television pictures and printed copies. The experiment demonstrated what may eventually be a system for state-to-federal fingerprint transmission using a permanent satellite system.

Presently, positive identification of the fingerprints of an arrested person may take two to three weeks. The prints are mailed to various identification centers and matched to existing print files. With the experimental system, however positive fingerprint identification may be reduced to just a few hours.

The fingerprint of an arrested person in Los Angeles, for example, would first be processed by an analog image scanner. The analog output of this scanner is converted by an a/d converter to compressed digital form. Data then passes through a 9600-bit/sec modem for transmission to a communications satellite, which then relays the information to a State-of-California criminal records center in Sacramento.

At Sacramento, the fingerprint data is processed through a modem and a d/a converter to produce an analog signal which drives a photographic facsimile recorder. The recorder produces an accurate paper copy of the original fingerprint. At the same time, the incoming digital signals are recorded on a digital magnetic tape recorder for pictorial data processing.

An attempt is made at Sacramento to match the fingerprint to preexisting records. If the attempt is not successful, the recorded digital data would be retransmitted via satellite to the national fingerprint identification center. For the purposes of this experiment, the national center was simulated by a receiving station in Tallahassee, Florida. At the receiving station, a d/a converter processes the incoming data for plotting on a facsimile recorder.

The SEARCH experiments, conducted December 6 to 17, 1971, have produced images of excellent quality, according to Paul K. Wormeli, national coordinator for project SEARCH and vice president, Public Systems, Inc. Wormeli said findings from the experiments will be used in a SEARCH technical report this spring. The report will evaluate the cost and benefits of fingerprint transmission via satellite.

Fingerprints via satellite are displayed on a television screen by "instant replay." The fingerprints were transmitted from Sacramento, California to Tallahassee, Florida by NASA's Hughes ATS-1 satellite and recorded on an Ampex videofile system.

Electromechanical generator produces clean waveforms of any desired shape.

Philips Research Laboratory in Hamburg, Germany has designed an electromechanical voltage function generator, which, in principle, can generate any desired function but is free of the usual electromechanical drawbacks.

Generation of an arbitrarily chosen voltage pattern is usually accomplished by mechanical means, an example of which is by a disc cam. The drawback lies in the fact that very adrupt voltage changes can be produced with difficulty, if at all. The use of disc cams is also accompanied by such troublesome effects as parasitic oscillations and heavy wear.

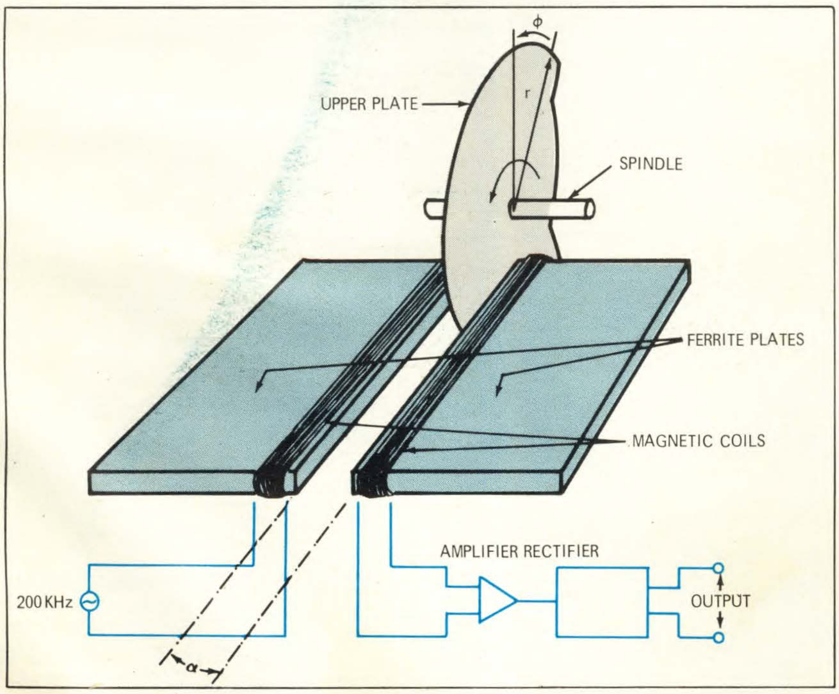
In the new function generator, use is made of the fact that a magnetic flux can be displaced by means of a copper plate. The plate in this case is shaped in accordance with the desired function. Designed by K. Rennicke of Philips Laboratory, the generator uses a 0.2mm-thick copper plate attached to a spindle. The shape of the perimeter of this disc-shaped foil is such that the distance "r" to the spindle corresponds (as a function of the angle of rotation, ϕ to the voltage function to be generated. The foil rotates in the air gap between two ferrite plates that serve as cores of two coupled magnetic coils.

A 200-kHz voltage is applied to the primary coil, which induces a proportional alternating voltage in the secondary. With no foil in the gap, the coupling between the two coils is maximum. On the other hand, the secondary coil signal becomes practically nil if it is completely screened from the primary by the foil.

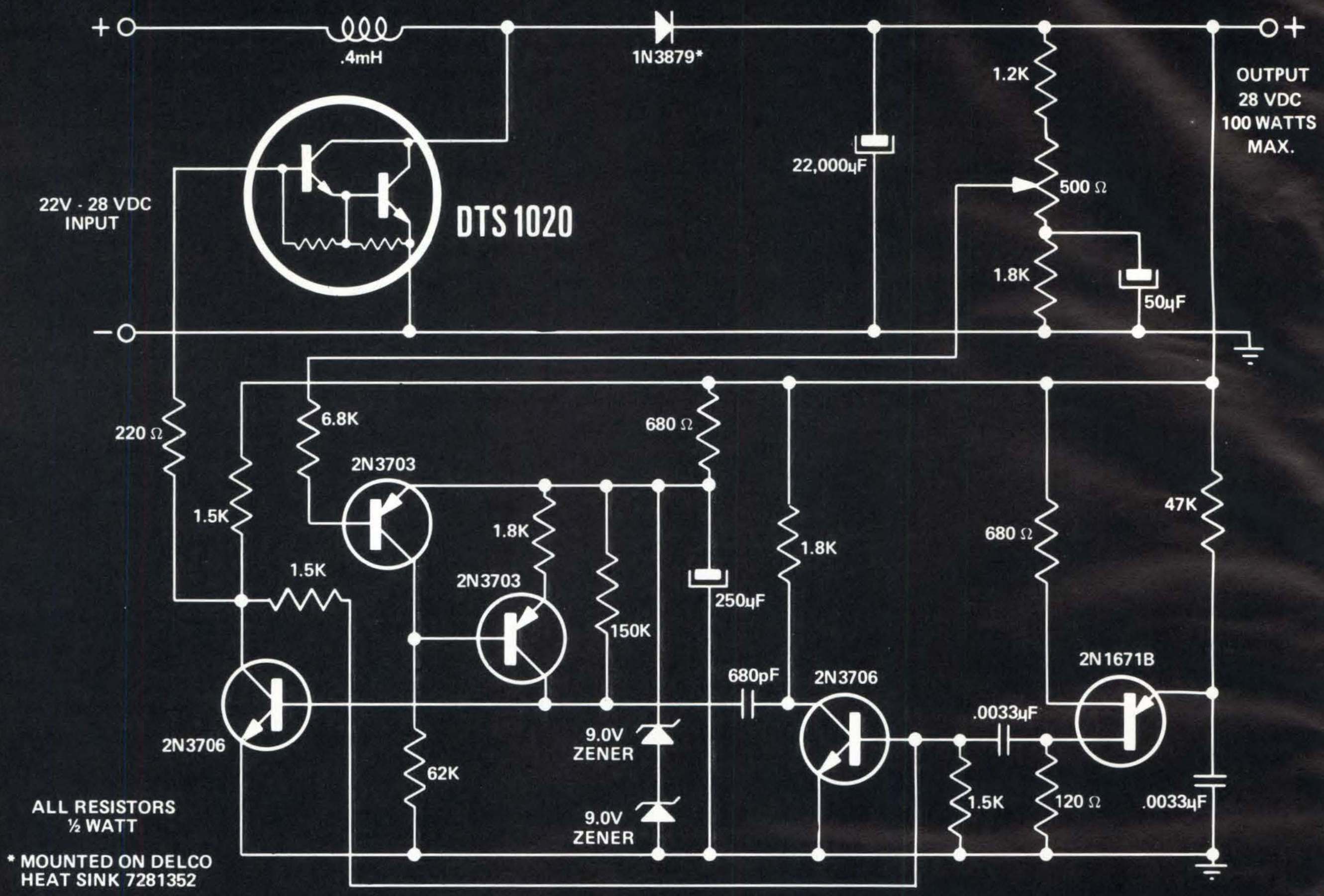
The output voltage can be rectified following selective amplification. With a uniformly rotating disc, the output voltage is a function of the angle of rotation, (ϕ), and time, and displays a pattern which derives directly from the shape of the perimeter of the disc.

In addition to its linearity advantages over disc cam types, the new device makes possible the generation of very steep edged waveforms. The new generator reportedly can also produce functions of a much higher frequency than those possible by purely mechanical generators.

An improvement in linearity between the amplitude of the secondary output voltage and the value of "r" is realized by deliberately aligning the two ferrite plates in a non-parallel manner—the plate edges are further apart on one end than on the other, which gives rise to a small angle "(α)" (see figure). Deviations from linearity are said to be less than 0.5%.



High frequency and closely tracked waveforms of any shape can be produced using this electromechanical generator. The output can take on any form in accordance with the shape of the rotating spindle.



SWITCHING REGULATOR

	V_{CEO} @ 0.1 mA	V_{EBO} @ 50 mA	$V_{CE(SUS)}$ @ 500 mA	h_{fe} @ 1 MHz (V_{CE}=10V, I_C=200 mA)	h_{FE} (V_{CE}=5V, I_C=10A)	$V_{CE(SAT)}$ @ 5.0 A	I_C	P_T @ 75°C
DTS-1010	120V	7V	80V	12	200	1.8V	10A	100W*
DTS-1020	120V	7V	80V	12	500	1.5V	10A	100W*

*100 percent tested at 2.5A, 40V.

Digital ICs offer new solutions for rough industrial problems

Here are some guides for choosing and interfacing digital ICs that will be used in severe commercial applications.

Ed Tynan and Bob Burlingame, Semiconductor Products Div., Motorola, Inc.

In the past few years digital ICs have made inroads into application areas far afield from their birthplace—computers. Perhaps the fastest growing new uses for digital ICs are to be found in industrial and commercial areas. Here, ICs are being used for wholesale replacement of electromechanical devices such as relays—(see Box), latches, and counters.

More significant is the fact that digital ICs are making possible entirely new approaches to the solution of problems encountered in designing for automated processing and production. For example, a programmable read-only memory can replace combinational logic arrays of great wiring complexity to ease the design of control logic and, with phase-locked loop techniques, high accuracy and resolution in the control of motors is possible despite varying torques.

In general, the jobs which digital ICs can be expected to perform for the industrial and commercial user include the following:

—Provide the means to achieve low cost monitoring of production and plant operations.

—Replace electro-mechanical devices such as relays and switches for greater reliability, smaller size, and lower overall cost.

—Provide the capability for extensive multi-signal data collection and processing.

—Control motor speeds and positioning-equipment locations.

—Eliminate repetitive, routine decision-making tasks done by human operators, thus permitting a higher degree of automation for cost reduction.

—Do all of these jobs with a high reliability, at low cost, in a small size, and with a low power consumption unmatchable by either discrete electronic or mechanical components.

As a result of the expansion of digital logic into industrial and commercial areas, many designers are being called upon to use unfamiliar devices for the very first time. Some of the considerations which should be made early in the design phase will be explored.

Selecting the logic type

Because of the severe electrical and physical environments in which industrial and commercial equipment is called upon to operate, choosing the type of digital logic and its package can be critical. The questions once was only, "which type of transistor-transistor logic (TTL) should I use?" Today TTL does still offer a low-cost approach, together with the widest variety of available logic functions. However, other types of logic, such as complementary metal oxide semiconductor (CMOS), emitter coupled logic (ECL), and high threshold logic (HTL), offer significant performance advances which can be vital to the success of a design.

TTL logic is moderately fast, but generates internal switching noise, often causing problems rather than eliminating them. Such noise, coupled into logic gates, can cause erratic operation. ECL operation is very fast and is quiet electrically, so it does not interfere with itself or nearby sensitive circuits. CMOS is characterized by a miniscule power consumption and a high immunity to noise. HTL offers circuit performance similar to TTL, but with a factor-of-5 improvement in noise immunity.

High switching threshold P-MOS logic offers the industrial user large scale integration (LSI) of many logic devices onto a single chip, in one small package. Exceedingly complex functions, like shift registers, character generators, memories, hundred-gate logic arrays, even complete processing subsystems on a chip, are today available in PMOS.

Frequently it may seem wise to the industrial designer to select a variety of different logic types for his system, so as to have the best features of each where needed. However, it then becomes necessary to consider whether the logic types can be interfaced to each other directly, or whether it will be necessary to adjust logic voltage levels among the different parts of a system. Unfortunately, translating among logic types can create more problems than it solves: multiple power supplies may be required; system noise immunity may be degraded; additional circuitry and cost will result from the requirement for interfacing logics; large temperature differences throughout such a system could play havoc with the performance of differing types of digital ICs patched into a single system. As a result, it is wise to limit the number of different types of logic within a system. In essence, select those logic types to make the best tradeoffs within the design boundary conditions:

—Cost

—System stability in the face of its environment

—Performance

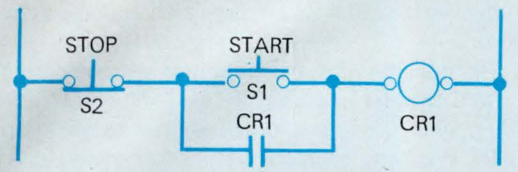
—Availability of digital functions

While selecting the logic types to be used, the system engineer must also decide what packaging requirements exist. Four types of package are in common use for standard digital ICs: ceramic and plastic dual in-line; ceramic flat packages; and metal cans. Of these, metal cans are rarely used except with a few MOS devices. The ceramic flat package has a long history of reliable use, and should be considered for application in high-reliability programs.

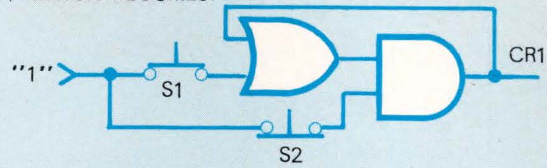
Plastic or ceramic packages?

Dual in-line packages are most suitable where high vol-

(a)



(d) WHICH BECOMES:



(b) Let: CR1 = Coil Function
S1 = Switch 1
S2 = Switch 2

The equation is:
(Coil activated) = (Switch 2 not activated) AND (Switch 1 activated OR N.O. contact activated)

which can be written:

$$CR1 = \overline{S2} \cdot (S1 + CR1)$$

THE LOGIC DIAGRAM IS:

(c)

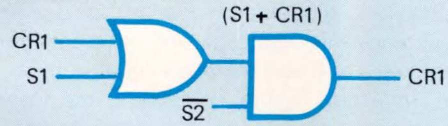


TABLE		
DEVICE	ACTIVATED STATE	DEACTIVATED STATE
N. O. S1	1	0
N. C. S2	0	1
N. O. CR1	1	0
N. C. $\overline{CR1}$	0	1
COIL CR1	1	0

Relay to IC conversion

The procedure for replacing control relays with digital ICs begins by writing a Boolean equation for the switching arrangement, using a consistent logic assignment as in the table. The Boolean equation is then implemented with IC logic functions. Simplifications may be made by manipulating the Boolean equations according to the usual rules of that algebra.

A very simple example is shown in the figure. In (a), a momentary push button energizes relay coil CR_1, closing contacts CR_1. S_2 maintains the CR_1 contacts closed and the CR_1 coil energized until a cycle is ended by opening S_2.

In (b) a Boolean equation for the circuit has been written. One logic implementation of the function is shown in (c). A cursory inspection reveals that the needed CR_1 input is available by feeding back the output (d).

If the equations for several relay circuits are combined, they can be converted into the complete control logic diagram. Or, the total diagram can be formed by drawing the logic diagrams for each equation and then interconnecting the individual diagrams.

The example shown might have been part of control circuitry from which no power was required. However, it is usually the case that at the output of the logic array, some power device will be required. The circuit shown might be used for controlling a dc motor in a linear actuator. If so, a power transistor switch would be required between the IC and the motor.

ume use demands a low unit cost. For most industrial and commercial applications the question is only whether to use plastic or ceramic dual in-line packages. In general, plastic is less expensive, but ceramic offers a proven hermetic seal, to give full protection to the IC chip.

A caution, however, is in order. Although a ceramic package as purchased may be hermetic, it can be damaged during wave-soldering. Particularly vulnerable is the glass seal at the leads. When the seal is made, the leads have not yet been plated. The glass seal is then made. Afterwards, all exposed metal is given plating for protection. If cracked, unprotected metal may be subject to corrosion by salt or caustic atmospheres, leading to a failure despite remaining hermeticity.

Surprisingly, a non-hermetic package using a corrosion-resistant lead material may be a better choice than a ceramic package. However, it must be remembered that moisture can enter the plastic package, particularly if moisture remains after cleaning flux from a PC board after assembly. To avoid problems, therefore, it is effective to bake the unit at 125°C for at least an hour before applying power. This will eliminate any moisture which has entered along the leads during the solder process. A longer period of time at a lower temperature may be used if components with lower storage temperatures are used.

One packaging possibility which should not be overlooked is the hybrid circuit. Particularly with custom designs, hybridizing all or part of a design offers an opportunity to select from an almost unlimited number of packages. Digital ICs, discrete transistors, SCRs, and passive components can all be combined into a hybrid package, to gain advantages in size. In addition, with a single package replacing dozens of separate components, a net cost advantage may be discovered when both direct and indirect costs of separate devices are considered. Indirect costs include the costs associated with ordering, testing, inventory, and assembly.

All electronic devices, not just digital ICs, are subject to problems with noise. In fact, digital systems do have an advantage in overall behavior: noise picked up at any giv-

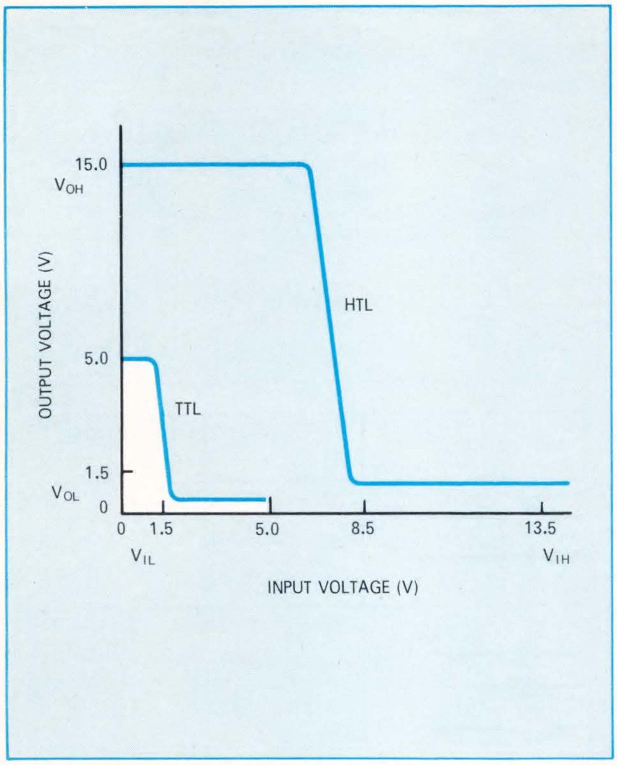


Fig. 1 – **Noise immunity as a function of logic swing.** One definition of noise immunity is the voltage swing needed to drive a gate from a quiescent point into its transition region. TTL devices, with their lower logic swings, have lower noise immunity than HTL devices.

en point, below gate switching thresholds, is not propagated through the system. This response of a digital system is in sharp contrast to a linear or analog system, in which even low amplitude noise may not only be propagated through the system, but might be amplified as well!

Noise sources are not always obvious

Digital ICs do not malfunction because of mechanical wear or jammed and stuck parts. But they are susceptible to electrical noise bombarding them from a surprising number of sources. Even though remedies are available after the fact, the industrial user can rationally expect noise to be a problem, and should tackle this nuisance at the outset.

Sources of noise range from fluorescent lights, wall switches, relays, motors, and solenoids, to arc-welders, power substations, elevators, and sources of RF energy. Routes to trouble in a digital circuit are threefold: signal and transmission lines; power supply lines; and ground lines. Sufficient noise on any or all of these can cause false and erratic operation of digital circuitry.

Noise immunity of a digital gate may be defined as a dc voltage specification measuring the immunity of the gate to false switching caused by noise voltages. This dc parameter, in some cases, is taken as the voltage difference between the worst-case output level. Such a definition focuses on the worst case output of one gate, coupling into a following worst-cast input.

Another definition of noise immunity derives from the voltage swing needed to drive a gate from its quiescent voltage into the transition region (**Fig. 1**).

An ac noise parameter can be obtained by cascading gates operated with worst-case logic levels, and then measuring the minimum noise voltage level that will propagate through the gates. Such a measurement can be more indicative of actual system operation than the dc specification.

The designer must be cautious when comparing specifications of noise immunity for the various families of logic. Although voltages are often referred to when specifying noise immunity characteristics, other variables enter into actual behaviors; for example, the duration of a pulse and the total energy contained in a noise burst. Thus, for a longer noise pulse there is a higher probability of false switching than for a shorter one (**Fig. 2**).

Avoidance of noise problems with a digital IC circuit demands attention to each of three areas:

- The noise source
- The mode by which noise is coupled
- The logic's noise immunity

Assuming that digital ICs are called upon to operate in proximity to noise sources, steps to be taken to minimize electrical interference should be considered. These include standard techniques, such as power-line bypass capacitors, diodes across relays to suppress high-amplitude transients, and capacitors across dc motor brushes. In rare cases of severe interference, as from electric arc welders, induction heating equipment, and so on, shielding of the source equipment may be considered, both to reduce RF radiation to within legal limits, and to prevent interference to electronic equipment.

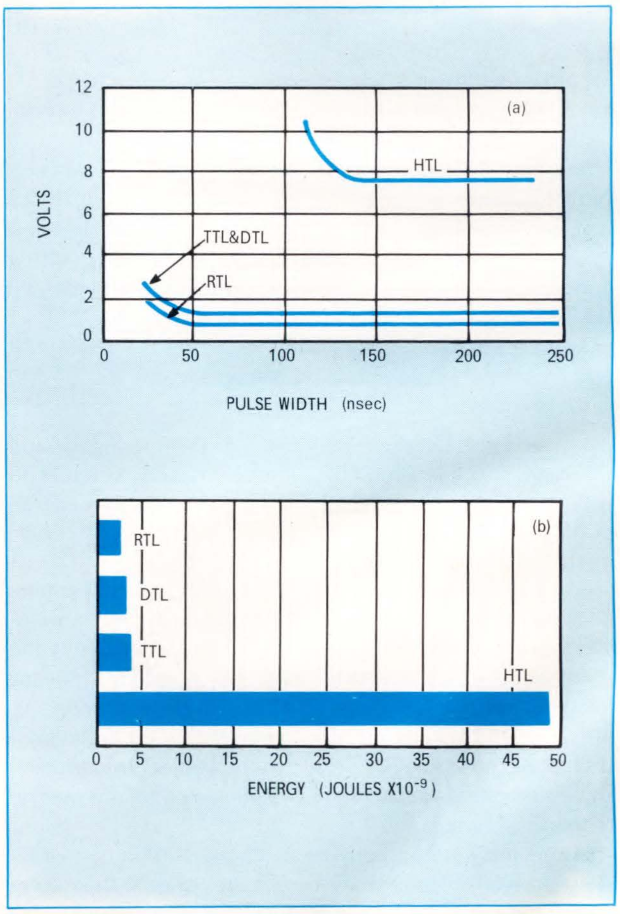


Fig. 2 – **Comparison of noise immunity to signal line noise.** The voltage threshold noise level is shown as a function of pulse width (a), and as a function of total noise pulse energy, (b), for a number of logic families in wide use for industrial applications.

Not to be overlooked is noise generated within the digital system itself.

On-card and power-line entry-point bypass capacitors are strongly recommended. In many cases, particularly with high-speed TTL systems, it may be necessary to use multilayer printed circuit boards, with one layer being used for shielding between layers of interconnections.

Also to be considered as internal to a digital system are any power output switching devices, such as SCR's, which are capable of generating noise spikes of high amplitude. Elimination of such interference may require a combination of filtering, bypassing, shielding, or remote location of the SCRs.

Examination of the second factor, mode of coupling, may suggest easy methods for minimizing noise. Coupling can be by direct electrical conduction from the noise source through power- or ground-line wiring to the digital system. In such a case, low-impedance bypassing with capacitors from the common lines to a ground point not part of a loop can remedy the problem.

A grounding system, as shown in **Fig. 3**, will go far toward keeping electrical noise from interfering with a system. All grounds should be connected to a common ground point—normally near the power supply. All logic circuits are connected to a circuit ground. All relays, solenoids, motors and other noise generating devices are wired to a separate ground network connected to the common ground point.

All mechanical parts such as panels, chassis, and cabinet doors should be grounded with a third ground. A mounting frame is often used for this if good conduction can be made at points of contact. If some pieces of equipment in the system are left ungrounded, they may carry transient voltages that will interfere with the rest of the system. The three separate ground systems connected to a common point will eliminate noise on the signal ground. Heavy ground leads should be used on large systems to minimize any voltage drop along the ground line run.

A second mode of coupling, somewhat less frequently encountered, is via RF radiation (electromagnetic coupling). Radiation may be picked up by long interconnecting lines between system units. For reduction of pickup, twisted pair or coaxial cable lines may be used. Merely relocating the position of interconnecting lines to move them further from the noise source may suffice when this is possible.

The third point to be considered, logic noise immunity, is first of all a property of the logic family selected. CMOS may well offer the highest noise immunity available, typically 45% of its operating supply voltage. That means that with a supply voltage of 16 volts, noise immunity could be over 7 volts. High threshold logic, HTL, offers an immunity of up to 6 volts, while TTL only promises 1.2 volts immunity.

The exceedingly small power current drain of a CMOS gate makes it easier than HTL to decouple from power-line noise, for example. A series resistance together with a shunt zener diode can suffice for an entire board of CMOS gates, even when very-high-amplitude noise pulses are present (as in SCR systems, at power-main substations, and in an automotive electrical system).

Design guidelines

After selecting the logic types, choosing the package type, and considering the noise question, the detailed design of the digital layout begins.

Some of the general considerations which must be translated into specific details for each particular logic type include the following:

- Power supply: voltage, current, and regulation required
- Effect of temperature
- Device maximum ratings
- Driving and loading limitations
- Interfacing at inputs and outputs of the digital system

Digital ICs are tested at specific supply voltages, usually specified as a nominal voltage ± either 5 or 10%. For example, the MC7400 series is tested at 4.75 and 5.25 volts. To do a worst-case design, the user must insure that the supply voltage is maintained within these limits under *all* possible conditions. Both supply ripple and regulation are therefore important.

Operation of digital ICs at supply voltages below the specified range can be expected to cause problems. The gates will usually function if output loading is reduced, but more complex circuits may quit entirely regardless of external loading. Likewise, operation above the specified limit is often unpredictable. The advice of the IC manufac-

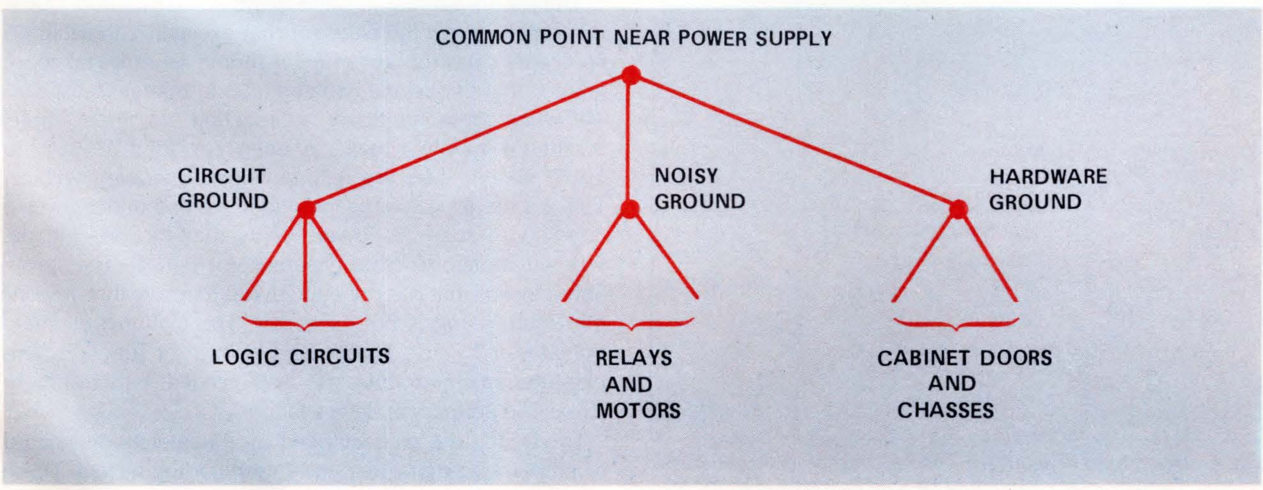


Fig. 3—**Good grounding techniques reduce noise problems.** Three separate grounds (logic, control and chassis) connected to a common system ground point minimizes noise on the signal lines. Heavy ground leads reduce voltage drops along the ground return.

turer should be obtained before designing a system to operate above its specified voltage limit.

Extremes in temperature can produce one of two problems with an integrated circuit. It can either fail to operate at that temperature extreme only, or catastrophic failure can occur, rendering the circuit inoperative even when the temperature extreme has been alleviated.

Operating at a temperature below the normal rating is usually not a cause for total failure unless thermal shock is involved. It is, however, quite likely to cause an operational failure at the extreme low temperature. Aside from the obvious result that some devices will not function at temperatures below a minimum level, the speed of the circuit is also affected. Such an effect can be critical if the circuitry is dependent on time delays.

Some compensation can be accomplished by reducing the loading on gate outputs. A complex circuit, however, may fail, either because the design relies on gate delays within the circuit (such as in an edge-triggered flip-flop), or because the integrated circuit was designed with maximum internal loading. A third possibility exists when master-slave flip-flops are used with different thresholds for the master and the slave. It is possible that these two thresholds may not track with temperature, thus causing an operational failure.

The user can normally determine the likelihood of any of these types of failures through a study of the schematics. Then, by reducing loading approximately 1% for each degree below the rated temperature limit, circuits specified at 0°C may be used as low as −55°C. As a precautionary measure, it is wise to consult the manufacturer prior to applying this rule.

ICs should not be operated above the maximum temperature specified. The reliability of an IC can also be impaired by operation above the maximum junction (die) temperature specified. This can come about by operating in higher than rated ambients, and can also be caused by overloading the output transistors, or by operating TTL at higher than rated speeds. The first two reasons are obvious: the third is a result of the switching spike inherent in TTL at the time when both transistors conduct simultaneously. The spike duration increases with temperature, causing additional power to be dissipated, thus contributing to the condition for thermal runaway.

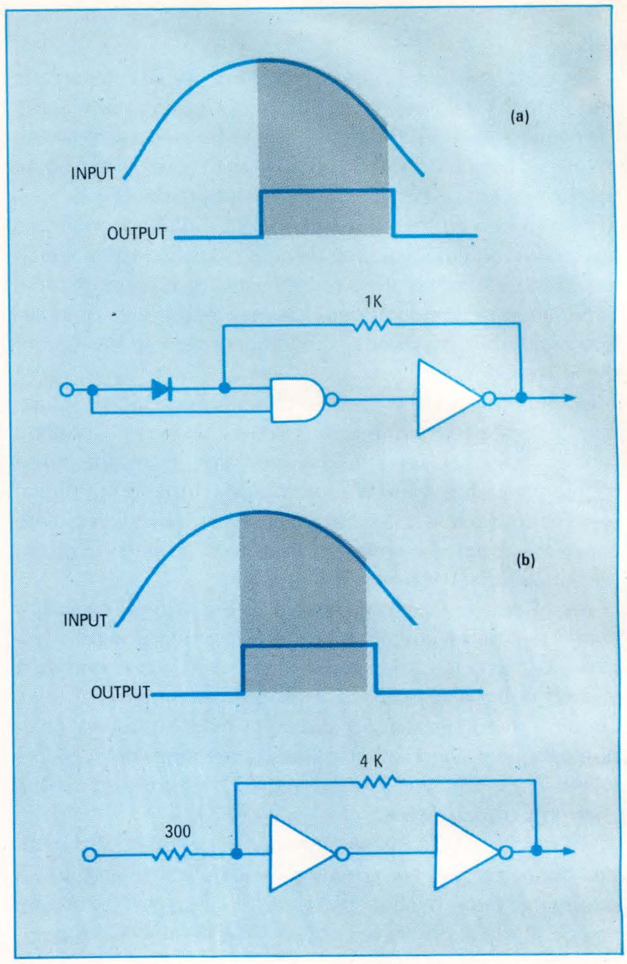


Fig. 5—**Wave-shaping circuits.** Slow rise or fall time inputs to digital ICs should be avoided to prevent oscillations at the output. The wave-shaping circuits shown can be used to obtain an output impedance of up to 1kΩ (a), or up to 300Ω, (b).

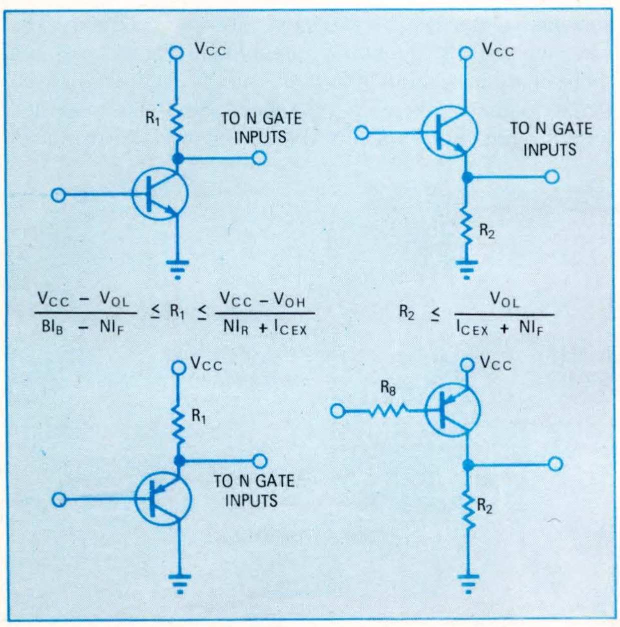


Fig. 4—**Discrete to IC interface.** Discrete transistors that are used to drive current-sinking logic must be able to supply both the forward and reverse current required. Shown are the minimum recommended load resistor values for the transistor interface.

The maximum ratings table found on device data sheets is meant to warn the engineer that exceeding these limits can cause catastrophic failure. It should never be taken for granted that the device will continue to operate satisfactorily when these limits are approached. As an example, maximum supply voltage is often specified at 50% to 100% greater than the recommended operating voltage. This is a design value meant to indicate that under adverse conditions—such as power supply malfunction—the device will probably not suffer permanent damage. The "probably" means that it is *not* enough just to insure that any one maximum rating is not exceeded. The malfunction mentioned could cause either input voltage or junction temperature maximum ratings to be exceeded. Either of these can cause permanent device failures.

Digital ICs are characterized by parameters designated as output loading factors and input loading factors. These are derived from four parameters noted on the data sheet. They are : (1) IOH, which is output logic ONE state source current capability, (2) IOL, which is output logic ZERO state sink current capability, (3) IF, which is input forward current requirement, and (4) IR, which is input reverse current leakage. In order to insure that overloading does not exist, the total forward current of all gates connected to an output, must not exceed the rated IOL of that output.

A similar condition exists for IOH and the sum of all reverse currents. The assignment of loading factors is an easy method for insuring that outputs are not overloaded. The rule *"The sum of input loading factors of all inputs connected to an output, shall not exceed the output loading factor of that output"* takes care of the situation. It is quite easy to apply, as long as all circuits are from one family.

The loading problem becomes somewhat more difficult when intermixing families. Not only is the designer confronted with a difference in values of the four important parameters, but a difference in test conditions is often encountered. For example, one logic series may be specified with an IR value measured at the minimum high-level output voltage of 2.4 volts, while another may specify this current at 4.5 volts.

Similarly, the ratio of IOL to IF may be used to determine the output loading factor on two separate device series. Although IOL or IF value for the separate device series may appear to be equal, further investigation may reveal that IOL and IF were both tested at the same power supply voltage for one series, while the other series' tests used worst-case power supplies in each case.

Therefore, interfacing rules are best based on the limits specified on the individual data sheets, with the realization that noise margins may be no better than the worst-case family used individually.

Interfacing with external components is somewhat more involved — particularly when a load requires current to be sourced into it. Such a situation can usually be analyzed by assuming that a ONE level gate-output corresponds to a voltage source of magnitude VOH in series with an impedance of VOH $I_{sc\ (min)}$. (VOH is minimum high-level output voltage, $I_{sc\ (min)}$ is the minimum short-circuit current). This is not truly a worst-case, since I_{sc} is measured with inputs at ground rather than at a worst-case zero level. However, it is adequate for most purposes.

Driving a load which requires a sink current presents no problem for current-sinking logic such as TTL, DTL, or HTL. It is only necessary to insure that the sink current required is no greater than the specified IOL of the gate circuit.

Driving current-sinking logic with a discrete NPN transistor operated as a common-emitter amplifier creates no particular dc problem. But the transistor and its load resistor must be able to supply the forward and reverse current required. A similar requirement exists for other transistor circuits, but they are somewhat more difficult to fulfill with an NPN transistor operated as an emitter-follower or a PNP used as a common-collector amplifier. **Fig. 4** shows minimum recommended resistor values for transistor interfaces.

AC requirements for interface circuits are not as immediately evident as the dc constraints. And, in fact, saturated logic (e.g.TTL) can break into spurious oscillations if inputs are biased at or near the switching threshold. Slow rise or fall time inputs to digital ICs should be avoided, since the output waveform might then contain oscillations at the leading or trailing edge of the output.

A good rule to follow is that rise and fall times of an input to a digital IC should be no longer than the propagation delay of a standard gate within that family. Rise and fall times as referred to here should be measured between VIH and VIL rather than 10% to 90% points. If the waveforms to be used do not correspond to this criterion, waveshaping circuitry, or one of the gate configurations shown in **Fig. 5** may be used.

Another facet of interfacing which may be critical is parasitic elements which are present in all digital ICs, and which may not show on data-sheet schematics. In general, each transistor in the circuit also has a diode connected from its collector to the ground terminal. The polarity of the diode is such that it is normally reverse biased (anode connected to ground), but this situation can be reversed if an attempt is made to pull an output below ground.

Likewise, a diode is usually present between any resistor and the power-supply terminal. (Cathode of the diode connected to power supply.) Thus, an attempt to increase the output voltage of a circuit with passive resistor pullup to a potential greater than the supply voltage can result in excessive current. ☐

Author's biography

Ed Tynan is a Product Engineer with Motorola, Inc., Semiconductor Products Division, Phoenix, Arizona. His present duties involve the communication of technical ideas. Mr. Tynan received his B.S. in Physics from Seattle University in 1963.

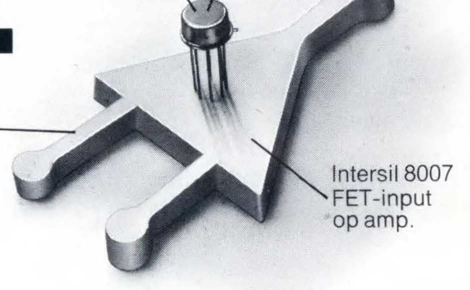
Author's Biography

Bob Burlingame has been a member of Motorola Semiconductor's Computer Applications Staff for six years where he has worked with all types of saturated logic products. He received a BSEE degree from Wichita State University in 1962.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE L61**

It costs $5.

2pA bias, 6V/µsec slewing.



Think of the places you can use it.

For instance.

Here's an op amp that's price competitive with the 101A, the 709, 740 and the 741. In its TO-5 can it's pin compatible with them all—and not a bit bigger.

But in performance it stands tall among the large complex modules.

It's the perfect answer for when 100kΩ to 500kΩ source impedances make amplifier input currents marginal, but price constraints force you to use a low cost bipolar op amp.

Surprise!

It's a FET-input op amp, the Intersil 8007. It costs only $5.00 in 100-piece quantities, and has a typical input bias of 2pA. (Model 8007A is available with I_B down to 1pA max.) It has a 6V/μsec slew rate (@ $A_{CL}=+1$) and internal frequency compensation.

Get one free.

Try it. Ask your Intersil distributor for a sample 8007 op amp. Discover the superb performance and design freedom it gives you compared to a marginal bipolar. Or use it instead of a big expensive module and save both dollars and real estate.

What you need in analog.

Remember the company that put it all together in analog technology. Intersil. 10900 N.Tantau Ave., Cupertino, CA 95014.

Get it here.

Intersil stocking distributors. Schweber Electronics; Century Electronics; Semiconductor Specialists; DeMambro Electronics; R. V. Weatherford Co.

Intersil area sales offices. Los Angeles (213) 370-5766; Metropolitan New York (201) 567-5585; Minneapolis (612) 925-1844; San Francisco Bay Area (408) 257-5450.

Overseas representatives. Clichy, France: Tranchant Electronique. Amsterdam, Holland: Klaasing Electronics. Tokyo, Japan: Internix. Zurich, Switzerland: Laser & Electronic Equipment. London, U. K.: Tranchant Electronique. Munich, West Germany: Spezial Electronics.

U. S. representatives in all major cities.

Intersil

CIRCLE NO. 12

For high-frequency communications equipment use balanced modulators

You can get linear operation as well as large signal-handling capabilities. This basic building block also serves as a detector, mixer and frequency doubler.

Roy Hejhall, *Motorola, Inc., Semiconductor Products Div.*

There are many requirements in high-frequency communications equipment for circuits having outputs proportional to the product of the input voltages. These include modulators, demodulators, detectors, mixers and frequency doublers. Most circuits used to perform these functions suffer from problems such as nonlinear gain change, poor signal-handling capability or temperature drift. And transformers are usually required.

By using the properties of a differential amplifier, a broadband, linear, temperature-stable balanced modulator circuit can be built using only standard IC's. In addition to its basic application as a double-sideband suppressed-carrier balanced modulator, the circuit can be used as a building block for SSB product detectors, AM, FM and frequency detectors, mixers and frequency doublers operating at frequencies up to UHF.

The design of any of these circuits requires a knowledge of the properties of differential amplifiers and the basic modulator circuit.

The basic modulator

The basic balanced modulator circuit, **Fig. 1**, consists of three differential amplifiers (Q_1-Q_2, Q_3-Q_4 and Q_5-Q_6) and a pair of constant-current sources. Individual differential amplifiers, pairs of differential amplifiers and even the complete modulator of **Fig. 1** are available in IC form. So, for purposes of the analysis, the following assumptions have been made for simplification: (1) devices of similar geometry within a monolithic chip are assumed identical and matched where necessary, and (2) transistor base currents are ignored with respect to the magnitude of collector currents; therefore, collector and emitter currents are assumed equal.

The analysis of operation of the circuit is based on the ability of the device to deliver an output which is proportional to the product of the input voltages V_X and V_Y. This holds true when the magnitudes of V_X and V_Y are maintained within the limits of linear operation of the three differential amplifiers in the device. Expressed mathematically, the output voltage (actually output current, which is converted to an output voltage by an external load resistance), V_o is given by

$$V_o = K\,V_X\,V_Y \qquad (1)$$

where the constant K may be adjusted by choice of external components.

Operation consists of applying a high-level input signal to the dual differential amplifiers, Q1, Q2, Q3, and Q4, (carrier input port) and a low-level input signal to the lower differential amplifier, Q5 and Q6, (modulating signal input port). This results in saturated switching operation of the carrier, dual differential ampliers, and linear operation of the modulating differential amplifiers.

