VOL. 29 NO. 3
MARCH 1970

CHILTON'S THE ELECTRONIC ENGINEER

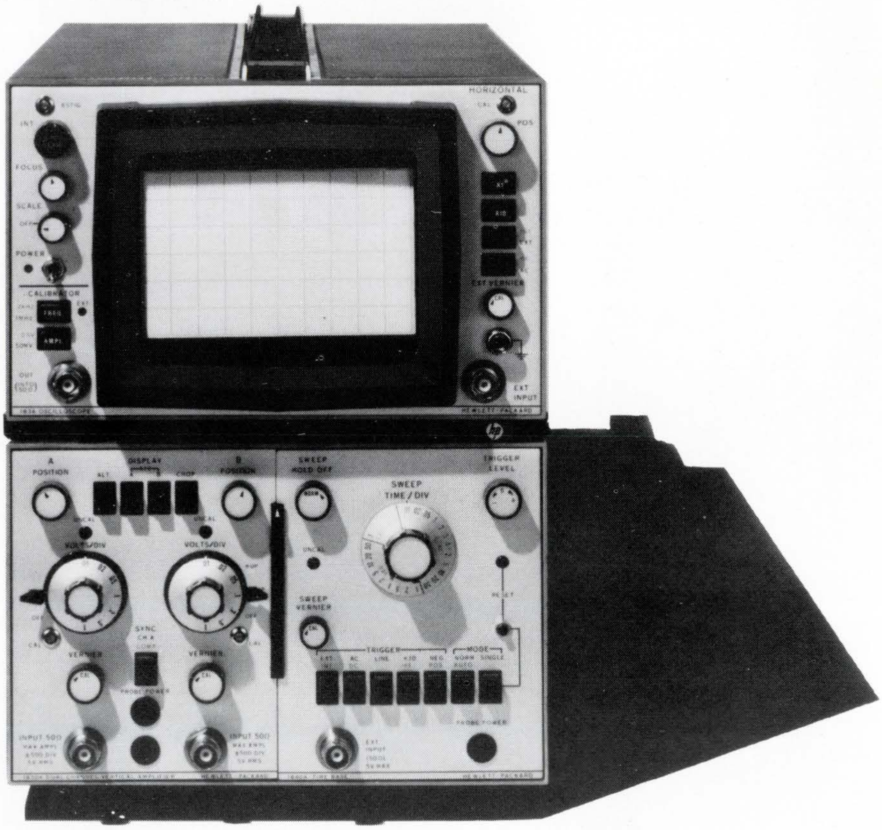
Harold B. Finger of HUD challenges you to help break the housing barrier. p. 46

Course on MOS ICs, part 2 p. 55

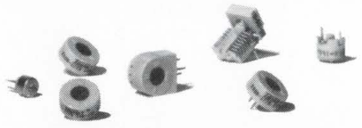
Oscillators and function generators p. 75

IEEE show preview p. 24

New HP 250 MHz Scope Takes the Pressure Off Calibration Labs



Components required to calibrate the HP 1830A vertical amplifier.



Components required to calibrate the HP 1840A horizontal time base.

The new 250 MHz real-time 183A scope has fewer calibration adjustments than any other high frequency scope on the market. That means you can cut the time required for scope calibration to a bare-bones minimum — and reduce your downtime at the same time!

Design of the 183A is new throughout — state-of-the-art technology, including integrated circuits, is used so fewer adjustments are necessary to provide calibration. For example, in the HP 1830A Dual Channel Vertical Amplifier, you have one high frequency R-C adjustment, pulse response — the *only* high frequency adjustment in this plug-in. And the 1840A Time Base has only one HF capacitive adjustment, stability! (Other calibration adjustments: 1830A — five variable resistors to set offset and sync balance. 1840A — five variable resistors, one variable capacitor to set sweep timing, balance, and trigger sensitivity.)

But that's not all! The calibrator built into the 183A mainframe gives you <1 ns rise time at 2 kHz or 1 MHz, with 50 mV or 500 mV amplitude. You can quickly spot check time, amplitude and pulse response calibration on the line or on the bench.

From the performance standpoint, the 183A mainframe works with any of the 180 series plug-ins, at full published specs — four channel, differential/dc offset, 12.4 GHz sampling, 35 ps time domain reflectometer, to mention only a few.

Count and compare the number of adjustments and you'll know why the 183A can take the pressure off your metrology or calibration lab.

With today's increasing demand for the newer, higher frequency scopes, you're going to have to stock a whole new series of parts — so, go with the low cal, high performance champ — the HP 183A Oscilloscope.

Get full details on the new 183A and the entire 180 Scope System from your nearest HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland. Price: HP 183A 250 MHz mainframe, $1750; HP 1830A 250 MHz Dual Channel Vertical Amplifier, $850; HP 1840A 250 MHz Time Base, $550.

080/1A

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

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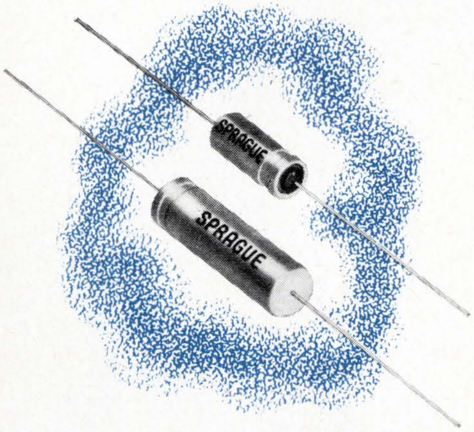
Use SPRAGUE Type 39D POWERLYTIC® CAPACITORS



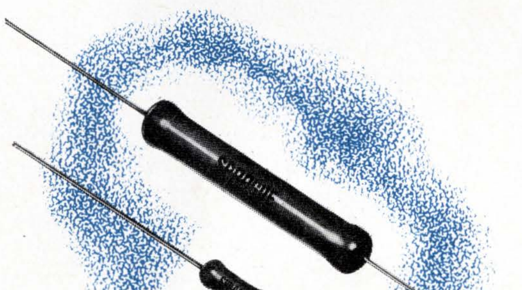
INFORMATION RETRIEVAL NO. 4

- Provide maximum capacitance in smaller cases with axial leads
- No internal riveted or pressure connections
- Welds at critical anode and cathode terminals
- Molded end covers
- Life expectancy of 10 years or more in normal service
- Very low effective series resistance and leakage current
- **Request Engineering Bulletin 3415**

4SC-9154R2

Buy resistors with built-in dependability...

Vitreous-enamel BLUE JACKET® POWER WIREWOUND RESISTORS



- All-welded end-cap construction eliminates moisture along leads, also anchors leads securely to resistor body
- Expansion coefficients of vitreous coating, ceramic core, and end caps are closely matched
- Standard wattage ratings include 1, 2, 2.5, 3, 5, 7, 10, and 11 watts
- Also available with radial tab terminals in ratings from 8 to 230 watts
- **Request Engineering Bulletin 7410D**

INFORMATION RETRIEVAL NO. 5

4SR-9145R2

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

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CHILTON'S **THE ELECTRONIC ENGINEER**

March 1970 Vol. 29 No. 3

COVER

Harold B. Finger, Assistant Secretary for Research and Technology at the Department of Housing and Urban Development, talks of exciting challenges in housing that may offer new opportunities for electronic engineers. Formerly with NASA, Assistant Secretary Finger assesses the potential of systems analysis applied to urban problems and the need for an integrated urban communications system. (Cover photograph: John DiJoseph, Jr., Washington, D.C.)

←Circle 2 on Inquiry Card

Big Jackpot in Connector Strain Relief

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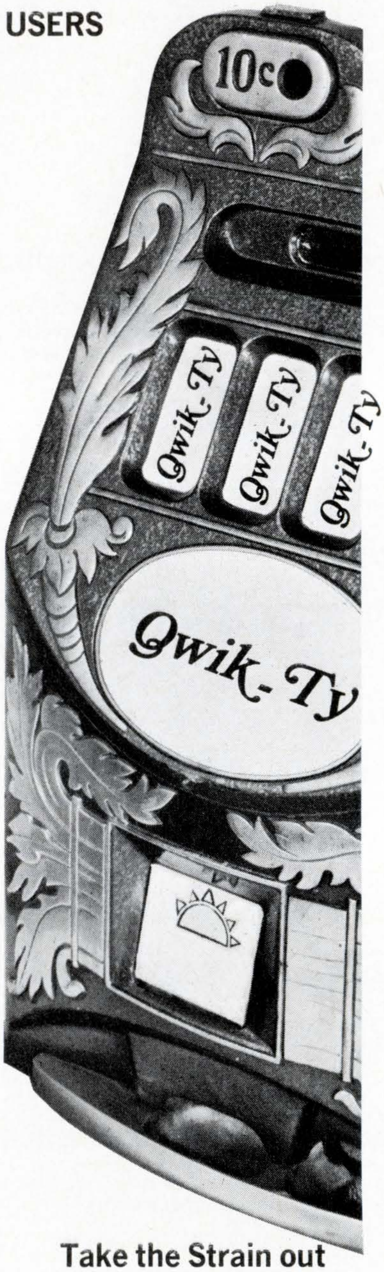
THE BIGGEST PAYOFF YET FOR CONNECTOR USERS

INSTALLED COST — DOWN
A 'lode' of installed cost saving with Qwik-Ty. Reduces assembly time up to **12 to 1** over conventional cable-clamping methods.

WEIGHT SAVING — UP
SLIM-LINE Qwik-Ty's weigh as much as 50% less than standard MS clamps. Additional FAT TRIMMING is achieved by eliminating wrapping tape used in present cable clamp installations.



HOW IT WORKS
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EASY MAINTENANCE TOO
For quick access to wires . . . cut the strap or cord, perform wire or connector maintenance, then tie off again. It's that easy.

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MIL-C-26482	GTR00
MIL-C-26500	GTR01
MIL-C-27599	GTR04
MIL-C-38300	GTR01
MIL-C-38999	GTR04
MIL-C-81511	GTR03
NAS-1599	GTR02

and others

Take the Strain out of Strain Relieving . . .

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Circle 3 on Inquiry Card

THE
ELECTRONIC
ENGINEER

Vol. 29 No. 3 March 1970

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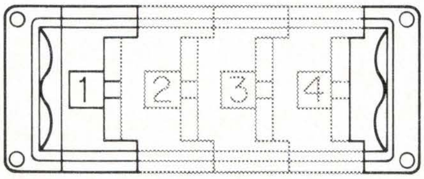
The Chilton Electronics and Instrumentation Group ● The Electronic Engineer ■ Instruments and Control Systems ■ Instrument & Apparatus News ■ Medical Electronics News ■ Electronic Component News

Never underestimate the power of the thumb.

Over ten years ago, Digitran developed the thumbwheel switch. This new device created new importance to the thumb by giving it (and the guy it belongs to), a new power... the power of accurate switching control.

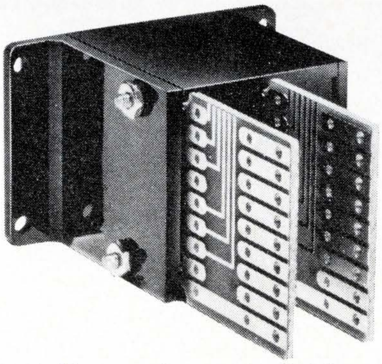
Perhaps a good name might have been **"ACCU-SWITCH,"** for the compact and cleverly designed product had a nice, solid, stop-action between each position. This made it very difficult to switch to the wrong position. The audible and definite click, click, between each position was, and still is, quite an improvement over most other types of switches (even copycat switches).

Maybe they should have named it **"MODU-SWITCH,"** because the second unique feature was the simple way one switch could be added to another to form as many units in a row as the owner of the thumb desired. Each switch fits perfectly together in building-block fashion with standard end sections containing back panel mounting holes.



"COMPAC-SWITCH" might have been an excellent name as well, since Digitran's design allowed the engineer to reduce the size of his panel. We'd like to see someone mount four typical rotary switches in a row and consume only 2.76" in length X 1.15" in height, not to mention the space savings behind the panel. Didn't rotary switches go out with high button shoes?

How about **"VERSI-SWITCH,"** because the entire stationary commutator and termination system on Digitran's switches are produced on printed circuit boards. It staggers the circuit and packaging engineer's imagination on what he can do, (or have us do) to the P/C board on the back end of these switches. You can plug them into a P/C connector. You can wire to them. You can interconnect easily from board to board. You can have extended boards with all kinds of additional circuitry on them. (i.e.: IC's, discretes, etc.) You can have "wire wrap" terminals and, oh yes, Digitran switches are available with replaceable lighting to illuminate each position.



Actually, the boss, who dreamed up the name Digitran, liked the names listed below best and although there are many other variations, the two major product lines are as follows:

DIGISWITCH® medium sized—sealed or unsealed 8, 10, 12 or 16 positions

MINISWITCH® miniature—sealed or unsealed 8 or 10 positions

For those of you who are still not filled in on the details of our thumbwheel switches, please write and we will send you our new complete catalog. Convince us that you have a project that can use our switches, and you can pretty easily put your thumb on a free sample.