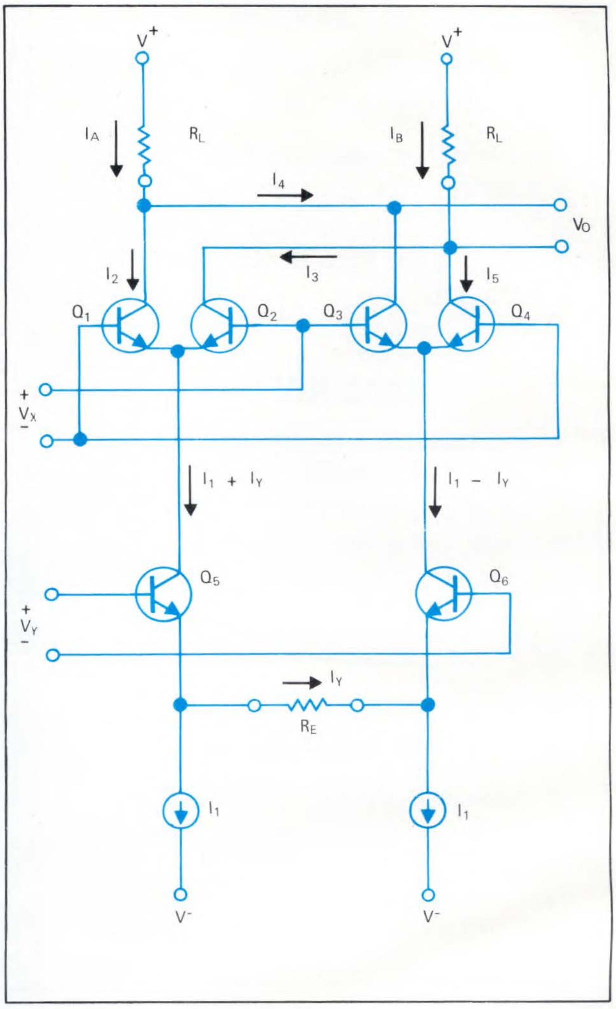


Fig. 1—**The basic modulator configuration** can be used for a wide variety of communications applications. The constant-current source can be either a common base or common emitter amplifier. The output voltage V_o is $KV_x\,V_y$ where K is a function of R_E.

The resulting output signal contains only the sum and difference frequency components and amplitude information of the modulating signal. For sine wave inputs where V_X and V_Y are $E_x \cos \omega_x t$ and $E_y \cos \omega_y t$, respectively, the output, V_o, is $K\,E_x\,E_y \cos(\omega_x + \omega_y)\,t + \cos(\omega_x - \omega_y)t$.

The carrier input differential amplifiers have no emitter degeneration. Therefore, the carrier input levels for linear and saturated operation are readily calculated. The crossover point is in the vicinity of 15-20 mV rms, with linear operation below this level and saturated operation above it. This permits selection of emitter degeneration resistance (R_E) and thereby tailoring of the linear dynamic range of the modulating-signal input port to a particular requirement. This resistor also determines device gain.

The approximate maximum level of modulating signal input for linear operation is given by

$$V_m \text{ (peak)} = I_1 R_E \quad (2)$$

Since base currents were assumed to be zero and transistors identical,

$$I_1 = I_5 \quad (3)$$

Therefore, Equation 2 becomes

$$V_y \text{ (peak)} = I_5 R_E \quad (4)$$

Device voltage gain (single-ended output with respect to modulating signal input) is given by the expression

$$A_V = \frac{R_L}{R_E} f(m) \quad (5)$$

$$\text{where } f(m) = \frac{e^{-m} - e^{m}}{(1 + e^{m})(1 + e^{-m})}, \text{ and}$$

$$m = \frac{V_X}{\frac{kT}{Q}}$$

and K is Boltzmann's constant, T is the temperature in degrees Kelvin, and q is the electron charge. f(m) may be approximated for the two general cases of high- and low-level carrier operation.
For the high-level case ($V_X > 100$ mV peak):

$$f(m) \approx 1 \quad (6)$$

$$\text{and } A_V \approx \frac{R_L}{R_E}. \quad (7)$$

The low-level case ($V_X < 50$mV peak) is given by:

$$f(m) \approx \frac{-m}{2} \quad (8)$$

$$\text{therefore } A_V \approx \frac{R_{Lm}}{2R_E}. \quad (9)$$

These expressions assume the condition $R_E \gg r_e$, where r_e is the dynamic emitter resistance of transistors Q_5 and Q_6. When $I_1 = 1$ mA, r_e is approximately 26 ohms at room temperature.

There are numerous applications where it is desirable to set R_E equal to some low value or zero. For this condition, Equations 7 and 9 can be expanded to the more general form:

$$\text{high-level } V_X\text{: } A_V \approx \frac{R_{Lm}}{2(R_E + 2r_e)}$$

$$\text{low-level } V_X\text{: } AV \approx \frac{R_{Lm}}{2(R_E + 2r_e)}$$

Let's look at several applications using this basic circuit configuration. For all applications described, the circuit of **Fig. 1** is used with the bias current I_1 (I_5) set at 1 mA. For purpose of illustration the Motorola MC1596 IC is used.

Balanced modulator

Fig. 2 shows the MC 1596 in a balanced modulator circuit operating with +12 and −8 volt supplies. Excellent gain and carrier suppression can be obtained with this circuit by operating the upper (carrier) differential amplifiers at a saturated level and the lower differential amplifier in a linear mode. The recommended input signal levels are 60 mV rms for the carrier and 300 mV rms for the maximum modulating signal levels.

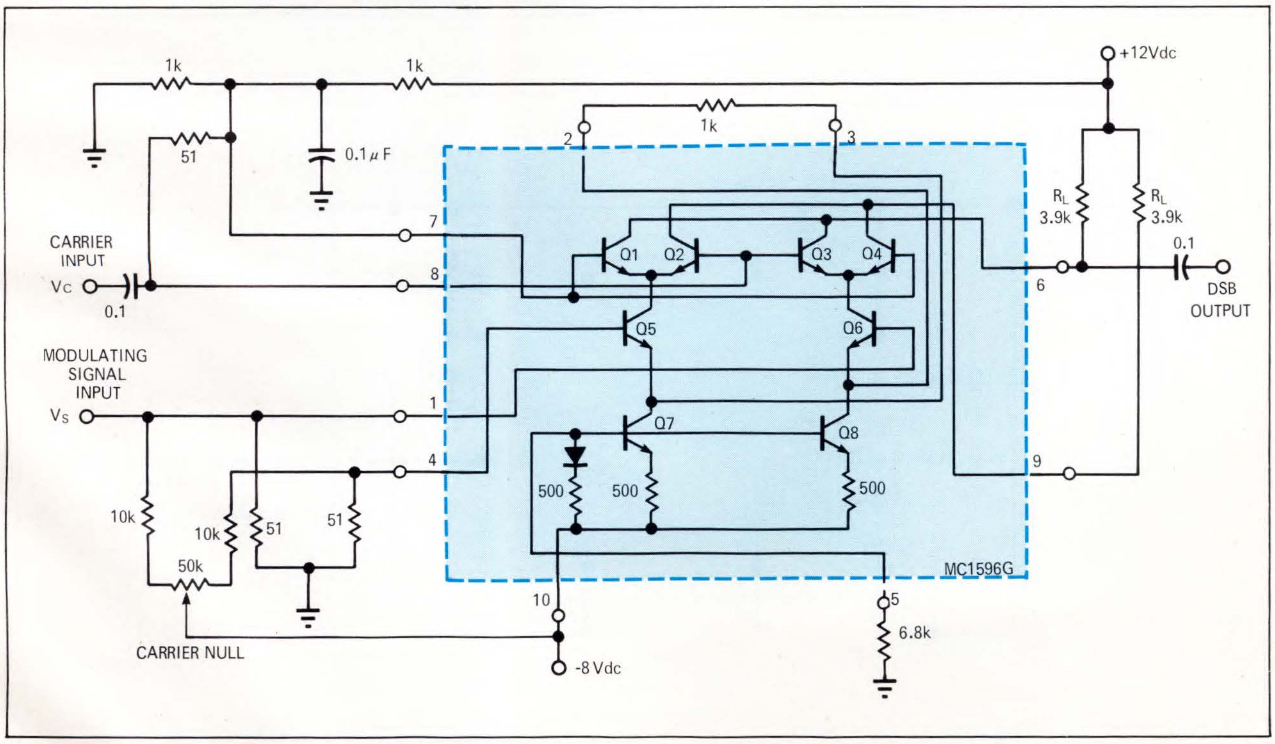


Fig. 2—**When used as a balanced modulator,** excellent carrier suppression can be obtained by operating the upper (carrier) differential amplifiers at a saturated level and the lower differential amplifier in a linear mode.

The modulating signal must be kept at a level sufficient to insure linear operation of lower differential amplifier Q_5-Q_6. If the signal input level is too high, harmonics of the modulating signal are generated and appear in the output as spurious sidebands of the suppressed carrier. For a maximum modulating signal input of 300 mV rms, the suppression of these spurious sidebands is typically 55 dB at a carrier frequency of 500 kHz.

Operating with a high-level carrier input has the advantages of maximizing device gain and insuring that any amplitude variations present on the carrier do not appear on the output sidebands. It has the disadvantage, though, of increasing some of the spurious signals.

Fourier analysis for a 50-percent duty cycle switching waveform at the carrier differential amplifiers predicts no even harmonics of the carrier. However, the second harmonic of the carrier is suppressed only about 20 dB in the LF and HF range with a 60 mV carrier injection level, apparently due to factors such as the waveform not being a perfect square wave and slight mismatch between transistors. If the sine-wave carrier signal is replaced with a 300 mV peak-to-peak square wave, an additional 15 dB of carrier second-harmonic suppression is achieved. Attempting to accomplish the same result by increasing carrier sine-wave amplitude degrades carrier suppression due to additional carrier feedthrough with, however, no increase in the desired sideband output levels.

Operation of the carrier differential amplifiers in a linear mode theoretically should produce only the desired sidebands with no spurious outputs. Such linear operation is achieved by reducing the carrier input level to 15 mV rms or less. This mode of operation does reduce spurious output levels significantly.

The decision to operate with a low- or high-level carrier input would of course depend on the application. For a typical filter-type SSB generator, the filter would remove all spurious outputs except some spurious sidebands of the carrier. For this reason, operation with a high-level carrier would probably be selected to maximize gain and insure that the desired sideband does not contain any spurious amplitude variations present on the carrier input signal.

On the other hand, in a low-frequency, broadband balanced modulator, spurious outputs at any frequency may be undesirable and low-level carrier operation may be the best choice.

Good carrier suppression over a wide temperature range requires low dc resistances between the bases of the lower differential amplifier (pins 1 and 4) and ground. The values of these resistors should not be increased significantly higher than the 51 ohms used in the circuits of **Fig. 2** in applications where carrier suppression is important over the full operating temperature range of −55 degrees C to +125 degrees C. Where operation is to be over a limited temperature range, resistance values of up to the low kilohm range may be used.

Amplitude modulator

The balanced modulator circuit shown in **Fig. 2** will function as an amplitude modulator with just one minor modification. All that is necessary is to unbalance the carrier null to insert the proper amount of carrier into the output signal. However, the null circuitry used for balanced modulator operation does not provide sufficient adjustment range and must be modified. This involves changing the 10 kΩ resistor to 750 Ω.

Product detector

Fig. 3 shows the circuit in an SSB product detector configuration. For this application, all frequencies except the desired demodulated audio are in the RF spectrum and can be easily filtered in the output. As a result, the carrier

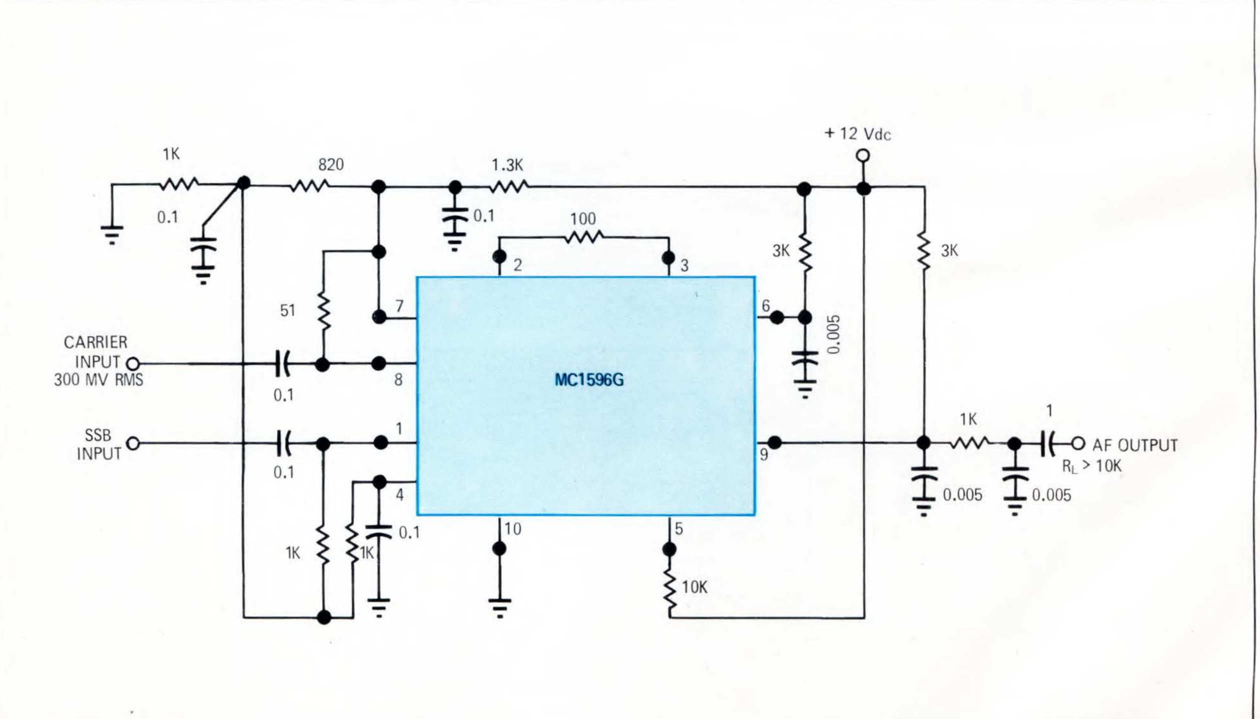


Fig. 3—**No transformers or tuned circuits are required** in this SSB product detector. All frequencies except the desired demodulated audio output are filtered in the output circuit. Thus, carrier null adjustment is not needed.

null adjustment need not be included.

Upper differential amplifiers, Q_1 - Q_2 and Q_3 - Q_4, are again driven with a high-level signal. Since carrier output level is not important in this application (carrier is filtered in the output), carrier input level is not critical. A high-level carrier input is desirable to maximize gain of the detector and to remove any carrier amplitude variations from the output. The circuit of **Fig. 3** performs well with a carrier input level of 100 to 500 mV rms.

The modulated signal (single-sideband, suppressed carrier) input level to the differential amplifier pair Q_5 - Q_6 is maintained within the limits of linear operation. Excellent linearity and undistorted audio output may be achieved with an SSB input signal level range up to 100 mV rms. Again, no transformers or tuned circuits are required for product detector performance from very low frequencies up to 100 MHz.

AM detector

The product detector circuit of **Fig. 3** may also be used as an AM detector. The modulated signal is applied to the upper differential amplifiers while the carrier signal is applied to the lower differential amplifier.

Ideally, a constant-amplitude carrier signal would be obtained by passing the modulated signal through a limiter ahead of the carrier input terminals. However, if the upper input signal is at a high enough level (>50 mV), its amplitude variations do not appear in the output signal. For this reason it is possible to use the product detector circuit shown in **Fig. 3** as an AM detector simply by applying the modulated signal to both inputs at a level of about 600 mV on modulation peaks without using a limiter ahead of the carrier input port. A small amount of distortion will be generated as the signal falls below 50 mV during modulation valleys, but it will probably not be significant in most applications.

Mixer

Since the modulator circuit generates an output signal consisting of the sum and difference frequencies of the two input signals only, it can also be used as a double balanced mixer.

Fig. 4 shows the circuit used as a high-frequency mixer with a broadband input and a tuned output at 9 MHz. The 3 dB bandwidth of the 9 MHz output tank is 450 kHz.

The local oscillator signal is injected at the upper input port at a level of 100 mV rms. The modulated signal is injected at the lower input port with a maximum level of about 15 mV rms. Note that for maximum conversion gain and sensitivity the external emitter resistance on the lower differential amplifier pair has been reduced to zero.

For a 30-MHz input signal and a 39-MHz local oscillator (LO), the mixer has a conversion gain of 13 dB and an input signal sensitivity of 7.5 microvolts for a 10 dB S + N/N ratio in the 9-MHz output signal. With a signal input level of 20 mV, the highest spurious output signal is at 78 MHz (2 f_{LO}), and it is better than 30 dB below the desired 9-MHz output. All other spurious outputs are down more than 50 dB.

As the input is broadband, the mixer may be operated at any HF and VHF input frequencies. The same circuit was operated with a 200-MHz input signal and a 209-MHz LO. At this frequency, the circuit had 9-dB conversion gain and a 14μV sensitivity.

Greater conversion gains can be achieved by using tuned circuits with impedance matching on the signal

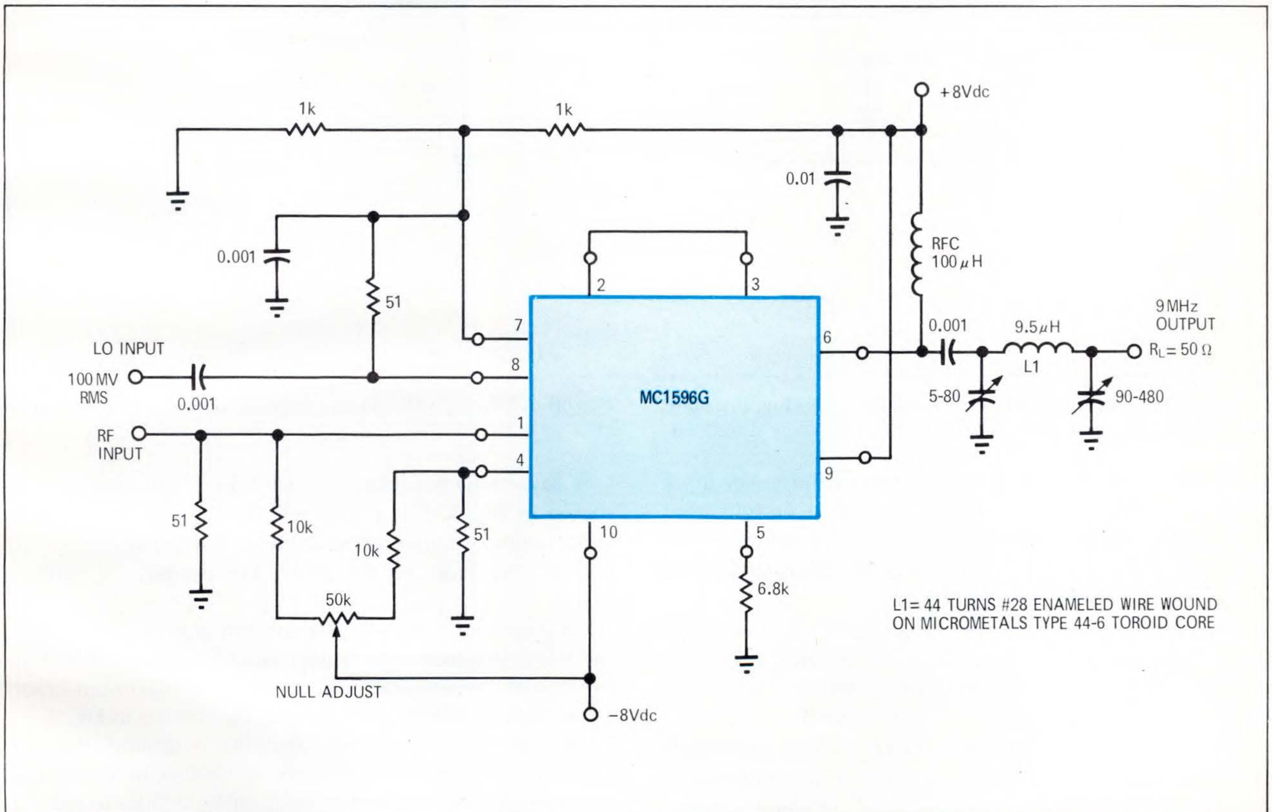


Fig. 4 – **The basic circuit will operate as a double balanced mixer** since it generates an output containing the sum and difference frequencies of the two input signals. The configuration shown is tuned for a 9 MHz output.

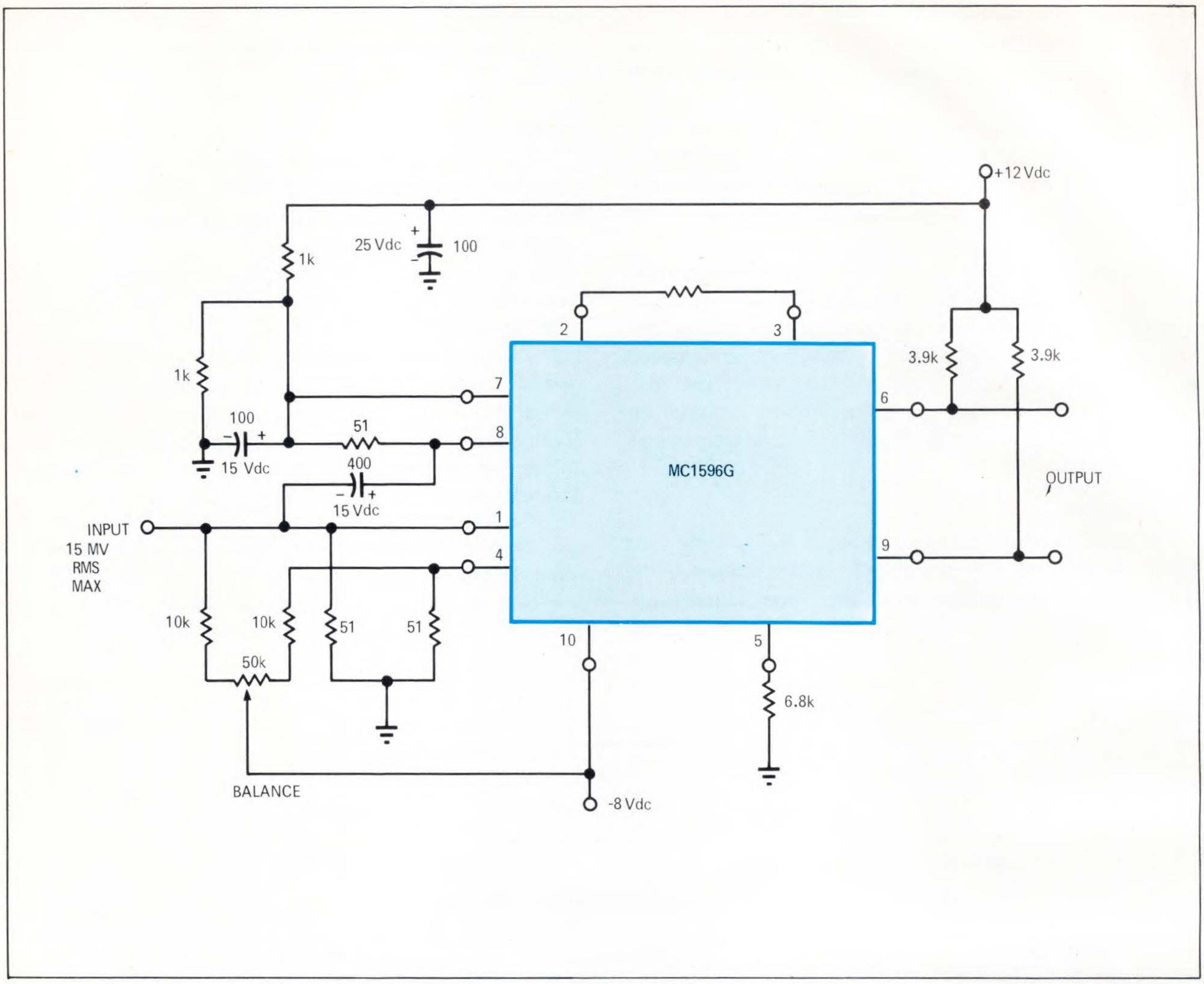


Fig. 5—**A frequency doubler is easily built** by injecting the same signal into both input ports. This circuit can be used at frequencies up to 1 MHz with spurious outputs more than 30 dB below zF_{in}.

input port. Since the input impedance of the lower input port is considerably higher than 50 ohms, even with zero emitter resistance, most of the signal input power in the broadband configuration shown is being dissipated in the 50-ohm resistor at the input port.

The circuit shown has the advantage of a broadband input, combined with simplicity and reasonable conversion gain. If greater conversion gain is desired, impedance matching at the signal input is recommended.

The nulling circuit (the two 10 kΩ resistors and 50 kΩ potentiometer) permits nulling of the local oscillator signal and results in a few dB additional local oscillator suppression in the mixer output.

Doubler

The basic circuit functions as a frequency doubler when the same signal is injected in both input ports. Since the output signal contains only $\omega_1 \pm \omega_2$ frequency components, there will be only a single output frequency at $2\omega_1$ when $\omega_1 = \omega_2$.

For operation as a broadband low-frequency doubler, the balanced modulator circuit of **Fig. 2** need be modified only by adding ac coupling between the two input ports and reducing the lower differential amplifier emitter resistance between pins 2 and 3 to zero. The latter modification increases the circuit sensitivity and doubler gain.

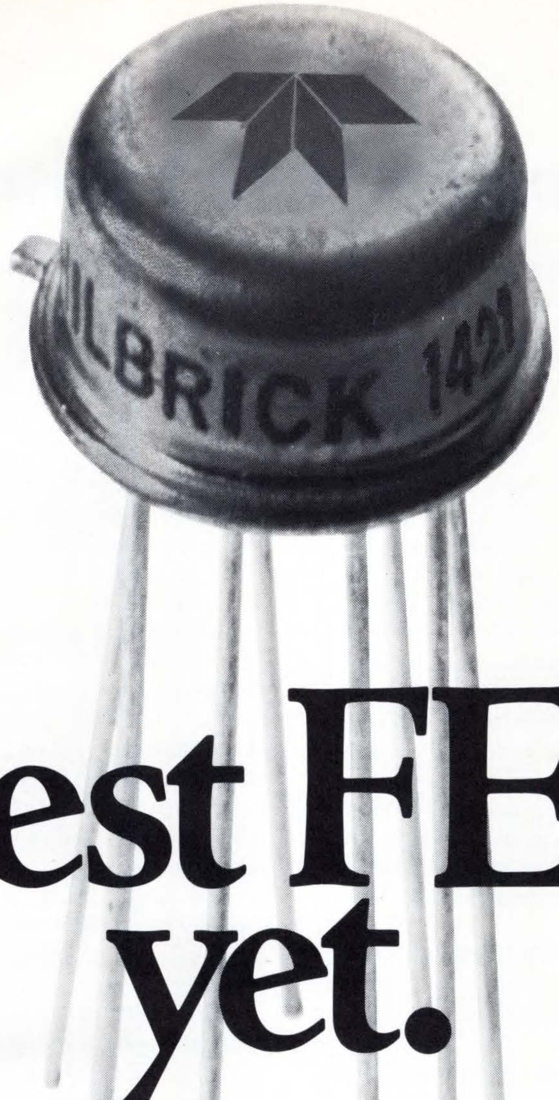
A low-frequency doubler with these modifications is shown in **Fig. 5**. This circuit will double in the audio and low frequency range below 1 MHz, with all spurious outputs greater than 30 dB below the desired $2f_{IN}$ output signal.

For optimum output-signal spectral purity, both upper and lower differential amplifiers should be operated within their linear ranges. This corresponds to a maximum input signal level of 15 mV rms for the circuit shown in **Fig. 5**.

If greater signal handling capability is desired, the circuit may be modified by using a 1000-ohm resistance between pins 2 and 3 and a 10:1 voltage divider to reduce the input signal at the upper port to 1/10 the signal level at the lower port. □

Author's Biography

Roy Hejhall is Manager of Communications Applications Engineering at Motorola Semiconductor Products, Inc. Phoenix, Arizona. He has been engaged in high frequency semiconductor applications work at Motorola for 10 years. Roy is a graduate of the U. S. Naval Academy and belongs to IEEE.



Best FET yet.

Only $8.50 in 100's.

Philbrick's 1421 FET operational amplifier is a guaranteed performer. Low bias current: less than 50pA *guaranteed.* High output current: ±10mA *guaranteed.* High CMRR: 4000 *guaranteed.* Common-mode voltage range: ±12V *guaranteed.* Unity-gain frequency: 1 MHz *guaranteed.*

These guarantees (and more) are all yours in a single TO-99 can. Attractive quantity discounts apply. Models 1421/01 and 1421/02 are the operational amplifiers with even tighter specs for more sophisticated applications.

And remember to power up with Philbrick Power Supplies for best performance.

Ask your local Philbrick representative for complete details or write, Teledyne Philbrick, Allied Drive at Route 128, Dedham, Massachusetts 02026. For toll-free ready data dial (800) 225-7883. In Massachusetts (617) 329-1600.

Philbrick Operational Amplifiers
The good ones.

CIRCLE NO. 13

The ABC's of asynchronous data transmission.

Equipment requirements for digital data transmission can be reduced using this technique. But be careful of the limitations.

Ralph K. Ungermann, Western Digital Corp.

The transfer of digital data over relatively long distances is generally accomplished by sending the data in serial form through a single communications channel using one of two general transmission techniques: asynchronous or synchronous. For many applications transmission equipment requirements are greatly reduced if asynchronous transmission is used. And with asynchronous transmission, characters need not be contiguous in time, but are transmitted as they become available. This is a particularly valuable feature when transmitting data from manual entry devices, such as a keyboard.

To take full advantage of the features of asynchronous data transmission, though, the designer must have an understanding of the operation and limitations of both synchronous and asynchronous transmission techniques.

Synchronous transmission uses only one clock

Synchronous data transmission requires that a clock signal be transmitted with the data in order to mark the location of the data bits for the receiver. A specified clock transition (either rising or falling) marks the start of each data bit interval, as shown in **Fig. 1**. In addition, special synchronization data patterns are added to the start of the transmission in order for the receiver to locate the first bit of the message. With synchronous transmission, each data bit must follow contiguously after the synch word, since one data bit is assumed for every clock period.

With asynchronous transmission, a clock signal is not transmitted with the data and the data bits need not be contiguous. In order for the receiver to properly recover the message, the bits are grouped into data characters (generally from 5 to 8 bits in length) and synchronizing start and stop elements are added to each character, as shown in **Fig. 2**.

The start element is a single logic ZERO (space) data bit that is added to the front of each character. The stop element is a logic ONE (mark) that is added to the end of each character. The stop element is maintained until the next data character is ready to be transmitted. (Asynchronous transmission is often referred to as start-stop transmission for obvious reasons). Although there is no upper limit to the length of the stop element, there is a lower limit that depends on the system characteristics. Typical lower limits are 1.0, 1.42 or 2.0 data bit intervals, although most modern systems use 1.0 or 2.0 The negative going transition of the start element defines the location of the data bits in one character. A clock source at the receiver is reset by this transition and is used to locate the center of each data bit.

The rate at which asynchronous data is transmitted is usually measured in bauds, where baud is defined to be the reciprocal of the shortest signal element (usually one data bit interval). It is interesting to note that the variable stop length is what makes the baud rate differ from the bit rate. For synchronous transmission, each element is one bit in length so that the baud rate equals the bit rate. The same is true for asynchronous transmission if the stop element is always one bit in duration (this is referred to as isochronous transmission). However, when the stop code is longer than one bit, as shown in **Fig. 3**, the baud rate differs from the bit rate.

Each character in **Fig. 3** is 11 data bit intervals in length, and if 15 characters are transmitted per second, then the shortest signal element (one data bit interval) is 66.6 msec/11 = 6.06 msec; giving a rate of 1/6.06 ms or 165 baud. However, since only 10 bits of information (8 data bits, one start bit and 1 stop bit) are transmitted every 66.6 msec, the bit rate is 150 bit/sec. Even though the stop element lasts for two data intervals, it still is only one bit of the total information being transmitted.

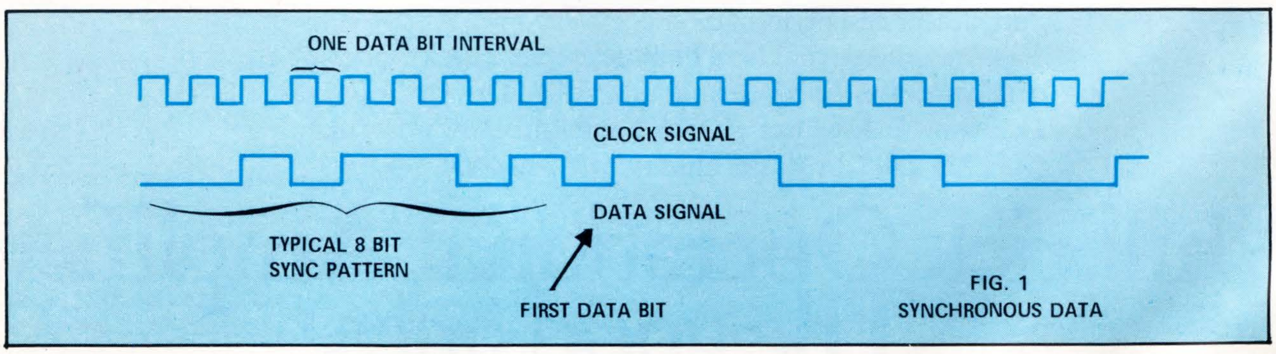


Fig. 1 – **Synchronous data transmission** requires that a clock signal be transmitted with the data to mark the location of the data bits for the receiver. Special synchronization patterns are added to the start of the transmission to indicate the location of the first bit.

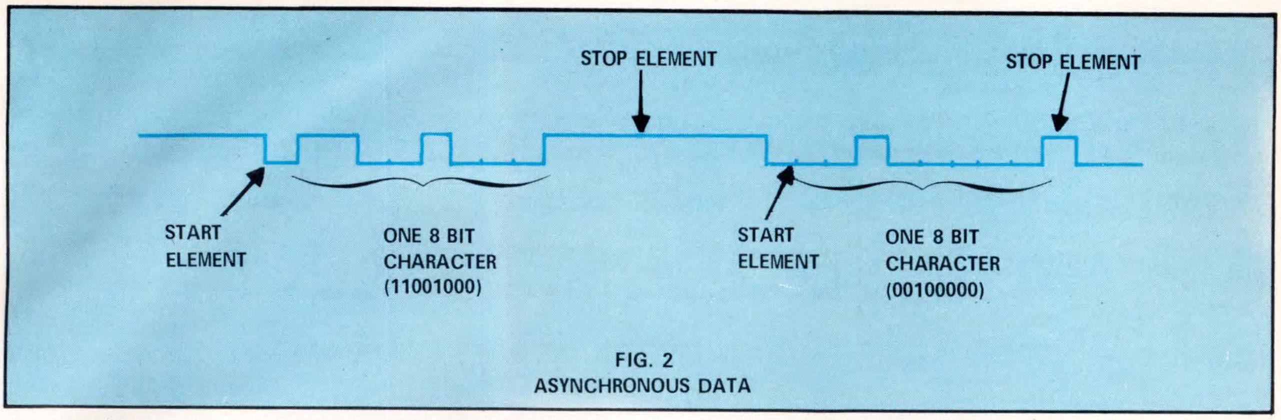


Fig. 2—**With asynchronous data transmission** data bits are grouped into fixed-length characters and synchronizing start and stop elements are added to each character. A clock signal is not transmitted with the data but an independent clock is required at the receiver.

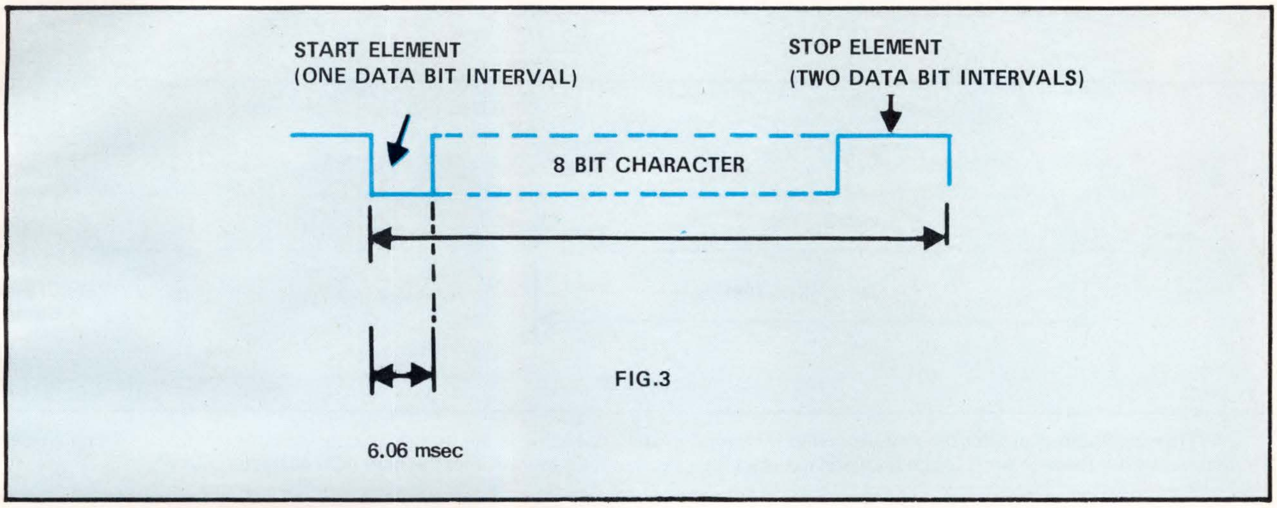


Fig. 3—**Baud, the data transmission rate,** differs from the bit rate if any of the signal elements are longer than one bit interval. As shown, each character is 11 data bit intervals in length but only 10 bits of information are transmitted every 66.6 msec.

Asynchronous transmission requires two clocks

There are several reasons for using asynchronous transmission. The major reason is that since a clock signal need not be transmitted with the data, transmission equipment requirements are greatly simplified. Note, however, that an independent clock source is still required at both the transmitter and receiver.

The major disadvantage of asynchronous transmission is that it requires a very large portion of the communication channel bandwidth for the synchronizing start and stop elements (a much smaller portion of the bandwidth is required for the synch words in synchronous transmission).

Asynchronous transmission over a simple twisted-wire pair can be accomplished at moderately high baud rates (10k baud or higher depending on the length of the wire, type of line drivers, etc.), while it is generally limited to approximately 2k baud over the telephone network. When operating over the telephone network, a modem is required to convert the data pulses to tones that can be transmitted through the network.

Signal distortion limits transmission speed

One of the major limiting factors in the speed of asynchronous transmission is the distortion of the signal elements. Distortion is defined as the time displacement between the actual signal level transition and the nominal transition (Δ), divided by the nominal data bit interval.

The nominal data bit interval is equal to the reciprocal of the nominal transmission baud rate, and all data transitions should ideally occur at an integer number of intervals from the negative going transition of the start bit. Actual data transitions may not occur at these nominal points in time, as shown in the lower waveform of **Fig. 4**. The distortion of any bit transition is equal to (Δ) multiplied by the nominal baud rate.

This distortion is generally caused by frequency jitter and frequency offset in the clock source used to generate the actual waveform, as well as transmission channel noise, etc. Thus, the amount of distortion that can be expected on any asynchronous signal depends on the device used to generate the signal and the characteristics of the communication channel over which it was sent. Electronic signal generators can be held to less than 1% distortion, while electromechanical devices (such as a teleprinter) typically generate up to 20% distortion. The transmission channel may typically add an additional 5% to 15% distortion.

The distortion previously described referred only to a single character, as all measurements were referenced to the start element transition of that character. However, there may also be distortion between characters when operating at the maximum possible baud rate (i.e., stop elements are of minimum length). This type of distortion is

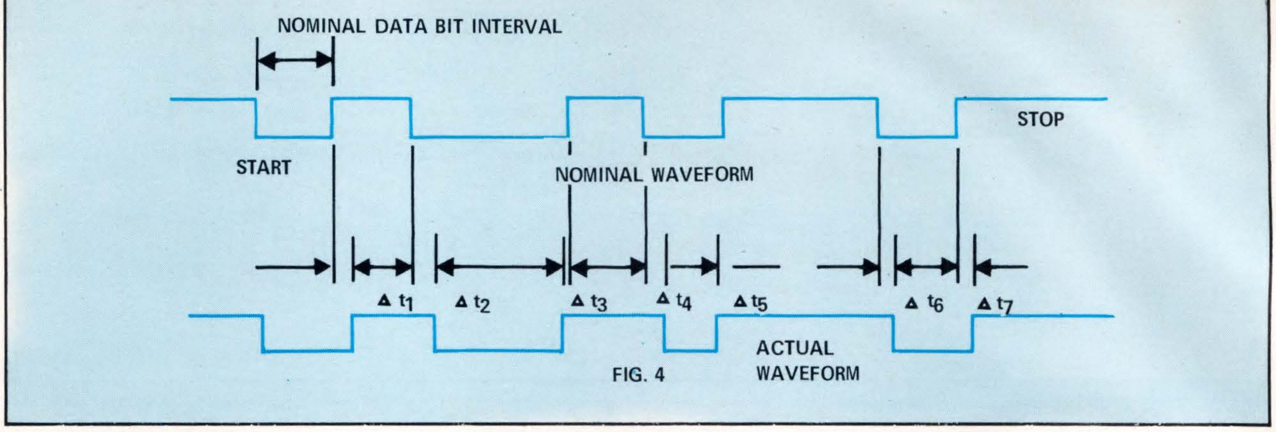


FIG. 4

Fig. 4 — **Distortion of the signal elements** is one of the major limiting factors in the speed of asynchronous transmission. Frequency jitter and offset in the clock source and transmission channel noise are the main distortion sources.

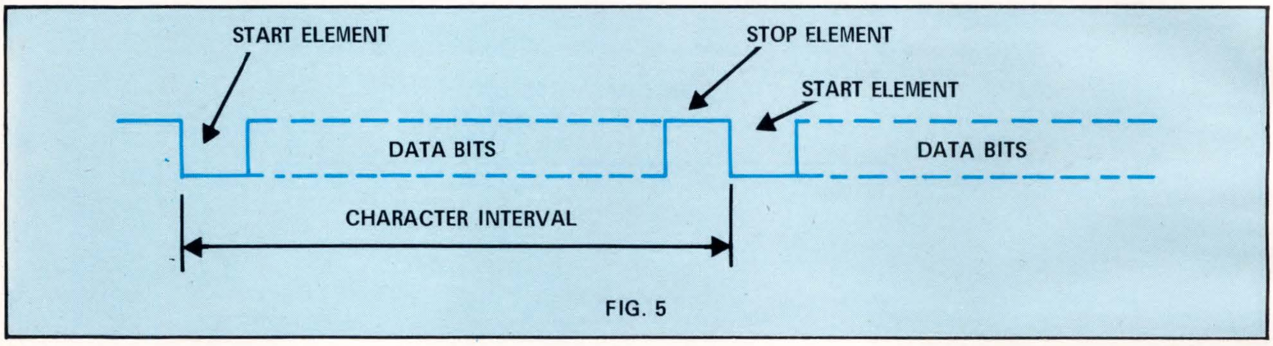


FIG. 5

Fig. 5 — **The minimum character interval distortion** is important when operating at the maximum data transmission rates. This parameter is important since the receiver must be prepared to detect the next start bit transition after the minimum character interval.

usually measured by the minimum character interval, as shown in **Fig. 5**.

The minimum character interval distortion is generally specified as the percentage of a nominal data bit interval that any character interval may be shortened from its nominal length. Since many of the same parameters that cause distortion of the data bits are also responsible for the character length distortion, the two distortions are often equal. However, some systems may exhibit character interval distortions of up to 50% of a data bit interval. This parameter is important when operating at the maximum baud rate, since the receiver must be prepared to detect the next start-bit transition after the minimum interval.

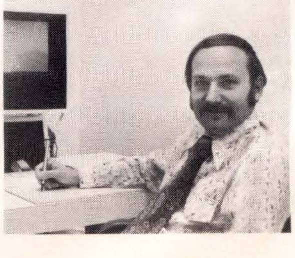
Asynchronous receivers operate by locating the nominal center of the data bits as measured from the negative-going transition of the start bit. However, due to receiver inaccuracies, the exact center may not be properly located.

In electromechanical devices such as teleprinters, the inaccuracy may be due to mechanical tolerances or variations in the power-line frequency. With electronic receivers, the inaccuracies are due to frequency offset, jitter and resolution of the clock source used to find the bit centers. (The bit centers are located by counting clock pulses). For example, even if the receiver clock had no jitter or offset, and it was 16 times the baud rate, then the center of the bit could only be located within 1/16 of a bit interval (or 6.25%) due to clock resolution. However, by properly phasing the clock, this tolerance can be adjusted so that the sample will always be within 1/16 of a bit interval (or 6.25% due to clock resolution). But, by properly phasing the clock, this tolerance can be adjusted so that the sample will always be within ±3.125% of the bit center.

Thus, signals with up to 46.875% distortion could be received. This number (the allowable receiver input distortion) is often referred to as the receiver distortion margin. Electromechanical receivers have distortion margins of 25 to 30%. The receiver must also be prepared to accept a new character after the minimum character interval. Most receivers are specified to operate with a minimum character interval distortion of 50%.

Author's Biography

Ralph K. Ungermann, recently joined Western Digital Corp., Newport Beach Ca., as supervisor of digital system products. He received his BSEE from the University of California at Berkeley and his MSEE from the University of California, at Irvine.



FOR A FREE COPY OF THIS ARTICLE **CIRCLE L63**

GTE Sylvania and Hudson Lamp have joined forces so our salesmen are coming on <u>twice</u> as strong.

Now that Hudson is part of the GTE Sylvania miniature lamp family you can say goodbye to multi-source buying, hello, single-salesman convenience. With GTE Sylvania T-2 slide base lamps and Hudson Lamp Company miniature incandescent lamps together in one product line, one call does it all. And fast.

Just name your application, and the lighting product you need is here in one of the industry's broadest lines of lighting products. But seeing is believing. So ask your Sylvania / Hudson salesman to show you the Hudson miniature, sub-miniature, micro-miniature and automotive lamps that have just joined the Sylvania family of T-2 slide base lamps and associated hardware.

And don't be surprised if he boasts a little. With all the more quality to sell, our network of representatives is coming on proud.

Check the list below for name of your nearest representative.

GTE SYLVANIA

West Main Street
Hillsboro, N. H. 03244
(603) 464-5533

Hudson LAMP COMPANY

A SUBSIDIARY OF
GTE SYLVANIA INCORPORATED
526 Elm Street
Kearny, N. J. 07032
(201) 997-1850

ARIZONA, Hamilton Rep., Tuscon (602) 297-2279 • **CALIF. (Northern),** W. W. Posey Company, Los Altos (415) 948-7771 • **CALIF. (Southern),** WESTREP, Pico Rivera (213) 949-2551 • **COLORADO,** Arrowhead Sales Corp., Broomfield (303) 222-6462 • **CONNECTICUT,** Coakley, Boyd & Abbett, Waterbury (203) 756-8766 **FLORIDA,** Hutto, Hawkins, Peregoy, Maitland (305) 831-2474 • Hutto, Hawkins, Peregoy, Pompano Beach (305) 943-9593 • Hutto, Hawkins, Peregoy, Tampa (813) 932-1800 • **ILLINOIS,** George E .Finnegan, Oak Park (312) 383-9098 • **INDIANA,** Southern Sales Corp., Indianapolis (317) 253-3359 • **KANSAS,** L. R. Harry & Assoc., Grandview, Mo. (816) 763-3634 • **MASSACHUSETTS,** Coakley, Boyd & Abbett, Needham (617) 444-5470 • **MICHIGAN (Western),** R. O. Whitesell & Assoc., St. Joseph (616) 983-7337 • **MICHIGAN (Eastern),** R. O. Whitesell & Assoc., Southfield (313) 358-2020 • **MICHIGAN (Central),** R. O. Whitesell & Assoc., Grand Rapids (616) 451-8901 • **MINNESOTA,** Erv Stoss Assoc., Inc., Minneapolis (612) 925-2757 • **MISSOURI,** L. R. Harry & Assoc., St. Louis (314) 872-3183 **NEW YORK (Upstate),** Fowler Beach Corp., Rochester (716) 586-0468 • **NEW YORK (Metro),** Hudson Lamp Company, Kearny, N. J. (201) 997-1850 • **OHIO (Southern),** R. O. Whitesell & Assoc., Cincinnati (513) 521-2290 • **OHIO (Northern),** R. O. Whitesell & Assoc., Cleveland (216) 333-2585 • **OHIO (Central),** R. O. Whitesell & Assoc., Dayton (513) 298-9546 • **PENNSYLVANIA (Eastern),** Shelmar Electronics Corp., Glenside (215) 885-0800 • **PENNSYLVANIA (Western),** R. O. Whitesell & Assoc., Pittsburgh (412) 242-0100 • **TENNESSEE,** R. O. Whitesell & Assoc., Bristol (615) 968-4195 • **TEXAS,** Jack Yount Company, Dallas (214) 391-4125 • **UTAH,** Arrowhead Sales Corp., Salt Lake City (801) 487-3444 • **WASHINGTON,** Blum & Associates, Seattle (206) 782-1600 • **WISCONSIN,** F. C. Du Bois & Assoc., Milwaukee (414) 774-3100

CIRCLE NO. 14

keep working at it

Now that you've seen the January 1 issue of EDN/EEE, you're probably working hard on your entry. Keep at it!

How to enter

Any reader of EDN/EEE may enter this contest. All you need do is study the January 1, 1972 issue of EDN/EEE very carefully...then set your imagination at work on designing a new device or circuit using the products advertised. Send schematics, drawings, diagrams, etc. to:

EDN/EEE
Design Contest
221 Columbus Avenue
Boston, Mass. 02116

Your entry must be sent by March 1st, 1972.

How your entry will be judged

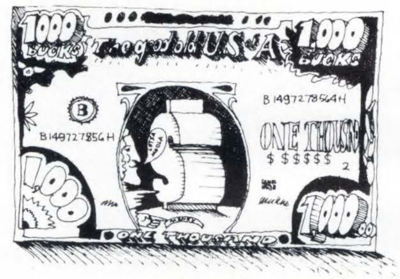
All entries will be judged by the Publisher and editors of EDN/EEE on the basis of 3 criteria:

1. Technical competence and utility
Is the design real . . . will it work?

2. Creative imagination
How unique and original is your idea? Does it perform a much needed function? Is it a source of fun! Will other designers get a real charge out of it?

3. Number of different advertised products used
Have you really studied the January 1st, 1972 issue of EDN/EEE. Have you imaginatively used components throughout the design? The more advertised products your design uses, the greater is your chance of winning.

Here are the prizes



1st prize:
$1,000 cash money

10 2nd prizes:
Portable electronic calculators worth $400 each.

Contest details

Any reader of EDN/EEE may enter. Contest is not open to employees of Cahners Publishing Co. or their families. All entries become the property of EDN/EEE. YOUR ENTRY MUST BE POSTMARKED NO LATER THAN MIDNIGHT, MARCH 1, 1972. Results will be announced and winning entries described in a later issue of EDN/EEE.

EDN/EEE

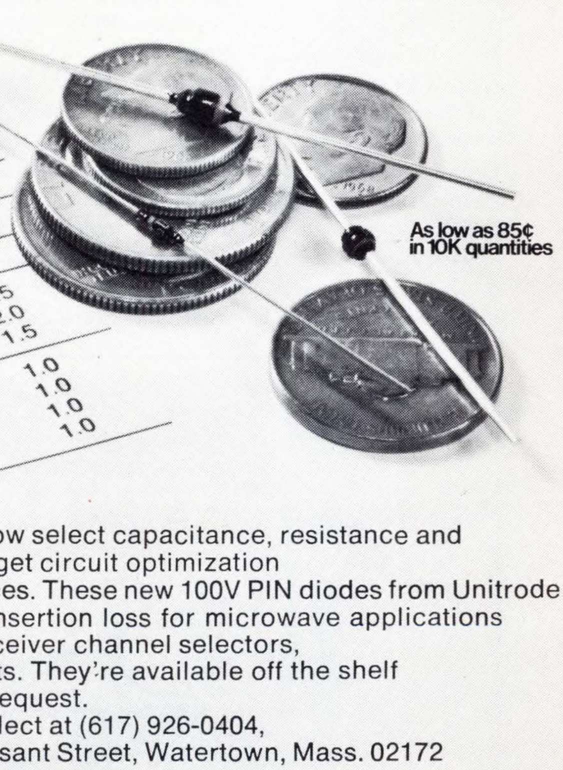
Cahners Publishing Company, Inc.
221 Columbus Avenue, Boston, Mass. 02116

¢-LINE MICROWAVE PIN DIODES

Choose the best and still pay less for your microwave switching needs

¢-LINE MICROWAVE PIN DIODES — SPECIFICATIONS

Type	Maximum Total Capacitance (0V, 1GHz) C_T pF	Maximum Series Resistance (100mA, 1GHz) R_s Ω	Minimum Carrier Lifetime (I_f = 10mA) τ us
UM4001B	3.0	0.5	5.0
UM7001B	0.9	1.0	2.5
UM7101B	1.2	0.6	2.0
UM7201B	2.2	0.2	1.5
UM6001B	0.5	1.7	1.0
UM6101B	0.7	1.0	1.0
UM6201B	1.1	0.4	1.0
UM6601B	0.4	2.5	1.0



As low as 85¢ in 10K quantities

You can now select capacitance, resistance and carrier lifetime and get circuit optimization at the industry's lowest prices. These new 100V PIN diodes from Unitrode all feature low distortion and low insertion loss for microwave applications such as TR switches, antenna selectors, receiver channel selectors, switching matrices and attenuators in AGC circuits. They're available off the shelf at your local Unitrode distributor. Samples on request.

For fast action, call Sales Engineering collect at (617) 926-0404, Unitrode Corporation, Dept. 2Z, 580 Pleasant Street, Watertown, Mass. 02172

UNITRODE quality takes the worry out of paying less.

CIRCLE NO. 16

Two switching regulators for battery-powered systems

Here's how two different designers solved the problem of supplying regulated voltage to low-level circuits without wasting power in the process.

S. W. Billingsley, NASA, and **Jeff Schlageter**, Fairchild Semiconductor

Designing power supplies for modern micropower systems has become quite a problem. The challenge is to devise a power suppply that does not dissipate more power than the circuitry it is feeding. The problem becomes apparent when you examine the stand-by power needs of the modern MOS logic families that are being used for micropower logic systems.

Nowadays, a low-power logic system often means a system of the complexity of a small minicomputer (1000 gates) that consumes only milliamperes of current at low voltages. The system may comsume more power when handling bursts of data, but when idling its power consumption may be even less. These low power consumation rates are due to the increased use of dynamic four-phase MOS and complementary MOS (CMOS) logic. There are also some low-power linear circuits, such as the Fairchild 776 and the Solitron UC4250C op amps.

The obvious answer is to use switching-regulator power supplies. However, not any switching regulator will do. The switching regulator itself should have the simplicity to maintain the high system reliability desired of these low-power systems, and it should not internally drain more power than it supplies. Fortunately, the most popular of the low-power logic, CMOS, has such a high noise immunity that it can often be used with just a bare switching regulator; it does not need to be followed with a series-pass regulator for clean-up filtering.

The two switching-regulator circuits shown come from space and military applications, respectively. The first is for a NASA scientific satellite that is still operating in orbit after three years. The second is a Fairchild design for an air-dropped intrusion detector intended for Asian warfare. Though neither of these applications involved the extreme case we have cited of powering a complete CMOS minicomputer, the designers say the design goals were similar.

Both applications used a battery for the source of power. This, however, should not make them less interesting for ordinary applications.

Both these circuits had to regulate against wide variations in battery voltage. They did this well, as it is one of the virtues of switching regulators to "losslessly" drop voltage. The voltage on the NASA satellite's battery could rise to as much as 40V when it was recharged by sunlight on the vehicle's solar cells. But when in the cold of the earth's shadow, the battery's voltage could drop as low as 23V. The intrusion detector's battery might start out fresh at 32V, but two months later, at the end of its life, it might drop to just 20V. The regulation problem is compounded in remote systems like these by the large voltage drops that occur when the radio transmitters are turned on.

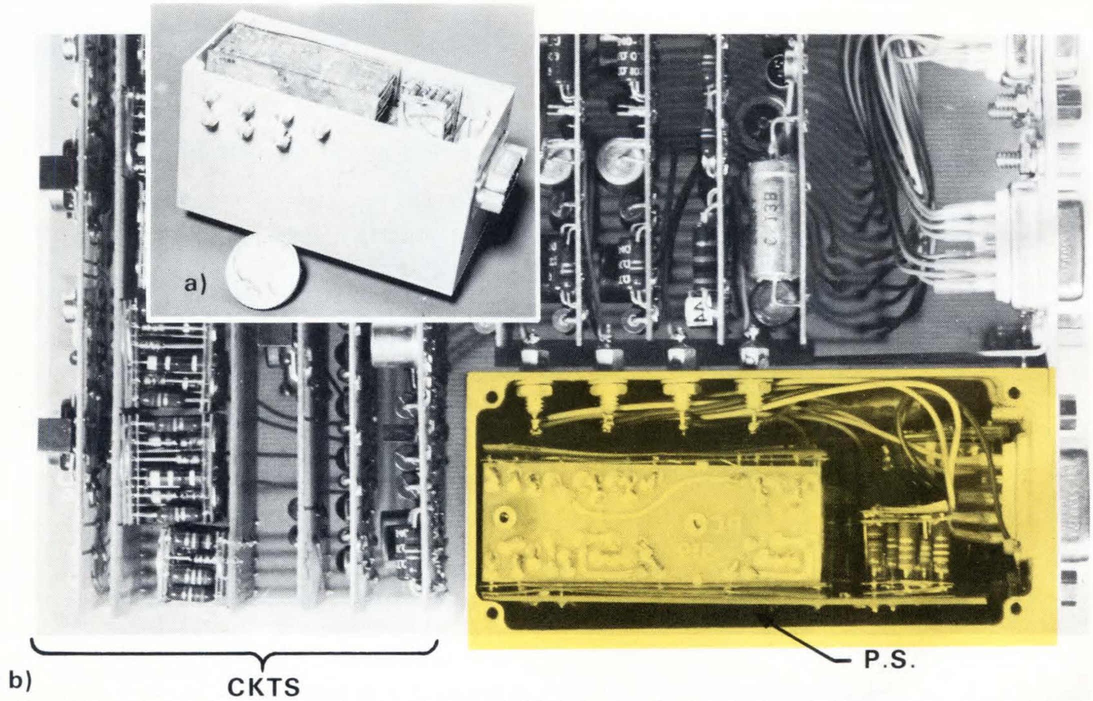


Fig. 1 – The satellite switching regulator (a) is part of a power supply that has been used for such applications as the Earth magnetic field experiment that is partially shown in (b). Because this is a low-volume product, but one that must be compact, it is often made as shown, with discrete components packaged in cordwood configuration.

For a long-life scientific satellite

A satellite's power supply should be efficient but it should also be reliable. The key to reliability in the switching regulator design of **Fig. 2** is the use of a simple Zener diode as both level detector and trigger. The diode specified has a very sharp breakdown knee in its reverse I-vs-V curve. It provides the sharp switching action that would otherwise demand a Schmitt trigger. Another advantage in using this Zener is that its temperature coefficient is the matching opposite of transistor Q_1's V_{be}.

Operation: The regulator's start up is initialized by Zener D_3 breaking down. This supplies the turn-on current for Q_2 by way of R_9, R_4 and R_5. When Q_2 turns ON, Q_3 and Q_4 are also driven hard ON, passing charging current for C_1 through L_1 until Q_1 turns OFF again. Q_1 turns OFF when the voltage at the junction of R_1 and R_2 exceeds the combined voltage of zener D_1 and the V_{be} of Q_1. This condition may

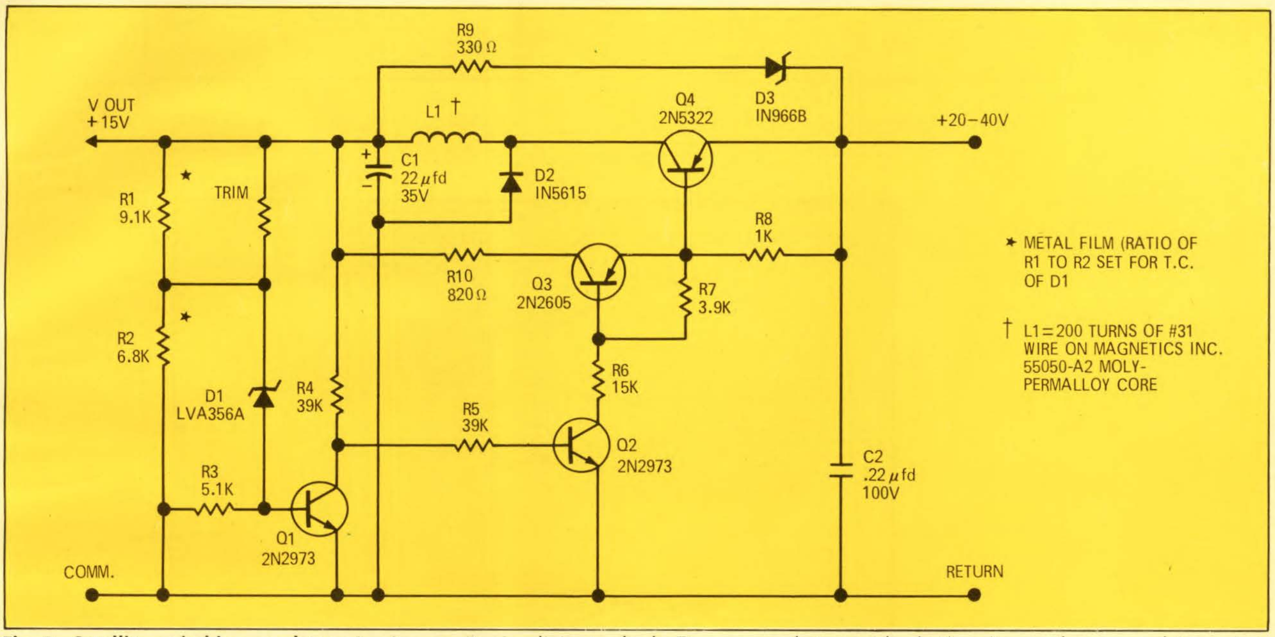


Fig. 2—Satellite switching regulator circuit owes its simplicity to diode D_1, a zener that provides both voltage reference and triggering functions.

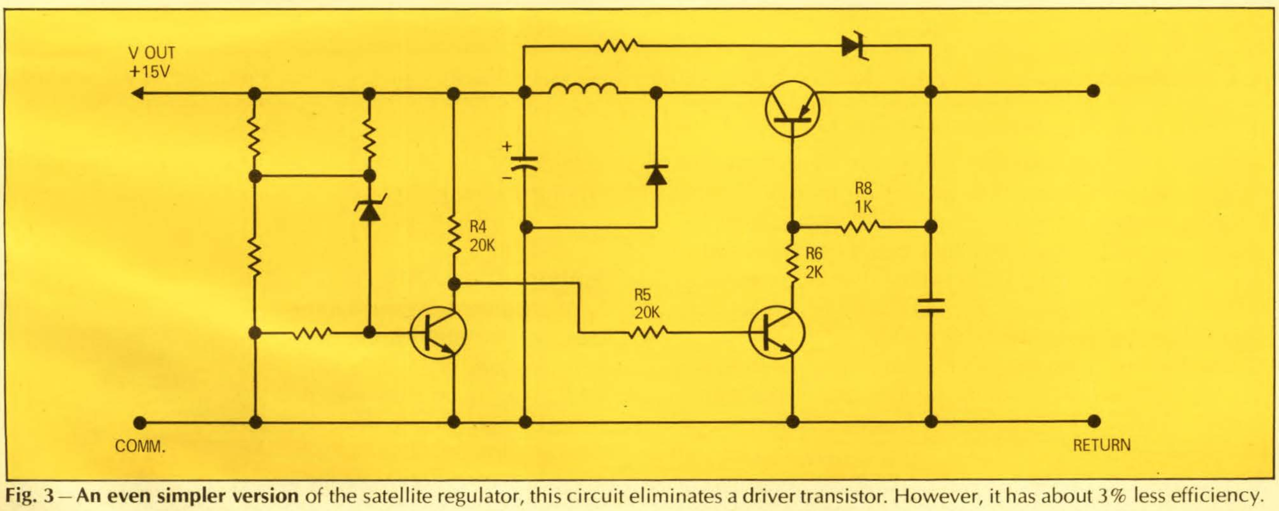


Fig. 3—An even simpler version of the satellite regulator, this circuit eliminates a driver transistor. However, it has about 3% less efficiency.

be calculated by:

$$V_{out} = (R_1 + R_2)\left(\frac{V_z + V_{be}}{R_2}\right)$$

With Q_1 ON, Q_2, Q_3 and Q_4 shut OFF. When Q_4 switches OFF, inductor L_1 begins to transfer its energy to capacitor C_1, with commutating diode D_2 completing the charging path. Q_4 will be turned ON and OFF in an oscillatory manner as the charge on C_1 varies about the level-detection threshold, in the typical manner of this form of LC switching regulator.

A nice feature of this design is that it is easy to provide over-load protection by selecting R_9 so that the start up won't occur if the load current exceeds a predetermined value.

The graphs of **Fig. 4,** a, b and c, show the performance achieved by this design. Note that for input voltages around the nominal 28V of satellite systems and at 250 mA load current, the efficiency is well over 85%. Meanwhile, the quiescent current drain is only 1-1/2 mA.

If some circuit efficiency can be sacrificed, the even simpler circuit of **Fig. 3** may be used. The efficiency of this cir-

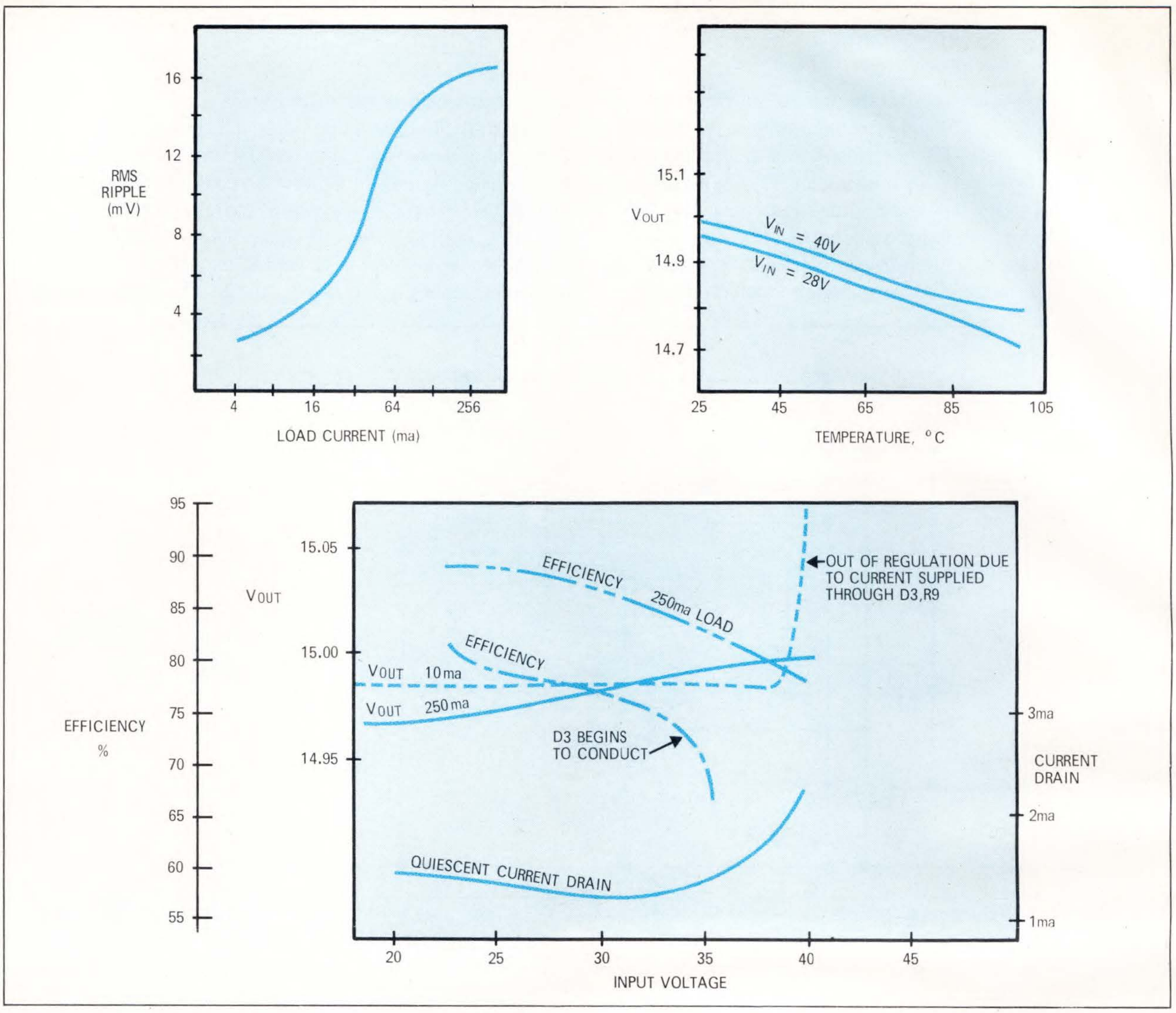


Fig. 4—Performance curves for the NASA satellite switching regulator show that efficiency is highest at low input (battery) voltages and high loads. At very high input voltages both the regulation and the efficiency suffers. These curves also show that the ripple is not excessive and the temperature stability is quite respectable.

cuit is about 3% less than that of the more complex version of **Fig. 2**. Another alternative would be to use a higher switching frequency to make the L and C components (especially L_1) smaller. The frequency could be raised two or three times higher than 20 kHz before the switching losses of the critical transistor, Q_4, became excessive. The 2N5322 has a 50-nsec switching speed.

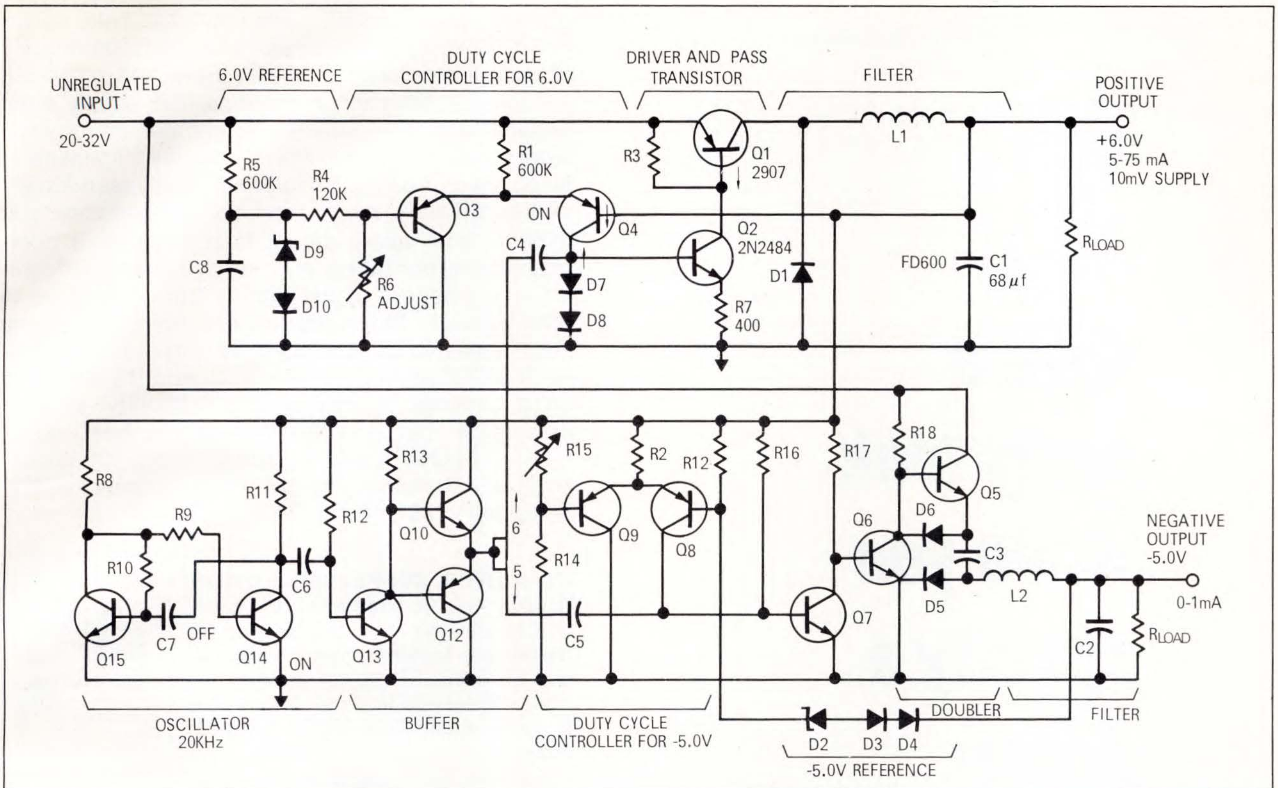
Tests: This regulator was put through a year's testing program that included vacuum-chamber and temperature-chamber cycling. One test, devised especially for this circuit, checked starting reliability. NASA wanted to be sure that the regulator would restart itself if for some reason there was a temporary loss of battery voltage. This off-on cycling verified what had been previously determined in analysis—that the regulator would not get "hung-up" in either its ON or OFF state—even when subjected to repeated shut downs and restarts.

Author's Biography

S. W. Billingsley is a circuit designer in the instrumentation section of NASA Goddard's magnetic and electric fields branch. He has designed optical-pumping and fluxgate magnetometers for satellites, as well as the power converters for ATS and IMP satellites described in this article.

For an air-dropped intrusion detector

This design, see **Fig. 5,** uses a fixed-frequency 20 kHz oscillator to command the switching rate. While free-running switching regulators (like the NASA design) can have reasonably constant frequencies despite varying duty cycles, a separate clock will provide closer frequency tolerance. A close control of the regulator's frequency may be desirable when its noise might interfere with other signals. The oscillator in this design turns the regulator ON for too short a time to maintain the desired output voltage, even with the lightest expected loads. The control loop



Q1	2N2907Q	C5,C6,C7	22pf	R2	100K
Q2,Q5,Q10	2N2484	C4	50pf	R3	45K
Q3,Q4,Q8,Q9,Q12	2N3963	C3	0.1µf TANTALUM	R4	120K
Q6	2N915	C2	22µf TANTALUM	R6,R15	REFERENCE ADJUST
Q13,Q14,Q15,Q7	2N2369	C1	68µf TANTALUM	R7	400 ohms
D9	1N754	L1	10MH	R13	400K
D2	1N757	L2	100MH	R8,R11,R18,R17	200K
D1,D3,D4,D5,D6,		C8	.01µf	R9	300K
D7,D8,D10	FD600	R1,R5	600K	R10,R12,R14	500K
				R16	1.5M

Fig. 5—Intrusion detector supply provides two voltages, one of which is below ground. A single multi-vibrator clocks the two separate switching regulators that supply these outputs.

then stretches the ON duty cycle as long as necessary to bring the voltage up to the desired level.

This design is really two separate switching regulators clocked by the same multivibrator. One supplies a positive voltage and the other—via a voltage-doubler scheme—provides a negative voltage. The current output levels are quite low, just 5-75 mA for the plus 6V and 0-1 mA for the minus 5V, so it was imperative that the quiescent current drain through the regulator circuit be kept very low.

Plus 6V supply: The multivibrator oscillator will normally turn on the Q_1-Q_2 combination that charges inductor L_1 and capacitor C_1 for a 15% duty cycle. This duration is so short that even with the maximum input voltage, 32V, and the minimum load, 5 mA, the output voltage will still be less than the desired 6V.

The control action consists of having the differential amplifier, Q_3 - Q_4, compare the output to the reference D_9, and then holding the Q_1, Q_2 combination ON longer to bring the output voltage up to the reference level. By design, the circuit will be able to supply the added charge and turn OFF before the next turn ON is commanded by the 15% duty cycle pulse from the oscillator, even at the lowest supply voltage, 19V, and the largest expected loading, 75 mA.

Minus 5V supply: This operates in a similar manner as the positive 6V supply, up to Q_7. Transistor Q_7 drives a voltage doubler, Q_6, Q_5, C_3 etc., that, like the positive supply, is driven off the positive battery terminal. When Q_5 goes ON, doubling-capacitor C_3 is charged. When Q_5 goes OFF, the top of C_3 is clamped to ground and the bottom is driven below ground to supply the negative voltage for the L_2, C_2 combination.

The pulses from the 20-kHz clock are extended by the feedback circuit to hold Q_5 OFF longer, so that L_2 and C_2 are charged longer. ▭

Author's Biography

Jess Schlageter received both his BSEE and MSEE from the University of California. He's now in the process of augmenting this technical foundation with an MBA from the same school. He has been in MOS design at Fairchild Semiconductor, Mountain View, Calif., since 1968. At the begining of this year, he moved "down the road a bit" at Mountain View to Standard Microsystems where he continues to work on MOS systems.

FOR A FREE REPRINT OF THIS ARTICLE, **CIRCLE NO. L64**

The world's most powerful tetrode switch tube is EIMAC's new baby.

Right on! Power tubes have come a long way since the nostalgic days of EIMAC's first triode, the 150T. All the way up to the giant X-2159 developmental tetrode having a plate dissipation of one and one-quarter megawatts.

The amazing X-2159 powerhouse tetrode can be used as a 60 kilovolt, 1,000 ampere switch tube, or as an extremely high power pulse modulator. It can also develop two megawatts of CW power up to 30 MHz or so with up to 17 decibels stage gain.

Two EIMAC X-2159s can be used in a 2.5 megawatt, 100% plate modulated medium or shortwave transmitter. At VLF, morever, two X-2159s can develop 4 megawatts of CW power.

The X-2159 is a thought provoking example of EIMAC's capability to produce tomorrow's tube today.

For full specifications on EIMAC's new super power tetrode and other outstanding products write: EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070. Or contact any of the more than 30 Varian/EIMAC Electron Tube and Device Group Sales Offices throughout the world.

Eimac®
division
varian

CIRCLE NO. 18

Need precise power pulses? Here are four ways to get them.

One basic low-power timer can be combined with a variety of output power drivers to provide precise power pulses that satisfy a wide range of output load requirements.

ROY W. FORSBERG, Boston Editor

Power pulsers are commonly used in applications such as print hammer drives for high-speed computer printouts, solenoid actuators, impulse or stepping motors, ferrite phase shifters, etc. Some applications require load voltage switching; others, constant drive current. Some require short precise pulses, and still others wide but consistent power pulses.

The following circuits will show how a basic PUT (programmable unijunction transistor) timing circuit along with modifications to the output driver can satisfy all the above applications.

A conventional approach for timing circuits is to use a monostable multivibrator. However, when compared to the PUT timer in **Fig. 1**, this technique has several disadvantages. The PUT type consumes less power, because the PUT and PNP amplifier draw no current when off and only 10 mA during the timed output pulse interval. Pulse widths are more stable and precise because the PUT firing threshold is low, timing network loading is low, and the circuit operates at higher voltages. Also, the PUT is not affected by supply variations, since its triggering threshold is determined by a voltage divider. Finally, the PUT timer has faster recovery because the timing capacitor is rapidly discharged at the end of the timing cycle through the PUT anode and the 6 KΩ resistor. Pulse widths attainable with this type timer range from 20μs to 10s.

The Darlington output in **Fig. 1** will provide a high power voltage pulse to any inductive, resistive, or capacitive load. With both collector and emitter available, the load can be placed in either the collector or emitter and can be driven by either +60V or −40V. Since the output is a voltage switch, load current will be a function of supply voltage and load resistance. Thus, as load resistance varies due to coil heating, so will applied load current.

In applications where current supplied must be closely controlled, several alternatives are possible. The load coil can be made with either low TC wire or can be compensated with thermistors; or, constant current drive circuits as shown in **Fig. 2** and **Fig. 3** can be used. The first approach can be expensive, while those in **Fig. 2** have low efficiency, high power dissipation, and output current limited by the Darlington's secondary breakdown capability.

The last alternative (**Fig. 3**) will switch a constant current through an inductive load independent of changes in load

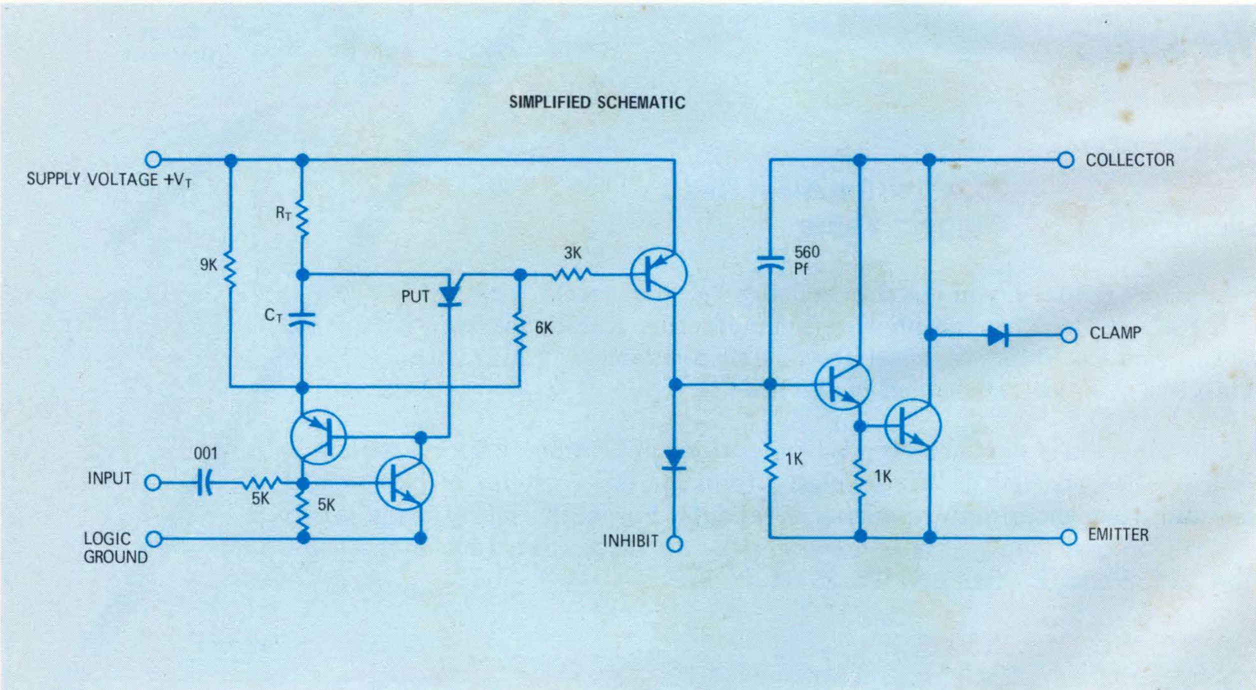


Fig. 1 — The power pulser works as follows: When an input pulse triggers the input switch, it latches, starts the PUT timer, and turns on amplifier Q4, which provides base drive to the Darlington output. At the end of the timing cycle, the PUT fires, disengages the latch, and turns everything off.

When the timing cycle is started by the latch circuit, C_T charges from zero volts toward the supply through R_T until it exceeds the reference established by the PUT gate voltage divider. At this point, the PUT fires, ending the timing cycle, discharging C_T, and turning off the latch, amplifier, and Darlington output.

A voltage of 0.25V or less on the inhibit line will prevent the Darlington from turning on.

resistance and supply variations. This capability is especially attractive in applications like print hammer and impulse motor drives, where variations in the current supplied will result in differences in energy applied by the electro-mechanical devices and consequently in such things as registration errors.

These design approaches are used by Unitrode Corporation in their PIC 400 series of hybrid power pulsers.

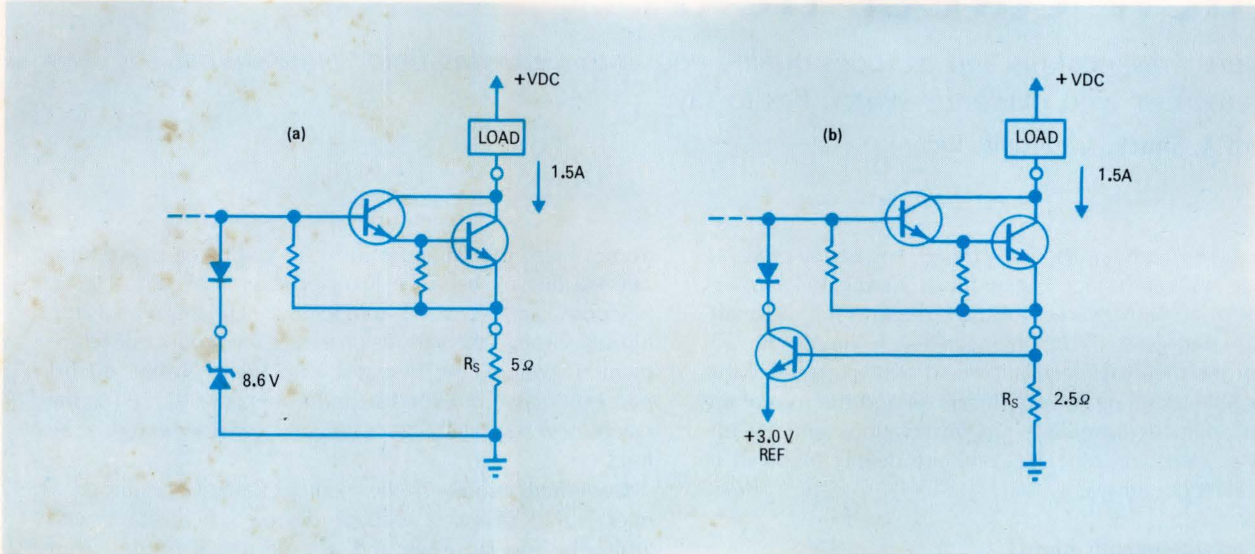


Fig. 2—To convert the voltage switch of Fig. 1 to a current controlled switch, the Darlington output stage is made a series linear amplifier, regulating the load current by dropping excess voltage across itself. To do this: a current sampling resistor is placed in series with the emitter output, and the inhibit line is returned to either a fixed reference voltage (**a**) or a reference comparison transistor (**b**).

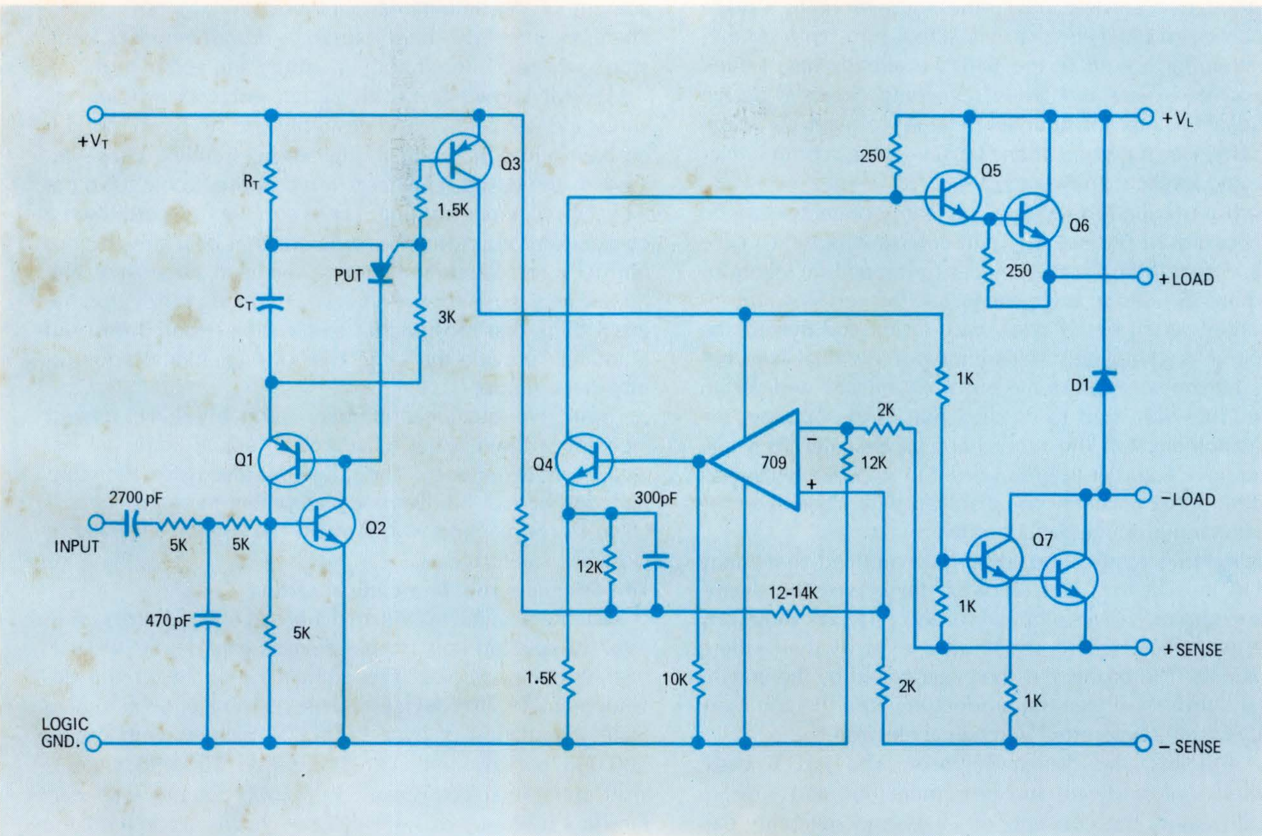


Fig. 3—In this power pulser with constant-current output, the timing is basically the same as in the circuit of Fig. 1. At the beginning of the timing interval Q6 and Q7 switch the full power supply voltage across the load until output current reaches the desired level (determined by the voltage across an external sampling resistor in series with the load). Q6 is then momentarily cut off, allowing the load current to decay. It will then switch on and off at 20-50 kHz to maintain the desired average load current.