THE DIGITRAN COMPANY

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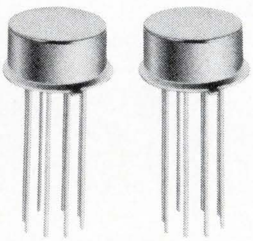
GIANTs™

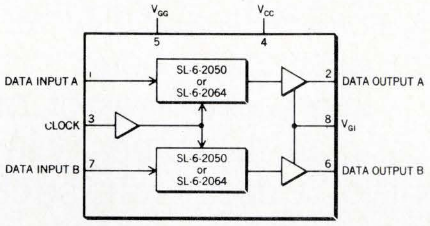
do it better

WITH DUAL 50-BIT
AND DUAL 64-BIT
STATIC SHIFT
REGISTERS

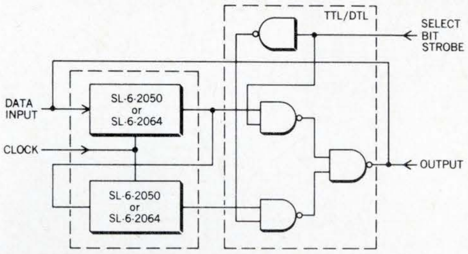


Now... GIANT Dual Registers – with exclusive TTL, DTL and MOS compatibility – provide performance, reliability and cost advantages previously unattainable in serial storage applications.

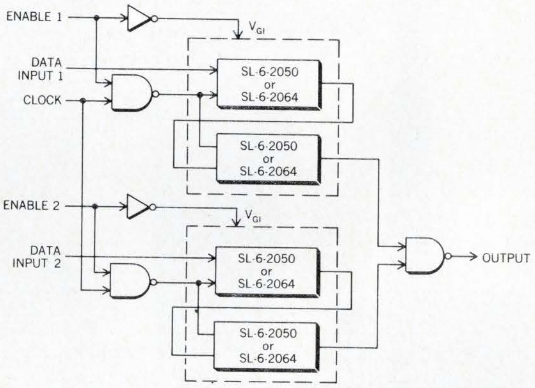
LOGIC DIAGRAM
DUAL 50-BIT (SL-6-2050) AND DUAL 64-BIT (SL-6-2064)
STATIC SHIFT REGISTERS



RECIRCULATING STORAGE APPLICATION



MULTIPLEXING SHIFT REGISTER APPLICATION



NOTE:
V_{GI} IS USED TO ENABLE AND DISABLE SHIFT REGISTER OUTPUT.

Parameters	Delay Line & Interface Electronics	GIANT Dual Shift Registers
Power Requirements	200 mA Typical @ ± 12 V	7 mA Typical @ +5V, −12V
Size	6″ x 1″ x ½″ Typical	.370″ Dia x .260″ H (TO-77)
Weight	1-5 lbs.	1 gram
Number of Parts	50-75	1
Operating Temperature	25°C +20°C, −10°C	−55°C to +125°C

Among their various and marked advantages over bipolar and delay line serial storage systems, General Instrument's GIANT Dual 50-bit and Dual 64-bit DC shift registers operate with the lowest power dissipation available for static registers . . . a mere 7 milliamps typical.

The GIANT Dual 50-bit and Dual 64-bit shift registers operate over the full military temperature range of −55°C to +125°C.

The well known performance and reliability advantages inherent to all MTNS (Metal-Thick Oxide-Nitride-Silicon) devices are, of course, present in these GIANT shift registers. They are directly compatible with TTL, DTL and MOS and require no interface electronics.

A perusal of the comparison chart (above right) should make clear the fact that in serial storage applications insofar as performance, reliability and cost savings are concerned . . . "GIANTS do it better."

The GIANT Dual 50-bit (SL-6-2050) and the Dual 64-bit (SL-6-2064) DC shift registers are available from your authorized General Instrument distributor. For full information write General Instrument Corporation, Dept. 56, 600 West John St., Hicksville, L.I., N.Y. 11802. (In Europe to General Instrument Europe S.P.A., Piazza Amendola 9, 20149 Milano, Italy; in the U.K., to General Instrument U.K., Ltd., Stonefield Way, Victoria Rd., South Ruislip, Middlesex, England.)

Price in quantities of 100 pcs.: SL-6-2050 @ $13.00 ea.; SL-6-2064 @ $16.75 ea.

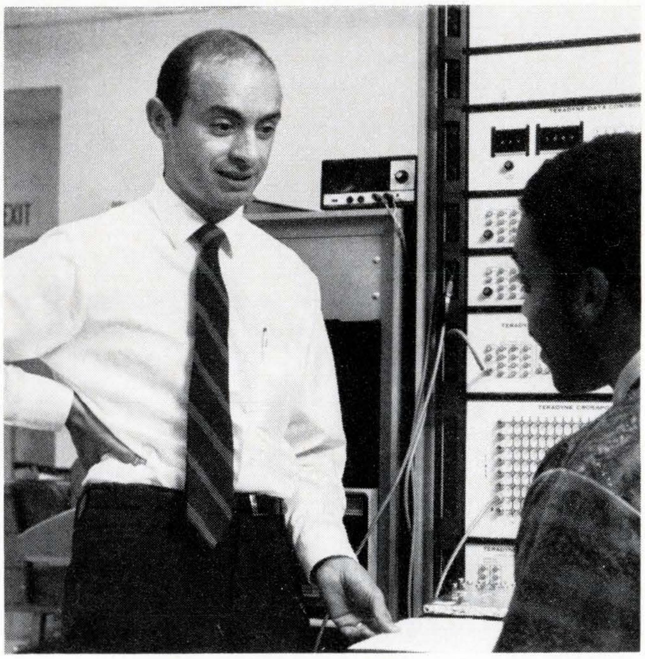
GENERAL INSTRUMENT

GENERAL INSTRUMENT CORPORATION • 600 WEST JOHN STREET, HICKSVILLE, L. I., NEW YORK

Circle 6 on Inquiry Card

Why Intel uses Teradyne J259's to test memory devices

When we asked Intel's test supervisor, Les Vadasz, what he liked most about the Teradyne J259 computer-operated IC test system, he smiled and said: "It runs."

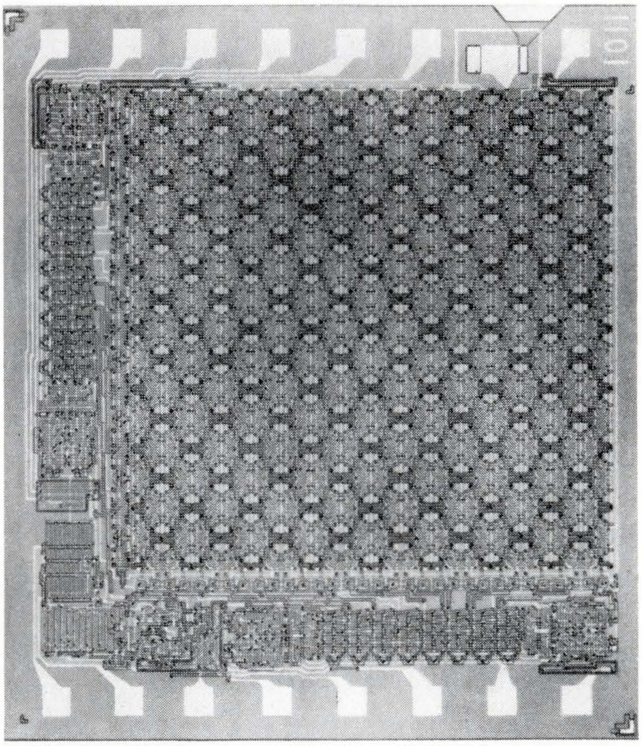


"Just running" is no small matter, as any IC producer can tell you. It's especially vital when you're testing 256-bit silicon-gate MOS memories like Intel's. When your devices are that exotic, you want the most unexotic test system you can find. One that doesn't go off the air once a week. One that doesn't need periodic calibration. One that "just runs."

How dependable are Intel's J259's? So dependable that Intel finds it hard to put a number on downtime, but estimates that less than *1 percent* of its test-facility downtime is attributable to the Teradyne systems.

And Intel's J259's work hard. They make as many as 10,000 functional and parametric tests on each 256-bit MOS memory. They also test all of Intel's new Schottky-barrier bipolar memories. They test packages. They test wafers. They classify devices. They datalog test results. They generate test summary sheets and distribution tables. Since everything is done on a time-shared basis, it all adds up to an awesome test capability per J259, hour after dependable hour.

Intel's new lines of memory devices mark the company as a leader in its field. So does its choice of test equipment—equipment that, in the best Teradyne tradition, "just runs."



Teradyne's J259 makes sense to Intel. If you're in the business of testing circuits—integrated or otherwise—it makes sense to find out more about the J259. Just use the reader service card or write to Teradyne, 183 Essex St., Boston, Massachusetts 02111.

Teradyne makes sense.

Circle 7 on Inquiry Card

EDITORIAL

Think and do

What does housing have to do with electronic engineers? We posed that question to Harold B. Finger, Assistant Secretary of Research and Technology for the Department of Housing and Urban Development (HUD). His answers are the basis for this month's CHALLENGE section, second in a series that began with the January issue. Secretary Finger does not promise electronic engineers jobs, does not necessarily promise future jobs, but instead wants them to think about the problem of mass housing and big-city development in the 1970's—the focal point of his "Operation Breakthrough." He's throwing out a challenge for new ideas and new concepts.

The important point Secretary Finger makes, is that the country needs the talent and knowledge of electronic engineers to solve many of the problems besetting it now, and that will beset it in the future. Some of these new ideas may prompt immediate action, some may stimulate future action, but most, curiously enough, will find applications to areas not directly related to the original challenge. Like many other government figures you will meet in CHALLENGE, Secretary Finger is not asking us to be concerned only for altruistic reasons. There is a big dollar sign behind that concern. If, as the government intends, the public becomes aware that we must begin protecting our environment in this decade, the same public will demand "clean" designs—which are more likely to use electronics.

When Secretary Finger speaks about integrated communications systems, he's not saying who will manage them, or whether they will use airwaves, cables, or waveguides. He's just telling you that if the price is right, the public will be willing to buy them.

These CHALLENGE articles join our technical articles to provide the right mix of thinking and doing that the new decade demands. They are on things for you, as an electronic engineer, to think about; the articles on components, circuits, instruments, and systems are for you to act upon.

Alberto Socolovsky
Editor

A test fixture is worth a thousand words

"It puts their money where their mouth is," said a design engineer as he and I observed an fm sideband appearing on the screen of the spectrum analyzer.

The scene took place in Philadelphia on February 17, during the Workshop and Seminar on "Applications of Integrated Circuits to Communications" organized by THE ELECTRONIC ENGINEER. As you probably learned from the previous announcements published in this magazine, the meeting featured not only technical papers, but also a "Workshop" session giving the speakers the opportunity to demonstrate the circuits, whose application they had just described, with real—and the latest—test equipment. They could test i-f and rf amplifiers with spectrum analyzers, phase-lock-loop ICs with network analyzers, plus 150-MHz scopes and signal generators.

Although the original intention of the Workshop was to give the audience an opportunity to evaluate those ICs and their applications that the papers had described, it turned out to have an unexpected bonus. According to many of those present, they had attended numerous other "paper" sessions (and read numerous articles) on circuits and their applications, only to find that those glowing reports had dimmed once they evaluated samples, or realized that many of the claimed specs could not be achieved simultaneously, only individually.

Not so with this Workshop session. The correlation between the promises on paper to their fulfillment on test jigs was instantaneous; the circuits that had been described in the morning were tested in the afternoon. You see, a fixture *is* worth a thousand words.

It happened last month . . .

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

Power from fossil-fuel . . . Energy Research Corp. now has a long-lasting thermionic diode which can be heated by fossil fuel. The unit, now under test, produces 70 W and has operated at this writing, for over 1000 hours with the test still continuing. In the past, corrosion and oxidation from fuels such as gasoline or diesel oil destroyed thermionic diodes. Energy Research Corp. developed a composite metal-ceramic protective shell which is compatible with fossil-fuel heating systems. The specific construction is proprietary.

Correction device . . . As anyone who has seen a color TV set knows, when there is a camera switch, or a change from live to videotape, the colors on the screen change. The problem is that color TV in the U.S. is transmitted as a NTSC (National Television Standards Committee) enclosed signal. (It's said that these initials stand for "never twice the same color.") Once the NTSC signal is encoded for transmission, it becomes difficult to modify easily without altering the color of the pictures received. Normally, if signal sources are to be matched color-metrically, they must be matched by controls at the originating cameras. However, CBS Laboratories has developed a color corrector to make small color-balance changes on the signal. The device does not process the enclosed signal, but rather generates a correction signal which is added to the original signal.

Unbundling aftermath . . . A one-day seminar, sponsored by Oyer Professional Computer Services, Inc., of New York, took a look at the aftermath of the IBM unbundling, effective January 1. The consensus was that the small users would be hit hardest by increased costs; that less than 15% of former IBM users had signed the system's engineer contract; and that for the large users, the initial impact of unbundling could mean an additional 15-20% increase in their data processing budgets.

Engineering shortage a buffer . . . Despite current unemployment figures and the anticipated slowdown of the economy, the Engineering Manpower Commission of Engineers Joint Council, believes that this will not materially affect engineers. They based this view on the existing backlog of unfilled jobs. This demand should serve as a cushion against any major unemployment of both engineers and technicians in 1970.