Q6 switching is controlled by an op amp which compares the voltage across the external sampling resistor against the V_t supply.

Both Q6 and Q7 are switched off at the end of the timed interval. This reverses voltage across the load inductance and forces load current through D1 back into the power supply, thereby giving fast current decay.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE L65**

What about medical electronics as a new career field?

Do your present skills and attitudes qualify you in this growing field? Here's what one engineer who made the switch has to say.

Edward A. Shuck, Medtronic, Inc.

These are trying times for many design engineers, especially those with aerospace backgrounds. Medical electronics can be an attractive career for these designers, if the qualifications and goals of the engineer match the role he will play in the medical electronics field. The purpose of this article is to examine the qualifications and the role of the design engineer based on my observations and experiences at Medtronic, Inc., a company deeply involved in medical electronics.

What are the qualifications?

Today's trade journals are currently filled with articles outlining the opportunities, or lack of opportunities, in the future projected growth fields, such as environmental control, transportation, health care, and others. The real question, though, is can we find in these growth fields a place for the design engineer that will allow him, with on-the-job retraining, to utilize the skills he already has. I think the answer is yes, and when reviewing potential design candidates, I look for qualities relating to team participation, engineering application, perseverance, communications, and medical knowledge.

Team participation—While the team concept seems to be an overused phrase, it is particularly important in the medical field. Many of the devices developed by Medtronic require the design engineer to use the services and information gained by his peers both inside and outside the company. A completely self-sufficient individual who believes he can solve all of the problems himself and design the product from start to finish is not, in my opinion, the best candidate. On the other hand, a designer who can accept advice and criticism in order to improve his understanding of the problems to be solved will probably enjoy his work and produce better hardware.

Engineering application—We have noticed that many clinical investigators distrust what they term the "aerospace complex". The reliability of the products touted by some aerospace firms is usually dispelled by their failure on patients. The problem is then aggravated by the inability of the firm to service the product because the company is only casually interested in medical electronics.

Nevertheless, the design engineer who has a basic knowledge of hardware and instrumentation and a desire to really apply the concepts of safety and reliability can use his aerospace background to good advantage. But he must remember that if a problem arises, he can't hide behind a mountain of paper work and specifications and argue who is right or wrong. He must apply good engineering principles to locate, solve, and implement corrective action.

Perseverance—To work effectively in the medical electronics field, the engineer must be willing to prove himself. He doesn't have the luxury of hierarchy of job titles, functions, and assumed competence. He must bootstrap himself through the various phases of the product development. Therefore, the designer who wants to rest on his past experience or expertise and not expose himself to the risk of new responsibilities shouldn't consider entering the field.

Communications—In the medical field the design engineer is not given a primary device specification with which he can sit down and assume that if he designs a black box to that specification, everything will be fine. Indeed, the engineer is usually the only one who will strive to accurately define the device, while his colleagues will, many times, accept anything that works; and no amount of documentation will help if it doesn't work. Therefore, I feel it is important for a design engineer to be able to express himself both in written and verbal form.

Medical knowledge—The design engineer would certainly add perspective and desirability to his background if he had formal biomedical engineering training. However, most of the design engineers hired at Medtronic have not had such previous training. Therefore, we have instituted a corporate product training program that provides the opportunity for classroom training for each employee. The opportunity exists for the engineer to retrain himself on the job. I think that most viable medical electronic firms will ultimately provide the same type of educational opportunity in the future.

These five qualification areas probably have limited meaning without being related to an actual hardware development experience. The following discussion therefore will describe a hardware development program undertaken in conjunction with Rancho Los Amigos Hospital in Downey, California.

The designers role in a clinical setting

Rancho Hospital established a broad clinical program in 1967 to develop implantable devices capable of stimulating peripheral nerves. The clinical rationale for the development of the devices is the existence of a United States population of over 2,000,000 patients with stroke, 500,000 patients with cerebral palsy, 100,000 patients with multiple sclerosis, and 1,000,000 patients with Parkinson's disease. All such diseases have in common the peripheral effects of loss of control of muscle action.

Medtronic joined Rancho in 1969 to develop clinical hardware to improve human locomotion and has focused on the stroke patient population of approximately 380,000 patients designated as hemiplegic. The hemiplegic has lost muscle control on one side of the body with somewhat normal control on the unafflicted side. We have further concentrated our effort at the present time to a hemiplegic condition known as "foot drop;" a condition in which the afflicted foot is "frozen" into a position that makes it very difficult to walk because the toe continually drags on the ground.

The equipment being developed (**Fig. 1**) consists of an implanted passive receiver which is connected by wires to electrodes wrapped around the nerve bundle of the afflicted foot. Power is inductively coupled to the implanted receiver through an external antenna connected to a stimulator unit which is supported at the waist by a belt. Stimulation of the nerve is synchronized with the proper gait cycle of the patient by means of a telemetering switch placed in the heel of the shoe. A cycler is also provided that will automatically program the stimulator so that the patient can exercise his muscles, for therapy, without walking.

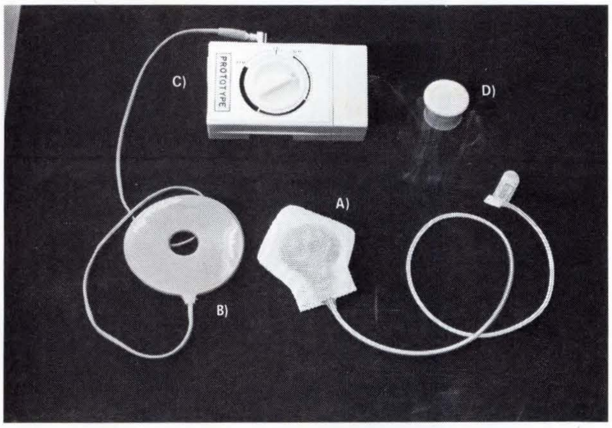


Fig. 1—**System components currently consist of** (a) the implanted receiver, leads, and electrodes; (b) the antenna; (c) the stimulator; and (d) the heel switch.

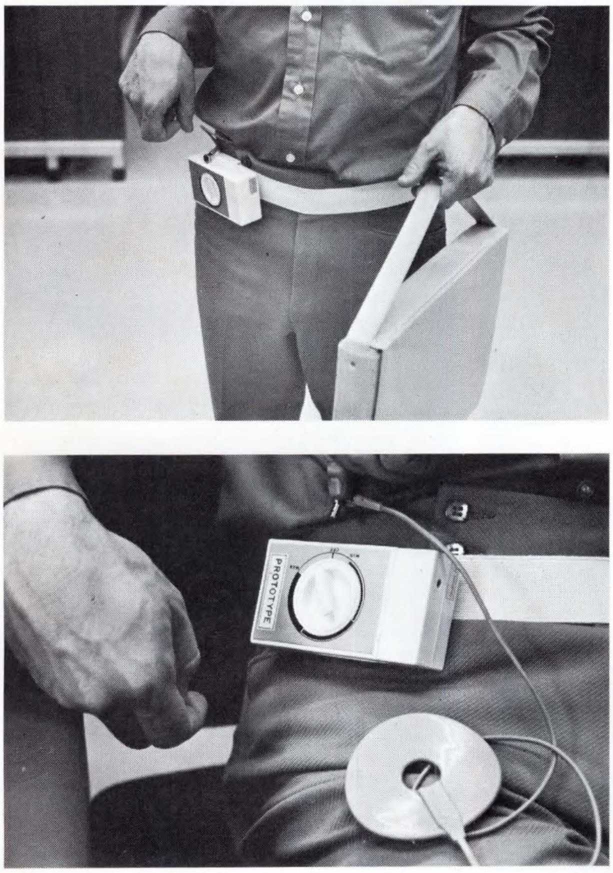


Fig. 2—**The stimulator package** is held by a belt worn by the patient (top). Connection from the antenna to the stimulator can be made with one hand (bottom).

With this general description of the clinical objectives of the program, let's see what role the design engineer plays in the development of the clinical hardware?

Team participation—The Rancho-Medtronic rehabilitation engineering team working on the foot-drop device currently consists of ten members, with supplementary resource personnel at each facility (**Table 1**).

At the present time the program is at the clinical application phase, where hardware is being applied to patients under the guidelines of a clinical protocol. The clinician (**see Table 1**) and associated resource personnel support patient selection, pre-operative procedures, implantation of the device, and post-operative evaluation and care. The director of neuro-motor-assist engineering and his personnel provide support during patient hardware fitting clinics, physiological studies, and equipment troubleshooting. Medtronic personnel provide hardware for the program, a service facility to repair equipment and back up support for the Rancho engineering team.

Engineering application—As a member of the overall team, the design engineer develops and implements evaluation criteria for the hardware to insure proper device performance and patient safety. The check list shown in **Table 2**, which is a general guide used by Medtronic, illustrates areas where the design engineer probably has some previous experience.

Perseverance—The designer goes through certain phases while he is developing hardware for clinical application. The following is a description of the phases this program has gone through so far. (We are entering our third year of development and still have many hurdles to overcome before we can talk of a marketable product.)

Phase—1	(1968-1969)	Evolution of devices based on the treatment of 17 patients at Rancho.
Phase—2	(1970-1971)	Design review of the hardware development based on Phase—1 results and the following: —Material toxicity —Device failure —Human factors —Environment —Reliability —Energy toxicity —Test method definition
Phase—3	(1971-1972)	Clinical application of the hardware designed in Phase—2. A twenty-patient series is currently underway at Rancho, with special emphasis on: —Patient selection criteria —Patient benefit —Clinical protocol —Device performance.

Communications—Communications is an important area of our relationship with Rancho because the team is separated both by distance and specialties. Medtronic personnel frequently travel to Rancho, with some members averaging one trip a month.

The following are typical agenda items covered at Rancho during these trips:

—Attend design reviews
—Witness surgery
—Attend patient equipment fitting clinics
—Observe animal research
—Conduct patient interviews
—Review hardware failures
—Provide hardware training and service.

Rancho personnel also visit Medtronic periodically, with the following agenda being typical:

—Observe facilities
—Conduct seminars for resource personnel
—Review program

The team meeting seems to be the best method of

Table 1. The Rancho—Medtronic rehabilitation engineering team

Description	Major role	Educational background	Previous experience
Rancho—Los Amigos			
Clinician	Orthopaedic Surgeon—responsible for surgery and patient evaluation and care with respect to hardware developed	M.D.	
Director of Neuro-motor-Assist Engineering	Director of Biomedical Research and Engineering. Supervises animal experiments, research instrumentation, and hardware development	Ph.D.	6 years orbital flight mechanics experience
Systems engineer	Develop research instrumentation and associated hardware for research programs	M.S. systems engineering	18 years aerospace system design experience
Research fellow	Run animal experiments to determine the physiological and neurological effects of electrical stimulation	Working towards an M.S.	No previous experience
Design engineer	Support clinical application of hardware, including patient fitting, inventory, trouble shooting	B.S.E.E.	
Medtronic			
Description	Major role	Educational background	Previous experience
Engineering manager	Coordinate product research and development	B.S.E.E.	8 years aerospace and industrial instrument design
Research engineer	Coordinate clinical research to evaluate the physiological parameters and associated design parameters with new devices	B.S. engineering	7 years biomed. engineering. Grad. Research assistant working with clinical, lab., cardiovascular, and pediatric instrumentation
Design engineer	Coordinate the design and development of hardware, including the electromechanical interface necessary to achieve the final systems	B.S.M.E.	9 years aerospace instrument design, and computer analysis
Engineering aide	Hardware construction to work closely with production engineering groups to insure that the hardware construction and testing flows smoothly	No degree	4 years biomedical instrumentation development
Marketing manager	To understand the market place and determine the operation of the rehabilitation process in the U.S.A. and Europe	B.S. biology	2 years medical sales and consulting experience

Resource personnel—
1. Reliability assurance
2. Production engineering
3. Quality control
4. Medical communications
5. Marketing research
6. Applied research
7. Animal research

Table 2. Design evaluation criteria for medical equipment

1. **Material toxicity**
   - Carcinogenicity — produce cancer
   - Thrombogenicity — produce blood clots
   - Hemolysis — destroy elements in the blood
   - Cytotoxicity — destroy cells
2. **Device failure**
   - Power source
   - Circuit and components
   - Leads
   - Enclosure
3. **Human factors**
   - Ease of controls
   - Method of attachment
   - Weight, size, and shape
   - Organization of controls
   - Connections
   - Power source replacement
   - Patient device tolerance
   - Conditions of use
   - Freedom of movement
4. **Environment**
   - Temperature — storage and use
   - Chemicals
   - Shock and vibration
   - Electromagnetic interference
5. **Reliability**
   - Component failure rates
   - Circuit failure rates — mathematical and empirical
6. **Energy toxicity**
   - Stimulation current level
   - Electromagnetic coupling from external sources
7. **Test method definition**
   - Configuration records
   - Performance specifications
   - Materials specifications
   - Special processes
   - Unit identification

communications, preceded by a one-page agenda and followed up with a one-page list of action items.

Medical knowledge—I came to Medtronic in 1970 with no experience in the clinical, anatomical, and physiological fields associated with peripheral nerve stimulation. I then attended the two-week full-time Medtronic product training seminar that introduced me to the basics of these subjects. These seminars, by the way, were conducted by Medtronic personnel, practicing physicians, and members of the University of Minnesota Faculty. This program provided excellent background for clinical awareness and understanding.

In addition, most of the physicians I meet in the clinical setting have been very helpful in recommending books, periodicals, and references to increase my knowledge in specific areas. □

Who is Medtronic, Inc.?

Medtronic started, in 1949, in Minneapolis as a partnership concerned primarily with representing and servicing other medical electronic companies' products. Although it became a corporation in 1957, meaningful sales did not occur until 1965, when the implantable pacemaker product line gained clinical acceptance. Since 1965, Medtronic has established a significant growth record, with net sales volume increasing from $3.2 million to $30.6 million. Rapid growth required that the administration establish long-range objectives, and since 1965 the decision to concentrate in the implantable prosthetic field and phase out its early efforts in telemetry and monitoring equipment fields has focused resources for continued growth.

As of 1972, Medtronic is truly an international manufacturer of boimedical devices, with over 1200 employees and products marketed in 60 countries.

Who is Rancho Los Amigos Hospital?

Rancho Los Amigos Hospital is the major chronic care facility of the Los Angeles County Department of Hospitals. In addition to a large experience in chronic care and rehabilitation of numerous categories of physical disabilities, this facility has a long history of contribution to the various fields of boimedical engineering.

Recently, in an effort to broaden its technical base and to aid the professional community in Southern California, Rancho instituted a program to redirect the skills and education of seven former aerospace engineers and scientists. This program was initiated in cooperation with the California Department of Human Resources and is funded under the Manpower Development Training Act by the Department of Labor.

Author's biography

Ed Schuck came to Medtronic in 1970 from an aerospace oriented company—Rosemount Engineering—where he held both design and management positions. At Medtronic he is manager of New Product Engineering. He received his B.S.E.E. from the University of Minnesota in 1963.

FOR A FREE COPY OF THIS ARTICLE, **CIRCLE L66**

Circuit Design Awards

Circuit remembers random data within periodic field

by **Stephen Kreinik**
CBS Laboratories Stamford, Conn.

This simple digital circuit can detect and remember the presence of randomly-distributed information occurring within a periodic field. For example, it can produce an output as long as information appears once per field or once per line on a TV raster.

The circuit (**Fig. 1**) can be used directly in digital systems, and, with suitable modification, it can also be used in analog systems. For analog applications, the input information must first be converted into a suitable digital signal. For example, a threshold discriminator could be used to detect the presence of a signal above a certain value.

Data to be remembered by the circuit of **Fig. 1** must be in the form of a negative-true logic signal. This signal (A) is applied directly to flip-flop FF_1. A second input signal (P) occurs once per field (in the original application it was the vertical blanking pulse) and is applied to FF_2 and to a one-shot circuit (SS_1) which produces a delayed pulse (DP).

When A is true (OV), the output (X) goes to logic-1 (+4V) and remains there as long as A occurs once in each field. X will go to logic-O within one field after A does not occur. The maximum allowable repetition rates for A and P are constrained by the propagation delay through the logic circuitry plus the pulse widths of DP, P and A.

The trailing edge of pulse P generates a delayed pulse, DP, at the output of SS_1. When the A input contains a pulse within the field defined by P, flip-flop FF_1 is set, producing a low output at point B and, therefore, setting FF_2.

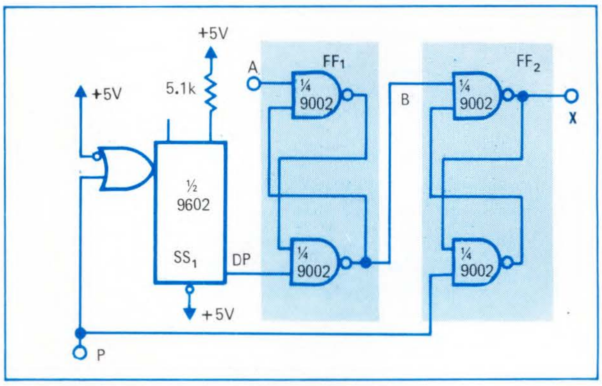


Fig. 1—**Digital circuit** produces an output at X provided an input pulse appears at point A sometime between each two consecutive pulses at point P.

This, in turn, produces a high output at X.

When another P pulse occurs, X would return to its low value if it were not inhibited by flip-flop input B, which is still low. Therefore, X stays high.

After P has returned to its high values, DP resets FF_1 and returns B to a high value. Since P is high, X remains high. The presence of A in the next field ensures that X will remain high. If A is removed from the field, FF_1 is not set, and the next P pulse resets X to logic-O where it remains until another A input occurs. ▭

To Vote For This Circuit
Circle 161

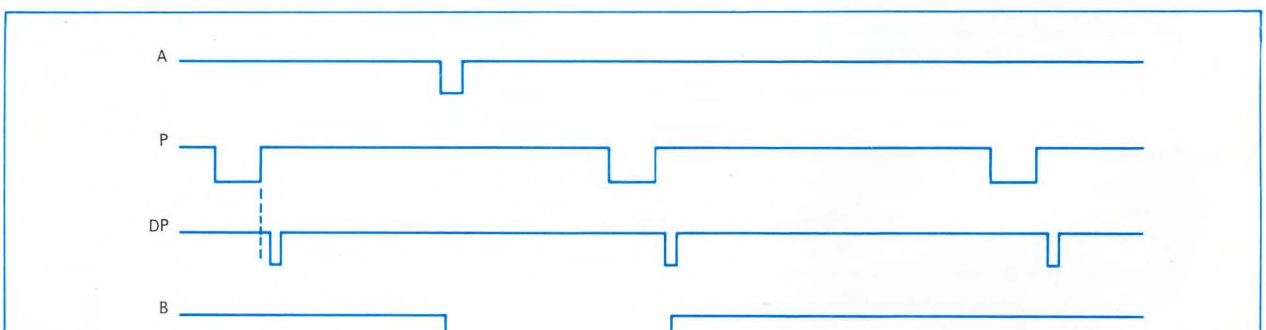


Fig. 2—**Timing diagram** shows how the output, X, depends on the two inputs, A and P. X goes high when an A pulse appears between P pulses. Because there is no A pulse between the second and third P pulses, the third P pulse returns X to its low state.

One shot triggers on both edges

by **Ury Priel**
National Semiconductor Corp. Santa Clara, Calif.

A modification to the external circuitry can make a monostable-multivibrator IC trigger on both edges of an input pulse. The required connections are shown in **Fig. 1**. This circuit is much simplier than other techniques which typically require several gates in addition to the basic one-shot IC.

Circuit operation can be best understood by referring to **Fig. 2** which shows the input portion of the circuitry on the IC chip. The one-shot fires when the second gate in the input circuit turns on, or in other words when Q_1 turns on.

Note that because of the added external diode, the second gate has a threshold approximately 0.7V lower than that of the first gate. Therefore, as the input voltage at point A rises, it will first reach the threshold of the second gate (whose output is Q_1). This causes a race condition because of the different propagation delays.

The timing diagram **(Fig. 3)** shows the relationships between the waveforms in the circuit of Fig. 2.

At time t_1, all the inputs to the second gate are high and thus point C goes low. When the input signal (point A) crosses 1.3V, point B goes low and thus the second gate turns off at time t_2.

On the falling side of the input pulse (point A), we have a similar situation. Before the input signal drops to 1.3V, point B is low and point C is high. When A reaches 1.3V, B goes high and C goes low. When A reaches 0.6V, the second gate turns off and C returns to the high condition.

The pulses at point C will always trigger the one-shot portion of the IC. Thus the complete circuit triggers from both edges of the input pulse.

The external RC network (R_1 and C_1) determines the output pulse width of the one-shot. The DM7850 has a minimum holding time of 40 nsec, therefore the minimum pulse width at point C must be 40 nsec. Because of this limitation, the circuit described here is restricted to applications where the pulse rise and fall rates are greater than 60 nsec/V (40 nsec/0.7V). This is the price that must be paid for circuit simplicity.

A further limitation of the circuit is reduced noise immunity resulting from the lowered threshold of the second gate. A bypass capacitor at the input can help correct this problem. ▭

To Vote For This Circuit
Circle 162

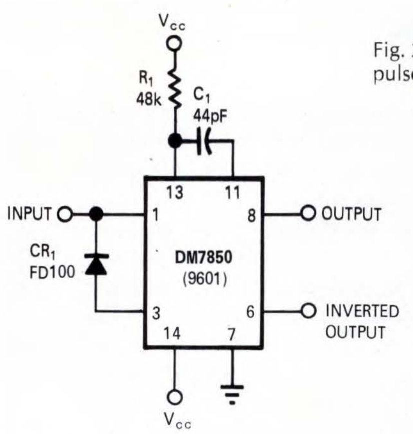
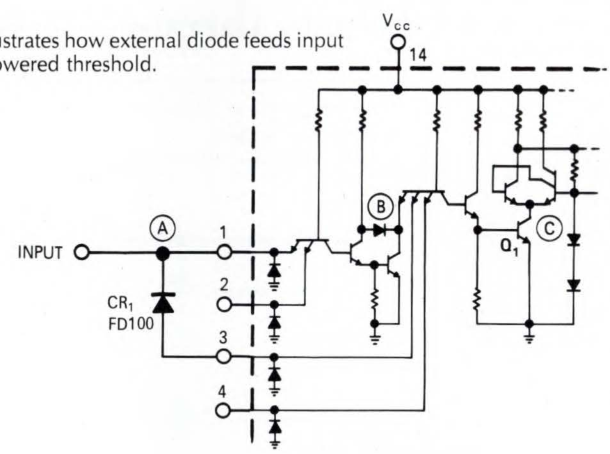


Fig 1—**Simple modification** involving an external diode circuit allows an IC one-shot to be triggered from both edges of the input pulse.

Fig. 2—**Partial schematic** illustrates how external diode feeds input pulses to second gate with lowered threshold.



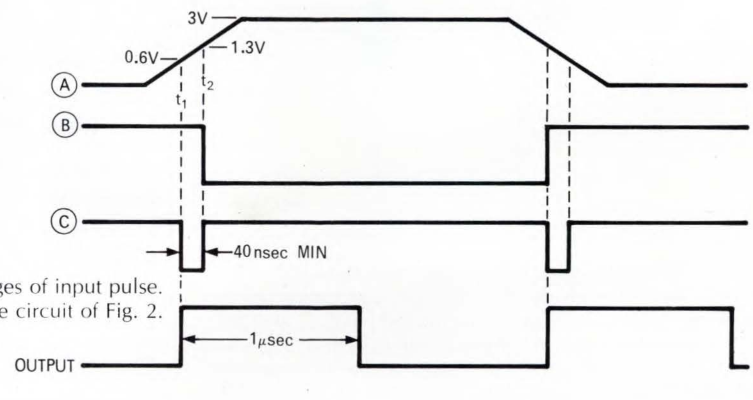


Fig. 3—**Output pulses** are triggered by both edges of input pulse. Lettered waveforms refer to various points in the circuit of Fig. 2.

J-FET generates clear or preset commands for low-power TTL

J. E. Buchanan, Westinghouse Electric
Corp. Baltimore, Maryland

A set or reset signal is often required to insure that a counter assumes a required state following power turn-on.

For the more common types of low-power TTL counters, a P-channel J-FET, two resistors and a capacitor as shown in **Fig. 1**, provide a set or reset circuit that will insure that the counter starts up in the required state.

When the logic supply (+5 volts) is first applied, the J-FET (Q_1) gate-source and gate-drain voltages are near zero, allowing Q_1 to turn fully ON to provide a sink path to ground for the clear or preset line. (The low-power 54L TTL counter requires a low-logic-level signal that is capable of sinking up to 0.18 mA of current per set or reset signal).

After power is applied, Q_1 remains ON for a given time, depending on the RC time constant of the gate RC network. As the gate voltage approaches the pinch-off level, the circuit begins functioning as a voltage follower; and as the gate voltage further increases so does the output, until a final value is reached that is near a pinch-off level and below the logic supply level. A low pinch-off, low on-resistance P-channel J-FET, such as the 2N2844 (V_p max. = 1.7 volts, R_{DS} typical = 560 ohms), is required.

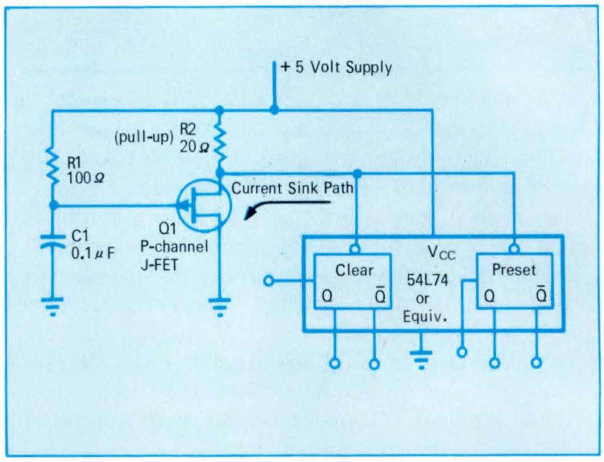


Fig. 1 – A clear or preset circuit for low power TTL counters requires only one active component and assures that all counters will be properly set upon application of power to the circuit.

Individual selection of the FET may be required to insure both the low ON-resistance and low pinch-off level. ☐

To Vote For This Circuit
Circle 163

Logic probe tests three-state logic circuits

Leslie K. Torok, University of Toronto
Toronto, Ont. Canada

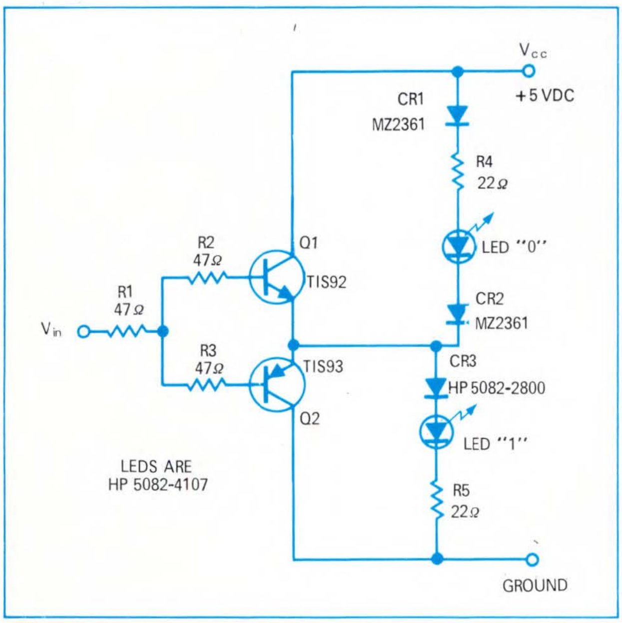


Fig. 1 – This three-state logic probe makes maximum use of its 2 LED bits by providing four distinct messages concerning the circuit under test. If there is a logic "1" at the test point, Q_1 will light LED "1". If there is a logic "0", then Q_2 will light LED "0". If the test point is in the third, or "Hi-Z," state neither transistor will have adequate base drive, and both LEDs will be unlighted. If the supply voltage exceeds +5.7V both LEDs will light before the probe is touched to the test point.

This logic probe can be neatly packaged into a P-6025 or other suitable probe-tip and only takes about an hour to assemble. The probe is powered by the circuit under test, and in addition to indicating "1", "0" or "Hi-Z" logic states it will indicate "overvoltage" from the supply if V_{cc} exceeds 5.7V.

Circuit operation is extremely simple, as shown in **Fig. 1**. If the device under test is in the "high impedance" state, there will be no base drive to either Q_1 or Q_2 and neither LED will light. If the logic state is "zero" (below 0.3V) Q_1 is biased off and Q_2 on. Current will be drawn through CR_1 and LED "0" will light. When Vin exceeds 2.4V (for a logic "one") Q_2 will be off and Q_1 will turn on, providing a current path for CR_3 and lighting LED "1". ☐

To Vote For This Circuit
Circle 164

Rules & Announcements

Your vote determines this issue's winner. All circuits published win a $25 U.S. Savings Bond. All issue winners receive an additional $50 U.S. Savings Bond and become eligible for the annual $1000 U.S. Savings Bond Grand Prize.

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

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

MEASUREMENT NEWS

information for better measurement

in this issue

An economical VHF signal generator

HP's new data acquisition system

At last: an X-Y recorder for OEMs

Counter intelligence for demanding buyers

These HP counters have so many well-planned features and options that you get out-of-this-world performance at down-to-earth prices.

Select *the* electronic counter/timer capability that you need without paying for unwanted extras. HP 5300 and 5326/5327 counters fill the bill at bare-bones prices, \$520 to \$2150. That includes capability to 550 MHz and many features you could never get before.

Take the 5300A six-digit mainframe, snap-on any of four function-determining modules in less than 15 seconds, and you have a 10 MHz or 500 MHz counter, 10 MHz/100 ns counter/timer, or 50 MHz multifunction counter. Snap-on a battery pack for portable use with any module. You can hold any 5300A in one hand; it's that compact.

(Continued on next page)

High-performance signal generator: small in size, small in price

HP's easy-to-use 10–512 MHz signal generator is versatile enough for almost every job.

Looking for a small, solid-state calibrated signal generator? One as easy on the budget as it is to operate? The 8654A VHF Signal Generator gives leveled and calibrated output over a 10 to 512 MHz frequency range. Stability is 20 ppm and residual FM is 5×10^{-7}.

The power level is variable from +3 dBm to −120 dBm, calibrated, and is leveled automatically over the whole frequency range. Modulate it externally or internally: continuously variable amplitude modulation, 0 to 80% (metered); and FM peak deviation 0 to 0.1%.

Its compactness fits the 8654A easily into production, mobile, airborne, and shipboard test locations. Its rugged solid-state construction recommends the 8654A for field maintenance and service applications. And its economy commends it for use *everywhere*—testing receivers, amplifiers, antennas, filter networks, etc.

The price? Only $1,135.

Perhaps you could use a high performance "economy" generator. For more information, return the HP Reply Card.

(continued from page 57)

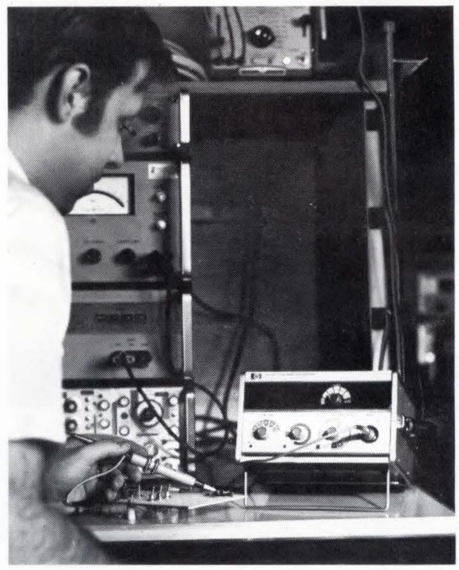
For more capability, step up to the 5326/5327 Series. Select seven or eight-digit readout, total remote programming, economical computer interface, time-interval averaging down to 150 picoseconds, a built-in DVM for dc voltage, or max-accuracy time interval measurement via digital trigger level setting, new ultrastable time bases or 10–25 mV sensitivity.

It's a six counter family: 5326 A/B/C (50 MHz) and 5327 A/B/C (550 MHz). The A and B models are universal timer-counters; the B models have a built-in DVM. The C models measure frequency, period, ratio, and totalize input.

For the *least* costly counters that will serve *all* your needs, discover the 5300 and 5326/5327 line of electronic counters.

Need more details? Just send the HP Reply Card.

True RMS goes digital at a reasonable price



Only 4½ by 7¾ by 9½ inches, the Model 3403A/B fits in any corner of your laboratory. Attach it to a calibration microphone or a semiconductor test system with equal ease.

The new digital 3403A/B True RMS Voltmeters offer combined capabilities never before available in one instrument:

- Wide voltage range—measures ac voltage from 10 mV to 1000 V full scale.
- Wide frequency range—from 1 Hz to 100 MHz.
- True rms accuracy—measures both simple and complex signals ±0.2% reading ±0.2% of range.
- Versatility—measures ac, dc, ac and dc, low frequency, RF levels, and complex signals.
- LED display—three digits with fourth digit for overrange.
- Volt or decibel readout—an option automatically converts measurements to decibels and reads dBV from −48 to +60 with a resolution of 0.1 dB.
- Economy—an eight-decade bandwidth and six-decade ac voltage range in one instrument, not two or three.

The 3403A True RMS Voltmeter sells for $1400 plus options; the 3403B (ac only) version starts at $1150. Six options, including BCD output, are available.

Interested? For more information, check the HP Reply Card.

Do IC troubleshooting ten times faster

The new 5010A Logic Troubleshooting Kit saves time, aggravation, and money. Use the Probe separately for pulse activity problems; the Clip, for logic state; and the Comparator, for logic fault. They analyze digital IC problems ten times faster than conventional techniques.

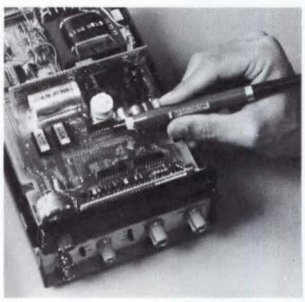
In design applications, the Probe can be a replacement for expensive oscilloscopes; it indicates logic states or pulses as narrow as 25 ns. The Clip monitors logic states on all 16 IC pins at a time. With the Comparator, the designer can be confident that all ICs are working even if his circuit is not.

These pieces may be purchased separately, or as a complete kit for $495.

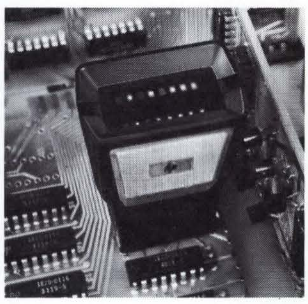
There's more. Just check the HP Reply Card.

The 10529A Logic Comparator finds the faulty pin in 5–10 seconds per IC; tests ICs dynamically in the circuit. Price: $295.

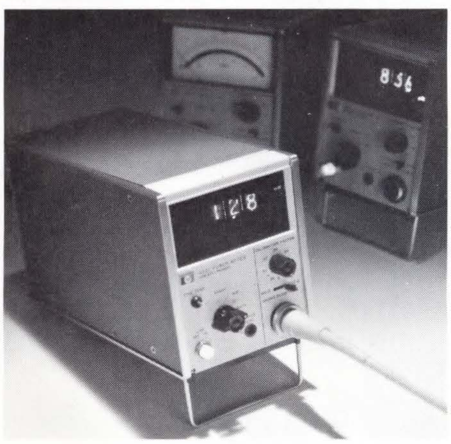
The 10525A Logic Probe detects static logic highs and lows, the presence or absence of pulse activity. Price: $95.



The 10528A Logic Clip "looks inside" the suspect IC. LEDs on the clip correspond to 16 IC pins so that each one is monitored. Price: $125.



Microwave power meter for automatic systems



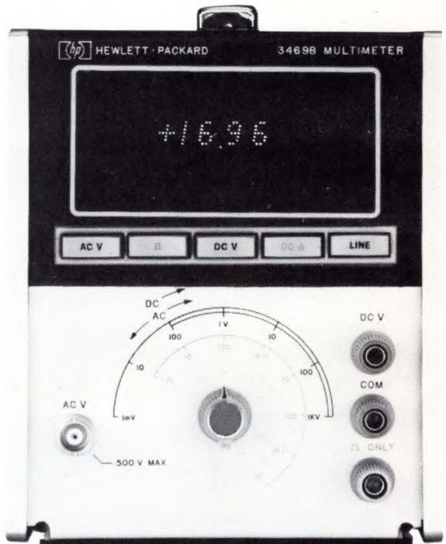
The 432C inputs and outputs are fully compatible with HP computers and digital recorders.

Now the HP 432 Power Meter family has a programmable member. The new 432C is a systems-oriented precision power meter with 1 μW to 10 mW range. Frequency coverage is 1 MHz to 40 GHz using HP's temperature-compensated thermistor mounts.

The 432C features include digital readout, autoranging and auto-zeroing (these can be accomplished with remote programming), BCD and analog outputs of measured power, and 0.5% f.s. accuracy. Price of the 432C is $1375.

Check the Reply Card for full information about all the 432 series power meters.

A digital multimeter with multi-features



The 3469B is a multimeter, milliohmmeter, dc ammeter, and dc voltmeter—all in one low-cost digital instrument.

Now you can choose 26 different combinations of range and function to make *digital* measurements of ac/dc voltage, dc current, and resistance.

The HP 3469B Digital Multimeter gives you five dc voltage ranges, six dc current ranges, seven ac voltage ranges with 10 MHz bandwidth, eight ohm ranges—all for $595.

The multimeter measures ac from 1 mV full scale to 500 V over a frequency range of 20 Hz to 10 MHz—particularly useful in communications, broadcasting, and audio applications.

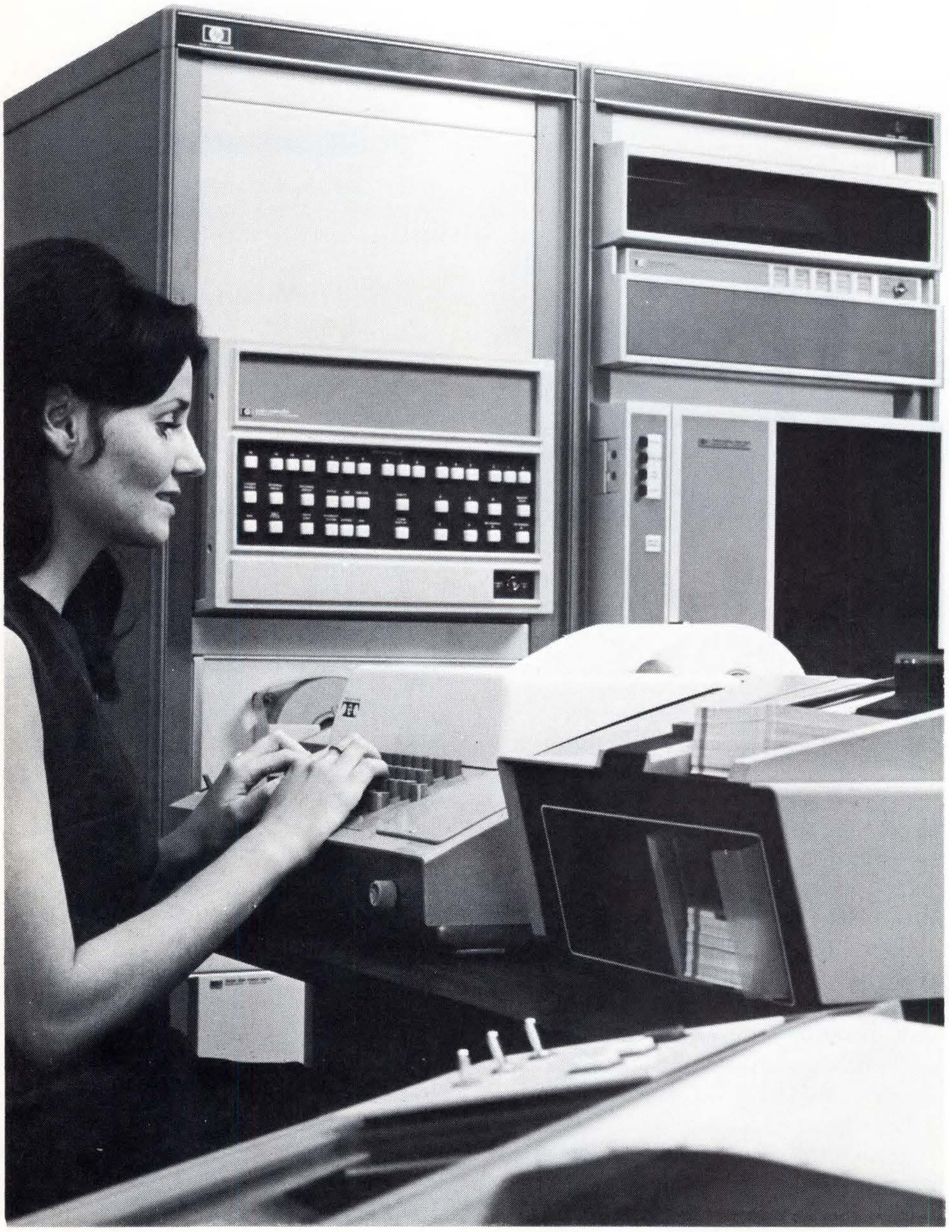
On its most sensitive resistance range, it is a milliohmmeter—one ohm full scale. Use it for contact resistance, components, and plated-through circuit board hole resistances.

The digital dc ammeter measures dc current from 1 microampere to 100 mA full scale.

The dc voltmeter measures from 100 mV to 1000 V full scale with an accuracy of ±0.2% to ±0.3%, depending on the range.

For more information, check the HP Reply Card.

Three new computer systems for low-cost batch, time-sharing or real time . . .



Dedicating a computer system to a specific processing task is now much easier, and costs less to do, with HP's new family of small disc-based systems. These systems can be applied to:

• Batch processing—for uninterrupted job processing with maximum throughput;
• Time-sharing—for direct man-machine interaction; and
• Real-time processing—for response to and control of external events while executing.

The fundamental system is the versatile new 2100A computer with a fast 7900A five-megabyte disc. Other mass storage devices provide up to 47 million bytes of disc storage. Each HP system interfaces with more than a dozen peripherals and plugs in to more than 50 HP instruments.

The reliable software is fully supported. The 2120 Disc Operating System features program chaining, extended file management, and a job processor that handles assembly language, ALGOL, and FORTRAN IV. It executes machine instructions or complex mathematical and logical operations with equal ease.

Just add 16 terminals, some hardware, and our easy-to-learn conversational programming language, HP BASIC, and you have the new 2000E time-sharing system. It can be expanded further to the new 2000F system with a dual processor and another 16 terminals.

With additional equipment and Real-Time Executive software, the disc system becomes a real-time system with priority interrupt and multi-programming capabilities.

Batch systems begin at $33,000, time-sharing and real-time from $50,000.

To learn more, check the HP Reply Card.

Batch, time-sharing, or real-time—HP's disc-based computer systems are particularly suitable when there's a need to access large data banks, and where ease of I/O interface is required.

. . . And a versatile new HP system family for sensor-based data acquisition

The new 9600 Series of modular data acquisition systems satisfies the need to handle multitudes of analog and digital inputs and outputs, all simultaneously. This new HP family of automated systems is specifically designed for applications in research, development, sensor-monitoring, and industrial control. The 9600 is based on the 2100A computer and features two new "plug-in" analog and digital subsystems, as well as three different software operating systems (RTE, DACE, and BCS).

The new **analog subsystem** is capable of scanning and digitizing both low and high level analog signals, and also outputting analog information, for purposes such as driving graphic displays and plotters. The unique feature is that all functional elements are contained on plug-in cards for greater flexibility with less cost and easier maintenance.

The main component is an analog-digital interface. Functional modules plug into the backplane and communicate with each other via analog and digital busses. The subsystem is controlled from the computer, through a control card in the interface. This card uses micro-programming and ROMs to generate the control and timing signals for various system functions. Depending on system needs, more than one interface can be used.

The **digital subsystem** includes the new HP 6940 multiprogrammer with 15 channels of 12-bit digital I/O and expansion capability up to 240 channels. Various plug-in cards let you monitor TTL, DTL, RTL, or contact-closure logic, and output TTL/DTL logic levels and contact-closures with read-back capability. The digital subsystem can also provide analog outputs (voltages and resistances) for controlling devices, such as power supplies.

Software for 9600 systems includes three different operating systems:

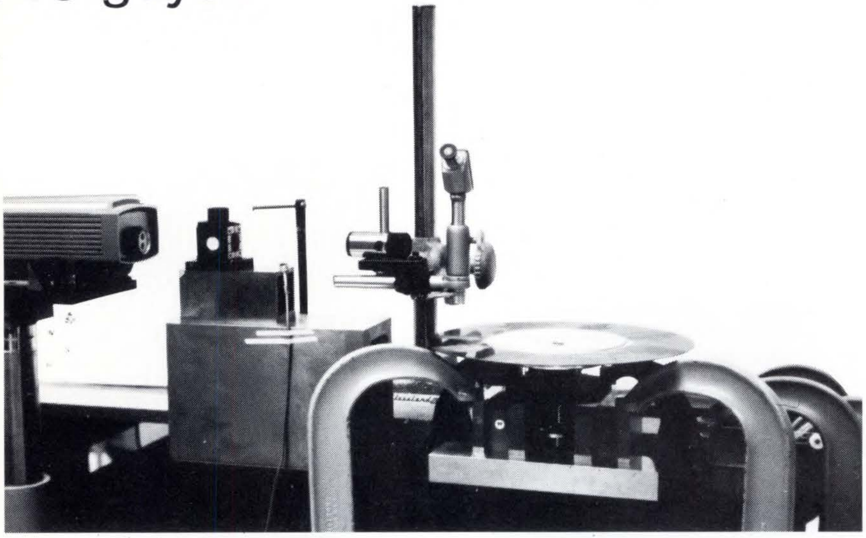
Fully integrated—rather than the all-too-familiar piecemeal assembly of data acquisition systems—is HP's 9600 Series. It features the 2100A computer, 7900A disc drive, 7970 magnetic tape unit, 2440A A-D interface, and the 6940 multiprogrammer.

- **Real-Time Executive**—Multiprogramming allows real-time programs to run concurrently with general-purpose background programs. Priority scheduling/interrupt controls your programs on the basis of time, event and critical need.
- **Data Acquisition and Control Executive (DACE)**—Schedules multiple tasks (measurement, computation and output) in real-time.
- **Basic Control System**—Features relocation and linking of user's programs, interrupt processing, input/output control, and a library of arithmetic, logic, and utility subroutines.

Configure a 9600 system to control a single test or experiment, or to automate a whole laboratory or factory. Systems start at approximately $22,000 and typical systems cost between $32,000 and $60,000.

To learn all the facts and features, check the HP Reply Card.

A laser device for computer or IC guys?



This laser interferometer is being used in HP's Gage Lab to measure spacing between the tracks of a memory disc.

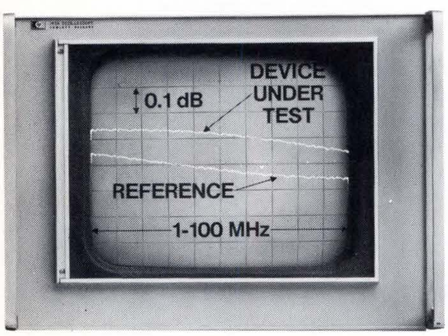
Use lasers in IC production or memory disc positioning? Why not? HP's 5525B Laser Interferometer measures displacements down to one microinch or, with the new K02-5525B Resolution Extender, down to one angstrom. This accessory electronically extends the laser's resolution by a factor of 10. The resolution extension is real-time, giving one microinch resolution at a high update rate, or 0.1 microinch at a lower rate. With two extenders cascaded together, resolution is 0.1 microinch in real-time; or .01 microinch, 10^{-10} meters, or one angstrom with the lower update rate.

The integrated circuit industry uses the Model 5525B both for calibration and for feedback control of artwork generators, step and repeat cameras, and mask inspection machines. For computer memory discs, the interferometer makes closer track spacing possible—thus improving the disc packing densities. It also calibrates the scales and actuator systems.

The 5525B costs $11,500. For the K02-5525B Resolution Extender, add $800.

Interested? Just send the HP Reply Card.

Fast yet precise RF measurements with high resolution



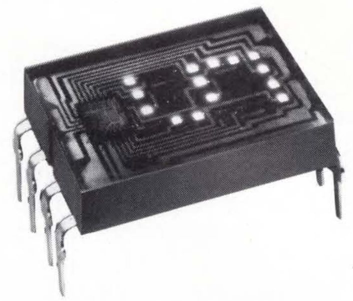
Comparisons over a 100 dB range, differences as small as 0.01 dB and 0.2° can be resolved.

Production-testing RF components normally calls for *swept-frequency* tests, but high precision and high resolution usually require *fixed frequency* tests. End the conflict. Use the new HP 8728A Network Comparator with the HP 8407A 0.1 to 110 MHz Network Analyzer, and make quick yet precise swept-frequency comparative measurements.

The 8728A is $2950. A typical complete system is approximately $12,000.

Discover many other features; check the HP Reply Card.

Low-cost displays come with onboard IC



The 5082-7300 numeric display is completely TTL-compatible.

We've built both the decoder/driver and the memory into our new 5082-7300 solid-state numeric display. All you do is address them directly with four-line BCD input. You can store data or have a real-time display at your fingertips.

The characters are .290 in. high for better readability over a wide viewing angle. Yet, it's a compact .6 by .4 inch package.

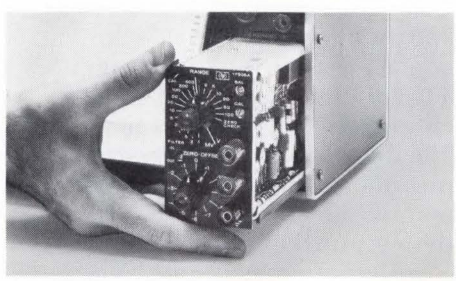
The displays cost $10 each in 1 K quantities, and are available from stock.

For more information, please check the HP Reply Card.

Increased sensitivity for 7100 recorders

One small input module increases the sensitivity of the 7100 Series recorders to 100 μV full scale. Just plug in the 17505A High Sensitivity Input Module; it measures input signal variations as low as 1 μV at maximum sensitivity. Your strip-chart recorder acquires a variable voltage span from 100 μV to 100 V full scale. There is even an optional calibrated offset capability in increments from one to ten, full scale. The 17505A costs $400.

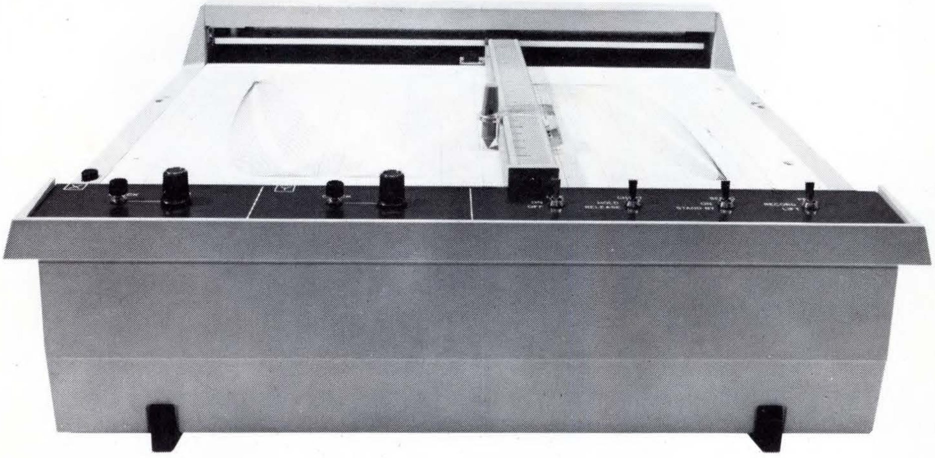
Interested? Just send your HP Reply Card.



HP 17505A plug-in for 7100 recorders.

OEM's get an x-y recorder of their very own

Forty OEM options include several X-Y range calibrations, metric scaling, a time base, an event marker that records in the top margin, rear connectors, and TTL logic control.



X-Y recorders used to be designed principally for laboratories; now, there is one designed specifically for original equipment manufacturers. The new 7040 does not require any special paper, calibration adjustment, or expensive maintenance.

The one-piece mainframe is die-cast aluminum—durable yet shock-resistant. The circuitry contains only ten hand-soldered connections—reliable and maintenance-free. The writing area is 10 by 15 inches (25 by 38 cm.) with an autogrip that holds 11 by 17 in. or international A3 size paper.

Accuracy is ±0.2% of full scale; linearity, ±0.1% of full scale. Standard features include a newly-developed hybrid potentiometer, disposable pens, 1 megohm input resistance, and 20 in./sec. minimum slewing speed. A new motor design on both axes lets the OEM recorder pen be driven offscale for an indefinite period of time without noise or damage.

The price, sans options, is $890.

For more information, check the HP Reply Card.

Set scope time bases as easy as 1-2-5

The HP 226A Time Mark Generator

When you need precise timing, the new HP 226A Time Mark Generator makes it easy to calibrate your oscilloscope and recorder time bases. With a room-temperature crystal that needs only ½-hour warm-up to give you 20 ppm accuracy (at 25°), the 226A generates one-volt markers (into 50 ohms) at 30 intervals ranging from 2 nanoseconds to 10 seconds and in a 1-2-5 sequence.

It's programmable, too, with an option that makes it operable in automatic systems.

The 226A costs $670. (For the programming option 003, add $150.)

To learn more about the 226A, just check the HP Reply Card.

18-40 GHz measurements with network analyzer

Now you can measure reflection and transmission coefficients—magnitude and phase—in the 18–26.5 and 26.5–40 GHz bands, using the new K8747A and R8747A waveguide test units for the 8410 Network Analyzer.

For full details on this much-needed high-frequency measurement capability, use the HP Reply Card.

OOPS!

That was some thermal recorder described in the last issue of MEASUREMENT NEWS. Unfortunately, its impressive specifications resulted from a typographic error. (We should have said 50 Hz and 100 Hz, instead of 50 MHz and 100 MHz.) Meanwhile, the HP 7414A is still a nifty performer.

computer hardware

FOR DESIGNERS OF COMPUTER MAINFRAMES, PERIPHERALS AND SYSTEMS

Inverting cell takes form

A CAHNERS PUBLICATION / FEBRUARY 15, 1972

The quiet one. Zero bounce noise.

This new flexing spring contact with four distinct current paths practically eliminates arcing line noise—makes Rowan's 2190E Mod A Relay ideal for power relay applications in place of or in conjunction with solid state circuitry where noise-free contact closure is critical.

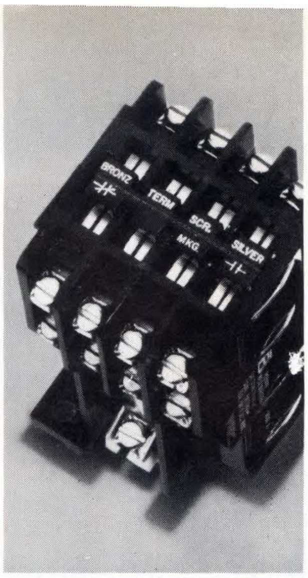
The Mod A provides a power relay of 10 amp—300 VAC with virtually zero bounce—less than 1 millisecond. Standard non-flexing contacts result in bounce exceeding 5 milliseconds on closing with each arcing bounce producing noise.

The quiet one represents a unique design concept in contacts. It's a double-break, bifurcated movable contact fashioned entirely of flexible spring silver. The industry's standard solid bar movable contact is normally made of heavy non-flexing brass with fine silver buttons.

Rowan's new Mod A Relay offers an extremely low contact resistance, a high fidelity (low energy) contact, while providing excellent resistance to accidental contact opening under vibration or shock. Independent tests show no contact malfunction, 0-5 KHz vibration, up to the machine test level of 6.5 g's.

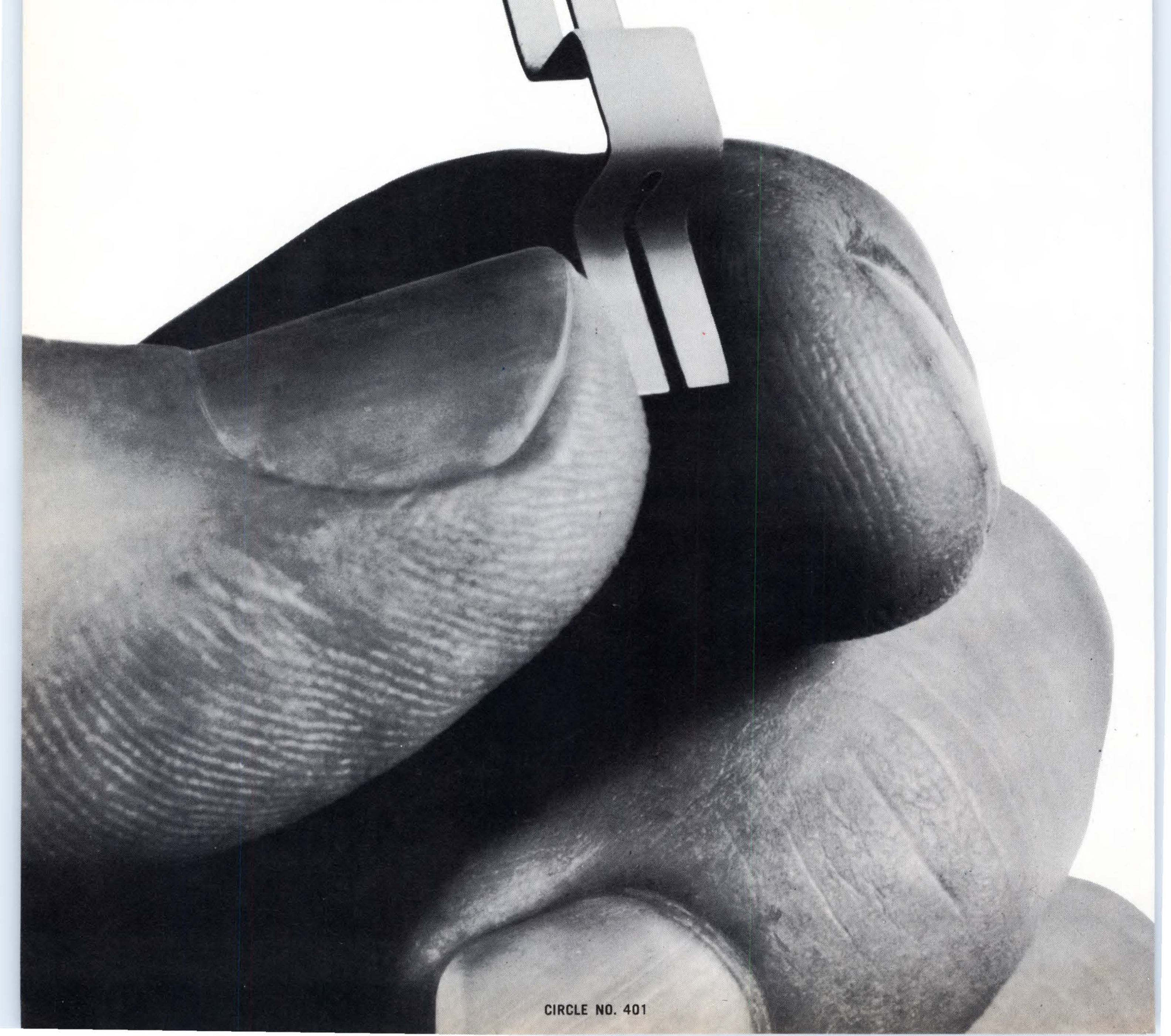
All these features are incorporated in the Rowan standard 2190E Mod A, 1 through 8 poles in combinations of N/O-N/C, plus solid state timer and latching version. Also available with gold flashed contacts for dry circuits. Another versatile relay in the tradition of Rowan Reliable Controls.

For further information, call your Rowan representative or distributor or write direct.



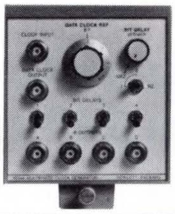
ROWAN CONTROLLER INC.
P.O. BOX 308, WESTMINSTER, MD. 21157
SUBSIDIARY OF I-T-E IMPERIAL CORPORATION

ROWAN

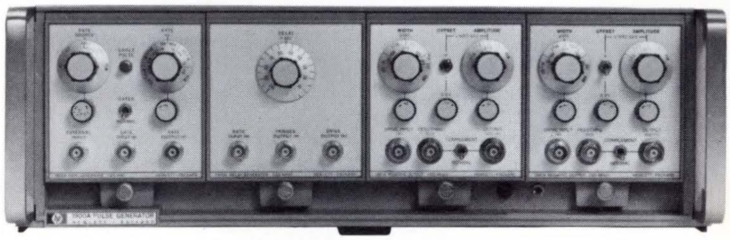


CIRCLE NO. 401

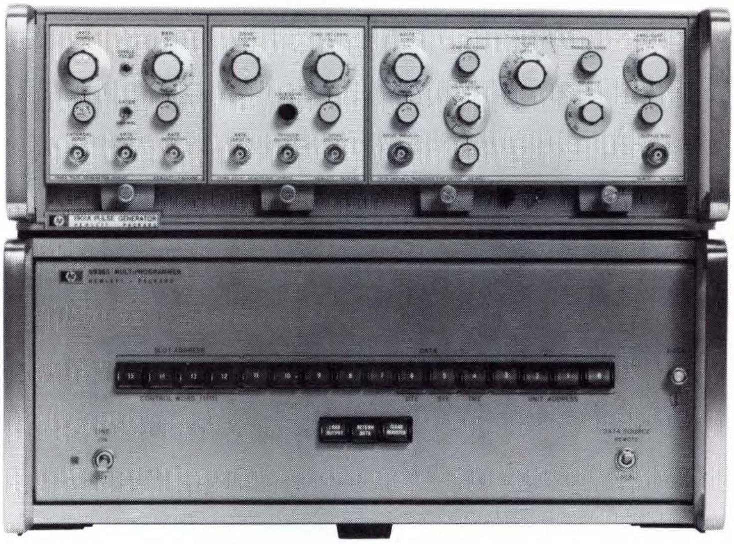
From HP—Three new dimensions in "pulser power"...



1. Multiphase MOS Testing
CIRCLE NO. 402



2. 125 MHz Capability
CIRCLE NO. 403



3. Digital Programmability
CIRCLE NO. 404

Hewlett-Packard's 1900 System, the pacesetter in pulse generation, now has three new capabilities that put it even farther ahead of all competitive pulsers.

1. Multiphase MOS Testing—The new 1934A Multiphase Clock plug-in lets you use the 1900 System to design and test MOS circuits with a minimum of effort. It gives you four-phase outputs to 12.5 MHz, or two-phase to 25 MHz...with variable phase pattern and variable phase overlap. The 1934A can be used with either high-threshold drivers (the 1915A) or low-threshold drivers (the 1917A); but the 1934A's price is strictly low-threshold...only $775.

2. 125 MHz Capability — Now, there are two 1900-System plug-ins that let you generate pulses at rep rates up to 125 MHz. The new 1921A (for positive pulses) and 1922A (negative pulses) are designed for testing fast T^2L and ECL logic—in computers and high-speed digital communications. Both have a fixed transition time of <2 ns, variable amplitude to 5 V, and variable ± 5V offset. Both have switch-selectable complement capability, plus feed-through pulse-adding capabilities and pulse shaping capabilities. And both are compatible with other 1900-System plug-ins such as the 1930A PRBS generator. Yet you can get either the 1921A or the 1922A for only $950.

3. Digital Programmability — Now, your 1900 System can be computer-controlled, for high-speed automatic testing applications... thanks to HP's new 6936S Multiprogrammer. Its 16-line parallel input lets you interface your 1900 System to a computer quickly and easily, using only one I/O slot...and the result is a fully programmable pulser system suitable for almost any testing or control purpose.

To tie together your 1900 System and the 6936S, HP provides an interfacing package (Option 005), which includes cables, program cards and software. This lets you assemble the combination of capabilities best suited to your own particular needs. For example, you can get the 1900 with three popular plug-ins (1905A rate generator, 1908A delay generator, and 1917A variable-transition-time output) *plus* the 6936S Multiprogrammer and interfacing option 005, for $5950.

For further information on any aspect of the pace-setting 1900 System, contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

081/15

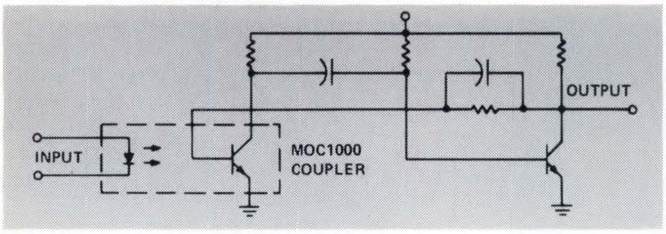
HEWLETT hp PACKARD

SIGNAL SOURCES

Isolate It Optically

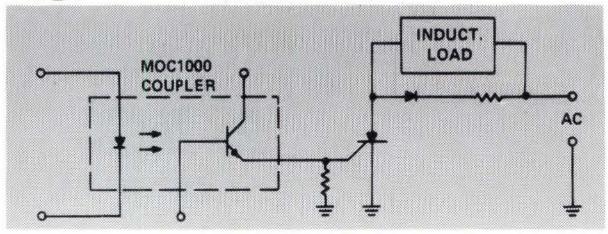
...solid-state lights on using the ideal switch — optoelectronic couplers

Pulse Stretcher



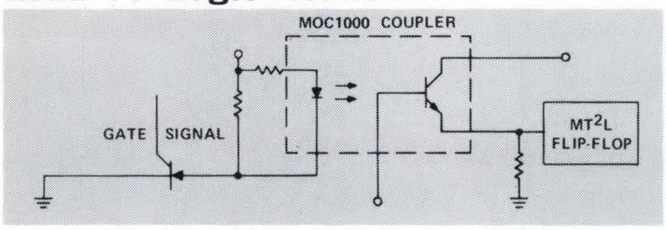
Very short input pulses can be adjusted to any desired pulse width in this circuit with the output completely independent of the input.

Logic-To-Load Translation



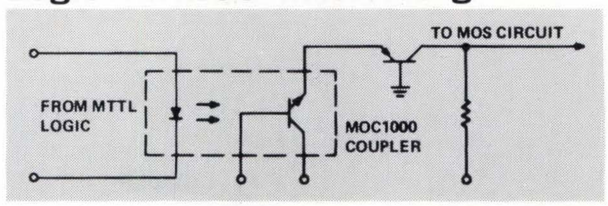
When the T²L gate input goes high, the SCR is activated and logic-to-load translation is achieved through optical coupling.

Load-To-Logic Translation



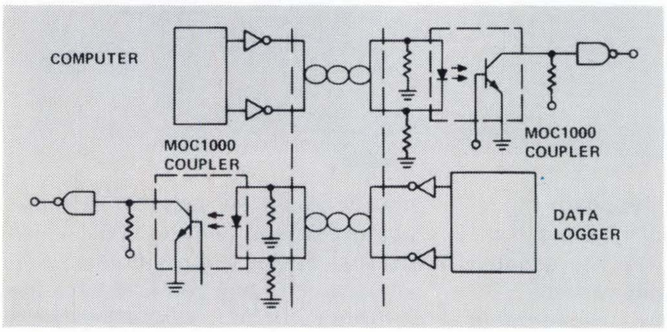
Monitoring an SCR-controlled load with an optical coupler provides a count of load operations each time the flip-flop is toggled through load activation.

Logic-To-MOS Interfacing



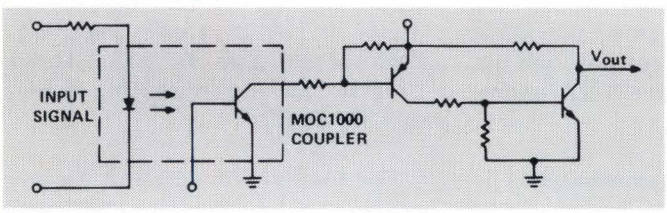
Easy interfacing between various logic forms (in this case T²L-to-MOS circuitry) can be achieved through optical coupling without regard to differences in logic swings.

Computer / Peripheral Interconnect



Couplers detect differential signals from twisted-pair lines and translate to single-ended output which provides complete ground-loop isolation.

Power Amplifier



Couplers amplify low-level logic to drive large loads and accomplish interfacing between logic power supplies and load power supplies.

Lights on: switch on. Lights off: switch off. Quickly. Simply. Reliably.

Optoelectronic couplers give you nearly perfect input/output isolation . . . 100 billion ohms. They afford 1,500 V minimum dielectric isolation. They provide 300 kHz typical frequency response and 60% typical transfer ratios. They furnish complex signal transmission without RFI at microsecond speeds. They offer low coupling capacitance: 1.3 pF typical.

They don't wear out, they don't use much power and they're immune to bouncing, arcing, shock and vibration. They're light, compact and have closed construction. They're IC-compatible and cost as little as $3.35, 100-999.

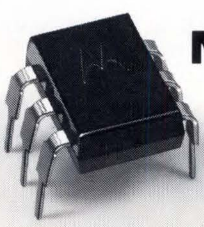
They're obvious replacements for mechanical relays.

Use them in interface and coupling systems, phase and feedback controls, amplifiers and general purpose switching.

To find out how, there's a new data sheet waiting through Box 20912, Phoenix, AZ 85036. Complete specs and a lot of applications information.

See your Motorola distributor or factory representative for prototype or production needs.

Lightly switch on today.



MOC1000 — the optoelectronic coupler

MOTOROLA OPTO
Let There Be Light

CIRCLE NO. 405

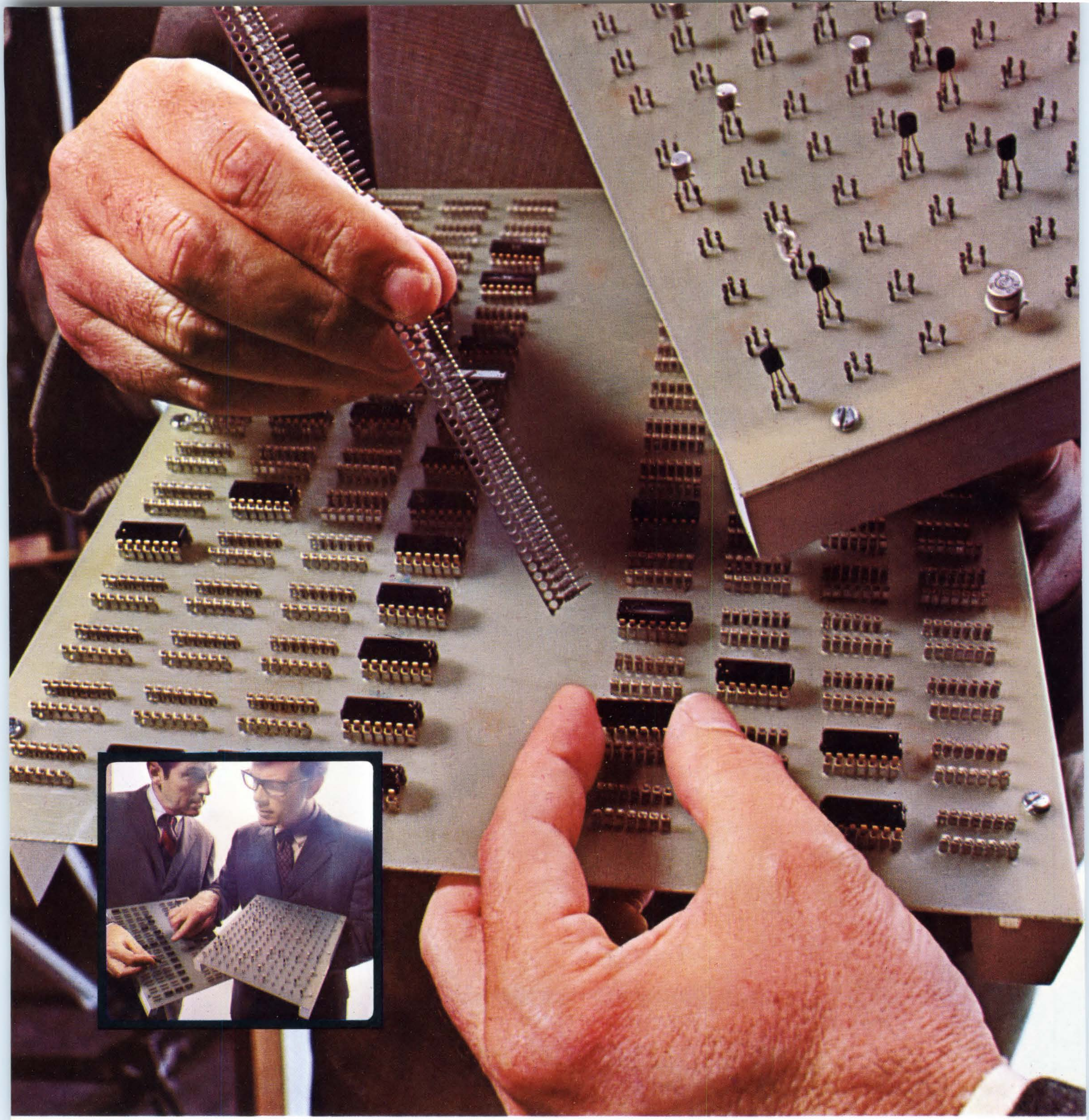
CONTENTS — FEBRUARY, 15, 1972

computer hardware

EXCLUSIVELY FOR DESIGNERS OF COMPUTER MAINFRAMES, PERIPHERALS, AND SYSTEMS

COVER

Cover photo furnished by Texas Instruments, Incorporated, depicts MOS/LSI photomasks produced by computer-driven mask cutters. This technique was used in producing the photomasks for the Honeywell RAM, as well as all TI MOS/LSI devices. See "Inverting cell conserves power in MOS RAM" on pg. CH 6.



HERE'S A NEW AND BETTER WAY: To make printed circuit board connections. Reliably. At low, low cost. They're Molex Soldercon® terminals. Integrated circuit and transistor terminals. Offering the convenience of plug-in I.C.'s and transistors *without* the cost of insulators. They fit directly on the board. And there is equipment available to do the job *automatically*. Fast! Soldercon terminals save time. Money. Speed installation. Make testing easier, too. And simplify service problems. It's another example of Molex ingenuity . . . in creating components that simplify circuitry. Molex has the know-how and facilities to provide the interconnecting system you need. You can make connections by calling (312) 969-4550. Or write . . . Molex Incorporated, Downers Grove, Illinois 60515.

. . . creating components that simplify circuitry

CIRCLE NO. 406

molex

M160

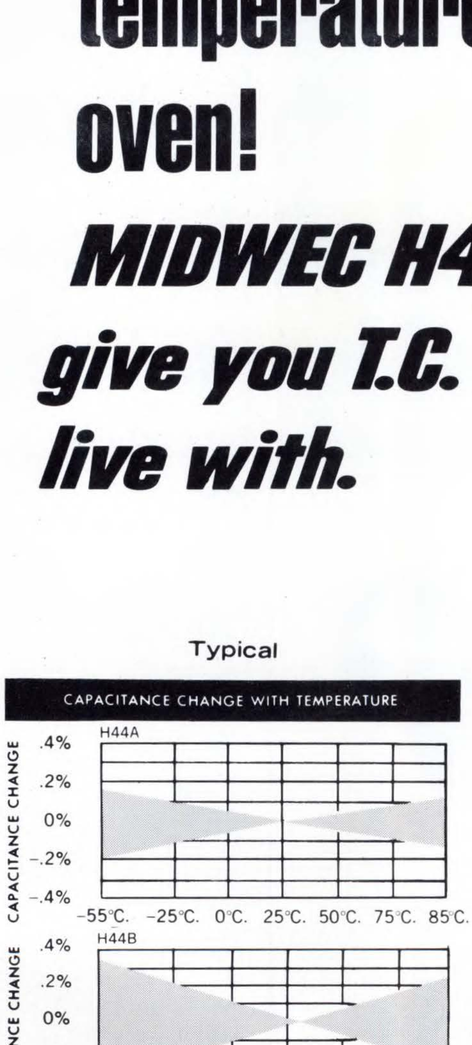
introducing

the end of the temperature compensating oven!

MIDWEC H44 CAPACITORS give you T.C. ratings you can live with.

H44A & H44B
FILM CAPACITOR

Typical



These new film capacitors achieve an almost zero temperature coefficient in the smallest possible physical size as a result of MIDWEC's exclusive design and processing techniques. Uniform performance of standard units is inherent because of the design and production procedures. Tighter TC than is shown in the charts at left can be attained on special order.

H44 capacitors are available in two standard TC ranges: H44A, ≦±20PPM/C°, and H44B, ≦±40PPM/C°. Capacitance range from .010 mfd to 1.0 mfd.

For complete data sheets, write to:

MIDWEC CORPORATION ®

MIDWEC CORPORATION
P.O. BOX 417
SCOTTSBLUFF, NEBRASKA 69361
Phone: 308/632-4127
A Subsidiary of Southwestern Research Corporation

CIRCLE NO. 407

Inverting cell conserves power in MOS RAM

A new 2K MOS RAM, developed by Honeywell, Billerica, Mass., utilizes the inverting cell concept to improve speed/power performance. A novel "circuit-come-logic" technique reduces storage power by a factor of two, and a different refresh method allows read cycles to be shorter than read/write cycles whenever refresh is not required.

The inverting cell is shown in **Fig. 1**. The Digit/Sense bus (D/S) is always precharged to -11V by $\Phi1$ prior to a read, write, or refresh cycle. Driving the $\Phi2$ bus performs a read operation and $\Phi3$, a write operation. If a logic "1" is stored on C_1 when $\Phi2$ is pulsed, the C_2 potential on the D/S bus will discharge through transistors R and S to V_{ss}, leaving the cell's complement ("0") stored on the D/S bus. Had a "0" been stored on C_1, transistor S would have remained OFF and C_2 could not have discharged to V_{ss}. Thus the cell's complement ("1") would have been stored on the D/S bus. A write is performed by pulsing $\Phi3$, which turns on transistor W, thereby storing the D/S potential on C_1.

A cell array of 2080 cells is arranged as in **Fig. 2**. One row × 32 columns is

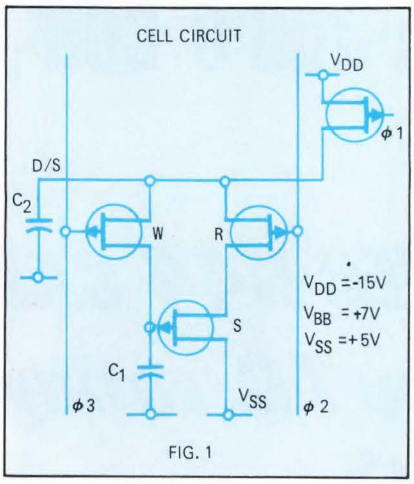


FIG. 1

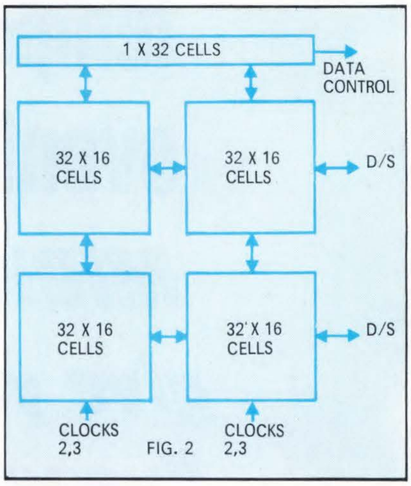


FIG. 2

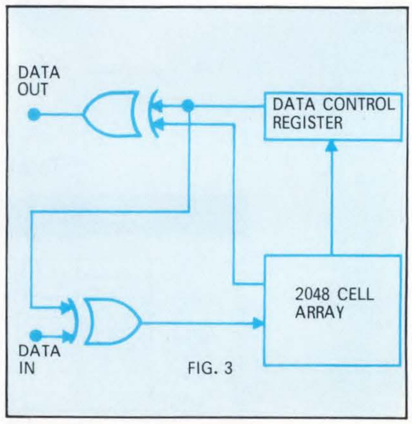


FIG. 3

electrically connected to form the data control register. Common connections for cells in a row are the D/S busses, and for cells in a column are the $\Phi 2$ and $\Phi 3$ clock busses. A cell is located by routing clocks to only one column and by multiplexing one D/S bus.

During a read cycle the stored data's complement is written on the D/S bus and then read out; however, in a read-refresh cycle the data is left on the D/S bus so that when $\Phi 3$ comes up after $\Phi 2$ ends, the data complement is written back into the cell — hence the term "inverting cell".

Since an entire column will invert each time it is addressed, column status must be monitored. This is done by utilizing the data control cells.

One data control cell will invert each time a column is addressed. If this data is exclusive OR'ed with either the appropriate stored data or input data, as in **Fig. 3**, the correct data will be either stored or read. In this manner a logic "1" in the data control cell (as shown in the truth table below) says that the addressed column is inverted; thus, the data complement will either be stored or read out.

TRUTH TABLE

READ CYCLE

DATA STORED	DATA CONTROL	OUTPUT DATA
0	0	0
0	1	1
1	0	1
1	1	0

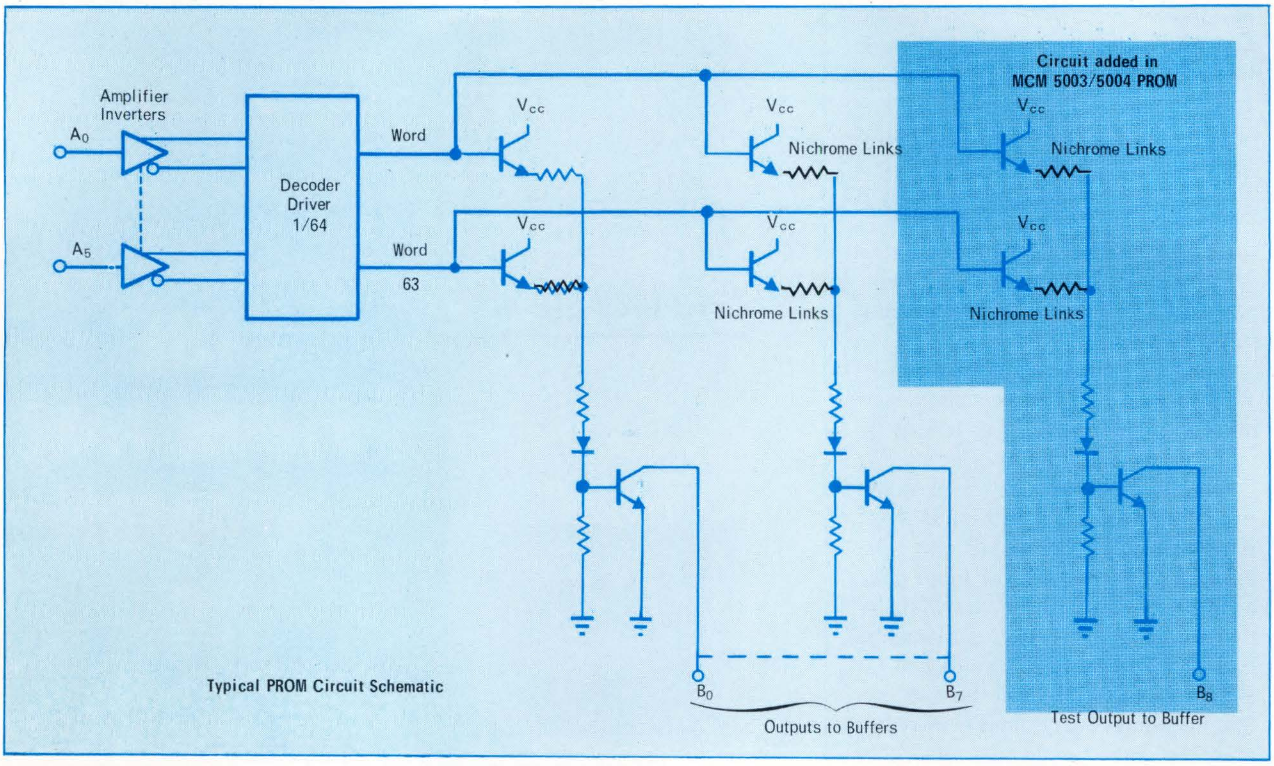
WRITE CYCLE

INPUT DATA	DATA CONTROL	DATA STORED
0	0	0
0	1	1
1	0	1
1	1	0

Test bits increase customer yields for field programmable ROMs

Field programmable ROMs have proven to be a powerful new tool for design engineers, especially in such areas as microprogramming. The programmable ROM eliminates the 4- to 8-week turnaround time required for mask programmed ROMs, and allows a user to stock only a few standard devices, which can be custom programmed as required.

If there has been a major drawback in the PROM concept, it was in the



Typical PROM Circuit Schematic

testing of unprogrammed devices. Acceptance testing had been, in essence, accomplished by the customer – after he had programmed the device.

A number of defects can elude detection in unprogrammed ROMs – such as, collector-emitter spikes, metal shorts, and emitter base shorts, which may not be detected until the ROM is programmed. Motorola's solution to the problem is an additional 9th bit in each word line of the MCM 5003/5004 PROMs. These 512-bit memories are organized into 64, 8-bit words, plus a test bit. The test bits are also physically located on the chip to provide worst-case propagation delay, thus making them doubly useful in testing. Sixteen of the test bits are mask programmed to have open links. This allows meaningful dc tests at the wafer-probe stage.

After packaging, another 16 bits are programmed for final testing in the same manner as the customer would program them. Final testing provides data on nichrome quality and word driver capability under actual programmed conditions. The customer receives his parts with 32 unprogrammed test bits which can be utilized in testing both the ROM and his own programming procedures.

Additionally, the MCM 5005 (a 1024-bit PROM), currently under development at Motorola, is manufactured as a 33 × 33 array to provide in-house test capability. However, the user will have access only to the main 32 × 32 array.

Black tin oxide process coats computer frames

Black tin oxide is no longer a mere decorative finish. Now computer frames are being finished with an improved black tin oxide process which produces a low-cost, uniform surface having high electrical conductivity and superior resistance to corrosion.

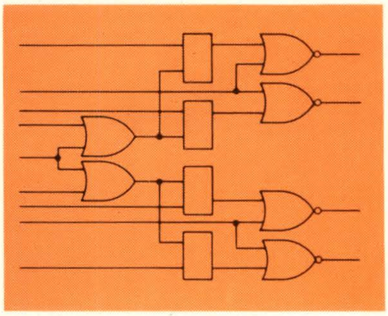
The improved process was developed at IBM's systems development laboratory in Poughkeepsie, N.Y. In it, the tin surface is anodized in a phosphate bath to produce the black color. This step also creates microscopic fractures on the nodular tin surface. The coated part is then dipped in unsaturated oil, drip-drained, and baked at 300°F for 30 minutes. This seals the microscopic surface fractures, provides superior corrosion resistance and produces an even, black matte finish that resists fingermarking.

Unlike most metal oxides, black tin is a good electrical conductor. Engineers found that sealing the surface with unsaturated oil also lowered the finish's contact impedance to less than 1 ohm. Samples of the improved finish, after accelerated 5-year tests, showed no degradation of conductivity. This makes the finish particularly suitable for computer frames which must be grounded to form an electrical shield.

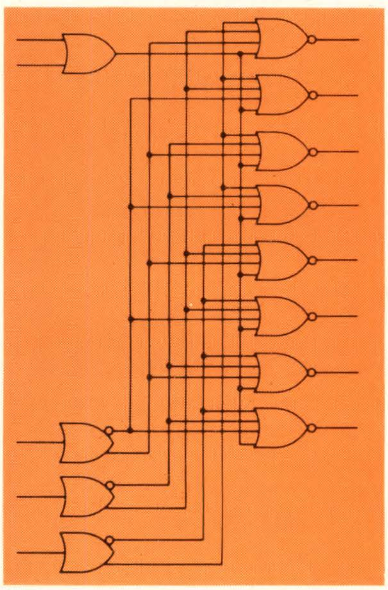
The black tin oxide finish is cost competitive with painting. No buffing or other finishing is needed. The finish is applied in under 1-mil thicknesses, and evenly covers complex geometries. Black tin oxide also demonstrates excellent adhesion.

Systematic savings through...