Automatic vehicle locating and monitoring . . . Hazeltine Corp., successfully demonstrated a new system for keeping track of vehicles in cities. Each vehicle is equipped with a transponder that automatically replies to an electronic roll call. The roll call can be done at a rate as fast as 1 second for each 1000 vehicles. Ninety-five percent of the time, the system can place a vehicle within 300 ft. of its actual location. Digitally coded information, such as calls for help, the vehicle's operating status, or passenger counts, can be included in the transponder. A single system may be used simultaneously by ambulance services and police, transit, fire, taxi, and delivery companies.

TTL price war? . . . Stephen Levy, VP and General Manager of Motorola Semiconductor, foresees price cutting as a possible result of so many companies moving into the TTL 54/74 market. Extreme price cutting may lead to serious profit cutting. If you have been watching TTL prices, you no doubt had noticed that they've already been dropping during the past year.

Radiation protection for consumers . . . Now in effect, new Federal regulations prescribe corrective action to be taken by manufacturers of such products as TV receivers, X-ray machines, infrared, and microwave ovens and heaters, lasers, electron microscopes, tanning and therapeutic lamps, welding equipment, vibrators and oscillators. Full details are contained in the "Federal Register."

Duplicate video recordings . . . A one-hour high band color videotape recording can be duplicated in less than six minutes. An experimental dynamic transfer system by Ampex Corporation has produced results that are indistinquishable from the original. A specially formulated master tape is used. This tape is brought into direct contact with a blank tape, and under a suitably applied magnetic field, causes the blank tape to assume the same magnetic particle arrangement. Because contact duplication is like printing, the material on the master is "backwards."

Circle 8 on Inquiry Card→

In a world that offers a million different connectors, who needs 7 more?

We don't want to complicate your life.

We want to make it easier for you.

And we think these 7 printed circuit connectors are just the ones that can do it.

Each one started as a special order for a customer like Univac, Automatic Electric, or Mohawk. Each had so many possibilities that we got permission to make them for everybody.

So here's the biggest little line of connectors in the business. Utterly unique, not available as standard items anywhere else.

All connectors are made with our famous welded gold-dot contact design that puts gold only where it's needed, yet holds contact resistance below 5mV drop at 5A.

Until recently, you couldn't buy off-the-shelf connectors like these for love or money.

You still can't buy them for love. Sylvania Metals & Chemicals, Parts Division, Warren, Pennsylvania 16365.

SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

Utility metering by phone line.

Bell Telephone Laboratories have started a trial whereby utility companies can read a home owner's electric, water, or gas meter automatically through the telephone line, and this will be done without ringing the phone or perceptibly tying up the line. The first test will involve 150 homes at Holmdel, N.J. Later on this year more extensive trials will be held in other locations.

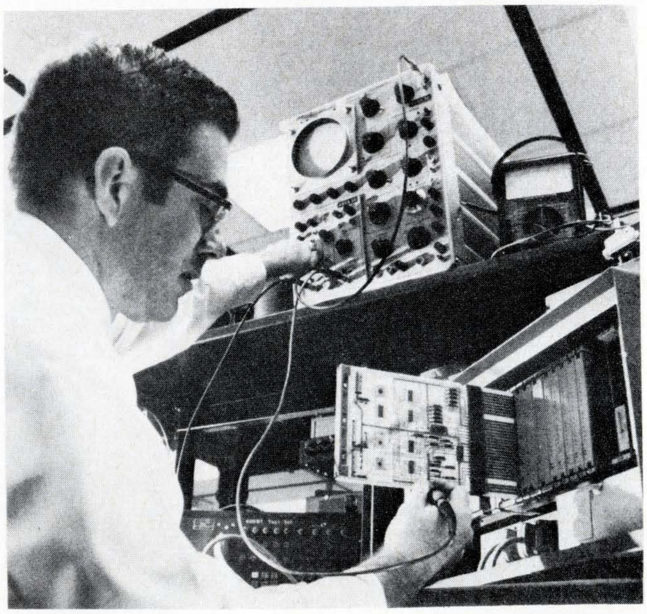
The full procedure of connection to recording a meter reading takes only a few seconds. The part of the process involving the subscriber's line is even faster. So fast, that someone starting to make a call or talking on a line would be unaware that a reading had just been taken. In such a meter reading system, Bell provides communications connections to and within the telephone network. The utility companies are responsible for providing the terminal equipment—the computer or recording unit at one end, and the meter and other attachments at the other.

In addition to the meter, the equipment requires an encoder to convert the mechanical dial readings into electrical form; a modulator or modem to translate electrical pulses into a series of tones suitable for transmission; and a coupler to connect the modulator to the telephone lines. The coding and modulation units are utility company supplied equipment, while the coupler is supplied by the telephone company.

The utility companies simply list the home owner's telephone number in their computer. When the time arrives for a reading, the computer automatically dials the home owner's phone number and takes the necessary reading. These trials will show how each piece of experimental equipment works in a complete system, and indicate any necessary design changes. Whether or not public utilities will ever use such a system will depend upon their view of the economic feasibility and other factors.

An interesting point, and the one that may mean more business for many companies in our field, is that the utilities will use meters and encoder brands of their own choosing. If this system proves successful, this could represent a large market for suppliers of equipment.

A logic circuit for a data communication terminal. Part of an experimental system for reading a gas, water or electric meter automatically over telephone lines is being tested. Through this terminal, a computer can dial a home owner's telephone number and take a meter reading.



Personal paging becomes more practical

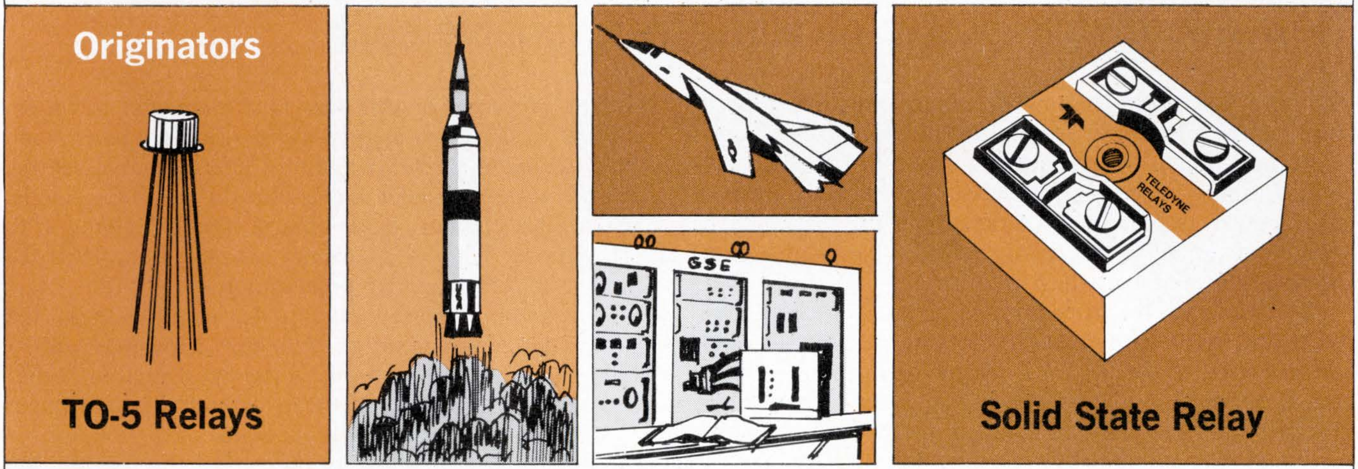
Engineers at Zenith Radio Corporation have developed receivers for paging that permit many more people to share the same frequency. Developed for a system called "SWAP" (system wide area paging), the receivers operate in the narrow band fm channels (150 to 160 MHz).

With the new system and receivers, up to 30.000 individual customers can share one narrow band channel. This is made possible by microcircuits and digital binary coding. Through further extension of the coding, it would be possible to raise the number of users to 100.000.

The receiver weighs only 4½ oz. and emits a tone signal only to the receiver called. The small unit can be slipped into a shirt pocket or pocketbook. Through the system, personal paging service would be practical for the general public.

400 Hz Solid State Relays

for military & commercial aircraft



The originators of TO-5 relays announce another first! Solid state relays that meet or exceed all categories of MIL-STD 704A. Transient protected on input and output. Features include an ultrasensitive "coil" (compatible with 5 volt logic systems, such as TTL), and a zero-voltage switching option to minimize RFI. They can switch over 5 KW, resistive or inductive loads (50-500 Hz).
Extremely high reliability and maintenance-free operation make them ideal for aircraft control and power system applications. Three input "coil" ranges are available, 3-8 VDC, 7-85 VDC and 90-230 VAC. Features include low contact resistance (50 milliohms typical) and contacts capable of withstanding overloads 1000% above ratings. Lack of moving contacts prevents arcing, permitting switching in explosive atmospheres, controlling motors, solenoid valves, actuators, transformers, etc.

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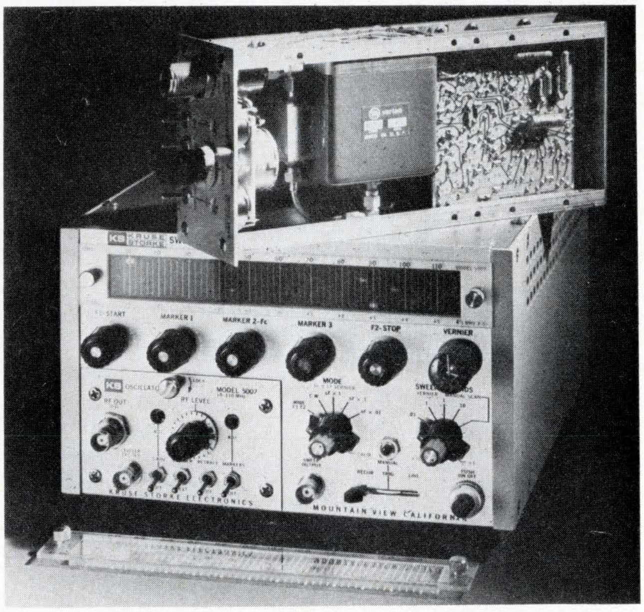
A working Gunn Effect diode

Varian engineers have developed a Gunn Effect diode, which when combined with YIG-tuning techniques results in an electronically tunable oscillator covering the microwave band from 8 to 12.4 GHz. Along with a high output (minimum of 10 mW), device supplies rapid tuning and noise level below that of a BWO (backward wave oscillator).

The new Gunn Effect diode is being used in a microwave sweeper manufactured by Kruse Electronics, a subsidiary of Systron-Donner. Kruse replaced the normal BWO used in sweepers because they were expensive, heavy and wore out in a year or two, besides requiring a big and heavy power supply. Now, with the new diode oscillator, only two small power supplies are required—regulated voltage and regulated current, both are low level and low in complexity and cost.

The complete Gunn Effect oscillator assembly is only 10 cu. in. and weighs just 1.5 lbs. Device is price competitive to that of the BWO.

The Gunn Effect is a phenomena that occurs when you apply a voltage across a chip of gallium arsenide (GaAs). The applied voltage causes a chip to oscillate in the microwave frequencies

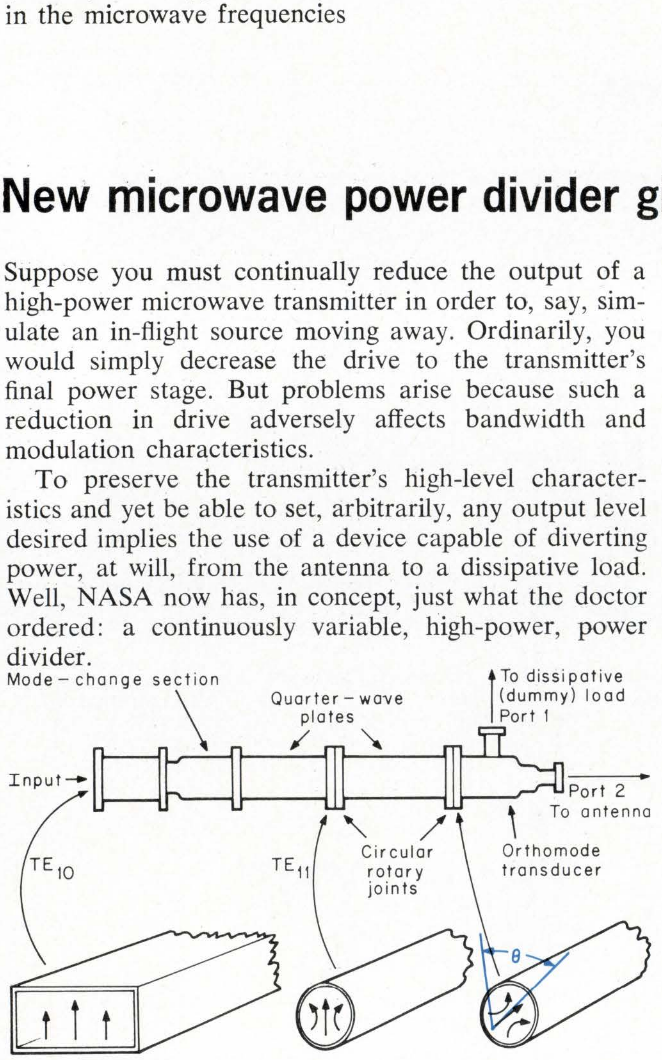


The Gunn Effect diode, operating from 8 to 12.4 GHz, is used by Kruse Electronics in their new microwave sweeper. Oscillator by Varian can be seen in the unit above.