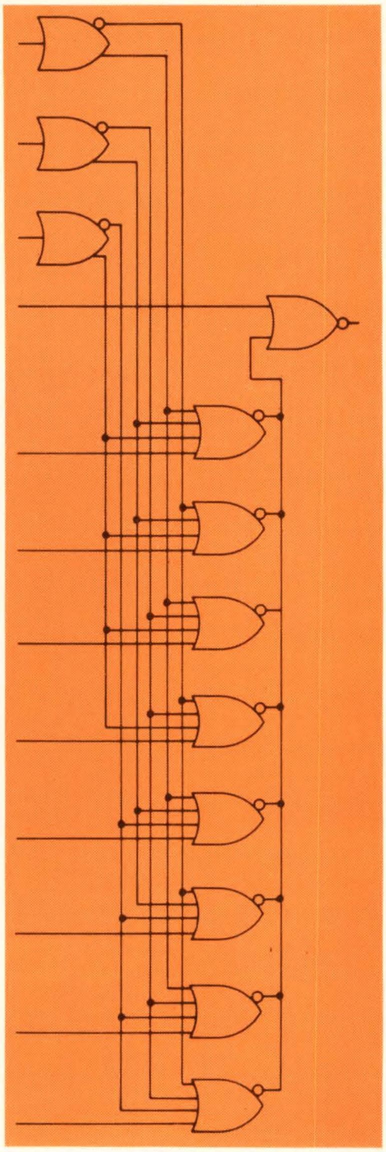
Up to this point we have stressed the increased system performance offered by MECL 10,000. Now let's consider system savings. As data processing systems become smaller and faster it is necessary to evaluate the effect of MSI approaches that will reduce package count and shorten processing times. Here ar four new MECL 10,000 MSI func tions that illustrate savings that ca be expected.



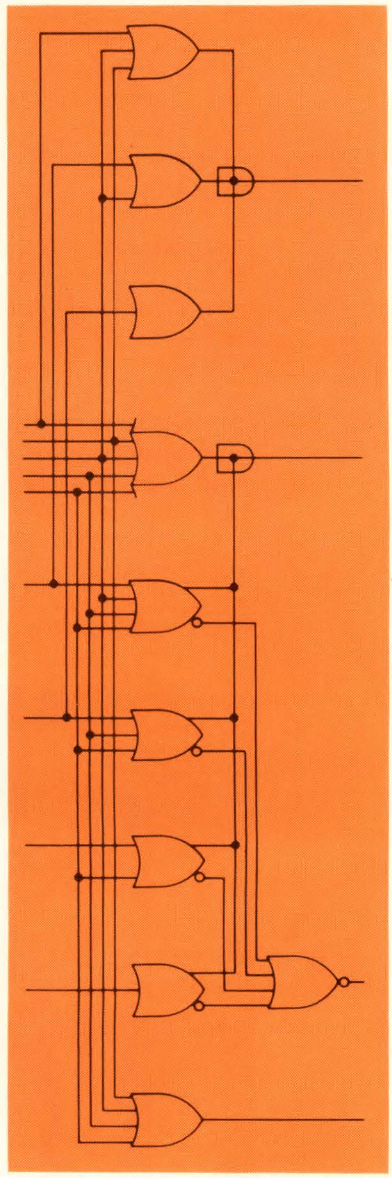
MC10133 Quad Latch — Consists of four bistable latch circuits with D type inputs and gated Q outputs. Latch outputs are gated, allowing direct wiring to a bus. All four latches may be clocked at one time with the common clock, or each half clocked separately with its own clock. Useful as a temporary storage element in high speed central processors, accumulators, register files, digital communication systems and instrumentation.



MC10162 Binary To One-Of-Eight Decoder — Decodes a three bit input word to a one-of-eight output. A high level on either enable forces the outputs low. Features true parallel operation; ie, propagation delay from every input to any given output is the same, eliminating unequal delay times found in other decoders. Allows easy expansion of memories or other computer addressable functions, and can be used as a data distributor.



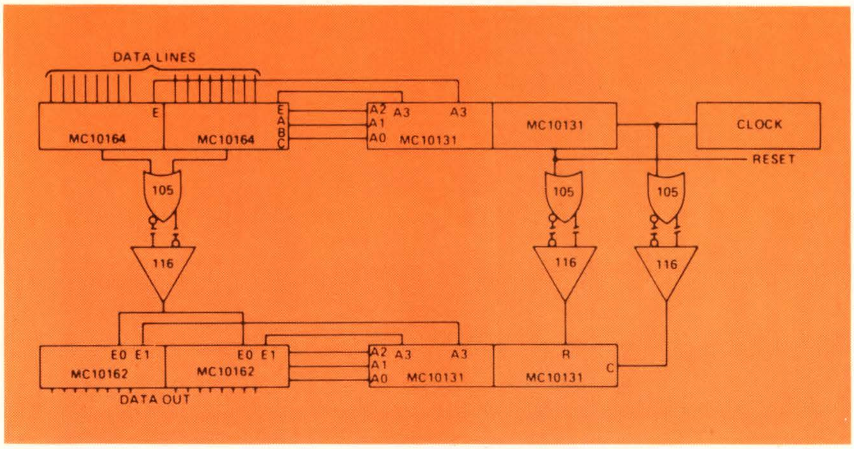
MC10164 8-Line Multiplexer — For use wherever data multiplexing or parallel to serial conversion is desirable. Full parallel gating permits equal delays through any data path. The output incorporates a buffer gate with eight data inputs and an enable. A high level on the enable forces the output low. The MC10164 can be connected directly to a data bus due to its open emitter output and output enable.

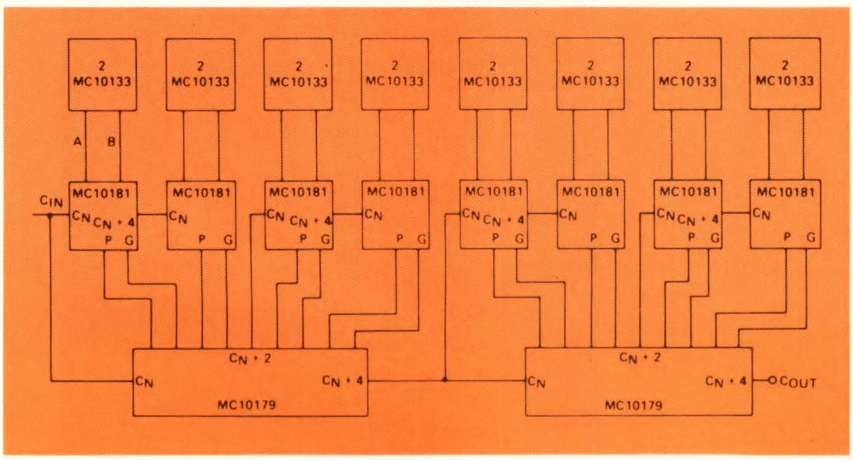


MC10179 Lock-Ahead Carry Block — A powerful MSI function consisting of 10 low power gates internally connected for the look-ahead carry function. Recommended for use with the MC10181 4-Bit ALU, or the MC10180 Dual Arithmetic Unit, to accomplish high speed arithmetic operations on long words. Highly useful for reducing system package count for the function generation of several variables.

MECL 10,000 designs

.et's look at typical applications; or example, this 16 line multiplex ystem utilizing the MC10164 and MC10162. Two MC10164's are used o multiplex 16 lines in to 1 total lata line out. A counter using MC-0131 flip-flops generates an address code to step through the 16 data lines. The data line and clock signal are sent to a demultiplexing system at the receiving point. MC10162 decoders are used to demultiplex the serial data to 16 lines out. A counter using MC10131's produces the decode address and a reset line is provided to synchronize the counters to the proper initialization state.



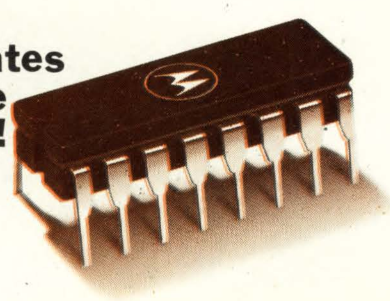


The system utilizes twisted pair transmission lines to send data. The MC10105 Triple OR/NOR Gate generates complementary output signals which are received by the MC10116 Triple Line Receiver. This system is capable of 150 megabit operation resulting from MSI advantages of less circuit delays and fewer circuit interconnects.

The adjacent illustration shows a typical 32-bit arithmetic processing subsystem comprised of a dual rank 32-bit storage register using the MC10133 Quad Latch with gated outputs. The clock to output delay is typically 3.5 ns with the gate or strobe delay of only 2 ns. With this approach, addition of two 32-bit words is improved from 30 ns with ripple-carry techniques, to 18 ns by using two MC10179 Look-Ahead Carry Units. Arithmetic operation times may be significantly reduced for words with larger bit counts by the simple addition of the MC10179 to the arithmetic operation.

These are a few ways that MECL 10,000 can offer systematic savings through new MSI techniques. For further specifications write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036. And for immediate evaluation call your nearby Motorola distributor.

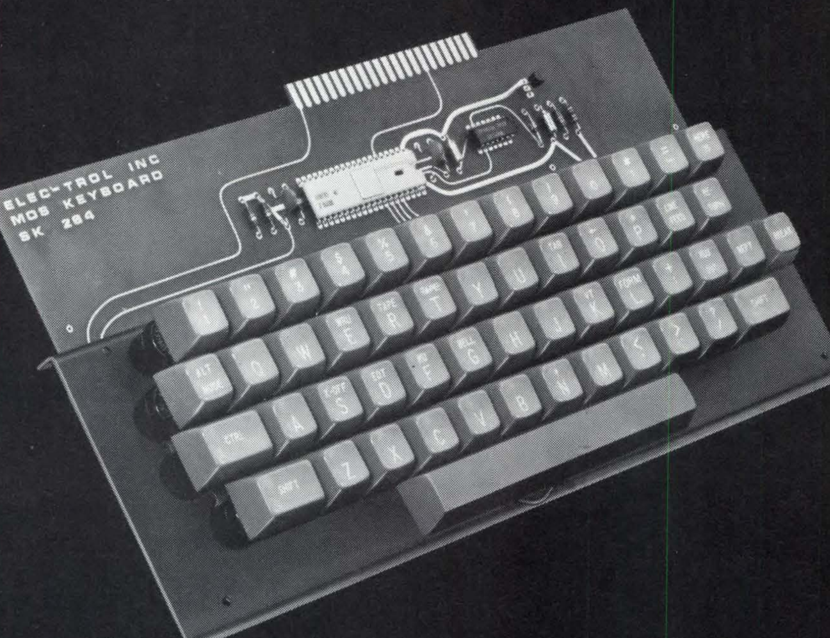
MECL 10,000 eliminates the alternatives. Evaluate and compare!



MOTOROLA MECL

. . . for faster computers & systems

CIRCLE NO. 412



MOS KEYBOARDS & DATAKEYS

MOS KEYBOARDS PROVIDE THE FOLLOWING OPTIONS:

- **ASCII Coding**
- **Custom Coding**
- **Multi-Key Roll-Over**
- **Interlock**
- **4 Mode Shifting**
- **Delayed Strobe**
- **Odd or Even Parity**
- **Repeat Function**
- **Output Latching**
- **TTL/DTL Compatibility**
- **Low Power Consumption**
- **Plug-in Code Changeability**
- **Wired-OR Capability**
- **Design Simplicity**

CUSTOM KEYBOARDS can be designed to your exact requirements using MOS or TTL logic circuitry.

DOUBLE SHOT LEGEND BUTTONS are available in a variety of sizes, colors and legends. Specials can be made to order.

RIGIDLY CONSTRUCTED ELEC-TROL KEYBOARDS employ a metal mounting panel to support the SNAP-LOCK DATAKEYS, thereby protecting the PC Board from operating stresses.

Phone, wire or write:

ELECTROL

26477 N. Golden Valley Road
Saugus, California 91350
Phone: (213) 788-7292
(805) 252-8330
TWX: 910-336-1556

DATAKEYS ARE AVAILABLE INDIVIDUALLY allowing you to manufacture your own keyboards and arrays. These units employ a hermetically sealed contact providing a minimum of 20 million operations from low level to 10 watt loads.

SNAP-LOCK DATAKEYS are particularly suited for data terminal keyboards:

- Touch, feel and stroke
- Ease of Assembly
- No mounting hardware required
- Internal diodes available

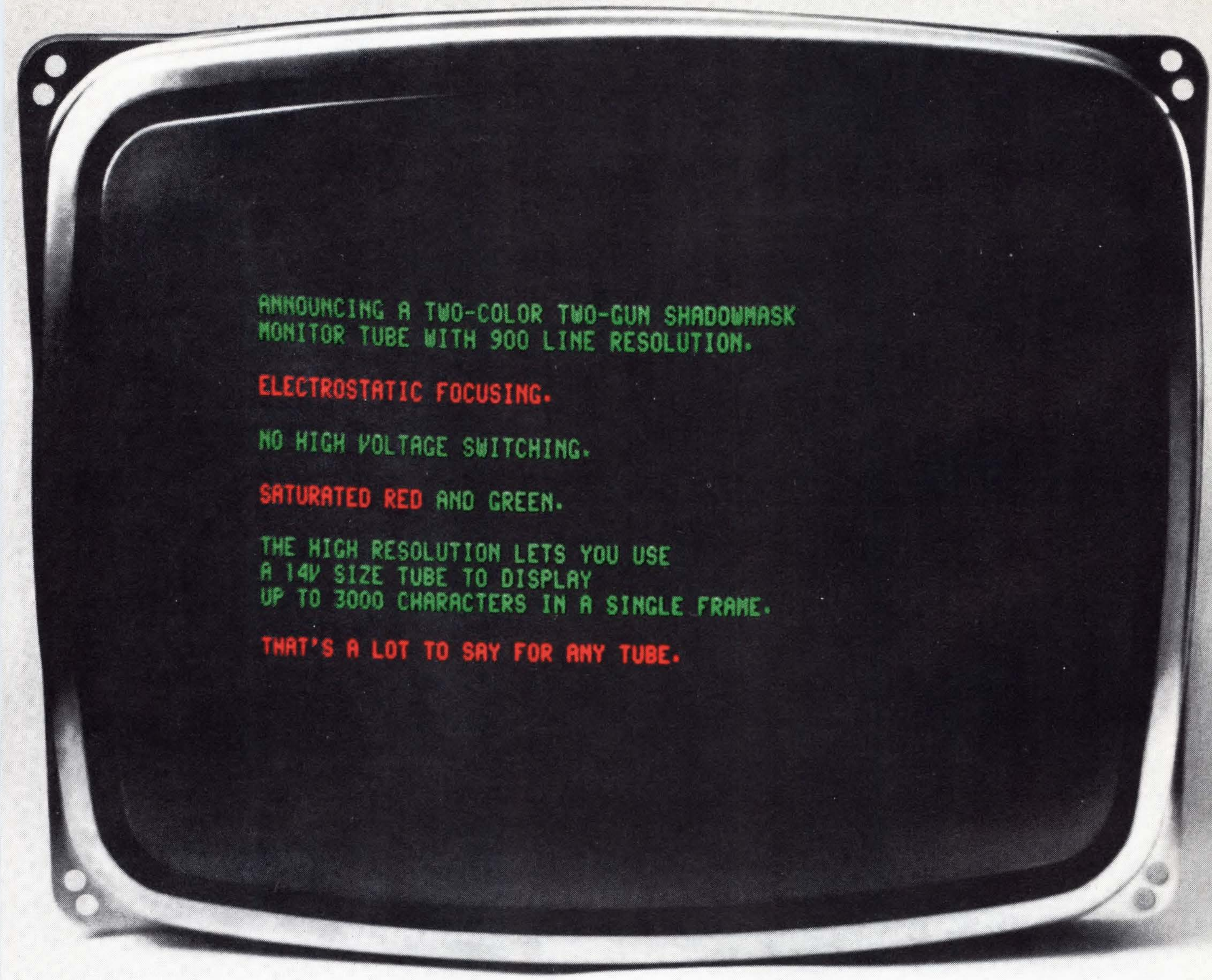
LOW-PROFILE DATAKEYS are designed for calculators, portable equipment or wherever minimum height is required:

- .750″ overall height
- Short Stroke
- Ease of Assembly
- Mounts directly on PC Board

KEY ARRAYS employing either **SNAP-LOCK** or **LOW-PROFILE DATAKEYS** are available. Custom arrays can be furnished to your exact requirements.

Reshaping concepts in electronic components and systems!

CIRCLE NO. 413


ANNOUNCING A TWO-COLOR TWO-GUN SHADOWMASK
MONITOR TUBE WITH 900 LINE RESOLUTION.
ELECTROSTATIC FOCUSING.
NO HIGH VOLTAGE SWITCHING.
SATURATED RED AND GREEN.
THE HIGH RESOLUTION LETS YOU USE
A 14V SIZE TUBE TO DISPLAY
UP TO 3000 CHARACTERS IN A SINGLE FRAME.
THAT'S A LOT TO SAY FOR ANY TUBE.

Microprogramming leads to an efficient virtual computing system.

Here is one way to implement a virtual computing system. The approach saves main memory space, speeds operations, and requires no special operating system monitors.

J. Kjell Hovik and Winston W. Hodge, International Peripherals and Computer, Corp.

There are several nagging problems inherent in today's large multiprogrammed computing systems. One is the tremendous overhead and machine inefficiency which occur with software systems, and another is simply insufficient main memory. One answer is the virtual concept—a configuration which permits programs to be written as if virtually unlimited storage was available. This system reduces overhead and provides complete transparency to operator and peripheral equipment.

An idea evolves

Even in single-program computers, programmers find themselves with routines that cannot be accommodated within the main memory. Superimposing program subroutines and swapping defined program space from main storage to disc was developed to reduce the problem of insufficient storage. Referred to as "core swapping," it is more specifically defined as a technique whereby primary information currently stored in main memory is exchanged with updated information in a backup or secondary storage. During swapping, programs and/or data are moved from primary to secondary storage to allow the transferring of the newly required information to the primary storage. Normally, the resident software performs the swap; thus, it is transparent to the user.

The concept of swapping evolves into the concepts of page exchanging or paging. Swapping refers to program overlays where the overlay size is not well defined. In paging schemes, all program and data storage requirements are divided into pages. Therefore, a certain number of pages make up a program. If the number of pages exceeds the main memory capacity, a paging routine in the system supervisor is called, and then only the required pages for a valid program operation are transferred into the main storage. In a large multiprogrammed system, many users' programs may exist simultaneously in memory. If main storage is insufficient to handle these separate programs, then the total program space is subdivided into pages. Therefore, paging can be performed on multiple simultaneous programs, with the total program space consisting of primary and secondary storage.

Primary storage is the main storage of the central processing unit (CPU), and the secondary storage generally is disc file or drum. This combined storage (primary and secondary) is called the virtual memory.

When the same system has both multiprogramming and a virtual memory, then each programmer appears to have complete control of the machine. The organization of data in **Fig. 1** illustrates how this occurs. This apparent machine is designated a virtual machine, and several virtual machines are referred to as a virtual system. Fundamental to the virtual system approach is core swapping or paging.

Virtual concept takes form.

Attaining certain design goals effectively requires a virtual memory and paging. These goals include:

—A virtual system must accommodate several operator control consoles, either local or remote to the computer. Each console must give the programmer or operator the appearance that he is in sole possession of the computer.

—Basically, the system should be a multiprogramming, batch processing oriented system capable of handling 16 to 200 simultaneous users.

—Each virtual machine must have a reasonable response time under worst-case loading conditions.

—The system should be flexible to permit, without any programming effort to the operating system, a change in the number of virtual machines within the virtual system.

Developing a practical virtual system requires the host CPU to have certain hardware features for proper control by the supervisor and to avoid excessive software overhead. These features include:

—Identical instruction set for the virtual machine and virtual system so that the machine can directly execute nonprivileged instructions.

—A virtual system must distinguish between privileged and nonprivileged instructions. A firmware supervisor must be aware of any attempt by a virtual machine to execute a privileged instruction or to change its operational mode.

—Main storage for the basic operating system must be protected from the various virtual machines.

—There must be complete isolation between virtual machines.

—All virtual machines should share common operating systems so that each virtual machine will not require redundant system operating monitors.

—Each virtual machine should have a virtual diagnostic program so that any machine can run diagnostics without interfering with other virtual machine operations.

—No special operating system should be required. The virtual machine concept should be microprogram controlled to increase the system efficiency. However, costly software support for this function is not tolerable.

Because the capacity of the main storage is insufficient for all users' virtual memory, the system employs the paging scheme. The virtual main memory is divided into 4096 byte blocks, designated pages. Only the currently active pages (such as those in current use) remain in the main

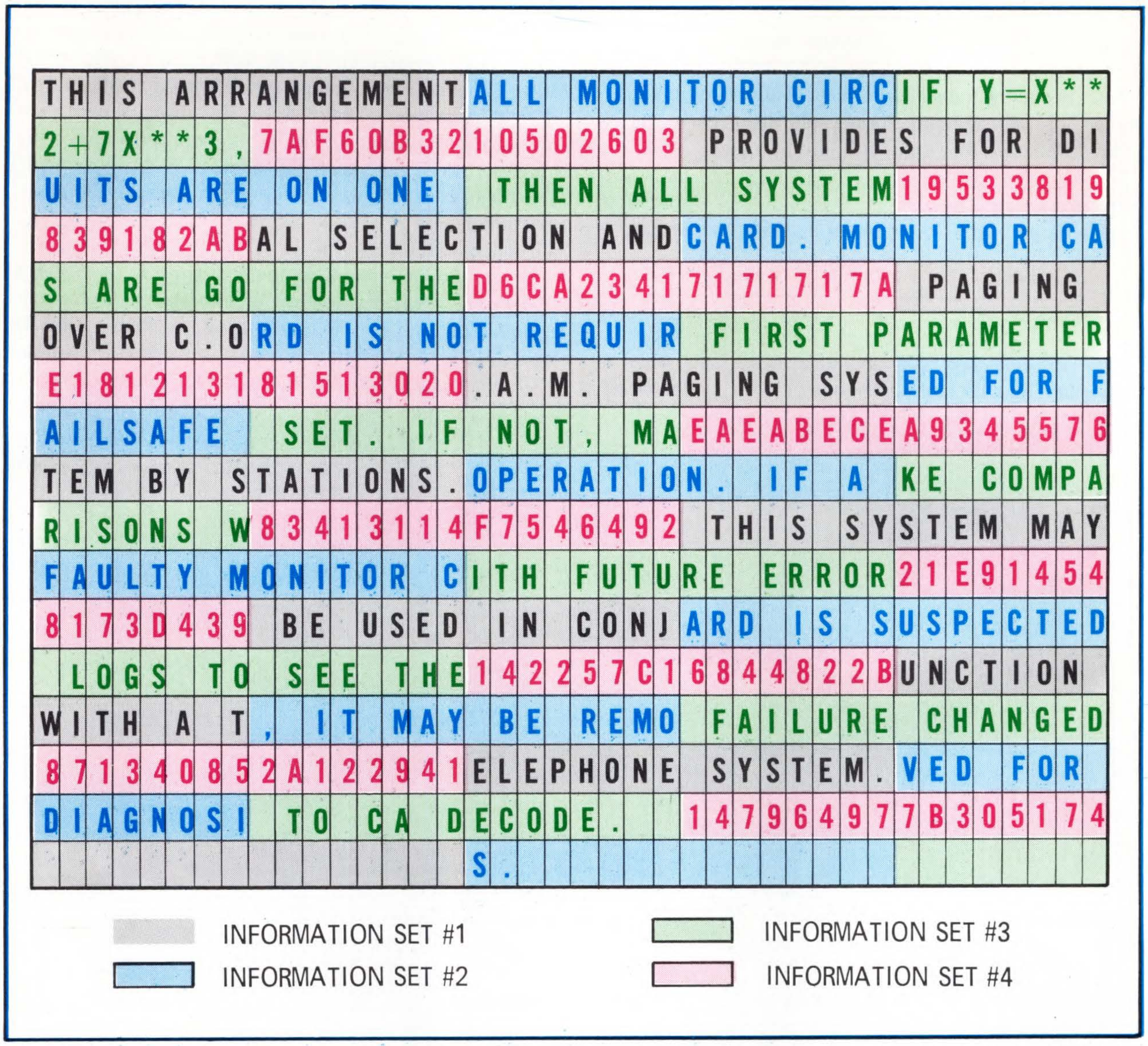


Fig. 1 Organization of data in the main storage of the virtual computer machine. The four different colors indicate four different users are using the machine simultaneously, without being aware of one anothers' presence on it. Data is organized into 16 byte information sets on a 40 byte memory field. As many as 200 users' data could be interleaved in the same manner.

storage, while the others are maintained in secondary storage. The activity of the pages is monitored and as a page falls under the inactive category, it is swapped with another page in the secondary storage. This swapping is transparent to the virtual machines, programmers, and operators. A paging routine in firmware determines which pages should be swapped, and part of the paging routine is the paging algorithm.

The paging algorithm is divided into two parts – analysis and paging routines. The analysis routine controls the processor whenever a paging queue occurs. This routine, using a special hardware analysis function, determines all pages involved in the execution of the instruction generating the interrupt. The analysis routine then determines which required pages are not resident in memory and builds a stack containing all information required to bring them into memory. Finally, the analysis routine enters the task that generated the interrupt into the paging routine's queue.

When the analysis routine terminates, the paging routine gains control of the processor whenever the disc responsible for paging detects an I/O termination or when that disc file is idle.

The scheme that accommodates the virtual storage concept whenever the storage addressing capability exceeds the main storage alone is called *dynamic address translation*. This approach, usually microprogrammed, obtains its relocation tables from an extended local storage. When dynamic address translation is activated, all storage addresses originating within the processor (except for hardware generated addresses) are subject to translation.

Virtual storage is divided into user identification numbers (UID) and pages, with a page table for each UID. To locate 4096 bytes of data in core storage, the dyanmic address translation microroutine references a UID table entry and page table entry in a two step process.

Prior to initiating the task process, the UID table location is entered into one of several control registers – the UID table registers. Actually, this is a specified area in the extended local storage. The UID table contains an entry for each UID number called for by the task, and each UID table entry designates the page table location. Each page table lists the 4096 byte units (pages) of main storage where data or instructions relevant to a task are located, and each page table entry designates the physical location of a page.

To expedite the translation of logical addresses in virtual storage into actual main storage addresses, each logical address is divided into four fields, as illustrated.

USER IDENTIFICATION NUMBER (UID)	PAGE	BYTE	CONTROL FIELD
4 bits	8 bits	12 bits	6 bits
0	4 11	12 23	24 29

The UID field serves as an index to the UID table. A corresponding UID table entry points to the main storage location of a page table. Page field is an index to the page table. The corresponding page table entry contains the address of the main storage block related to the virtual storage page under translation. The displacement field undergoes no change during translation and reduces the translated main storage block address to the byte level. The control field contains information necessary to attain efficient paging.

Virtual system takes form

Most third-generation computer architectures (See **Fig. 2**) employ a virtual memory or virtual system concept. Special op codes are microprogrammed within a software operating system monitor and exist as resident firmware in a system to adapt software to the virtual memory concept.

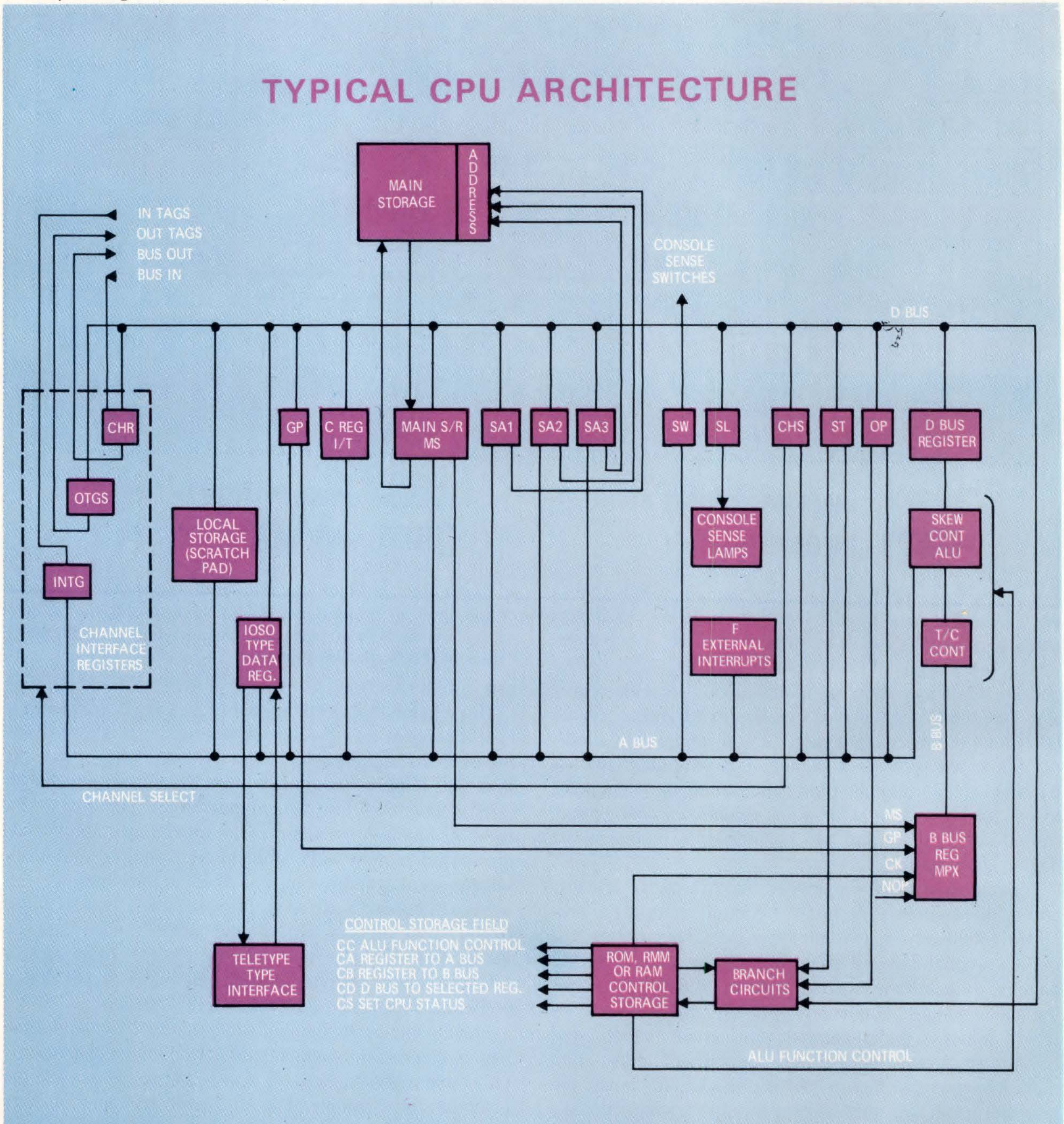


Fig. 2 Typical CPU architecture of a third generation computer depicts the main frame building blocks and method of interfacing main storage, local storage, and I/O devices via standard channels. As shown, it can accommodate virtual computing systems as implemented by special microprogramming.

For example, IBM generated one new op code to accomplish their virtual memory system along with some hardware modifications. To speed up the transfer between the CPU and their associative memory box, a new SI type instruction was added to the System 360 repertoire. This associative memory instruction requires about 30 microinstructions and is a privileged instruction that can be used only in the supervisor state.

IBM achieves their virtual memory systems with some microprogramming or firmware assistance. However, substantial software support is required, and IBM actually "SIMULATES" a virtual memory system rather than "EMULATE" the virtual system concept with firmware. All paging and memory management, if built entirely under microprogram control, provides much more efficient machine operation, because emulation is more effective timewise than simulation. In addition, an emulated virtual memory system requires no special operating software. Third-generation architecture is used by IBM, and this concept is achieved with minimal hardware modifications.

Going from virtual to main.

In transferring data from virtual to main memory, microprogrammed matching algorithms perform the UID matching that provides dynamic address translation in real time. For a machine having 16 virtual systems, programming (in the local storage unit) stimulates a 16- by 16-bit associative memory. There is a 1:1 correspondance between the 16 words of the emulated associative memory and the 16 pages of the main memory.

Each word of the associative memory is divided into three fields. The first field is the user identification field that specifies the user ID number. Page address is the next field, and the last field represents the main storage location for the virtual memory data.

A microprogram loads the associative memory words. An instruction, such as the latest additions to the standard IBM 360/370 instruction set for generating the virtual concept, loads or assigns a user ID number to each virtual machine. The virtual address field of a given associative memory register in the local memory stores the page

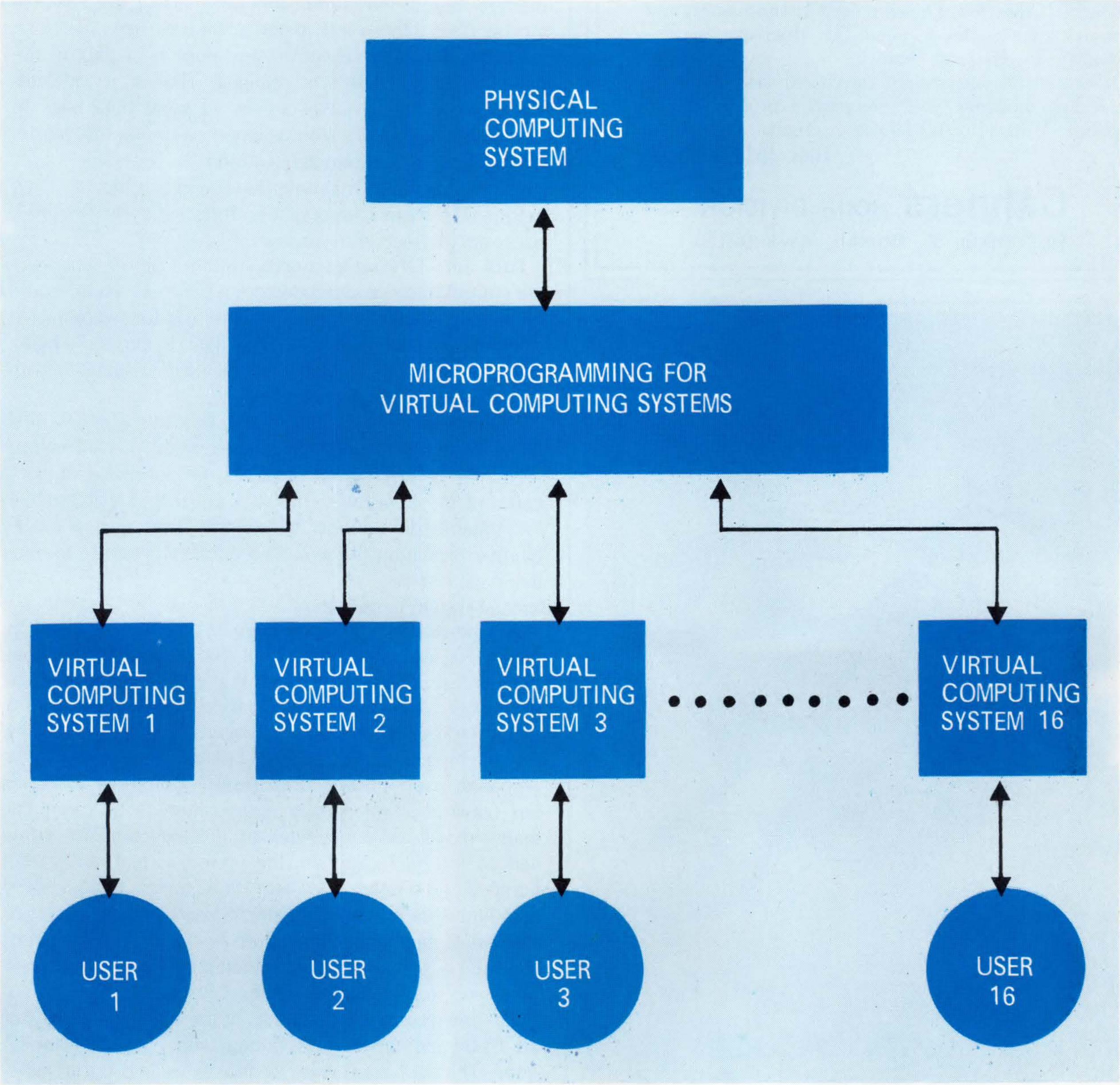


Fig. 3 A time-shared virtual computing system appears to the user as if he is the exclusive user of it.

number of the virtual page that currently occupies the physical page in main memory, which is located by that given associated memory register. The user ID field of a given associative memory register will store the user number assigned by the control microprogram for that particular user currently utilizing the physical page associated with that associative memory register. Six control bits form the control field. These bits help develop the various page replacement algorithms necessary for determining which page to replace when page swapping occurs. Page swapping takes place when the physical memory is full and a new page is called for. These six bits are:

Use bit—ON when a corresponding page has been used. When all bits are ON, the microprogram resets them, and a new cycle is initiated.

Activity bit—ON every time the corresponding page is used and reset only when the page is swapped. This bit enables the control microprogram to load main storage with pages that might be used. On execution, when the memory is full, the control program interrogates the activity bit to see if these anticipated pages have been used.

Change bit—ON whenever any portion of data in the page which it controls is changed. That is, it indicates whether it is or is not necessary to write data back in through the secondary storage when swapping that particular page. If data originated within the secondary source (such as a disc into main memory), and if it has not been modified in main memory, it is unnecessary to rewrite it back into the secondary storage.

Lock bit—ON under microprogram control whenever the control microprogram decides a particular page should not be considered as a possible candidate for swapping.

Transit bit—ON indicates the data is currently being swapped into or out of the actual page associated with that associative memory register.

Vacancy bit—one per word and indicates which words, and therefore which actual pages, are still vacant or unused. The microprogram indicates the address, in binary code, of the associative memory word that matches the interrogating data during the memory interrogation cycle. During translation this encoded address becomes the actual page address.

Virtual system in operation

A time-shared virtual memory system is illustrated in **Fig. 3**. An interesting fact about this configuration is that the microprogram regenerates the main storage address from both a virtual address in local storage and from a natural address in the main storage address register using the machine data flow and ALU. After the first address is prepared, main storage is addressed. Constants added to the previous main storage address generate subsequent main-storage addresses. After an allocated time, as specified by the microprogram, the present virtual machine is dumped and another is loaded. When the computer system is in time-sharing mode, the microprogrammed associative memory is interrogated each time a new address is generated. Then a new address is generated by the microprogram as a main storage address for the CPU.

The interrogating tag consists of the high order 6-bits of an 18-bit memory address along with the 4-bit user ID code. The user code was previously set into the associative memory by the microprogram. If a unique match occurs in coded 8-bit addresses, it is substituted for the original 8-bit virtual address. This encoded address and the original low order 12-bit address are then put on the memory address bus, and the cycle-initiate pulse is sent to the memory.

When in the time-sharing mode, if the microprogram determines there is no match, the control microprogram is informed that the virtual page being addressed by the current user is not in main memory. The microprogram, by interrogating the various control bits and the vacancy bits, determines the actual page to use for storing the required virtual page. Once the actual page is determined, the transit bit, that represents a particular page, is set ON, the appropriate I/O command is given, and the CPU control is then turned over to the next user.

If when in a time-sharing mode the microprogram indicates that more than one match is discovered during address translation (which should not occur) an error routine is entered and in-line diagnostics are run. A special place on the disc file system is employed for writing all diagnostic information that can be accessed by a customer engineer at the appropriate customer engineering service time.

The above description applies to the 360/370 system, and it is possible for an instruction to cross page boundaries while using the basic IBM 360/370 instruction set. Likewise, it is possible for the operands of certain instructions to cross page boundaries. The problem of what happens when an instruction or one of the variable operands crosses a page boundary and the next page is not in main storage must still be solved. A possible solution is as follows: When an instruction crosses a page boundary where the second page is not in main storage, it is possible to calculate through microprograming, the beginning address of the instruction being fetched. Also, since execution does not occur until the last part of the instruction is read from main storage, the restart problem is just a matter of starting the instruction fetch from the beginning, once the balance of the instruction is available. ▭

Authors Biography

J. Kjell Hovik, president of International Peripherals and Computer, Newport Beach, California, received his BSEE and MSEE from the Norwegian Institute of Technology. His previous experience includes president of Datapac, Inc., and manager of memory development at Varian Data Machines.

Winston W. Hodge, vice president and director of IPC, received his BSEE from Chapman College and is currently doing graduate work at UCLA and California State College. Mr. Hodge was previously director, Systems Division at Datapac, Inc., and holds three patents.

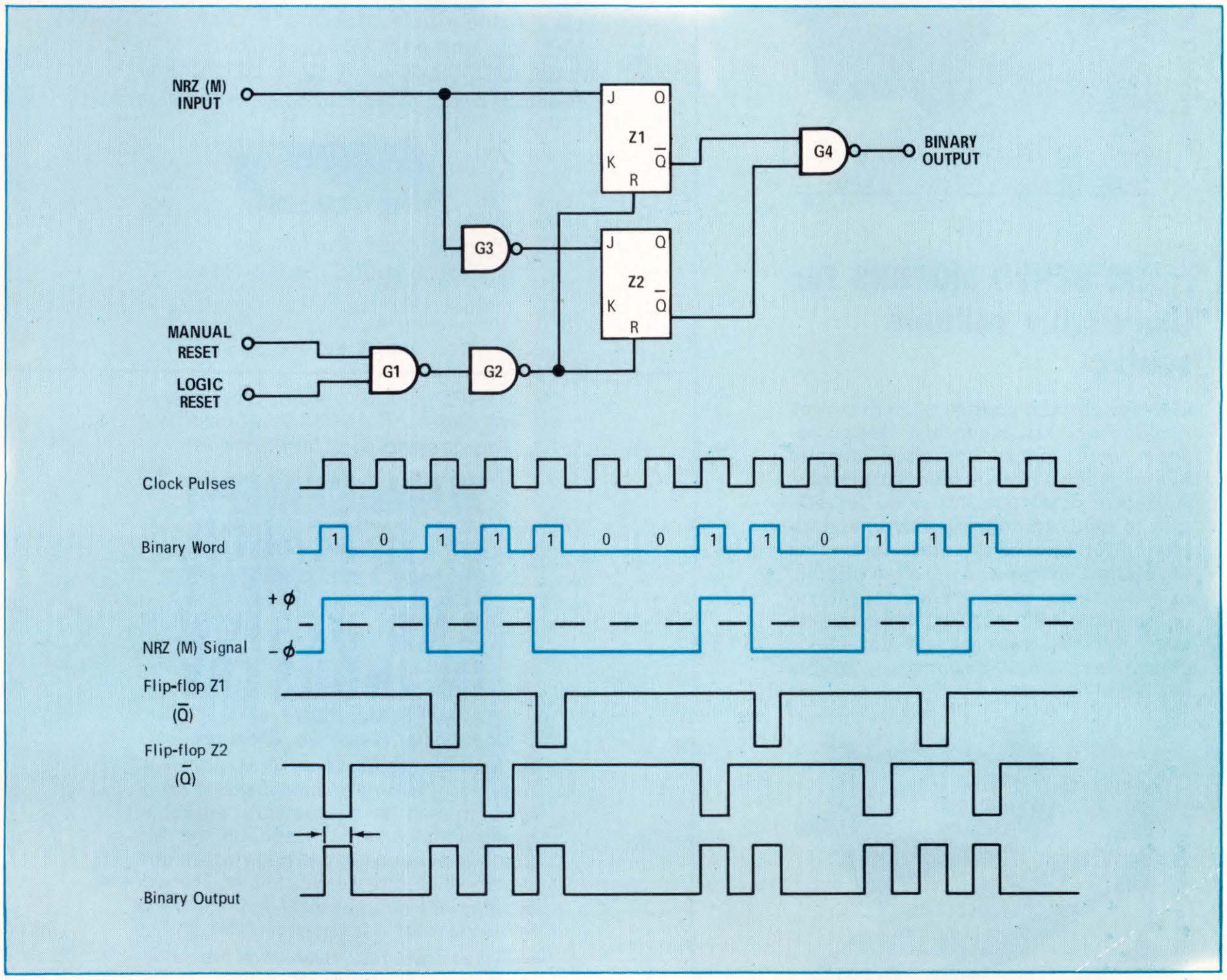
FOR A FREE REPRINT OF THIS ARTICLE, **CIRCLE NO. 480**

Convert NRZ(M) signals to binary with little muss 'n fuss

The translation of non-return-to-zero (mark) code to binary is a straightforward task and requires only a handful of ICs.

In NRZ(M) recording, magnetic tape is always saturated in one direction or the other. The reversal in polarity occurs each time a logic "1" of binary data is recorded. To process this recorded information, the data reduction system must convert the NRZ(M) code to the binary equivalent.

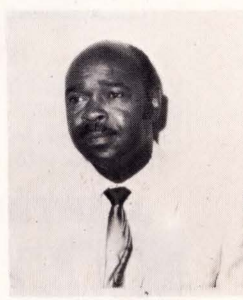
The timing diagram illustrates the NRZ(M) representation for the binary word 101110011011 1. The circuit shown converts only one track of recorded information, in other words a single circuit/track. Before a logic "1" (rising or falling edge) occurs, flip-flops Z1 and Z2 are reset either manually or externally by gates G1 and G2. (For multi-track applications the reset signal for all circuits



should originate at the same source.) Because the flip-flops react on the falling edge of a signal, Z1 toggles when the input NRZ(M) goes low and Z2 toggles when the input goes high. Consequently, either condition makes the output gate, G4, generate a high level.