New microwave power divider gives variable split

Suppose you must continually reduce the output of a high-power microwave transmitter in order to, say, simulate an in-flight source moving away. Ordinarily, you would simply decrease the drive to the transmitter's final power stage. But problems arise because such a reduction in drive adversely affects bandwidth and modulation characteristics.

To preserve the transmitter's high-level characteristics and yet be able to set, arbitrarily, any output level desired implies the use of a device capable of diverting power, at will, from the antenna to a dissipative load. Well, NASA now has, in concept, just what the doctor ordered: a continuously variable, high-power, power divider.



The proposed divider has four elements: a *mode-change section;* two *quarter-wave, rotatable plates;* and an *orthomode transducer.* Input energy arrives at the divider via rectangular waveguide in the TE_{10} mode, which the circular mode-change section changes to TE_{11} mode. The first quarter-wave plate completes the change to TE_{11} circular polarization.

The second quarter-wave plate again changes the polarization: this time to rotatable (through 360°) linear polarization. And this is the heart of the matter, because the final element—the orthomode transducer—splits the power between its ports as a function of the polarization angle of its input. In other words, the rotary setting of the second quarter-wave plate determines the power distribution between the output ports of the orthomode transducer.

The amount of power that reaches the antenna (port 2) is $P_{in}cos^2\theta$, while that which reaches the dissipative load (port 1) is $P_{in}sin^2\theta$. So the attenuation between the input and the antenna is $10\log cos^2\theta = 20\log cos\theta$, in dB. Note that this attenuation depends only upon the rotation angle θ of the second quarter-wave plate (the direction of polarization at the divider's input port is defined as zero degrees), which means that you can remotely control and read the attenuation.

R. B. Kolbly, of Cal Tech's Jet Propulsion Lab, performed this work for NASA's Pasadena office.

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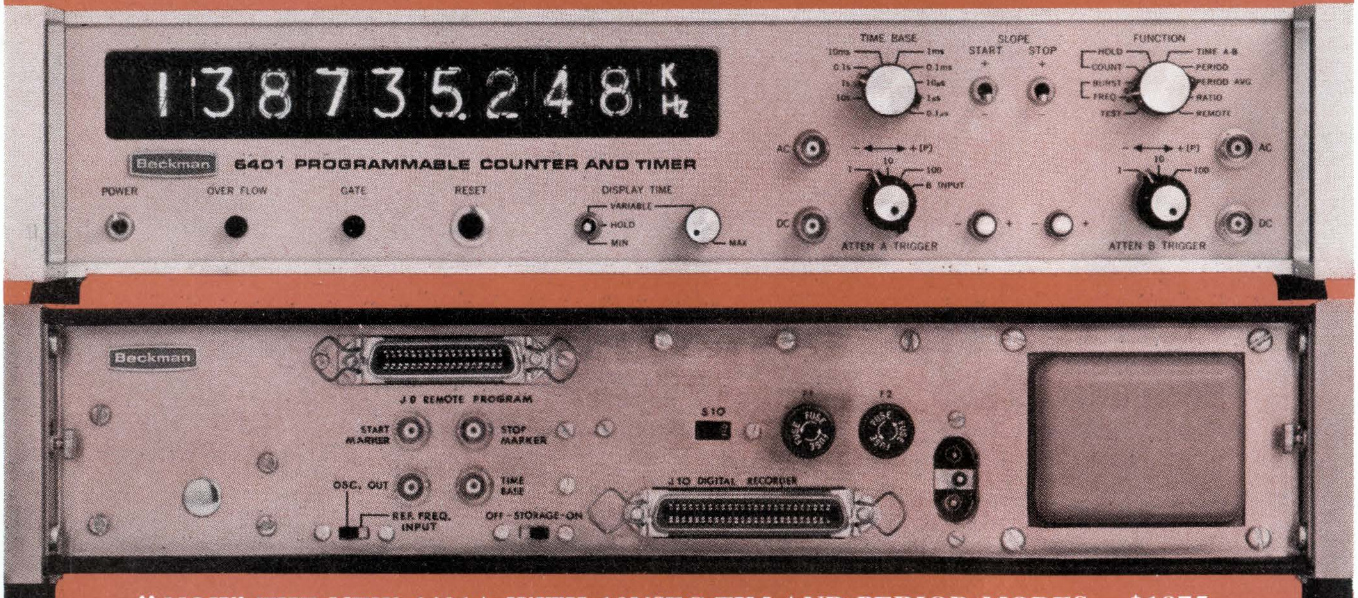

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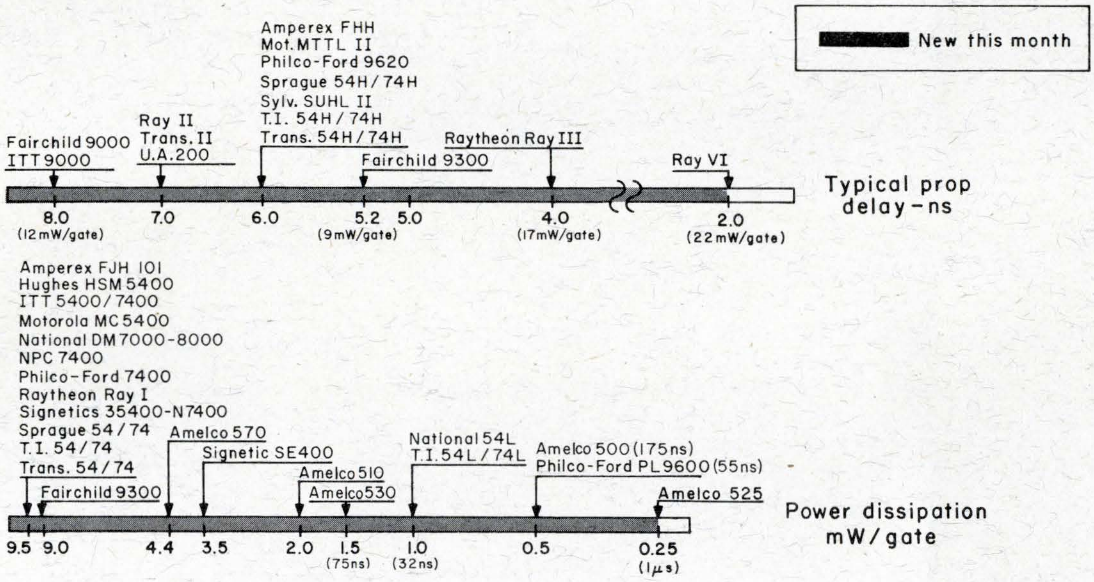
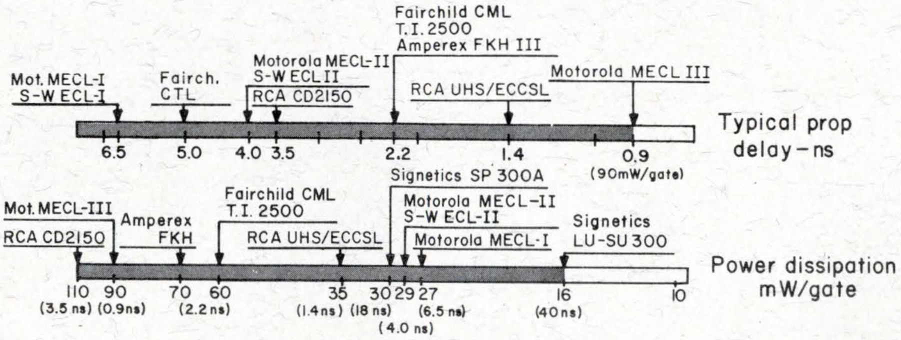
Do not use these charts to specify. Get complete specifications first, directly from the manufacturers.

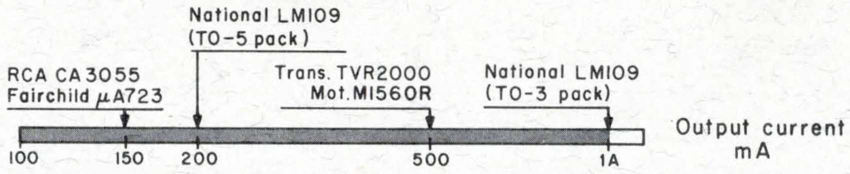
INTEGRATED CIRCUITS

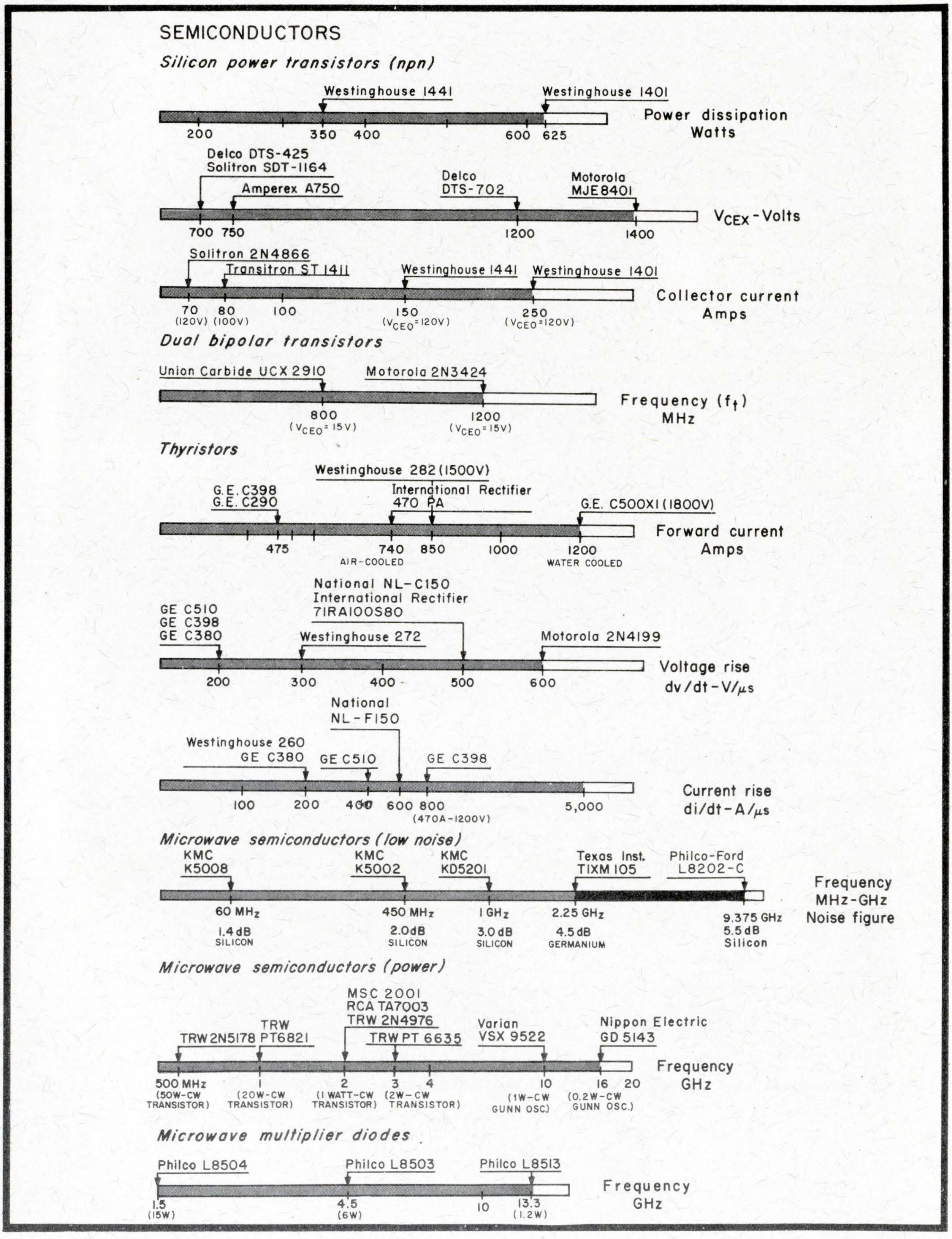


Digital ICs (ECL and special types)



Voltage regulators





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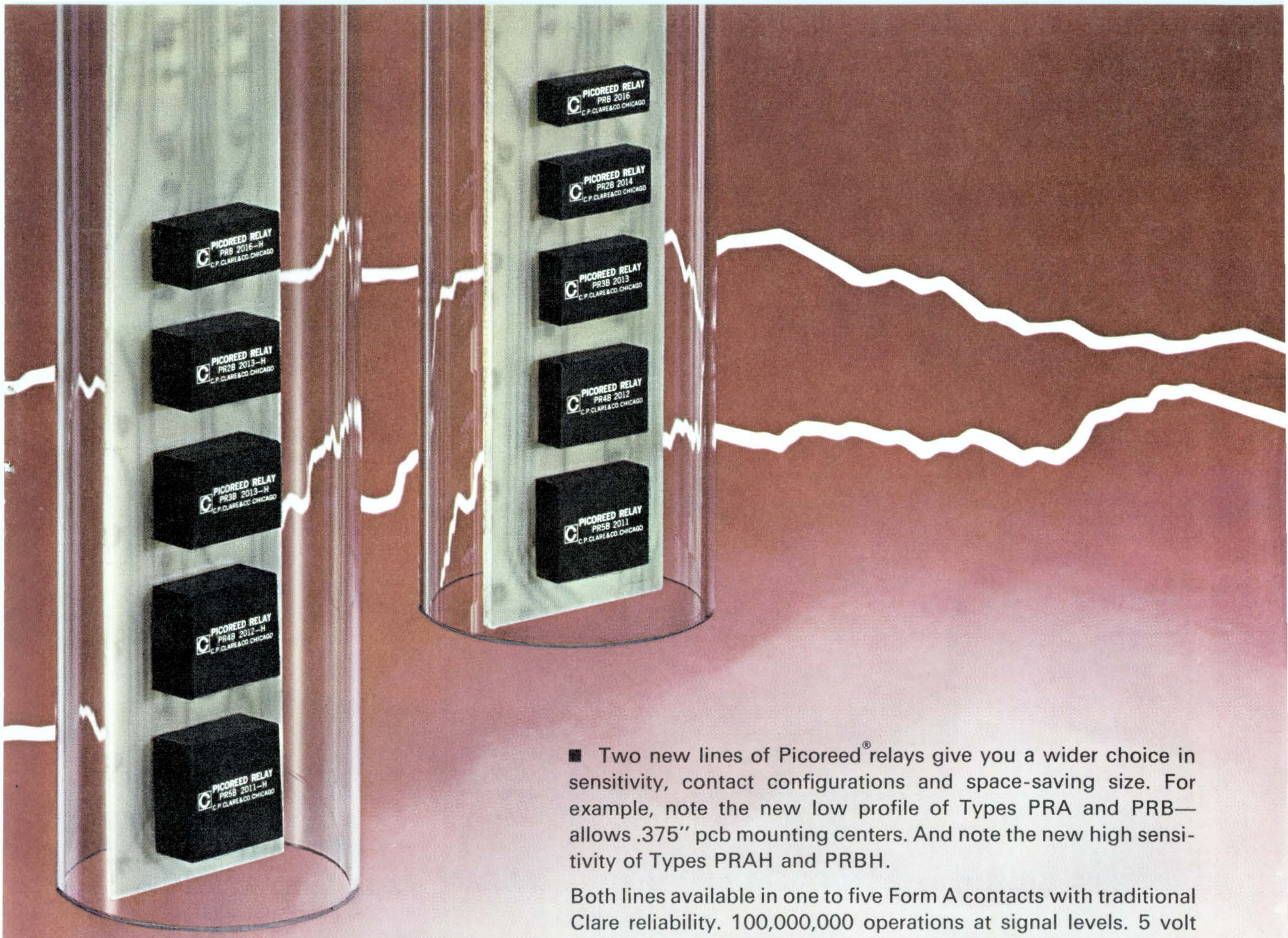

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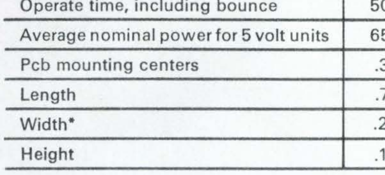
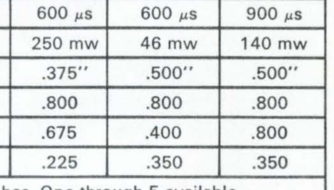


High Sensitivity



Electrical and Dimensional Characteristics	Types PRA/PRB— Low Profile		Types PRAH/PRBH— High Sensitivity	
	Form 1A	Form 5A	Form 1A	Form 5A
Operate time, including bounce	500 μs	600 μs	600 μs	900 μs
Average nominal power for 5 volt units	65 mw	250 mw	46 mw	140 mw
Pcb mounting centers	.375"	.375"	.500"	.500"
Length	.781	.800	.800	.800
Width*	.250	.675	.400	.800
Height	.187	.225	.350	.350

*Widths vary according to number of switches. One through 5 available.

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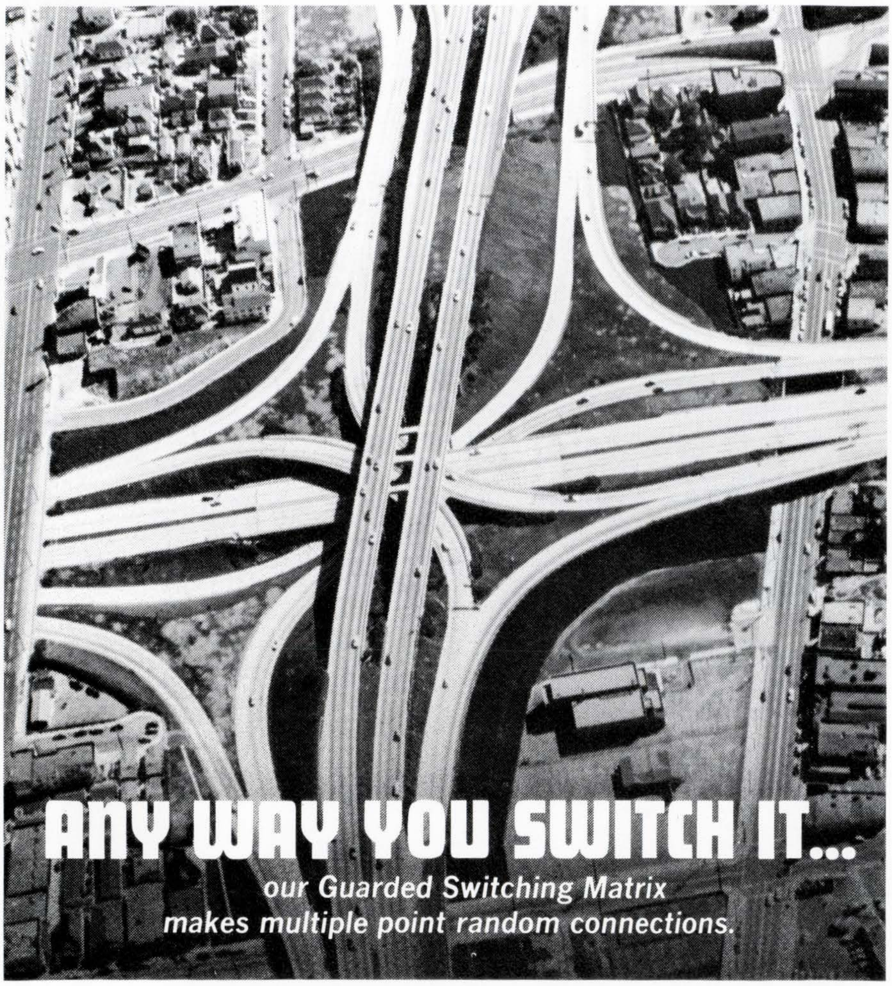

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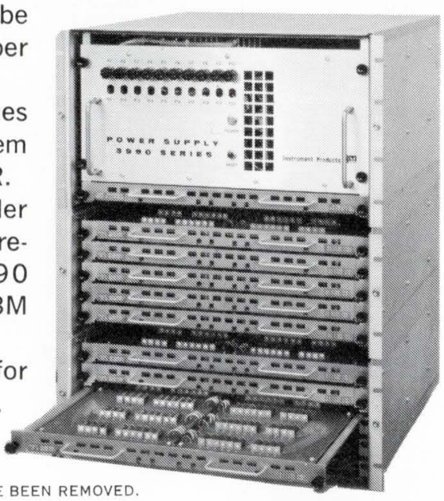

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COURSES

Communications Concepts and Technology: March 17-19, New York; March 31-April 2, Chicago; $290. Designed to update and review the participant's knowledge in the communications field. The program presents state-of-the-art advancements in communications techniques and the new applications and approaches within the communications industry. Sylvania, 63 Second Ave., Waltham, Mass. 02154.

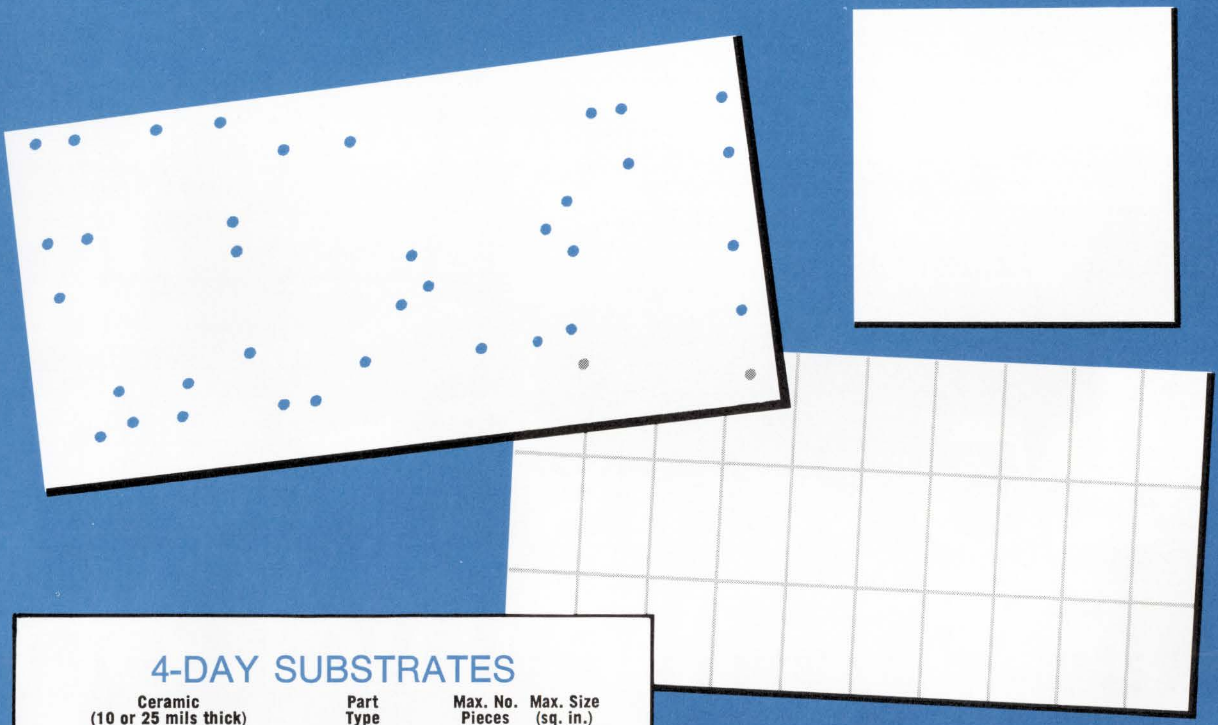
Printed Circuit Technology: March 23-26, Los Angeles; March 31-April 3, Chicago; $345. An in-depth survey of the design and production of PC boards. Sylvania Training Services, 63 Second Ave., Waltham, Mass. 02154.

Expanding Use of Computers in the 70's: March 30-April 1, UCLA; $100. The course will look at the many ways in which the computer will affect society during the next ten years: massive increases in the number of computer installations in industry, the economic impact of the effective use of computers and the use of the computer as an everyday control in finance and manufacturing. Engineering and Physical Sciences Extension, UCLA, Box 24902, Los Angeles, Calif. 90024.

The Methodology of Technological Forecasting: April 14-16, Los Angeles, $325. Government and industry are developing many new ways to forecast future technical developments, but the payoff comes when these projections are incorporated as part of the R&D planning process. This course will give you information on how to integrate technological forecasts with data on future needs, probabilities of success and potential funding levels. Technological Forecasting Institute, Sub. Gordon and Breach Inc., 150 Fifth Ave., New York, N. Y. 10011.

Electromagnetic Compatibility Analysis: April 16-17, Dallas; April 20-21, Los Angeles; $175. To provide the engineer with the philosophy and methodology for critical analysis of generated EMI susceptibility, filtering, shielding and grounding of system and subsystem hardware. Technical Services, Div. White Electromagnetics Inc., 656 Lofstrand La., Rockville, Md. 20850.

the 4-day substrate



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Coors/CERAMICS

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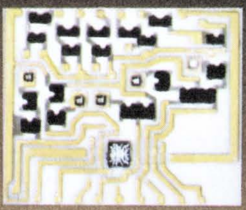
25 years in the thick of it



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SPEAK UP

Electronic engineers on Vietnam

Sir:

Congratulations on your recognition that engineers do not live in a social vacuum. Why try to separate a man technically from his ideals and obligations—we have a duty to speak out thru every means of communication, secular and technical, that represents us.

And I would guess that the large majority of us think the war in Vietnam is stupid or unjust or both, and that Washington is doing much less than it should to end the killing there. We are not fighting Communism; we are not aiding the people of Vietnam; we are not helping America at home or around the world—we are playing face saving politics with the corrupt Saigon opportunists. And the pawns in the game are the youth of America!

Ed Schempp
Scientronics div. of
American Electronic Controls
Roslyn, Pa.

Sir:

When I pick up a technical manual or magazine, I want information regarding my vocation . . . I do not want comments regarding Viet Nam, the Moratorium, or any other political or social controversy.

I vote for your magazine to stick to technical electronic information. My newspaper — and almost everything else—carries the other topics!

Don Bayer
Claremont, Calif.

Sir:

I want to encourage you to encourage others, especially in the face of what I expect is a lot of advice to 'mind your own business.' I cannot imagine what could be more our business, especially since so many electronic engineers are engaged, often so cheerfully, in devising yet newer ways to destroy more Vietnamese.