This circuit is designed such that both flip-flops are reset 7.5 μsec after a set operation. Thus, the 7.5 μsec positive pulses on the output represent the logic "1" for the required binary information. Both flip-flops are WM 215 (J-K type) and all gates are NAND circuits.

Author's biography

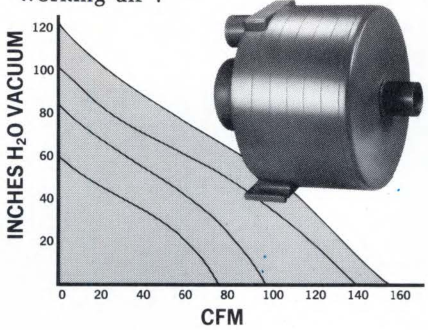


William W. Barber manages the design of test equipment in the Ordnance Systems Dept. at Westinghouse Electric Corp., where he has been employed for 16 years. Mr. Barber is a member of IEEE.

LAMB ELECTRIC OFFERS COMPUTER-ORIENTED PRECISION

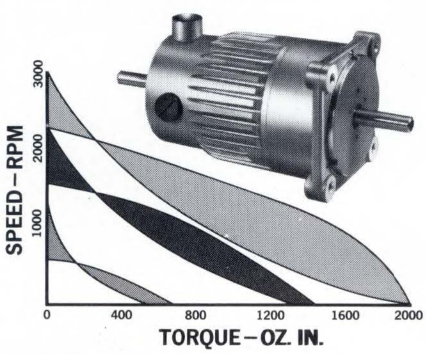
Windjammer® blowers for quiet, "working air"...

Motorized centrifugal blower systems provide pressure or vacuum, or both—economically. Wide range of operating characteristics can be obtained by modular "stages" of fan system. Units function in any position, are easy to install. APPLICATIONS: tape decks, office copiers, data terminals, and virtually any type of equipment utilizing "working air".



...DC SERVO MOTORS for thoroughly reliable control.

Lightweight and compact, Lamb servos respond quickly, smoothly. Design assures cool motor operation despite heavy cycling over prolonged periods. Armature diameters are small in relation to field, minimizing inertia and allowing for greater extremes in cycling of rotation, torque and speed. Available in wide range to suit your torque requirements. APPLICATIONS: magnetic tape drives, paper tape handlers, closed-loop servo systems, variable speed drives, etc.



For additional information, contact AMETEK/Lamb Electric, Kent, Ohio 44240
Telephone: (216) 673-3451

AMETEK / Lamb Electric

AMETEK

CIRCLE NO. 418

World's smallest

power supply for op amps...$14

This 2.3 x 1.8 x 1-inch module has tracking outputs of ±15 V @ 25 ma with regulation of ±0.1% and ripple of 1 mv. It costs $14.00 in 1,000 lots and only $24.00 for one. Requisition Model D15-03. (For ±12 V @ 25 ma, order Model D12-03.) Three-day shipment guaranteed.

Acopian

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

CIRCLE NO. 419

A REQUIRED *volume for every manager of an R&D laboratory, engineering or scientific team . . .*

MANAGEMENT OF RESEARCH, DEVELOPMENT AND DESIGN IN INDUSTRY

By T. S. McLEOD *Technical Coordinator, Plessy Co., Great Britain*

Budgeting, organization, cost effectiveness and day-to-day management problems treated in a practical, workable, professional method based on the author's experience in reorganizing 50 laboratories of diverse disciplines in over 50 different geographical locations and involving over 6,000 specialists., $12.50

—— 15 DAY FREE TRIAL EXAMINATON PERIOD ——

Cahners Books

EDN

89 Franklin St., Boston, Ma. 02116

Please send me____copies of MANAGEMENT OF RESEARCH, DEVELOPMENT AND DESIGN IN INDUSTRY at $12.50

( ) Bill Me ( ) Bill Company

( ) Check Enclosed (We Pay Postage)

Name________________

Company________________

Address________________

City/State/Zip________________

Mass. Residents Add 3% Sales Tax

Modular power supply line comes in three sizes and spans 44 models

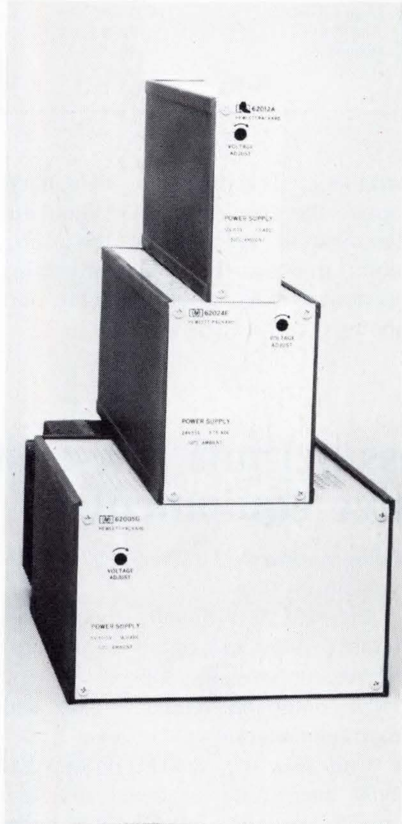
PROGRESS IN POWER SUPPLIES

Hewlett-Packard, a pioneer and leader in laboratory bench-type supplies, is going into the modular power supply business in a big way. It's New Jersey Division is introducing a family of 44 modular power supplies (the Series 62000) with outputs ranging from 3 to 48V and 0.45 to 17A. Available in three rack sizes (1/8, two 1/4 and 1/2), the series includes 11 voltage steps of 3, 4, 5, 6, 10, 12, 15, 18, 24, 28 and 48V. Each voltage step is available in four different current ratings (see box). Rated output voltages are adjustable within ±0.5V or ±15%, whichever is greater. Input is 104 to 127V ac, 48 to 63 Hz and is completely isolated from the output.

The Series 62000 units are series regulated and feature 0.01% line and load regulation. Ripple and noise is less than 1 mV rms and 3 mV peak-to-peak (dc to 20 MHz). Temperature coefficient is 0.01%/°C. All supplies are rated to deliver the full output to 50°C and are derated to 71°C. Transient recovery to within 15 mV is in 50 μsec.

Hewlett-Packard took a semi-integrated circuit approach in designing these supplies (the voltage-error, overcurrent-limiting and reference-supply amplifiers are ICs) to allow for flexibility in changing standard supply models to custom-designed ones.

In addition to built-in overcurrent protection (103% and 10% activation-point limits) each supply has overvoltage protection via an optional internal crowbar whose trip level can be adjusted from 0.5V above the minium rated output voltage to 2.0V above the maximum output voltage by a rear-panel screwdriver-adjustable control. Over-temperature protection is also provided through a heatsink-mounted thermostat, which opens the fused ac line if the supply ambient temperature rises too high and causes supply overheating. The thermostat automatically resets itself when the ambient temperature drops down to a safe operating level.



Three different rack sizes covering 44 models are the start of a new line of modular power supplies for the Hewlett-Packard New Jersey Division. The supplies cover 3 to 48V and 0.45 to 17A.

Additional protection is provided against reverse voltages. Remote voltage sensing is standard and the load is protected against damage by inadvertent opening of a sensing lead.

An interesting systems feature of the Series 62000 supplies is the optional overvoltage protection which can be crowbarred with an external trigger input. It also provides an output signal for triggering other power supply crowbars, if needed. As part of the same option, access to the supply summing point is provided for remote turn-on or turn-off of the dc output.

Prices are $89 for the 1/8-rack supplies, $125 and $145 for the 1/4-rack versions (higher-priced 1/4-rack versions have twice as much output current) and $195 for the 1/2-rack supplies. OEM discounts will apply. Delivery on standard models will be stock to 2 weeks, starting in April 1972. Custom supplies may take up to 6 weeks. **325**

62000 Series modular power supplies

	Current (amperes)			
dc *voltage*	1/8 rack *(A module)*	1/4 rack *(C module)*	1/4 rack *(E module)*	1/2 rack *(G module)*
3	2.0	4.25	8.5	17.0
4	2.0	4.0	8.0	16.0
5	2.0	4.0	8.0	16.0
6	1.75	3.75	7.5	15.0
10	1.5	3.25	6.5	13.0
12	1.5	3.0	6.0	12.0
15	1.25	2.5	5.0	10.0
18	1.0	2.25	4.5	9.0
24	0.75	1.75	3.75	7.5
28	0.70	1.5	3.25	6.5
48	0.45	1.0	2.0	4.0

Reed switch senses temperature limits and resets automatically

PROGRESS IN REED SWITCHES

Everytime someone predicts the demise of electromechanical switching, new advancement not only forestalls that death, but further strengthens the relay's position in the industry.

The introduction of the TS-55 and TS-75 temperature sensors is just such an advancement. Before now, reed switches may have been used in circuits that protected against overtemperature, but a discrete sensing element was required. The TS-55 and 75 reed switch/temperature sensors are magnetically biased with a segmented magnet which encircles the reed capsule. These magnets are seperated by a special material which, at normal temperatures, will shunt the magnetic flux lines away from the reed mechanism. When the Curie point of this separation material is reached, it becomes non-magnetic. The magnetic field then opens the reed contacts. When the temperature falls below the Curie point, the separation material regains its normal magnetic permeability, and the reed contacts close.

Table 1—General specifications

Electrical characteristics:		
Contact arrangement	SPST NC	
Switching ratings	dc—28V	100 mA
	ac —110V	50 mA
Actuate time	5-10 sec	
Thermal characteristics:		
	TS - 75	TS - 55
Open temperature	65°-75°C	45°-55°
Close temperature	60°-70°C	40°-50°
Hysterisis	10°C max	10° max
Unit repeatability	±0.5°C	±0.5°C
Physical characteristics:		
Overall length	1.235 in.	
Trim length	0.750 in.	
Diameter	0.250 in.	
Weight	1.2 grams	

The TS-55 and TS-75 reed switch/temperature sensors are preset to trigger at 50 or 70°C. Reset is automatic, and the devices are hermetically sealed

By varying the composition of the shunt material, the Curie point can be set to virtually any temperature above 50°C (122°F). These sensors are set to operate at 50° ±5°C and 70° ±5°C. Hamlin, Inc., Lake Mills, WI, 53551.

327

Decapsulation process permits low-cost refurbishing of obsolete or defective equipment.

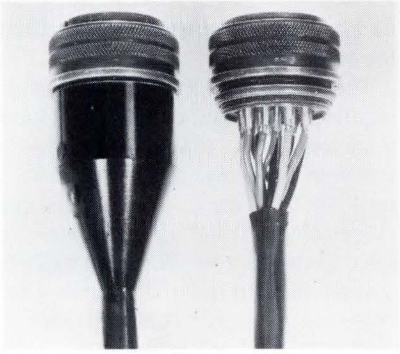
PROGRESS IN PACKAGING

Both manufacturers and users of encapsulated parts and equipment may benefit from a new process which removes most potting compounds completely and harmlessly.

The new process, called ACCESS, is the property of the Amphenol SAMS Div. of Bunker-Ramo Corp., which acquired it from its developers, Decapsulation Services, Inc. The ACCESS process is proprietary and, other than to say that it is a complex process that varies according to the encapsulant being removed, Amphenol is not divulging any details.

They do say, though, that it can remove such compounds as polyurethanes, polysulfides, silicon rubbers, butyl compounds, epoxies, foams and room-temperature vulcanizers.

Until now the ACCESS process has only been used in certain military modification programs. But Amphenol expects that it can have even wider use in the general aerospace and industrial fields, particularly if it is considered in the design of items that will require access for engineering or maintenance purposes at a later date. **343**



Cable harness termination (left) can be stripped of its polyurethene encapsulant completely and with no damage to insulation or parts by the ACCESS process (right).

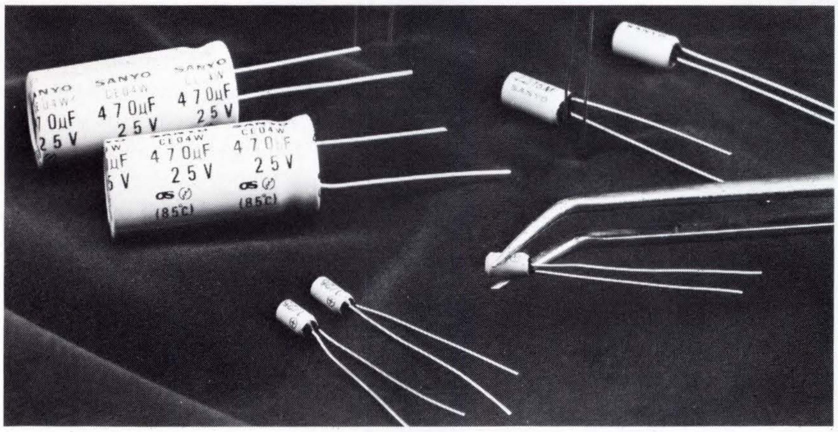
New capacitors fill the gap between aluminum and tantalum

PROGRESS IN CAPACITORS

Alsicon, a new line of sintered aluminum capacitors, and SP-Con solid electrolytics fill an important slot that has been empty for a long time. Performance of these capacitors rivals that of tantalum in many areas such as leakage current, especially at elevated temperatures, as typified in **Fig. 1**. Physical size of the new capacitors is much smaller than that of comparable aluminum electrolytics. For example, a standard aluminum 2.2μF capacitor that measures 1/4 × 1/2 in. can be replaced with an equivalent Alsicon which measures only 1/8 × 1/4 in.

Perhaps the most impressive feature of these capacitors is their price. Unlike their performance, which leans toward the tantalum side of the scale, Alsicon and SP-Con capacitors are priced only about 10 percent higher than aluminum, or around half the price of tantalum.

Readers of EDN/EEE can request an evaluation sample (on company letterhead). Sakata/Sanyo, Sakata International, 208 South La Salle St., Chicago, IL 60604. **328**



Newly introduced Alsicon and SP-Con capacitors rival solid tantalum in size and performance but are priced almost as low as aluminum electrolytics.

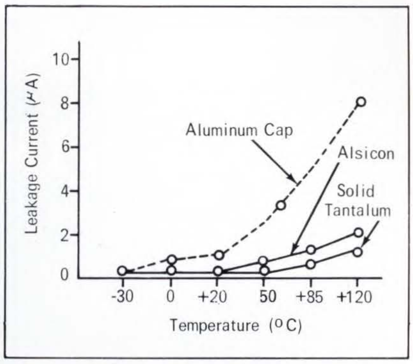


Fig. 1—Typical leakage current-vs-temperature curves show how closely the new sintered aluminum Alsicon capacitors resemble tantalum devices.

Low-cost double-balanced mixers increase in performance

PROGRESS IN BALANCED MIXERS

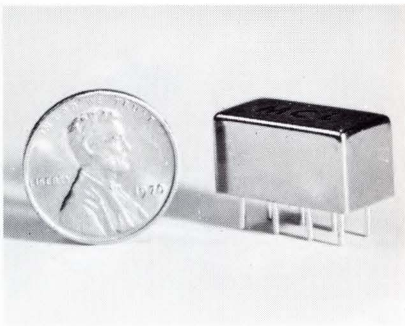
Mini-Circuits Laboratory of Brooklyn, N.Y. is not a very large company by contemporary standards, although it's growing. The firm is certainly big, however, when it comes to high-performance, low-cost double-balanced mixers. The company has introduced a dc-to-500 MHZ mixer with left and right rf ports rated for a frequency range of 0.1 to 500 MHz and costing. only $9.95 in 500 quantities.

Additional SRA-1-1 specifications include a 6-dB conversion loss, isolation of 40 dB and a fairly low noise figure—1/2 to 1 dB greater than the conversion loss. Input impedance is 50Ω for all ports and operating temperature range is −55 to +100°C.

Absolute ratings include total input power of 50 mW, total peak input current of 40 mA and a pin temperature rated for 10 seconds at 510°F.

Packaged within an emi-shielded metal enclosure and a hermetically sealed header, the mixer measures 0.8 by 0.4 by 0.4 in.

Mini-Circuits Laboratory, 2913 Quentin Rd., Brooklyn, NY 11229. Phone: (212) 252-5252. **326**



Mini-Circuits' SRA-1-1 double-balanced mixer covers an rf range of 0.1 to 500 MHz yet costs only $9.95 (500 quantities). Even for quantities as low as 6 units, the price is only $11.95.

Digitally-controlled microwave attenuator has stable characteristics

PROGRESS IN PACKAGED CIRCUITS

A new series of digitally-programmable microwave attenuators from Engelmann Microwave offers significant performance advantages over conventional diode attenuators.

Whereas most PIN-diode attenuators are designed to control relatively low-power signals of only a few millivolts, the new MOD series can handle powers of up to 20W in C-Band. And the phase and impedance characteristics are stable over a wide frequency range.

Thick-film Resistors

Like pure diode attenuators, the new MOD-series units use PIN diodes to provide fast switching, but the actual attenuation is provided by thick-film ceramic resistors. Because resistors are passive the attenuation and phase shift do not depend on frequency. Each diode is normally in one of two stable states—it is either ON or OFF.

Stripline circuitry

The attenuators are packaged in rugged modular assemblies. The base section of the assembly houses the RF circuitry which is built using stripline techniques. A removable box containing the driving and filtering circuitry mounts on top of the aluminum base section. Thus the driver section can be modified or repaired without disturbing the critical RF section.

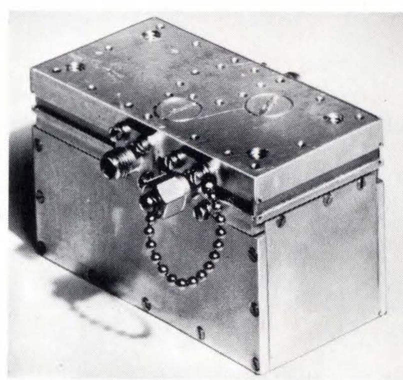
In the stripline assembly, individual metal-film "T" networks are switched by pairs of high-speed PIN diodes. The number of "T" networks provided determines the number of discrete increments of programmable attenuation. Because of the constant-impedance characteristics of the chip resistors, line-length variations can be easily compensated by including phase shifters in each transmission path to provide value-to-value phase linearity.

Additional circuitry in the driver module provides the correct switching currents for the diodes and interfaces the attenuator with conventional TTL-logic circuits. Filters isolate the RF circuits from the control logic.

Stable phase shift

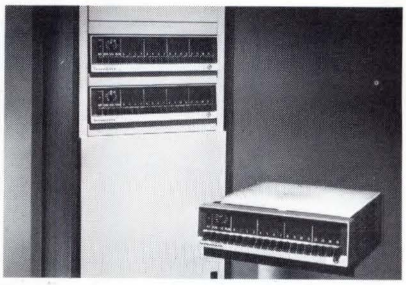
Each MOD-series attenuator covers a frequency band of up to a full octave. Different versions are available for frequencies from UHF to Ku band. Performance depends, of course, on the specific frequency band and attenuation range specified. A typical S-Band attenuator has a maximum phase-shift variation of 3° across the band 3.1 to 3.5 MHz, with a dynamic range of 10 dB. Versions can be built with total attenuation of up to 100 dB and with programmable increments as small as 1 dB.

In small quantities, standard versions in the MOD series cost from $800 to $1200 each. Engelmann Microwave Co., Skyline Dr., Montville, N J 07045 **329**



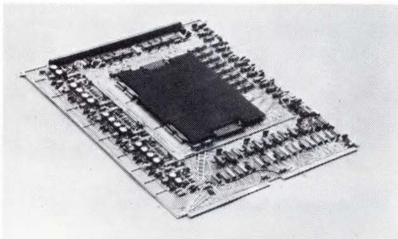
Unpainted version of one of Engelmann's new digitally-controlled microwave attenuators. The base section (shown at the top here) is a stripline assembly sandwiched between two aluminum heat sinks. The removable compartment screwed to the base section houses the driver circuits.

PROGRAMMABLE CRT TERMINAL. Series 200 features a programmable MOS ROM of up to 4K, 16-bit words and a MOS RAM of 2K, 10-bit words for display refresh. Character set is 64 ASCII upper and lower case. Page format has 80 characters/line × 25 lines/page. Serial interfaces handle 110 to 9600 baud rates; transfer rates are up to 350K 10-bit bytes/sec. Price is $4570; discounts available. Computek, Inc. 143 Albany St. Cambridge, MA 02139. **193**

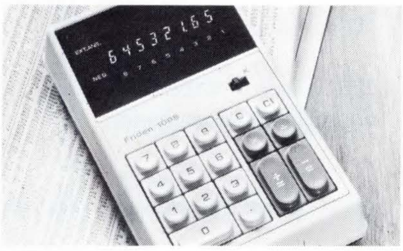


TWO DC MINICOMPUTERS. Model 50 is a 16-bit data communications processor. It features an LSI ROM with 80 nsec cycle time and up to 65K bytes of core main memory with 1.0 μsec cycle time. Price is $6800 with 8K bytes core memory. Model 55 is a 16-bit dual-processor communications system. Used in parallel, instruction execution time is 500 nsec. Price is $15,900 with 16K bytes core memory. Interdata, Inc., Two Crescent Place, Oceanport, N J 07757. Phone (201) 229-4040. **195**

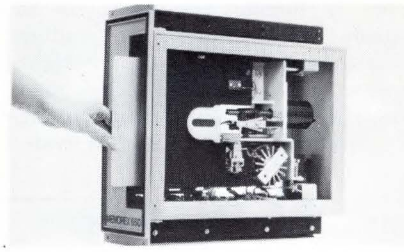
MINICOMPUTER PRINTER. System 5096 interfaces with the DEC PDP-8 family and gives a 100-character/sec printout rate. It consists of a serial impact printer, a DATUM controller, diagnostic and I/O driver software and all necessary cables. Other features are multiple copies and low cost (under $3000). Standard model prints the 64-character upper-case ASCII subset. Other formats are available. Datum, Inc., 170 East Liberty Ave., Anaheim, CA 92801. Phone (714) 879-3070. **198**



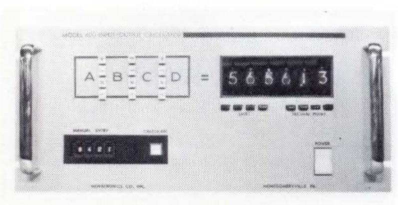
MINICOMPUTER CORE MEMORY. An 8 192 word, 16-bit core memory unit mounted on one 15-inch square pc board is available for Nova-line computers. One 8K board costs less than two of the present 4K memories. Prices are $4100 for the 1200 nsec version and $4400 for the 800 nsec model. Quantity discounts are available. Data General Corp., Southboro, MA 01772. Phone (617) 485-9100. **194**



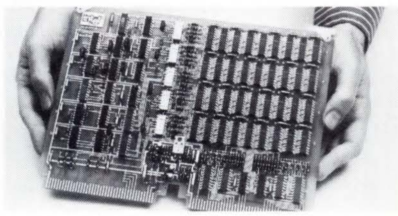
MINIATURE CALCULATOR Model 1008 is only 5 × 7 inches, weighs about a pound, and runs from a self-contained rechargeable battery. Features include 8-digit display, positive and negative multiplication, constant factor multiplication and division, power calculations, and underflow answer protection. The $325 price includes travel cover and a battery charger—ac adapter powerpack. Friden Div., The Singer Co., San Leandro CA 94577. Phone (415) 357-6800. **196**



DISC FILE. The 650 flexible disc file is a read-only device designed for digital applications, and can write and read discs interchangeably from unit to unit at a transfer rate of 200 kilobits/sec. It includes drive mechanism, recording head, head actuator, and related electronics. Capacity is 1.5 megabits, track-to-track access time is less than 50 msec. Memorex Corp., San Thomas at Central Expressway, Santa Clara, CA 95052 Phone (408) 987-2200. **199**



DIGITAL INPUT/OUTPUT CALCULATOR. Model 400 is an automatic, real time, all solid-state, programmable calculator that performs arithmetic operations on numbers entered in BCD form directly from digital measuring instruments, thumb-wheel switches, card readers, etc. Price of Model 400 with two 5-digit BCD inputs is $1850. Each additional 5-digit BCD input is $250. Novatronics Co., Inc., P.O. Box 516, Stump Rd., Montgomeryville, PA 18936. Phone (215) 368-4400. **192**

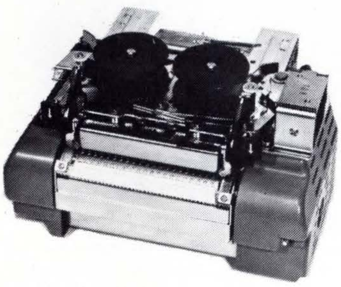


MOS RAM MEMORY SYSTEM. Type 1103LC memory system uses Intel 1103 dynamic MOS RAMs and stores 4K, 9-bit words on one 7 × 10 inch pc board, including all clock drivers, decoders, level shifters, and other interfacing circuits. Price is about 1c/bit in OEM quantity. Max cycle time is 950 nsec and max access is 600 nsec. A system may be expanded by adding identical boards. Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051. Phone (408) 246-7501. **197**

A MINICOMPUTER NAMED SUE, derived from the term "System User Engineered," offers a choice of four memory modules—two core and two LSI—intermixed in any combination. System capacity is 30K x 16. A SUE computer with 4K memory sells for $4295. An 8K version sells for $5895, and a 16K version is $9795. Lockheed Electronics, Inc., Data Products, Div., 6201 E. Randolph St., Los Angeles, CA 90040. Phone (213) 722-6810. **200**

DIGITAL PRINTING MECHANISM

MODEL EP-101



- Low Cost
- High Reliability
- Low Power Consumption
- Compact
- Field Tested
- Long-Life Patented Motor
- Black and Red Printing

SPECIFICATIONS:

SPEED: 2.8 Lines/Sec.
COLUMN CAPACITY: 21 Columns
NO. CHARACTERS: 16 per Column
CHARACTER SIZE: 0.114 in. Width
0.071 in. Heigth
DATA ENTRY: Parallel

SIZE: 6.4 in. Width
5.3 in. Heigth
4.0 in. Length
WEIGTH: 5.5 lbs.
POWER: 15 ± 3 VDC.

SALES AGENT IN NORTH AMERICA:

C. ITOH & CO. (AMERICA) INC.
624 So. Grand Avenue
Los Angeles, Ca 90017
(213) 627-3175

245 Park Avenue
New York, NY 10017
(212) 986-7900

CIRCLE NO. 23

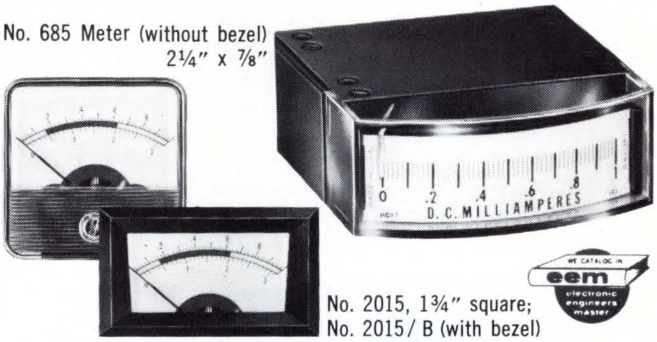
COMPACT Hoyt METERS

Best for size, performance

No. 685 Moving Coil pancake edgewise meters, without barrel projection, may be mounted together for comparison reading applications. 30% larger dial area for better readability. Shielded high torque movement for all ranges 50 UA up to 750 volts, VU meters, and AC rectifier type voltmeters.

No. 2015 Custom 1½" Panel Meter. Hoyt proven high torque movements, quick response, fine damping. Linear design cases with optional color variations. No. 2015/B distinguishes panels with die cast metal bezel for mounting meter behind panel. Small, compact and unique in design. Available in all DC, VU and rectifier type movements. **Visit booth 2346 at IEEE Show.**

No. 685 Meter (without bezel) 2¼" x ⅞"



No. 2015, 1¾" square;
No. 2015/B (with bezel)

Hoyt SINCE 1904

HOYT ELECTRICAL INSTRUMENT WORKS, INC.
BURTON-ROGERS COMPANY / Sales Division
556 Trapelo Road, Belmont, Massachusetts 02179
(617) 489-1520

CIRCLE NO. 24

Flyweights – from "The Cube" – with more VA per pound. Like 2.5 KVA from 2.7 pounds. And only 3.75 x 4.00 inches, too. Because they're wound with aluminum foil instead of wire. No way you can get that brand of volumetric efficiency with wire. Ten standard units from 150 VA to 2.5 KVA, open frame and hermetically sealed. Efficiencies from 90-96%, regulation 3-5%. For 400 Hz with 115 V input. Other ratings, frequencies, for isolation or auto transformers on request. Take poundage penalties off your airborne or mobile systems with these. And without adding cost. Write us at 1710 South Del Mar Avenue, San Gabriel, California 91776. Or call (213) 283-0511.

electrocube /Capacitors, EMI Filters, RC Networks

Aluminum foil-wound transformers

CIRCLE NO. 25

Power module for Nixie* displays

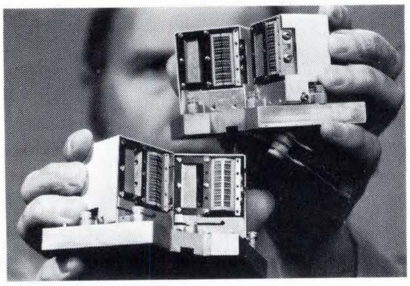
This rugged module, designed specifically for use with high voltage display devices, provides a nominal output of 185 VDC at 25 ma . . . drives up to seven Nixies. Only 3.5" x 2.3" x 1". May be mounted directly on a p-c board. Order Model NX-25. Price: $35.00. Shipment: Three days.

Acopian

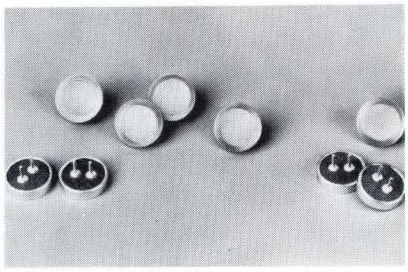
Acopian Corp., Easton, Pa. 18042
Telephone (215) 258-5441

*Registered trademark, Burroughs Corporation

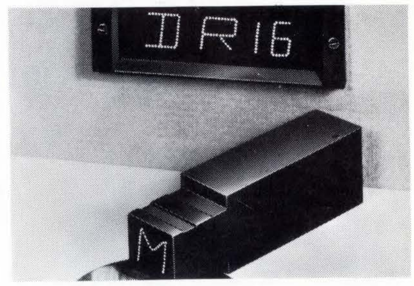
CIRCLE NO. 26



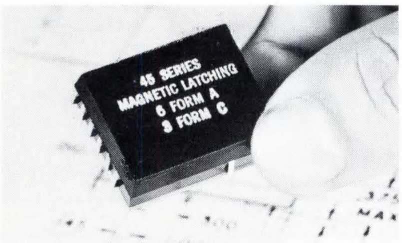
FERRITE RECORDING HEADS for instrumentation recording and reproduction are warranted for 4000 hours. The heads will be offered initially in Ampex Model FR-2000 systems. They also are available as replacements for FR-2000s currently in use. Price of a complete head assembly ranges from $8010 to $9500, depending on size of tape. AMPEX Corporation, 401 Broadway, Redwood City, CA 94063. Phone (415) 367-4151. **170**



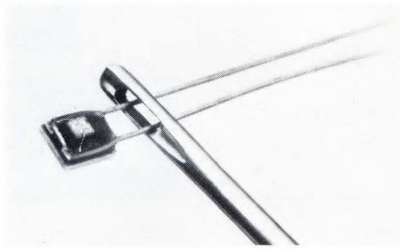
SWITCH CAPSULES of the TC-1/C series use a newly patented multi-unit parallel contact grating to replace conventional contacts. A travel of only 0.005 in. is required to activate these switches, and this point is repeatable to within 0.001 in. The units are available with ratings between 50mA/12V ac and 5A/220V ac. Wild Rover Corp., 97 Oak St., Norwood, N. J. 07648. Phone 201-768-8393. **173**



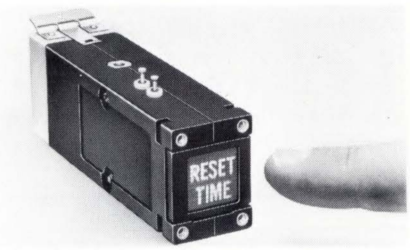
16-SEGMENT FIBER-OPTIC READOUT has built-in decode/drive ICs. Model 902 is compatible with TTL and operates from +5V. It will generate all alpha-numeric characters, plus a number of symbols. Character size is 0.420 by 0.420 in. and it is available in six standard colors. Master Specialties Co. 140 Monrovia St., Costa Mesa, CA 92627 Telephone: (714) 642-2427 **176**



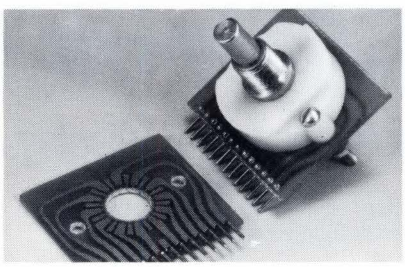
MAGNETIC LATCHING RELAY features contact memory. Set to operate at 5, 6, or 12Vdc nominal these relays are furnished with contacts which will transfer from a 5.5 msec pulse. With "magnetic memory" the contacts will remain in open or closed position without requiring any holding current. Package has 3/8" height, and power required is 13 mW per pole. Frederick Controls Division, North American Philips Corporation, Frederick, MD. 21701. **171**



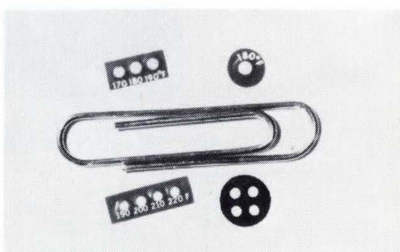
GaAs LED, Type He-500, is world's smallest discrete infrared light source. This GaAs device radiates at a peak wave-length of 900nM. Continuous forward current is rated at 50mA continuous and 1A peak. Forward voltage drop is 1.35V and radiated power is lmW at 50mA. Typically rise time is 15 nsec and fall time 50 nsec. Price in 1000 piece quantities is $1.25 each. HEI, Inc., Jonathon Industrial Center, Chaska, Minn. 55318. Phone 612-448-3510. **174**



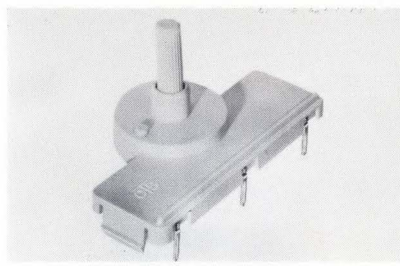
"SCREEN SWITCH" developed for use with rear projection displays. The series 0123 Readout incorporates a switch with a single-pole momentary contact, consisting of two copper laminated mylar squares, separated by a plain mylar square with a built-in aperture. Price of the Readout is $44.50 each. Industrial Electronic Engineers, Inc., 7720-40 Lemona Ave., Van Nuys, CA 91405. Phone (213) 787-0311 **177**



PRINTED CIRCUIT ROTARY SWITCH is vertically mounted. Twelve active terminals and a "common" are brought down to a common junction point. Thirteen pins, equally spaced on 0.100" centers, protrude downward for soldering into the receiving printed circuit. No hand wiring is necessary, and prices start at $1.85 each in quantities of 1000. Stackpole Components Company, P.O. Box 14466, Raleigh, NC 27610. **172**



MICRO-MINIATURE TEMP RECORDERS feature −1% Accuracy. When exposed to the rated critical temperature, the indicator window turns in less than one second from pastel to black, for a direct readout which is permanent and irreversible. Free evaluation sample and complete specifications from William Wahl Corporation, Temp-Plate Division, 12908 Panama Street, Los Angeles, CA 90066. **175**



FLAT PLATE RESISTOR NETWORK has adjustable portion. The symmetrical substrate design provides for an adjustable pick-off voltage (capabilities to 30 megohms) centered between two fixed resistors with resistors up to 50 megohms each, provided voltage rating is not exceeded. The price is approximately 86¢ each in production quantities. CTS Corp., Elkhart Division, 1142 West Beardsley Avenue, Elkhart, IN 46514. Phone (219) 523-0210. **178**

COMPONENTS/MATERIALS

12-BIT R/2R RESISTOR NETWORK, Model 310979, is pin-for-pin replacement for Series 811 ladder. The network, 1 × 1 × ¼ in. high, features full scale accuracy of ±0.12 percent over the total range of −55° to +125°C. Standard values are 1K/2K, 2.5K/5K, 5K/10K, and 10K/20K. Vishay Intertechnology, Inc., 63 Lincoln Highway, Malvern, PA 19355. **179**

TANTALUM CAPACITATORS, Type DNS, are solid electrolyte, dipped devices offering higher stability and volumetric efficiency than conventional electrolytes. Available in units rated from 6 to 50 WVdc and 0.1 to 330μF, their standard tolerance is ±20 percent, with ±10 percent or ±5 percent units available on order. National Components Industries, Inc., 5900 Australian Ave., West Palm Beach, FL 33407. Phone (305) 842-3201. **180**

OVERVOLTAGE PROTECTORS are designed to protect electronic equipment against damage from over-voltage. The units are connected anywhere along the dc line and use a silicon SCR "crow-bar" circuit and solid-state reference unit. Trip voltage range is 4.5 – 40V dc. Response is within 10 μsec. Prices range from $65 to $110, dependent on quantities. ERA Transpac Corp., 67 Sand Park, Rd., Cedar Grove, N J 07009. Phone (201) 239-3000. **181**

CRT CONTRAST ENHANCER, the FM52, allows CRT displays to be viewed in direct sunlight, for use in locations such as aircraft cockpits. The ultra-high-contrast filters can be furnished as separate bezel mounted units or permanently bonded to customer specified CRT's. CRT phosphors matched by the FM52 filter include P1, P22G, P31, and P39. Hartman Systems Div. of A-T-O, Inc., Huntington Station, Long Island, NY 11746 Phone (516) 427-7500. **182**

PULSE RATE CONVERTER will convert electrical pulses into an equivalent direct current; this enables metering of pulses to be displayed on a standard instrument. The low rated unit will take inputs of 2-20 pulses/min. The second unit operates in the ranges 4-40 pulses/min. Both transducers have an output range of 0-10 mA into loads up to 1500 ohms. Ferranti Ltd., Instrumentation Div., Monston, Manchester, England. Phone (061) 681-2000. **183**

MULTI-LAYER MATERIALS for interconnecting offer compatibility and dimensional stability. Multi-layer boards may be designed using flexible tongues as extensions for interconnecting, resulting in the elimination of interconnecting hardware. Fortin Laminating Corp., 1323 Truman St., San Fernando, CA 91340. Phone (213) 365-9651. **184**

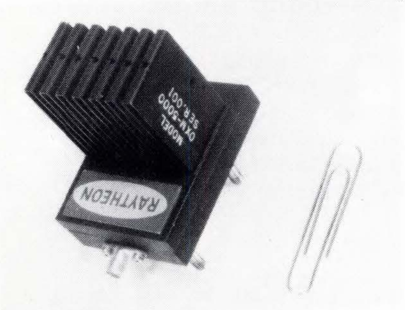
SOLID STATE READOUTS, the 740 series, offer character heights of 0.125 or 0.205 in. Characters are formed by monolithic GaAsP diodes and require only 90 mA at 5V, including display and decoder. Logic input is BCD at TTL levels. Dialight Corp., 60 Stewart Ave., Brooklyn, NY 11237. Phone (212) 497-7600. **185**

HIGH BRIGHTNESS LED INDICATORS, the CM4-20 series, are provided in a choice of clear or diffused epoxy lens. IC compatible, the GaAsP series produces 2600 foot-Lamberts at 70 mA or 50 f-L at 10 mA. Chicago Miniature Lamp Works, 4433 N. Ravenswood Ave., Chicago, Il 60640. Phone (312) 784-1020. **186**

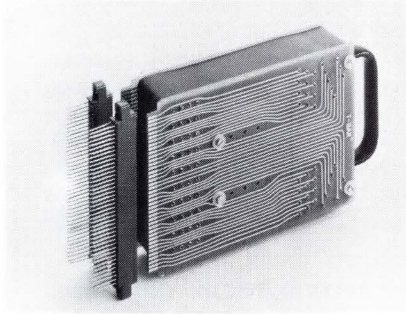
FREE WALL PLAQUE – Connector selection guide/"Mad Maze". This two-sided, 14 × 22 in. wall plaque has information on insulator materials, contact and plating materials and a glossary of connector terms. The other side is a humorous "interconnection maze." Elco Corp., Willow Grove, PA 10090. Phone (215) 659-7000. **187**

DOUBLE BALANCED MIXERS, Models M6D and M6E, offer frequency ranges of 0.05 to 200 MHz and 5 to 500 MHz. Both mixers are guaranteed to meet their specifications during and after environmental stressing, per MIL-STD-202D. Price, in unit quantities, is $37 each. Relcom, 3333 Hillview Ave., Palo Alto, CA 94304 Phone (415) 961-6265. **188**

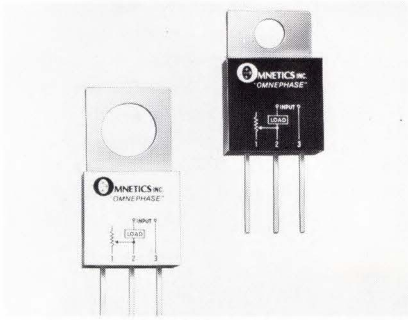
FREE SAMPLES – 150 deg. C. metallized polysulfone capacitors. More than 200 capacitance values are available for each of four voltage ratings – 100, 200, 400, and 600Vdc. Six case styles can be furnished. Samples are offered in round wrap-and-fill case. Electrocube, Inc., 1710 S. Del Mar Ave., San Gabriel, CA 91776. Phone 473-3765. **339**



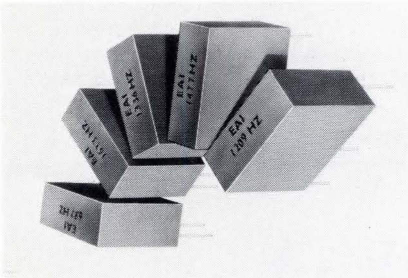
A 1-W CW AVALANCHE DIODE OSCILLATOR operating at 10.5 GHz (X-band) is the Model OXM-5000. Including its own heat sink, the oscillator weighs only 12 oz. Temperature range is 0 to +55°C. Load VSWR is 1.2:1.0 and noise factor is 200 Hz in a 1-kHz bandwidth from 10 to 100 kHz away from the carrier. Raytheon Co., 130 Second Ave., Waltham, Mass. 02154. Phone (617) 862-6600. **291**



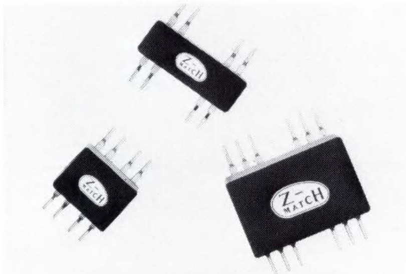
PLUG-IN RELAYS the 6800 series, provide high-density switching capability. The relays are packaged between PC boards for direct plugging into card-edge connectors in a standard card frame allowing for common wiring by Wire-Wrap or DIP solder backplane. Available with 36 to 72 poles, the relays enable as many as 21,600 switching points to be packaged into a 19-by-94-in. rack. Cost is $1 per pole in quantities. T-Bar, Inc., Wilton, CT. Phone (203) 762-8351. **340**



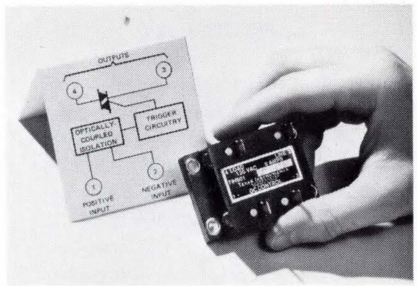
AC PHASE CONTROL called Omnephase is only the size of a postage stamp yet is capable of governing load power up to 3000W at 220V. The device occupies less than 1/4-in.^{3} of space. Cost ranges from less than $1 in production quantities (series 602) to $7.22 (series 1504) in 1 to 9 quantities. Omnetics, Inc., Box 113, Syracuse, NY 13211. Phone (315) 455-5731. **297**



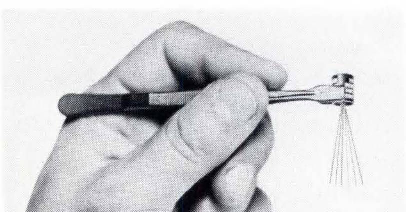
BAND-PASS TOUCH-TONE FILTERS are specifically designed for the data transmission industry. Standard center frequencies of 697, 770, 852, 941, 1209, 1336, 1477 and 1633 Hz located within ±0.5% are available to conform to telephone industry standards and requirements. Price is approximately $19.50 each in lots of 100. Electronic Associates, Inc., W. Long Branch. N J. 07764. Phone (201) 229-1100. **292**



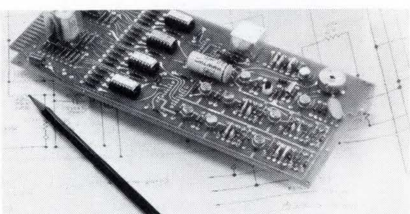
DIP DOUBLE-BALANCED MIXERS cover 0.05 to 1500 MHz. Z-Match units offer low conversion loss (5 to 6 dB), low intermodulation generation, high interport isolations (40 dB), and −55 to +100°C operating temperature range. All types employ carefully matched Mil-grade Schottky barrier diodes and wideband hybrid transformers. Var-L Co., Inc., 3883 Monaco Parkway, Denver, CO. 80207. Phone (303) 321-1511. **341**



TWO SOLID-STATE RELAYS are priced 30% less than comparable units. Designated the TIH501 and TIH502, the relays are priced at $6.50 each in 1000-piece quantities. Both relays feature triac outputs with optically coupled 1500V isolation between input and output. They have zero-crossing detection and are rated for 140V ac and 8A. Texas Instruments, Inc., 13500 N. Central Expressway, Dallas, TX. 75222 Phone (214) 238-2011. **298**



ULTRA-MINIATURE TRANSFORMERS have guaranteed thermal stability. Typical specifications are primary and secondary impedances of 3 to 250 kΩ, ±3-dB, 300-Hz-to-100-kHz response, 600-mV dissipation and maximum dimensions of 11/32 in. diameter and 15/32 in. in length. Prices span $3 to $10. Pico Electronics, Inc., 316 W. First St., Mount Vernon, NY 10550. Phone (914) 699-5514. **293**



DUAL TOUCH-TONE RECEIVER, the QTTR-30, can be programmed for up to 720 addresses for automatic control operations over radio. Fast response time and high noise immunity are features of this unit for use over the switched telephone network. Entire receiver circuit is mounted on a single PC board. Quindar Electronics, 60 Fadem Rd., Springfield, N J. 07081. Phone (201) 379-7400. **296**

CASCADABLE MICROWAVE THIN-FILM AMPLIFIERS ranging from 5 to 400 MHz with usuable gain through 1000 MHz are the TO-12 GPD devices. Each GPD can be plugged into a PC board with ease. GPD units are available with either 9 or 13-dB gain with noise figures ranging from 6 to 9 dB. Cost is under $30 (production quantities) and delivery is from stock. Avantek, Inc., 2981 Copper Rd., Santa Clara, CA. 95051. Phone (408) 739-6170. **342**

POWER CONVERTER MODULE converts 115V ac 60 Hz to 6A dc (Model Z6). Conversion of 47 to 440-Hz ac lines to 50W of regulated power is achieved in a package that measures only 4 by 2-1/4 in. Delivery is 7 days and price is $219 (1 to 4). Abbott Transistor Laboratories, Inc., 5200 W. Jefferson Blvd., Los Angeles, CA. 90016. Phone (213) 936-8185. **300**

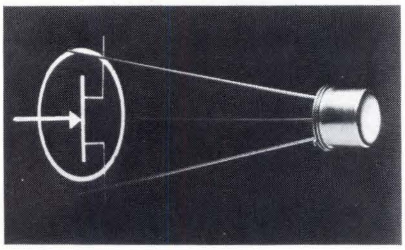
DUAL DC POWER SUPPLY (±15V at 200 mA) for powering linear ICs includes an input isolation transformer. At constant input voltage, the output regulation of the DPM-15/200 for load changes of no load to full load is ±0.1% and voltage regulation for line changes at constant load is ±0.05%. Price is $69 and delivery is from stock. Datel Systems, Inc., 1020 Turnpike St., Canton, MA. 02021. Phone (617) 828-6395. **301**

REGULATED DC-AC INVERTERS with sinusoidal output handle 250 VA of power. They convert 28V dc nominal inputs into 115V ac, 60 or 400-Hz outputs. New models feature a master oscillator power amplifier design which separates the load from the frequency determining elements. Prices range from $335 to $450 and delivery is within 30 days. ERA Transpac Corp., 67 Sand Park Rd., Cedar Grove, N. J. 07009. Phone (201) 239-300. **304**

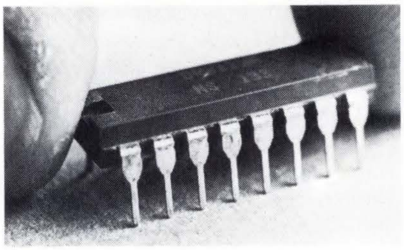
D/S, 14-BIT CONVERTER composed of Standard Hardware Program modules is designed to NAFI requirements (Naval Avionics Facility, Indianapolis). It consists of a single transformer-card module and 7 circuit-card modules designed for mounting in a simplified rack. Total width of all modules combined is 7.5 in. Astrosystems, Inc., 6 Nevada Dr., Lake Success, NY. 11040. Phone (516) 328-1600. **303**

INDUSTRIAL LOGIC MODULES for process control and monitoring applications are designed to link monitoring and control devices to standard DTL and TTL logic. The N J Series modules use photo isolation to provide high noise rejection and up to 1500V of ground isolation. Price is from $82 to $120. Zerox Data Systems, 701 S. Aviation Blvd., El Segundo, CA. 90245. Phone (213) 679-4511. **302**

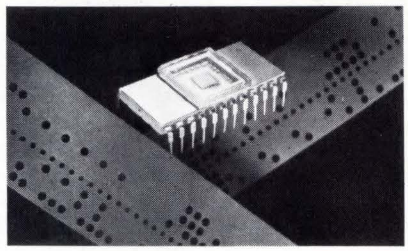
S/D AND D/S 14-BIT CONVERTERS for military and commercial applications include standard models for either 60 or 400-Hz systems. They provide accuracies to ±4 minutes and angle resolutions to 1.32 minutes of arc. Angular rates of 1500 degrees/sec with 400-Hz synchros and 225 degrees/sec with 60-Hz synchros. Bendix Corp., Environmental Science Div., 1400 Taylor Ave., Baltimore, MD. 21204. Phone (301) 825-5200. **305**



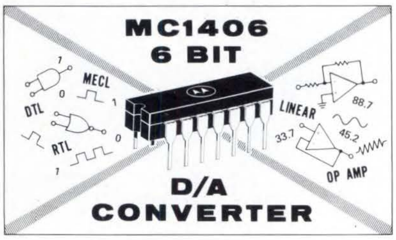
FET features 140 dB dynamic range. Transconductance of the CP640 is typically 75,000 mhos at 50 mA drain current, which is an order of magnitude greater than the average small signal FET. When used in common-gate configuration, the CP640 has an input impedance of 25Ω and interfaces well with 50Ω or 72Ω antenna lead-ins. Price is $15 each in small quantities. Teledyne Crystalonics, 147 Sherman Street, Cambridge, MA 02140. Phone (617) 491-1670. **215**



QUAD 2-INPUT MULTIPLEXER, the DM7123/8123, multiplexes two groups of 4 bits each to four parallel outputs. A disable command puts all outputs into the high-impedance state, allowing up to 128 outputs to be bus-connected. When enabled, the outputs will source up to 5.2 mA and will sink 16mA. Prices are $18.60 each for the 7123 (−55 to +125° C) and $6.20 for the 8123 (0 to +70°C) in unit quantities. National Semiconductor, 2900 Semiconductor Drive, Santa Clara, CA 95051, Phone (408) 732-5000. **222**

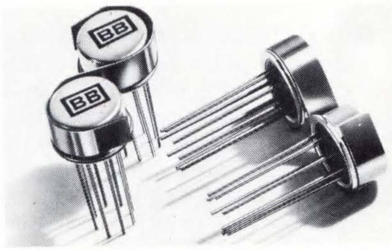


2048-BIT STATIC ROM type MM 5203Q is erasable and reprogrammable. The silicon gate MOS device features a maximum access time of 1μsec and Tri-State outputs. It may be organized as 512 words × 4-bits or 256 words × 8-bits. Data is stored only when the programming input is pulsed, and the stored program is erased by shining ultraviolet light through the quartz lid. Price is $150 in small quantities. National Semiconductor, 2900 Semiconductor Drive, Santa Clara, CA 95051. Phone: (408) 732-5000. **221**

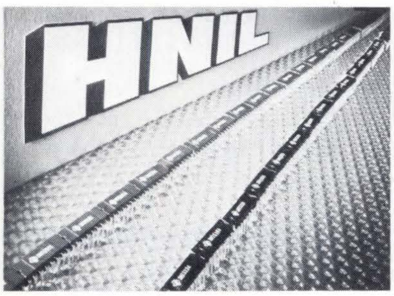


SIX BIT D/A CONVERTER, the MC 1406, uses diffused resistors rather than the NiCr resistors used in most hybrid devices. Settling time (to±1/2 LSB) is 200 nsec, and the analog output is current mode, with 2.0mA max. output. Price is $3.95 each in quantities of 100 or more. Motorola Semiconductor Products Div., Box 20924, Phoenix, Arizona 85036. Phone 602-273-6900. **216**

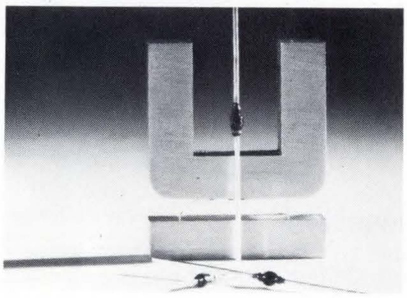
MAGNETIC FLUX SENSITIVE DIODES, type AHY10 A & B, are two specially diffused germanium diodes that exhibit a change in internal resistance when an external magnetic field is applied. Of the two, the AHY 10B is the more sensitive, and can be biased to provide a 1.0 to 1.5V per kilogauss output signal. Full data and an 8-page application note are available. European Electronic Products, 10150 W. Jefferson Blvd., Culver City, CA 90230. Phone (213) 833-1912 **219**



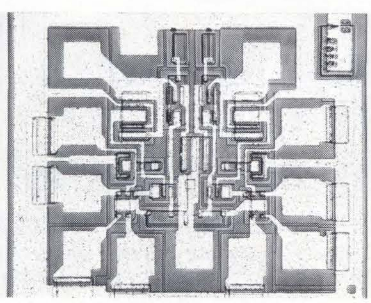
LOW DRIFT IC OP AMP, the 3500MP, is a pair of op amps whose initial offset voltage and drift are matched to 200μV and 1.0μV/° C max. Computer matching of characteristics is used to select the 3500MP pairs from the standard 3500B production line. Price per pair is $16.90 in 100 quantities. Burr-Brown, International Airport Industrial Park, Tucson, Arizona 85706. Phone: 602-294-1431. **218**



HIGH NOISE-IMMUNITY LOGIC IC's, designated Series 15300, are second-source pin-for-pin replacements to Series 300 HNIL. 20 various logic functions are included in the initial product line, packaged in 16-pin plastic or ceramic DIP's. Series 15300 devices are available from stock and their Mil. temp. range equivalents, Series 15400, are available 6 weeks ARO. Texas Instruments, Inc., 13500 North Central Expressway, Dallas, Texas 75222. Phone 214-238-2011. **217**



1.5 WATT ZENER DIODES, of the 1N4461-89 series, are available in JAN and JANTX versions that comply with MIL-S-19500/406 in most voltages from 6.8 to 11V. Reliability is increased by a double-pin bonded design, with the silicon chip bonded directly between the terminal pins. Prices begin at $1.60 each in quantities of 100. Unitrode Corp., 580 Pleasant St., Watertown, MA 02172. Phone (617) 926-0404. **220**



SCHOTTKY TTL/SSI DEVICES, the 9S series, are second-source replacements for the 54/74 and 9N series of standard TTL/SSI units. Typical gate propagation for these circuits is 3nsec, and power dissipation is typically 22mW per gate. Initially, the line will consist of 8 standard devices and will be expanded. Fairchild Semiconductor 464 Ellis St., Mt. View, CA 94040. Phone 405-962-3816. **223**

NEVER-SEEZ®

ANTI-SEIZE AND LUBRICATING COMPOUND

NEVER-SEEZ is easily applied for uniform parts coverage to assure absolute parts protection. Speeds assembly and disassembly. Available in 8 oz. brush top cans, 1/4 and 1 lb. applicator top plastic squeeze bottles, 16 oz. aerosol spray container and 1/4 lb. to 425 lb. standard metal containers.

WRITE FOR FREE 16 PAGE CATALOG

NEVER-SEEZ COMPOUND CORPORATION
2914-24 S. 18th Avenue, Broadview, Illinois 60153

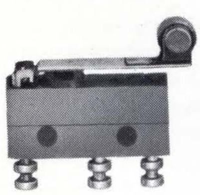
CIRCLE NO. 32

NEW

smallest precision snap action switch yet!

Case dimensions of our new 4900 Series MINI-MITE switches are less than .250″ by .300″ by .100″. Ratings are 2 amp. 125-250V AC; 2 amp. (Res.) and 1 amp. (Ind.), 30V DC. Meet MIL-S-8805 specs. Available with 4 types of terminals, pin plunger and various lever type actuators.

new sub-miniature switches



Our new 4800 Series sub-miniature switches are rated 5 amp. 125-250V AC with 5 amp. resistive and 2½ amp. inductive ratings at 30V DC. Case dimensions are approximately .400″ by .800″ by .250″. Available with 6 terminal types, a variety of lever actuators and optional bifurcated or dual gold contacts. Meet MIL-S-8805 specs. McGill Manufacturing Co., Inc., Electrical Division, Valparaiso, Indiana 46383

Available from Authorized McGill Electrical and Electronic Distributors

McGILL®
ENGINEERED SWITCHES

CIRCLE NO. 33

The AN/PRC-25
(Army Back Pack Radio Case)
had to be:

Deep drawn, Spot welded, Heat treated, Embossed, Pierced, Assembled and Finished.

The AN/PRC 25 is a portable military field radio tough enough to withstand the roughest battlefield conditions. It has two sections . . . transceiver case and a watertight battery box.

AMALCO produced both cases from 6061-T6 aluminum to the precise MIL-SPECS. Complete facilities handle the job from the starting blank to finishing. For the AN/PRC 25 this also included a waterproof seal and mating extrusion.
(Delivery was on time.)

AMALCO supplied **all** the prime contractors for the AN/PRC 25 - AN/PRC 77.

We also:
• Engineer and Design • Stamp • Test
• Brake Fabricate • Hydroform • Heliarc Weld
• Spin • Anodize

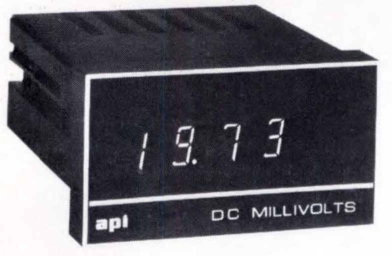
But this is all just **part** of the AMALCO story. Get the rest from Charles W. Hunter collect (201) 233-3500 today.

Manufacturers of Aluminum Products for Industry Since 1910.

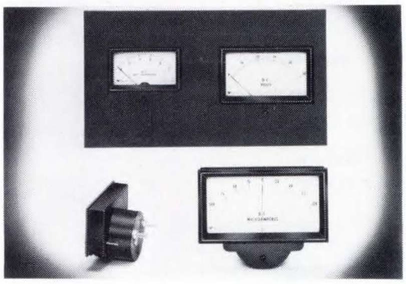
AMALCO
AMERICAN ALUMINUM COMPANY
230 SHEFFIELD ST., MOUNTAINSIDE, N. J. 07092

76

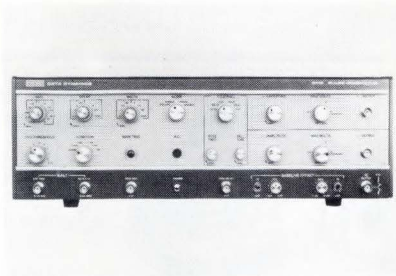
CIRCLE NO. 34



DPM, 3-1/2-digit Model 4352, has planar seven-segment 1/2-in.-high readout. Input impedance is to 1000 MΩ. An extended operating temperature range permits operation from 0 to 55° C. Standard features include: auto-polarity, display hold, programmable decimal point and conversion command. LFE Corp., 1601 Trapelo Rd., Waltham, Mass. 02154. Phone (617) 890-2000. **224**

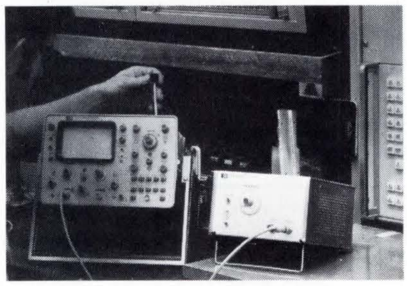


PANEL METERS, Series "GL/b", feature flat and rectangular black phenolic meters with glass windows and modern fronts that resemble bezels so the meters may be easily mounted behind the panel similar to bezel-mounted meters. Three basic sizes are available: 3-1/2 in. (model 320-GL/B), 4-1/2 in. (model 420-GL/B) and 5-1/2 in. (model 520-GL/B). Triplett Corp., Bluffton, OH 45817. Phone (419) 358-5015. **227**

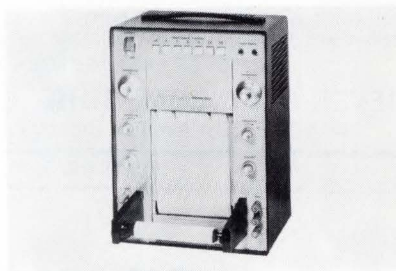


PULSE GENERATOR features an output of 10V into 50Ω. Its variable rise and fall times are adjustable from 6 nsec to 500 msec. A separate baseline offset controls the dc level for both the positive and negative pulse outputs. The unit is capable of duty cycles up to 100% at all pulses repetition rates up to 50 MHz. Price of the 5113 is $950 and delivery is 2 to 4 weeks. Data Dynamics Div., 240 Humphrey St., Englewood, N J 07631. Phone (201) 567-5300. **230**

MULTIMETER, 3-1/2-digit Model 3300A, includes 27 measurement ranges and is priced at $435. Both internal battery-pack and ac-line operation are standard. Model 3300A measures 100 mV to 1 kV ac and dc in 5 ranges each, 100 μA to 1A ac and dc in 5 ranges each and 100Ω to 100 MΩ in 7 ranges. Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, OH 44108. Phone (216) 531-8060. **225**



TIME-MARK GENERATOR, Model 226A, supplies narrow 1V pulses at precise time intervals for calibrating the time bases of scopes and recorders. A single front-panel control selects 30 time intervals that range from 2 nsec to 10 sec in a 1, 2, 5 sequence, and correspond to the sweep timing on most scopes. Price is $670 and delivery is 6 weeks. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, CA 94304. Phone (415) 493-1501. **228**

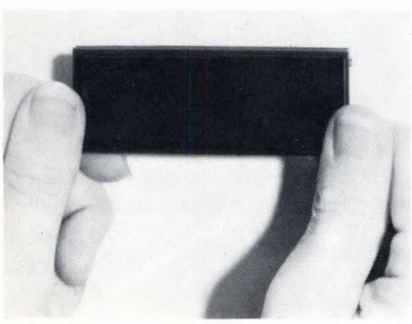


TWO-CHANNEL RECORDER, Brush Model 222, has an internal battery supply and charger permitting it to be used independent of external power sources as well as from them. In the self-powered mode, two sealed, lead-lead-dioxide batteries allow continuous operation up to 12 hours. Gould Inc., 3631 Perkins Ave., Cleveland, OH 44114. Phone (216) 361-3315. **231**

DPM, 3-1/2-digit Model AN2532, features 0.1% accuracy and 55-ppm/° C stability from 0° to 50°C. A floating differential input is available in unipolar or bipolar models with 1.999V or 199.9 mV full scale, including 100% overrange. CMR is better than 70 dB. A choice of Nixie or 7-segment inplane display is available. Price (100-up) is $95. Analogic, Audubon Rd., Wakefield, Mass. 01880. Phone (617) 246-0300. **226**

LIQUID-CRYSTAL DPM, Model 4352, has 7-segment liquid-crystal display with excellent readability in direct sunlight. Specifications are: 0 to ±1.999V range, accuracy of ±0.1% of reading ±1 digit, automatic polarity, and input impedance of 10 MΩ. In quantities of 100, the price is $85, with shipment scheduled for March, 1972. Digilin, 1007 Air Way, Glendale, CA 91201. Phone (213) 240-1200. **229**

TWO SWEEP GENERATORS, Models 1204 and 1205, have up to 7 frequency markers. The $1095 1204 covers 0 to 500 MHz in a single band, with bandwidths from 200 Hz to full sweep of 500 MHz. The $1395 1205 covers 0 to 1500 MHz in three bands with sweep widths from 200 Hz to 600 MHz. Telonic Industries, Inc., Box 277, Laguna Beach, CA 92652. Phone (714) 494-9401. **232**



EQUIPMENT

RECORDER BUILDING BLOCKS provide a new method of chart loading, a special anti-jamming provision, a new 6-month warranty on the recorder stylus, and an 18-month recorder warranty. Features include automatic chart loading, inkless recti-linear writing, dc-to-125-Hz response and multi-speed chart drives. Gulton/Techni-Rite, Route 2 and Middle Rd., E. Greenwich, R.I. 02818. Phone (401) 884-6800. **233**

DIGITAL MULTIMETER has fully automatic ranging; 27 ranges, including dc and ac voltages, resistance and current; an automatic polarity indicator; range hold/display hold control; and is accurate to 0.5% on ac. Cost is $350. Marubeni-Iida (America) Inc., 200 Park Ave., New York, NY. 10017. Phone (212) 973-7152. **234**

TWO STRIP CHART RECORDERS are the single-channel Model 2761 with 3 ranges for temperature coverage from −50 to + 250 degrees F, and the Model 2762 dual-channel with 2 ranges from −40 to +150 degrees F. Both are calibrated for use with standard thermistor sensors. Simpson Electric Co., 5200 W. Kinzie St., Chicago, Ill. 60644. Phone (312) 379-1121. **235**

A PRECISION FILM DRIVE for use with a 35-mm shutterless camera has been developed to record data from a CRT tube face. The face contains an intensity modulated line trace which is imaged on the film for recording. Film speed is continuously variable from 0.5 to 20 in./sec. Inland Controls, Inc., 250 Alpha Dr., Pittsburgh, PA, 15238. Phone (412) 782-3516. **236**

LOCK-IN AMPLIFIER, Model/391, provides a tracking front-end filter that eliminates harmonics and overloading interference without manual filters. Other features include frequency from 0.1 Hz to 200 kHz, 100-nV full scale sensitivity and a built-in sine oscillator. Ithaco, Inc., 735 W. Clinton St., Ithaca, N.Y. 14850. Phone (607) 272-7640. **237**

PHASEMETER, designated Model 305C, features a 5-digit direct-reading panel display with resolution of 0.01° and an absolute accuracy of better than 0.1° over a frequency range of 50 Hz to 50 kHz. Price is $2000 to $3500, depending upon plug-in and options desired. Dranetz Engineering Laboratories, Inc., 1233 North Ave., Plainfield, N J 07062. Phone (201) 755-7080. **238**

DIGITAL MULTIMETER, Model 5800, uses a new rms distortion-insensitive ac converter which equips the instrument to measure the rms value of sine waves having up to 5% total harmonic distortion. The Series 5800 features 0.003% dc accuracy and 4 dc ranges (1V to 1000V). Cost is $3150. Dana Laboratories, Inc., 2401 Campus Dr. Irvine, CA. 92664. Phone (714) 833-1234. **239**

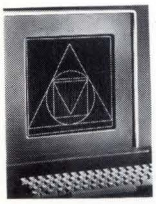
INDUSTRIAL ELECTRONIC COUNTER and accessories includes a four-digit, dual-preset model with Nixie readouts. Input circuits can be timed-dwell, multichannel-combining or divide-by-ten. Outputs may be ordered as: timed-closure, alternating or solid-state. Controlcraft Corp., 213 Main St., W. Chicago, Ill. 60185. Phone (312) 231-7511. **240**

CLOSED-CIRCUIT TV CAMERA (TE-26-S) is designed for hands-off operation under a wide latitude of lighting conditions. The TE-26-S utilizes a GE "Epicon" which makes it four times more sensitive under IR light than conventional vidicon cameras. General Electric Closed Circuit Television, Box 4197, Lynchburg, VA, 24502. Phone (703) 846-7311. **241**

MEMORY EXERCISER, Model 4602, is a fast, versatile general-purpose test system for development and production testing of magnetic memories. Front-panel selection of up to 65,536 addresses of a 40-bit word and 192 data patterns in 6 operating modes is standard. Price is $21,950 and delivery is 4 weeks. Technitrol, Inc., 1953 E. Allegheny Ave. Philadelphia, Pa. 19134. Phone (215) 426-9105. **242**

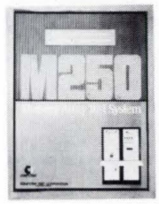
TONE-BURST GATED GENERATOR Model TBG-4 can deliver a 3-dB 2-MHz bandwidth. Its features include an adjustable burst width from 1 μsec to 100 msec and a variable period from 10 μsec to 1 sec. Rise and fall times are 170 nsec. The instrument accepts input from any lab signal source and is priced at $179.95 ($105.95 in kit form). TFE, Box 2232, Denver, CO. 80201. **243**

AM-FM SIGNAL GENERATOR covers 0.4 to 484 MHz. Type SMDA features a guaranteed s/n ratio of 120 dB/Hz at 20 kHz from the carrier. It contains six internal modulating frequencies up to 6 kHz, with external modulation possible from 40 Hz to 20 kHz. Price is $5400. Rohde and Schwarz Sales Co. (USA) Inc., Passaic, N. J. 07055. Phone (201) 773-8010. **244**

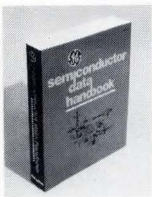


DIGIVUE DISPLAYS, Owen's Illinois' line of display/memory units, are described in an illustrated brochure. The ten-page booklet discusses such memory features as inherent memory, selective writing, rear projection and hard-copy potential. Sizes and resolutions available are also described along with details on suggested applications. Owens-Illinois, Inc., Toledo, OH 43601. **249**

NON-LINEAR/LINEAR DATA MODULES of all sorts are described in a 48-page color-keyed product guide. The booklet includes photos, charts, schematics, pricing, and specifications on Philbrick's linear modules, non-linear function modules, data-conversion modules, power supplies and regulators and testers. Teledyne Philbrick, Allied Dr. at Route 128, Dedham, MA 02026. **250**



CORE-MEMORY TEST SYSTEM is described in a four-page brochure. The array test system is designed for use in production testing of single or limited numbers of individual types of memory core arrays. The brochure lists application examples and contains a schematic diagram of the timing and logic configurations of the tester. Computer Test Corp., 3 Computer Dr., Cherry Hill, N J 08034. **251**



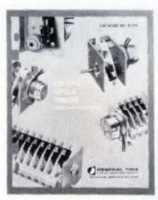
SEMICONDUCTOR DATA HANDBOOK consists of three sections—the index, the selector guide section offering product information on all semiconductors, and the spec-sheet section containing detailed product specifications. Available from G.E. distributors or by sending $3.95 and applicable tax to General Electric Semiconductor Products Department, Electronics Park, Bldg. 7, Mail drop 49, Syracuse NY 13201. **252**

COAXIAL INSTRUMENTATION is the subject of a 16-page catalog. A dozen applications are described. Included are detailed specifications for reflectometers, admittance and standing-wave meters, bridges and slotted lines, amplifiers, detectors and programmable attenuators. General Radio, 300 Baker Ave., Concord, MA 01742. **253**

A/D/A CONVERTERS are detailed in a comprehensive 12-page catalog. It contains detailed electrical and mechanical information on converters, accessories, sample-and-hold units, analog multiplexers and miniature dc power supplies. The hardware described forms the basic building blocks for many systems. Datel Systems, 1020 Turnpike St., Canton, MA 02021. **254**

TEST EQUIPMENT is detailed in an 84-page illustrated catalog. The book lists new and reconditioned electronic test equipment for sale from a huge inventory of over 250 different manufacturers. Included are analyzers, meters, oscilloscopes, power supplies, recorders and signal sources. Tucker Electronics Co., Box 435, Edison, N J 08817. **255**

SOLID STATE TIME-DELAY RELAYS are the subject of a six-page illustrated catalog. Photographs, cross-section connection drawings, specifications, details and suggested applications are included for all models that feature delays up to 300 seconds. All specifications are listed in the catalog. Durakool, Inc., 1010 N. Main St., Elkhart, IN 46514. **256**



ON/OFF CYCLE TIMERS that provide precise control of programmed multiple switching functions are illustrated and described in a new catalog. These timers feature precise adjustment of switch differential, replaceable switches, simple adjustable cams, hundreds of timing and switch combinations and rugged frame construction. General Time Corp., 135 S. Main St., Thomaston, CT 06787. **257**

ANALYZING RANDOM SIGNALS through the use of signal averaging computers in random processes is described in a 4-page application note. The note discusses the use of this technique in boundary layer turbulence measurements in the field of fluid mechanics. Princeton Applied Research Corp., Box 565, Princeton, N J 08540. **258**

IR PRODUCTS ranging from IR detectors and detector arrays to glass and metal dewars, IR components, special systems and instrumentation are described in a 54-page booklet. The new brochure gives detailed technical descriptions and specifications of the various IR products. Santa Barbara Research Center, 75 Coromar Dr., Goleta, CA 93017. **259**

SPECTRUM ANALYZERS are described in a 12-page brochure. Features, specifications and applications of Models UA-10A (200-line), UA-14A (400-line) and UA-15A (500-line) miniature Mini-Ubiq portable real-time spectrum analyzers are given. Federal Scientific Corp., 615 W. 131st St., New York, NY 10027. **260**

PHOTO CHEMICAL MACHINING BROCHURE has been published by the Photo Chemical Machining Institute. It describes the new metalworking process that may be an answer to some of your production problems. This process is adaptable to parts that are similar to thin gauge stampings, with a material thickness between 0.005 and 0.060 in. $2.00 per copy from the Photo Chemical Machining Institute, 1717 Howard St., Evanston, Ill. 60202. **261**

DC DIFFERENTIAL AMPLIFIER, Model 707-10D, is described in a new bulletin. The amplifier has adjustable gain from 1 to 2500 with fixed steps from 1, 2, 5, 10, 20, 50, 100, 200, 500 and 1000 and a vernier adjustment of X1 to X2.5. Its dc accuracy is 0.1% and linearity is 0.01% of full scale. Bandwidth of ±3 dB is 100 kHz. B & F Instruments, Inc., Cornwells Heights, PA 19020. **262**

LINEAR-IC TEST SYSTEM is detailed in a new 30-page illustrated brochure. The system is described with regard to its application to the testing of a variety of commercial devices. Among the linear ICs whose testing is discussed are stereo demodulators, chroma demodulators, TV and FM sound systems and voltage regulators. Teradyne, 183 Essex St., Boston, MA 02111. **263**

REAL-TIME SPECTRUM ANALYZERS are described in a pocket guide. Applications of real-time analysis described in the guide range from display of acoustic and vibration spectra to performing near-instantaneous analysis of high-speed rotating machinery. The guide lists an entire family of equipment. Spectral Dynamics Corp., Box 671, San Diego, CA 92112. **264**

INSTRUMENTATION PRODUCTS of Singer's Los Angeles Operation are described briefly in this 16-page brochure. They include emi/field-intensity meters, FM/AM/SSB communications test instrumentation, frequency meters, signal and tone generators, phase-angle and electrostatic voltmeters. The Singer Co., Los Angeles Operation, 3211 S. LaCienega Blvd., Los Angeles, CA 90016. **265**

A NEW PSD NOMOGRAPH from Federal Scientific Corp. provides a fast means of calibrating a real-time power spectral density system in terms of PSD level using a sine-wave calibration signal. It is intended to make it possible for the user of Federals' Ubiquitous spectrum analysis systems to easily scale the output data in terms of g^2/Hz or V^2/Hz. Federal Scientific Corp., 615 W. 131st St., New York, NY 10027. **266**

POWER-METER CALIBRATOR, Model 305B, is described in a bulletin. The new push-button, precision calibrator is designed for use with thermoelectric power meters and amplifiers. It is self-contained and requires no external equipment for the calibration procedure. Accuracy of 0.05% and excellent long-term stability are featured. General Microwave Co., 155 Marine St., Farmingdale, NY 11735. **267**

DATA-ACQUISITION SYSTEM is described in an 8-page brochure. The modular system can automatically receive, record and analyze data from instrumentation and, if desired, control the instrumented system generating the data. The system's modules may be combined in many ways for applications in research, engineering or production situations. Princeton Applied Research Corp., Box 2565, Princeton, NJ 08540. **271**

LINEAR-IC TESTER and accessories are described in a new 12-page brochure. Comprehensive component test specifications augmented with a technical description of large-signal measurement techniques are presented. Information on transfer-function characteristics and their relation to test specifications is also included. Signetics, 811 E. Arques Av., Sunnyvale, CA 94086. **272**

LITERATURE

AC POWER ANALYZER, Model PA-7125, is described in a bulletin. The publication covers technical features and specifications of the unit which simultaneously measures and indicates true rms values of voltage, current, frequency and kilowatts or kilovars in both poly-phase and single-phase circuits. Multi-Amp Corp., Cranford, N J 07016. **276**

VOLTAGE-TUNABLE ACTIVE FILTERS are described in a four-page report. The report includes methods of optimizing usage and many applications. Chebychev, Butterworth and Bessel filters (0.1 to 20,000 Hz) having simultaneous low, high, and bandpass outputs are described. Frequency Devices, Inc., 25 Locust St., Haverhill, MA 01830. **277**

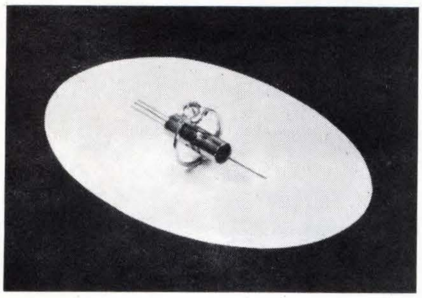
DISTORTION FREE POWER to your computer is described in a brochure outlining a new 60 Hz power line stabilizer. This new family of power line stabilizers provides full power line isolation and constant distortion free power. Georator Corp., 9016 Prince William St., Manassas, VA 22110. **278**

STRIP-CHART RECORDER, Model TR-722, is detailed in a data sheet. The 2-channel portable unit will record from dc to 125 Hz and features 4 electrically selectable chart speeds, inkless rectilinear writing, a unique IC pen motor/amplifier and ac or dc operation. Gulton/Techni-Rite, Route 2, E. Greenwich, RI 02818. **279**

AUTOMATIC DIALING MODULE—a small, solid-state remote programmable module that provides automatic dialing of remotely programmed numbers over the public telephone network—is described in a new product bulletin. G-V Controls Div. of Sola Basic Industries, 101 Okner Pkwy., Livingston, N J 07309. **280**

COMPUTERS . . . Now available is a 28-page brochure featuring three-color block diagrams that describe characteristics of the 16-bit MODCOMP computer family, and system building blocks that include real-time process peripherals and subsystems as well as DP peripherals. Modular Computer Systems, 2709 North Dixie Highway, Fort Lauderdale, FL 33308. **281**

LOW-PRICE REED RELAY



A new low-cost reed relay is being offered for as low as 29¢ (1 million quantities). Other price breaks are: 39¢ for 100,000; 56¢ for 10,000; and 80¢ for 1000 quantities. This new relay features MIL-Q-9858A specifications, a magnetic shield for high-density packing and contact resistance of less than 100 mΩ. Its contacts are rated at 1 A or 250-V switching at 20 W. Coils are available for 1, 3, 5, 6, 10, 12, 15 and 24 V. The relay's size is 0.275-in. in outside diameter by 0.95-in. long. Free samples are available. Electronic Applications Co. 2213 Edwards Ave. S. El Monte, Cal. 91733 (213) 442-3212.

CIRCLE NO. 45

CIRCLE NO. 46

SALES OFFICE

E. Patrick Wiesner
Publisher
221 Columbus Ave.
Boston, Mass. 02116
(617) 536-7780

Hugh R. Roome
National Sales Director
205 E. 42nd St.
New York City, New York 10017
(212) 689-3250

NEW YORK CITY 10017
Gerry Hoberman, District Manager
Richard Millar, District Manager
205 E. 42nd St.
(212) 689-3250

BOSTON 02110
Richard Parker, District Manager
Hal Short, District Manager
89 Franklin St.
(617) 482-6786.

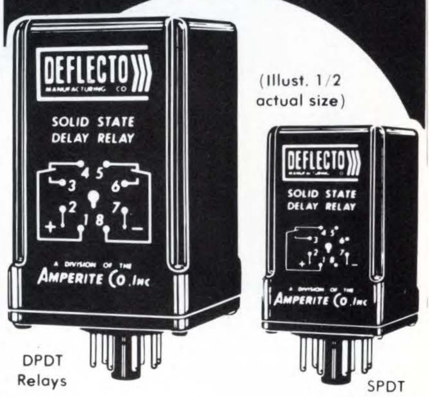
PHILADELPHIA 19103
Steve Farkas, District Manager
Penn Towers
1819 John F. Kennedy Blvd.
(215) 569-2424

CHICAGO
John Huff, Regional Manager
Terry McDermott, District Manager
15 Spinning Wheel Rd.
Hinsdale, Illinois 60521
(312) 654-2390

DENVER 80206
John Huff, Regional Manager
270 St. Paul St.
(303) 388-4511

SAN FRANCISCO 94103
William J. Healey, District Manager
1111 Hearst Building
(415) 362-8547

LOS ANGELES 90036
Ed Schrader, Regional Manager
Harry Fisher, District Manager
5670 Wilshire Blvd.
(213) 933-9525



CIRCLE NO. 47

ADVERTISERS INDEX

Application Notes

A GUIDELINE TO COMPONENT BURN-IN TECHNOLOGY covering economics, techniques, systems, procedures, and equipment selection is available. The 36-page text covers sections on burn-in and life testing of semiconductors. It includes data on high-temperature reverse bias, power aging, thermal fatigue, ambient (free air) burn-in and ac blocking. Wakefield Engineering, Inc., Audubon Rd., Wakefield, MA 01880. **330**

LINEARITY OF TRAVELING-WAVE TUBES is discussed in paper originally published in the Siemens Electronic Components Bulletin. The paper describes the use of a phase compensator to increase the output power of traveling-wave tubes. The two-page paper includes a circuit diagram, measurements, and other illustrations. Copies are available from Siemens Corp., 186 Wood Ave. S., Iselin, N J 08830. **331**

MEASUREMENT OF POPCORN NOISE in linear IC's is covered in this application note. Burst or popcorn noise is random abrupt output voltage pulses. Standard techniques are not suitable to measure such noise. This note details the method by which RCA tests its op amps. Schematic diagrams, a block diagram, and a photo of the test unit are also included. A copy of ICAN-6732 is available from RCA Solid State Division, Box 3200, Somerville, N J 08876. **332**

A PRINTED-WIRING-BOARD REPAIR MANUAL is available to manufacturers and users of printed-wiring structures. The 54-page manual offers suggested procedures for rectifing conditions which may occur to printed-wiring boards during their manufacture or assembly. Copies are available from the Institute of Printed Circuits, 1717 Howard St., Evanston, IL 60202, at a cost of $5 per copy. **333**

REED SWITCH APPLICATION GUIDE to the selection of reed switches for any type of switching application. The piece also covers various forms of actuation, including proximity switching with permanent magnets, bias switching, shielding and electromagnetic action. Hamlin, Inc., Lake and Grove Sts., Lake Mills, Wis. 53551. Ask for Catalog A00001A. **334**

MICROPROGRAMMING HANDBOOK just published is a free 448-page second edition as a sequel to the shorter first edition. The expanded version covers the subject of microprogramming in a very practical and comprehensive manner. In precise terms it tells how to microprogram, why the concept is effective, and when it is most appropriate. Microdata Corp., 644 East Young St., Santa Ana, CA 92705. **335**

APPLICATION NOTES FOR EIA STANDARD RS-232C reviews methods of operation of data terminal and data communications equipment which interface according to the provisions of EIA Standard RS-232C. Part of the document contains a unique coding format. EIA Bulletin #9 costs $2.60. Electronic Industries Assoc., 2001 Eye St., N.W., Washington, D C 20006. **336**

COMPUTER DISPLAY SYSTEM—An eight page brochure describes applications, block diagrams, and system hardware for computer graphic display systems. Data Disc, Inc., 686 West Maude Ave., Sunnyvale, CA 94086. **337**

HIGH-POWER OP AMP, the RCA HC2000, is described with respect to its performance and use in a new 6-page application note. General application considerations are discussed for this 100W-rms device. The note discusses systems that combine the HC2000 with other ICs. RCA Solid State Div., Box 3200, Somerville, N J 08876. **338**

REFERENCE COPIES AVAILABLE

Reference copies of the following articles are available without charge:

R.S. NO.	TITLE	PAGE NO.
L61	Digital ICs offer new solutions for rough industrial problems	20
L62	For high frequency communications equipment, use balanced modulators	28
L63	The ABCs of asynchronous data transmission	34
L64	Two switching regulators for battery-powered systems	40
L65	Four ways of getting precise power pulses	48
L66	What about medical electronics as a new career field?	50

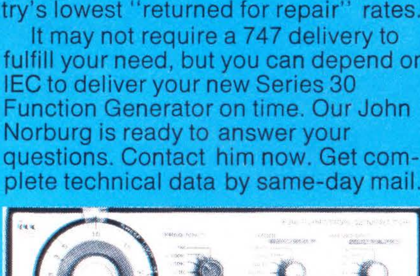
EDN/EEE INDEX

We put eight IEC F34 Function Generators aboard this 747. Tagged for Paris, France, with one-way tickets.

IF YOU'D LIKE TO FIND OUT WHY, CALL JOHN NORBURG AT 714-772-2811 COLLECT

It's nothing unusual. Our various agents overseas, including Tekelec Airtronic of France, represent a very interesting line of Function Generators. The IEC Series 30. Four of the most advanced-concept test instruments available in the Free World. Designed to fit the exact needs of our customers, whether here or abroad. And priced from $295 to $495 to provide the most for the money. Take the IEC F34 (illustrated) for example. At $495, it does everything an oscillator can do and then some! Square waves and triangles, voltage offset, sweep, trigger, gate and pulse. Plus better sine wave purity than comparably-priced oscillators. The F34, like all Series 30 models, provides extra-special features that make it a bargain. Together with such inherent quality that we boast one of the industry's lowest "returned for repair" rates.

It may not require a 747 delivery to fulfill your need, but you can depend on IEC to deliver your new Series 30 Function Generator on time. Our John Norburg is ready to answer your questions. Contact him now. Get complete technical data by same-day mail.



IEC F34 Function Generator

SERIES 30 HIGHLIGHTS F34: ($495) — *Frequency Range:* 0.03 Hz to 3 MHz. *Waveforms:* Sine, square, triangle, dc, pulse. *Output Amplitude:* 10 mv pp to 10 v pp into 50Ω. *Sine Distortion:* <0.3% up to 30 kHz, <0.5% to 300 kHz, <2% to 3 MHz. *Rise/Fall Times:* <60 ns. *Offset:* ±5 v into 50Ω. *VCG Range:* >1000:1. *Operating Modes:* Continuous, Triggered, Gated, Tone Burst, Continuous Sweep, Triggered Sweep. *Sweep Width:* up to 1000:1. Set width directly on tuning dial. *Sweep Time:* 10μsec to 100 sec. *Other Features:* Voltage Analog of Frequency, Sync Input, Output Limit Indicator, plug-in IC's. **F33: ($395)** —Same as F34, but without Sweep, Tone Burst and Voltage Analog of Frequency. **F32: ($345)** — Same as F33, but without Pulse, Trigger and Gate Modes and Sync Input. **F31: ($295)** — Same as F32, but without VCG and Output Limit Indicator. Output Amplitude is 100 mv pp to 10 v pp into 50Ω.

IEC GIVES YOU THE MOST FOR YOUR MONEY

INTERSTATE ELECTRONICS CORPORATION *A Subsidiary of* A-T-O Inc. Dept. 7000, Box 3117, Anaheim, Cal. 92803 (714) 772-2811 TWX 714-776-0280 TELEX 655443 & 655419

CIRCLE NO. 53