T. R. Jackson
Corinth, Vt.

Sir:

In reply to your invitation to write to you on the subject of the moratorium I believe people have a right to express their opinion in this way, but draw the line at the display of North Vietnamese flags and slogans. I also think that the vast majority of people are against this type of thing and, for that reason, it will fail.

I recently conducted a survey of friends and acquaintances on the moratorium question and got two hundred signatures against it and two for it. I am sending the results to the President. This was only done for a small number of people and it would be very interesting to see the results of a large sampling. Why don't you do this in your magazine: you can cover the country, I only covered a small section.

As for Vietnam, I think we should get out, in time. I think we should support the President in his efforts to do this. We should protest about our prisoners, they are not to blame for Government decisions in having them there.

There are also a number of politicians who are using the war as a means of furthering their own ends rather than trying to present a united front to this nation and the rest of the world.

The North Vietnamese could be right, yet, if we keep on as we are doing, the war will be won for them right in this country. One thing we lack—which they have, and we don't want—is a complete disregard for human life, so they will keep fighting for years, if we encourage them.

F. E. Day Lewis
Tyngsboro, Mass.

Sir:

Thank you for your courage and correctness in discussing Vietnam in your technically-oriented journal. It is very much our business to be concerned with the welfare of our nation and the social problems of our times.

Louis E. Owen
Portsmouth, Ohio

Sir:

Let's get out fast! This thing is bleeding us white, economically and otherwise and there is no excuse for continuing.

Peter G. Sulzer
Potomac, Md.

Filters or oscillators?

Sir:

Your design feature "Four ways to get active . . . with filters" [**The Electronic Engineer,** January 1970, p. 50] should be entitled "Four ways to get oscillators." Most of your figures show what should be negative feedback returning to the non-inverting input of the op amp.

C. Hill, Sr. Engineer
Westinghouse Aerospace Div.
Baltimore, Md. 21203

EDITOR's NOTE: Our thanks to Mr. Hill, and to many other readers who pointed out our mistake: the polarities for the op amp inputs are reversed on Figs. 2 to 5 of that article.

← Circle 15 on Inquiry Card

Circle 16 on Inquiry Card →

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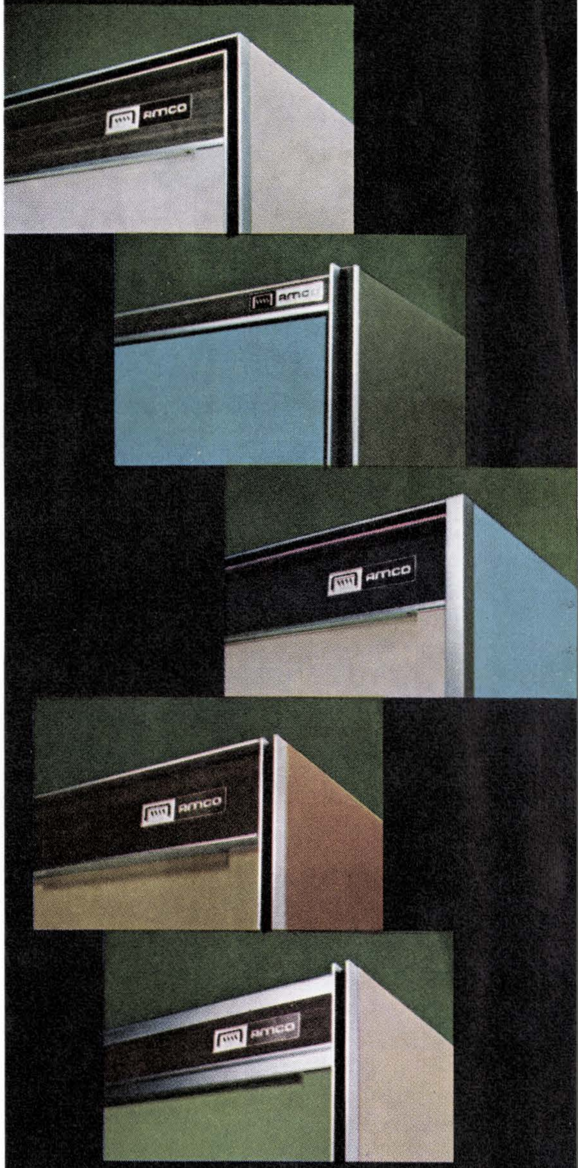

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As in past years, the IEEE extravaganza that offers such irresistible attractions as New York, an industry-wide exhibit (with some reservations; see below), first rate sessions by experts, and many opportunities to plant your resume in fertile soil, will be divided between the Show (exhibits at the Coliseum) and the Convention (sessions mostly at the New York Hilton). From Monday, March 23, to Friday, March 27, the shuttle bus service running between the Hilton and Coliseum will have to do yeoman service to keep up with all the activities at each end of the line.

The Show

Every year the IEEE Show tries to be all things to all people—and, as might be expected, it rarely succeeds but the attempt makes it worthwhile. This year will be no exception. Although the Coliseum will see approximately the same number of exhibitors as last year, the IC manufacturers throughout the country continue to drop out of the Show. Signetics is the latest of the big names to "desert the ship." There are, however, more European and Japanese companies showing their wares this year.

The Show will be held Monday through Thursday, March 23 to 26, from 10 a.m. to 8 p.m. Here is the floor layout for the exhibitions: first floor—production equipment and service organizations; second floor—instruments and systems; and third and fourth floors—components, with microwave components on the third floor.

The Convention

The Convention schedule seems to be diversified enough to please most of the attendees. Fifty-three sessions have been planned for the big week, and most of the action will take place at the New York Hilton. Two new additions planned for the Convention are seven Technical Applications sessions to be held on the fourth floor of the Coliseum, and seven Technical IEEE Group sessions which will be held at the Hilton on Thursday and Friday.

The fifty-three sessions will run the gamut from basic sciences to device technology, communications, computers, medical electronics, manufacturing technology, pollution, transportation, power and management.

Another new feature this year will be the Keystone Session in addition to the traditional evening favorite, the Highlight Session, which is scheduled for Monday at 8 p.m. in Hilton's Trianon Ballroom. D. G. Marquis, Director of the Sloan School of Management, will assemble various speakers to speak on "Planning for Change." The thrust of the Monday session will be to explore how an organization recognizes and adapts to changing priorities.

The second and newest evening gathering, the Keystone Session, Tuesday evening in the Grand Ballroom, will be moderated by H. H. Heffner, Deputy Director of the Office of Science and Technology, Executive Office of the President. Among the areas to be covered in "The Emerging 70s" are materials and device technology, computers and communications in this new decade.

The hot ones

The latest areas of technical interest will be well represented in the convention program. We have highlighted these sessions in the chart of the convention program and, as you can see, very few of the more important sessions conflict with each other. We've picked a few of the choice ones below:

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NEW YORK HILTON HOTEL	MONDAY MARCH 23		TUESDAY MARCH 24		WEDNESDAY MARCH 25		THURSDAY MARCH 26		FRIDAY, MARCH 27 Group Sponsored Meetings	
	9:30 A.M.– 12:00 P.M.	2:00–4:30 P.M.	9:30 A.M. 12:00 P.M.	2:00–4:30 P.M.	9:30 A.M.– 12:00 P.M.	2:00–4:30 P.M.	9:30 A.M.– 12:00 P.M.	2:00–4:30 P.M.	10:00 A.M.– 12:00 P.M.	2:00–4:30 P.M.
Trianon Ballroom (A)	SESSION 1A Electro-Acusto-Opto-Magneto-Elasto Interactions	SESSION 2A Optoelectronics: New Advances in Light-Emitting Diodes and Other Display Devices	SESSION 3A Achieving MOS Bipolar Compatibility	SESSION 4A Integrated Silicon Devices – A Projection Through the 70's	SESSION 5A Solid State Microwave Power Sources and Amplifiers	SESSION 6A Optic-Magnetic-Semiconductor Memory	SESSION 7A Integrated Systems – Interconnection Problems	SESSION 8A Integrated Circuits for Consumer Applications		
Mercury Ballroom (B)	SESSION 1B Satellite Communications for the 70's	SESSION 2B A Broadband Communications Network of the Next Decade – Cable Television	SESSION 3B Millimeter-Wave and Optical Systems: Superhighways for Telecommunications	SESSION 4B Digital Processing of Analog Signals	SESSION 5B Video Telephones – A New Way of Communicating	SESSION 6B The Digital Mating Call of Computers and Communications	SESSION 7B Holography	SESSION 8B Recent Advances in Antennas		
Sutton Ballroom North (C)	SESSION 1C Computer Techniques in Urban Management	SESSION 2C Artwork Generation for Integrated Circuits	SESSION 3C Aeronautics in the 70's	SESSION 4C Ground Traffic Control for the 70's	SESSION 5C Gigabit Digital Circuits	SESSION 6C Lasers in the 70's: Toward Higher Efficiencies	SESSION 7C Recent Trends and Applications of Thermionic Microwave Power Amplifiers	SESSION 8C The Path to Successful Automation in the Manufacturing Process		
Sutton Ballroom South (D)		SESSION 2D Augmentation for the Severely Handicapped	SESSION 3D What's New in Video Displays	SESSION 4D Progress in the Electromagnetic Compatiblity Field	SESSION 5D Educational Technology	SESSION 6D Environmental Pollution – Today's Engineering Challenge	SESSION 7D New Directions for Information Theory in the 70's	SESSION 8D Modern Network Techniques for Device, Circuit, and System Design		
Nassau Suite (E)	SESSION 1E Electrography – Electronic Hardcopy	SESSION 2E Power Systems Dynamics – New Aspects and Novel Analysis Methods	SESSION 3E Bioscanning in the 70's	SESSION 4E Engineering in Emergency Medicine	SESSION 5E Patent Pay for Engineers	SESSION 6E Educational Programs in Industry	SESSION 7E Control Applications in Large-Scale Systems	GROUP EI MEETING Insulation for Advanced Electronic Systems		
Murray Hill Suite (F)	SESSION 1F Frontiers in Power Engineering	SESSION 2F Acoustics in Oceanography – Navigation and Object Location	SESSION 3F Systems Engineering – How Can We Use it Effectively?	SESSION 4F There's Another Way to Get Your Message Across	SESSION 5F Laser Applications in Manufacture	SESSION 6F Microwave Integrated Circuits	SESSION 7F Trends in Computer Applications for the 70's		GROUP B MEETING A Slowed-Down Video Facsimile System Design and Application	
Grammercy Suite (G)	SESSION 1G Computer-Controlled Testing of LSI	SESSION 2G Software for the 70's	SESSION 3G Interactive Terminals – The Search for Cost and Performance	SESSION 4G Computer Graphics in Action	SESSION 5G The Minicomputer Phenomenon	SESSION 6G Prospects for Time-Sharing in the 70's	GROUP SSC MEETING The Urban Regional Problem – New Communities for the Year 2000			
		HIGHLIGHT SESSION 2H 8:00–10:30 P.M. Trianon Ballroom Planning for Change		KEYNOTE SESSION 4K 8:00–10:30 P.M. Grand Ballroom The Emerging Seventies					GROUP AC MEETING Regent Room Tutorial Exposition of Estimation and Prediction Techniques in Modern System Theory	
Sutton Ballroom South	SESSION 1P 8:30–9:15 A.M. Play/Panel Discussion: The Fatal Abstract		SESSION 3P 8:00–9:15 A.M. Play/Panel Discussion: The Fatal Abstract					GROUP COM-TECH MEETING 8:00–10:30 P.M. Solid State Sources for Microwave Trans. Systems	GROUP COM-TECH MEETING The Telephone Utility Serving the Electric Power Station	GROUP COM-TECH MEETING Advances in Data Communication
NEW YORK COLISEUM Technical Application Sessions Fourth Floor	TA 1 – 10:30 A.M.–1:00 P.M. 2:30–5:00 P.M. How to Get Started in Hybrid IC's		TA 2 – 10:30 A.M.–1:00 P.M. Design and Application of Microstrip Circuits	TA 3 – 2:30–5:00 P.M. Applications of Microwave Semiconductor Devices	TA 4 – 10:30 A.M.–1:00 P.M. How to Reduce Interference in Electronic Equipment	TA 5 – 2:30–5:00 P.M. Applications of Infrared Radiation	TA 6 – 10:30 A.M.–1:00 P.M. Time-Shared Computer–Aided Circuit Analysis	TA 7 – 2:30–5:00 P.M. Using Small Computers		
Film Theater Fourth Floor	Continuous Film Theater – 10:30 A.M.–6:00 P.M. – Monday through Thursday									

SPECIAL EDUCATIONAL OPPORTUNITIES DURING THE CONVENTION – NEW YORK HILTON

TUTORIAL SEMINARS	($85 for members; $115 for non-members)			
West Ballroom 8:00–9:30 A.M.	Computers and Patient Care	Mon., Tues., Wed., Thurs.		
East Ballroom 8:00–9:30 A.M.	Programming	Mon., Tues., Wed., Thurs.		
Rhinelander (South) 8:00–9:30 A.M.	Digital Filters: Design and Application	Mon., Tues., Wed., Thurs.		
TWO-DAY SEMINARS	($100 for members; $130 for non-members)			
Rhinelander (North) 9:00 A.M.– 5:00 P.M.	Using Quantum Electronics Today	Mon., Tues.	Monolithic Integrated Circuits: Economics – Design – Applications – LSI	Wed., Thurs.

These sessions recommended by The ELECTRONIC ENGINEER editors. ☐

- Session 2A, Optoelectronics. The interest in this area of technology is very high, thanks to the advantages in modulation, bandwidth and loading immunity that optical coupling and transmission offer.
- Session 3A will explore the compatibility between MOS and bipolar integrated circuits. This subject, which is treated in detail in the February installment of our course on MOS integrated circuits (THE ELECTRONIC ENGINEER, February 1969, pp. 57-64), is still most important to users, and, of course, to manufacturers.
- Session 6A. Just as last year, semiconductor memories will again be covered, with the addition this year of optical and magnetic memories
- Digital filtering. One of the Tutorial Seminars will look at both the design and application of digital filters.

Something for everyone

Once again, the IEEE will explore the interface between electronics and other disciplines. And since it's impossible for you to attend all of the technical sessions, and since it's just as impossible for us to detail them all here, we've selected those we believe to be especially worthy of your attention. For your convenience we have listed them by day.

- Monday, March 23, at 2 p.m. will see a new approach to an old problem in a session titled, "Augumentation for the Severely Handicapped." Basically a tutorial state-of-the-art survey with selected examples, this seminar will look at devices and systems designed to help handicapped people deal with their environment. Scheduled for Sutton Ballroom South, the meeting will be chaired by L. D. Harmon of Bell Telephone Labs.
- Tuesday, March 24, at 2 p.m. Session 4E in the Nassau suite, "Engineering in Emergency Medicine" will cover the collaboration of biomedical engineering with medical researchers and clinicians to organize and develop emergency treatment systems and facilities.

If you drove in for the Convention, you may appreciate "Ground Traffic Control for the 70s" at 2 p.m. in the Sutton Ballroom North. Hopefully, this examination of the increased congestion of the nation's highways will come up with some practical solutions.

- Wednesday, March 25. You can take your pick of two valuable morning sessions. In the Sutton Ballroom South, "Educational Technology" will be discussed. Such educational and training tools as closed circuit TV and computer-aided instruction will be stressed.

Probably closer to home is the subject covered in the Nassau Suite—"Patent Pay for Engineers." Various points of view will be presented to see if a more equitable distribution of benefits couldn't be arranged from work for which a patent has been issued.

A very topical problem, "Environmental Pollution —Today's Engineering Challenge," will be featured in the Sutton Ballroom South at 2 p.m. The engineer's role in combating pollution will be emphasized; current programs will be described. Don't forget that President Nixon has budgeted $800 million a year for the next five years to fight water pollution alone.

Extra-added attractions

The Technical Application Sessions, which will take place during the Show on the fourth floor of the Coliseum, will cover such topics as design and application of microstrip circuits, microwave semiconductor devices, infrared radiation, time-shared computer-aided circuit design, small computers, interference reduction, and, a session titled "How to Get Started in Hybrid ICs," scheduled for Monday at 10:30 a.m. The general theme of all the Technical Application Sessions is "how to do it," and methods, techniques and approaches used in solving real, everyday problems will be featured.

As was the case in previous years, the film theater on the fourth floor of the Coliseum will show technical films from 10:30 a.m. to 6 p.m. throughout the Show. The films will illustrate some of the latest scientific and engineering developments in the areas of space programs, computers, microelectronics, atom energy, and power generation. Check your convention guide for more detailed information.

There are also a few good IEEE Group-sponsored meetings planned, beginning Thursday, March 26, and concluding on Friday. They are being held at the Hilton. Thursday's Group-sponsored technical session, titled "The Urban-Regional Problem—New Communities for the Year 2000," will be held at the Hilton's Gramercy Suite at 9:30 a.m. Questions to be discussed include: should we concentrate on further developments of large metropolitan centers or on more dispersed patterns of cities of a one-quarter million?; and should decisions be made to maximize economic productivity or human fulfillment? This could be a good session to attend and get involved in, both as engineers and as individuals.

Another IEEE Group-sponsored session is titled "Comtech—Advances in Data Communication," which is a continuation of sessions previously held at the Convention. It will take place on Friday, March 27 at 2 p.m. in the Sutton Ballroom South. For this session, information received from manufacturers around the world of new equipment, illustrating and describing unique design features has been compiled. The session chairman is K. D. Young of the New England Telephone and Telegraph Company in Boston.

In addition to the above sessions, there will be three Tutorial Seminars held Monday through Thursday from 8-9:30 a.m. at the Hilton. These seminars will cover Computers and Patient Care, Programming for Industrial Process Computers, and Digital Filters: Design and Application. There is a fee for each of these seminars ($85 for members and $115 for non-members) and advanced registration is required.

A two-day seminar, scheduled for March 23 and 24 from 9:30 a.m. to 5 p.m. at the Hilton's Rhinelander North, is titled "Using Quantum Electronics Today." Because engineers are finding greater applications of quantum electronic techniques from the laboratory to potential consumer products, the knowledge gained through participating in this session should prove valuable.

Monolithic ICs is the subject for the two-day seminar planned for March 25 and 26, 9:30 a.m.-5 p.m. in the Rhinelander North. This eight-session seminar is directed primarily at design and systems engineers. Basic and advanced concepts required by design engineers wishing to benefit from the microelectronics revolution will be presented. The cost for each of the two-day seminars is $100 for members and $130 for non-members.

Registration

Registration can be taken care of either at the New York Hilton or the Coliseum. The Hilton's "checking in" period is from 2 to 8 p.m. on Sunday, March 22 and from 9 a.m. to 5 p.m. during the Show period. The hours are extended to 8 p.m. on both Monday and Tuesday, March 23 and 24, because of the evening sessions. If you decide to register at the Coliseum, you can do so from 9 a.m. to 8 p.m., March 23 through 26. Fees for IEEE members, group affiliates, and members of military services (including civilian employees of government establishments) are $4.00. Non-members are eligible to register for the Show for $8.00.

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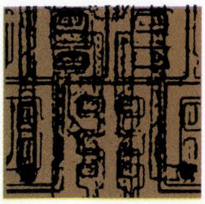

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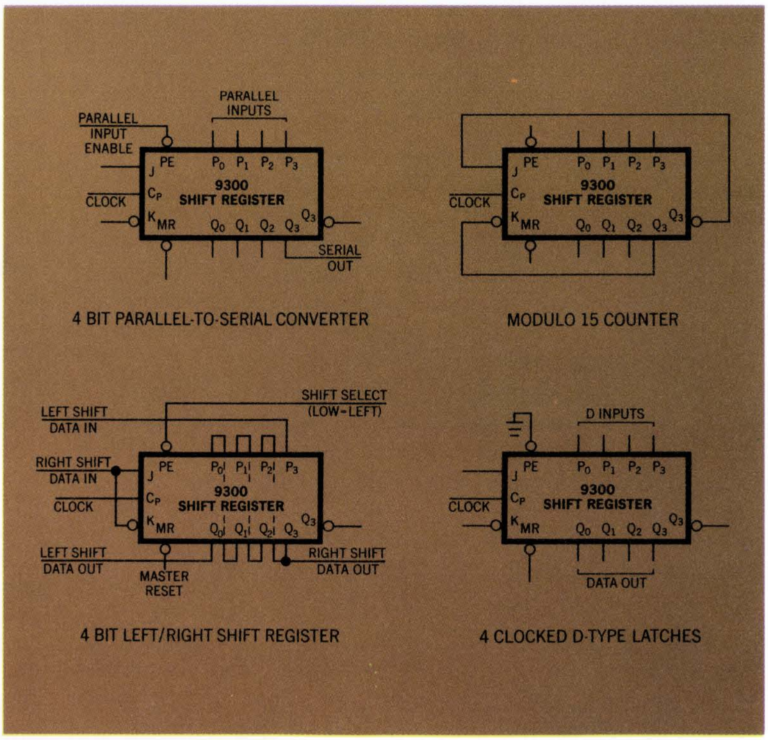

To order the 9300, call your Fairchild Distributor and ask for:

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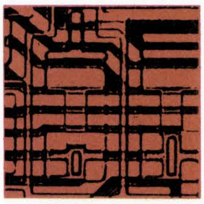
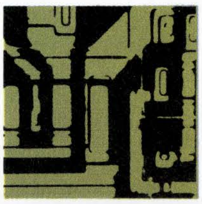
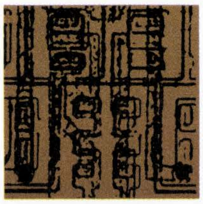


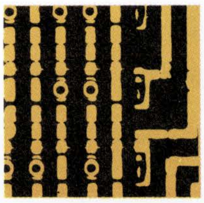
OPERATORS
9304 –Dual Full Adder/Parity Generator



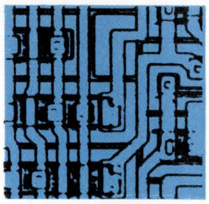
LATCHES
9308 –Dual 4-Bit Latch
9314 –Quad Latch



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

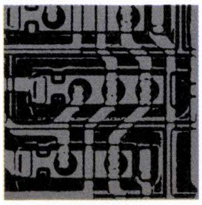


MULTIPLEXERS
9309 –Dual 4-Input Digital Multiplexer
9312 –8-Input Digital Multiplexer



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

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



ENCODERS
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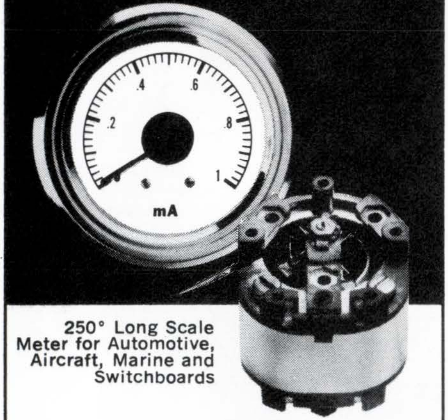

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CALENDAR

MARCH

22	23	24	25	26	27	28
29	30	31				

Mar. 23-26: IEEE 1970 Int'l Convention, New York Hilton and the New York Coliseum. Addtl. Info.—IEEE Inc., 345 E. 47th Street, N.Y., N.Y. 10017.

Mar. 24: Regional Technical Conf. (RETEC) on Rigid Vinyls set for Plastics Engineers, Cherry Hill Inn, Cherry Hill, N.J. Addtl. Info.—Society of Plastics Engineers, 656 W. Putnam Ave., Greenwich, Conn. 06830.

APRIL

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Apr. 8-10: 7th Annual Meeting and Technical Conf. of the Numerical Control Society, Statler-Hilton Hotel, Boston, Mass. Addtl. Info.—Numerical Control Society, 44 Nassau St., Princeton, N.J. 08540.

Apr. 12-16: I.E.S. Annual Meeting Program, Sheraton-Boston Hotel, Boston. Addtl. Info.—I.E.S., 940 East Northwest Highway, Mt. Prospect, Ill. 60056.

Apr. 13-16: 1970 Computer Graphics Int'l Symp., Brunel University, Uxbridge, Middlesex, England. Addtl. Info.—R. Elliott Green, CG. 70, Brunel Univ., Uxbridge, Middlesex, England.

Apr. 16-18: USNC/URSI-IEEE Spring Meeting, Statler Hilton, Washington, D.C. Addtl. Info.—The Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street, New York, N.Y. 10017.

Apr. 22-24: Southwestern IEEE Conference & Exhibition (SWIEEECO), Memorial Auditorium, Dallas, Texas. Addtl. Info.—A. P. Sage, Inst. of Tech., SMU, Dallas, Texas 75222.

Apr. 27-30: IEEE Nat'l Telemetering Conference, Los Angeles Hilton Hotel, Los Angeles, Calif. Addtl. Info.—Ray W. Sanders General Chairman, NTC/70, Computer Transmission Corp., Los Angeles, Calif.

MAY

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May 4-7: International Conference on ION Implantation, North American Rockwell Science Center, Thousand Oaks, Calif. Addtl. Info.—AFCRL (CRWG/Sven Roosild), L. G. Hanscome Field. Bedford, Mass. 01730.

May 5-7: Spring Joint Computer Conference, Convention Hall, Atlantic City, N.J. Addtl. Info.—AFIPS Hdqs., 210 Summit Ave., Montvale, N.J. 07645.

May 5-6: 1970 IEEE Appliance Technical Conference, Leland Motor Hotel, Mansfield, Ohio. Addtl. Info.—W. H. Lynn, Registration Chairman, The Tappan Co., 250 Wayne St., Mansfield, Ohio 44906.

May 11-13: NEW Show, Hilton Hotel, Chicago, Ill. Addtl. Info.—Show Office, 100 South Wacker Drive, Chicago, Ill. 60606.

'70 Conference Highlights

IEEE—Institute of Electrical and Electronics Engineers Int'l Convention & Exhibition, March 23-26; New York, New York.

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

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

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

Call for Papers

The IEEE Transactions on Microwave Theory and Techniques plan to devote a special issue to Microwave Aspects of Avalanche Diode and Transferred Electron Devices, to be published in Nov. 1970. Submit three copies of each complete manuscript not later than April 15, 1970 to Mr. A. H. Solomon, Sylvania Electric Products, Inc., 100 Sylvan Road, Woburn, Mass. 01801.

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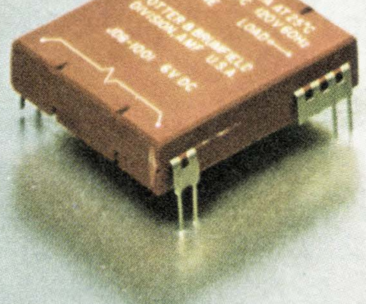
Input/output isolation normally associated with relays is maintained. Installation is conventional, too . . . direct onto printed circuit boards or in a wide choice of sockets. These new products represent a happy melding of semiconductors and relays to enhance the qualities of both. Here is a look at tomorrow's switching devices. We have them today!

① **SOLID STATE/REED AC SWITCH** Our JDB Series has a height of only .275″. It offers the input/output isolation of a reed relay plus the power switching capability and long life of a thyristor. Its 1 Form A contacts will switch loads of 1.7A rms at 25°C ambient for more than 10 million times.

② **AMPLIFIER-DRIVEN JDT RELAYS** Signals as low as 25 microwatts will operate this modified version of our low profile, Thinline JDT Series. Two dry reed contact forms are available: 2 Form A and 4 Form A. In the 2 Form A configuration, input voltages range from 5 to 24 VDC. In the 4 Form A package, from 12 to 24 VDC. This Series—our JDA—allows for 0.5″ centers for printed circuit boards.

③ **ALTERNATE, DIRECT-ACTION, IMPULSE RELAY** This hybrid relay is unique. The DPDT relay employs a permanent magnet in parallel with its normal, single coil, magnetic circuit. Added to this is a solid state flip flop circuit. Thus, our KUR Series has both permanent memory and alternate action features and is controlled from a single, non-polarized, DC source. Contacts are rated 5 or 10 amperes. Because the KUR is designed to transfer its contacts when it receives a specified input pulse and then hold in that mode with or without power, it is recommended for on-off operation or alternate energizing of two loads.

④ **AMPLIFIER-DRIVEN KUP RELAY** The KUA Series significantly expands our family of KUP general purpose relays. Its sensitivity is in the 25 microwatts range . . . and its



New from P&B! solid state relay/hybrids that advance the art of switching

DPDT contacts will switch 5 amperes at 28 VDC resistive or 120V 60 Hz, 80% P.F. It is designed for continuous duty and to fit the wide choice of KUP sockets and enclosures.

⑤ **SOLID STATE HYBRID RELAY** Our EBT Series is a solid state AC switch controlled by a reed relay. This device will switch 7 amperes rms, 60 Hz at 25°C ambient. It is fast (operate time is approximately 2 milliseconds), and the relay provides input/output isolation. Coil voltages range from 6 to 48 VDC. Convenient octal-type socket mounting is provided. Life greater than 10 million operations can be expected.

⑥ **SENSITIVE SOLID STATE HYBRID RELAY** Our EBA Series is similar to the EBT (above) except considerably more sensitive. It will accept a signal of only 12 microwatts. It, too, will switch a 7 ampere load in 2 milliseconds and, like the EBT, incorporates an RC network for dv/dt suppression. As semiconductors accomplish the switching, it is bounce-free.

These devices widen the dimensions of electromagnetic switching. They are engineered and tooled. They offer a ready solution to going from low power logic sources to work-performing loads. Information is available from your P&B representative or contact the factory.

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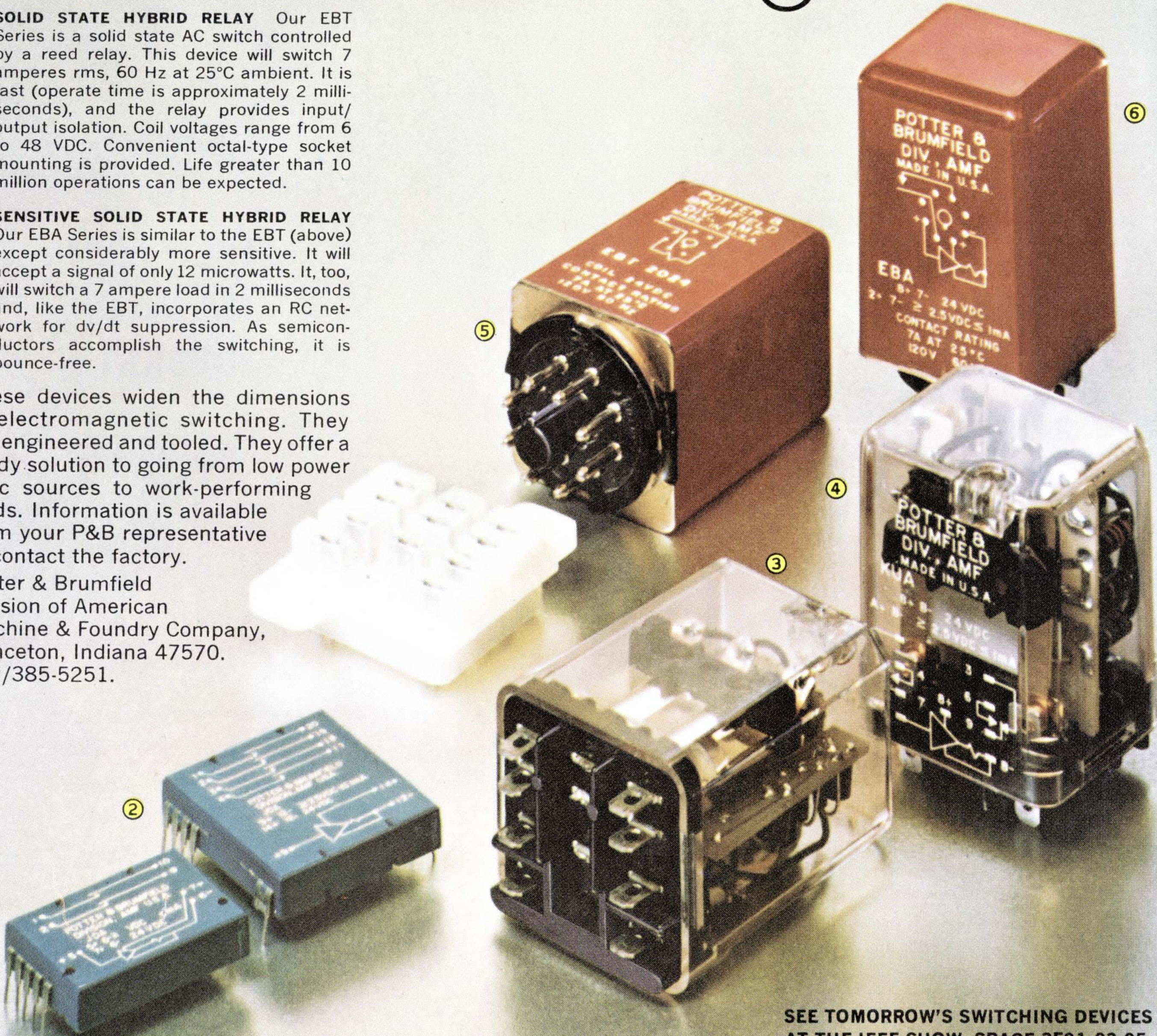

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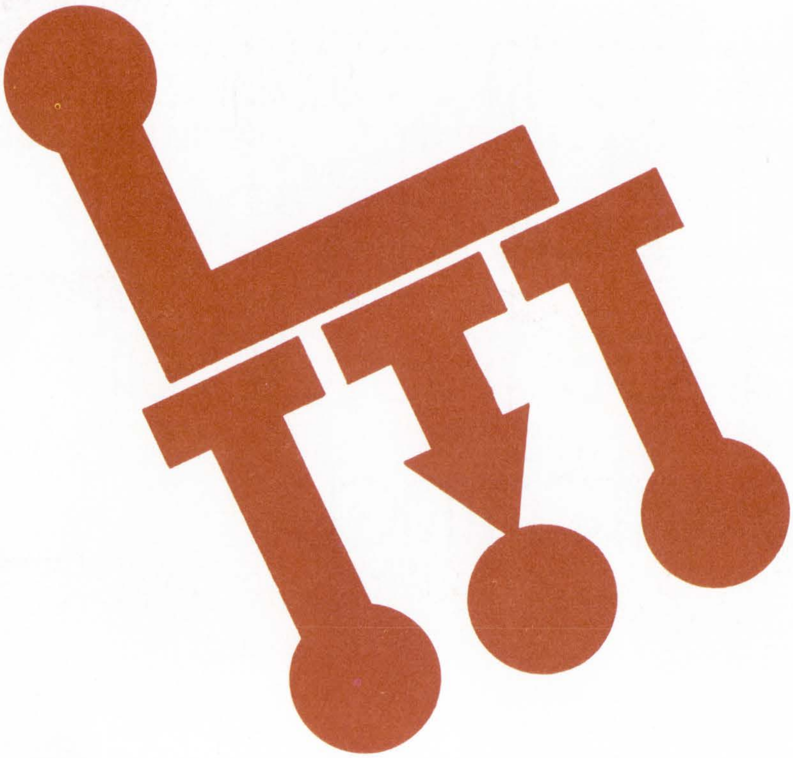

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WELCOME

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

Sun shines on the microcircuit field

Florida sunshine welcomed Fabri-Tek Micro-Systems Inc., an affiliate of Fabri-Tek Incorporated in Minneapolis, Minn., to its new home in Pompano Beach. The new firm was established as an engineering, manufacturing and marketing facility for the production of various miniaturized circuit systems.

All four founders were formerly associated with Radiation Inc. Harris T. Richards now serves as executive vice president of the new firm. Marvin Harding will act as vice president in charge of IC operations, and Emory Lane as vice president of marketing.

Trygve Ivesdal offers an unusual and competent background supporting his appointment to the position of president at Fabri-Tek Micro-Systems. He graduated in general science from a technical college in Oslo, Norway, and earned bachelor and masters degrees in electrical engineering from Michigan Technological University. Ivesdal has had 13 years experience in engineering and marketing. After nine years with Raytheon he joined Radiation as manager of product marketing for the Microelectronics Division.

William Foss, president of Fabri-Tek, said that the new firm would engage in two major efforts — the manufacturing, packaging and testing of hybrid microcircuits, and the establishment of a thick- and thin-film microcircuit laboratory.

Dealing in microsystems and subsystems, Fabri-Tek Micro-Systems specializes in the design of hybrid circuits for both digital and linear applications. For example, should a company request help in reducing the size of its equipment by going to hybrid circuits, Fabri-Tek Micro-Systems will determine whether hybrid circuits rather than discrete components are suitable for the request. While using chips from larger suppliers, the new firm will develop a design for the smaller company and build it a prototype. Should the design be found effective, Fabri-Tek Micro-Systems will fill the production order.

The company, however, is also concerned with proprietary products tailored for mass production. "We want to start eliminating the job shop classification frequently used as a label for the hybrid business," stated Mr. Ivesdal. "We look at hybrids as a natural extension of the monolithic technology and have found the major role of a hybrid manufacturer should be one of adding value to monolithic designs."

Substantial growth has already taken place at Fabri-Tek Micro-Systems. Acquisition of all production equipment from Hybrid Electronics Inc., in Bedford, Mass., took place in December, 1969. Mr Ivesdal reports that installation in Florida is complete and that their first product, the FTD-1001 7-Segment Decoder/Driver is rolling off the production line, along with custom products.

Circle 498 on Inquiry Card

ICs in the mainstream

What does a group of integrated circuit designers do with their expertise? How can they best use their knowledge of large-die fabrication, high-performance monolithic device structures, and precision matching?

One such group of men took the plunge last May, and founded Advanced Micro Devices, Inc., in Sunnyvale, Calif. The San Francisco Bay area is a spawning ground for semiconductor firms, and certainly Fairchild Semiconductor is one of the very favorite hatching spots. And Advanced Micro Devices is no exception; its founders sprang full-blown from that nest with a combined IC experience almost six times that of the 8-year age of the industry itself, an 8-year-old already $400,000,000 big and still growing by leaps and bounds.

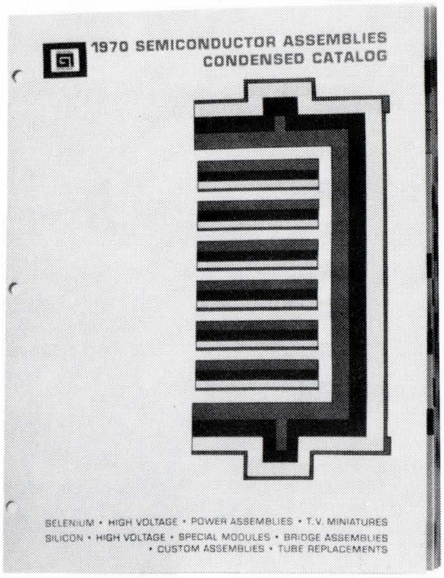
Jerry Sanders is president and chairman of the board of the new IC house. He was formerly director of marketing for Fairchild Semiconductor. Jack Gifford, director of marketing and business development, was linear products marketing manager and then national sales manager for computer accounts at Fairchild, before leaving to join Sanders at Advanced Micro Devices.

Other founders are Larry Stenger, managing director, analog operations; Frank Botte, manager of analog development; and Jim Giles, director of analog engineering. These three, together with Gifford, were instrumental in starting the linear operations at Fairchild, and went on to computerize linear circuit testing there.

On the digital front, there is John Carey, managing director, digital op-

(*Continued on page* 52)

"must reading"



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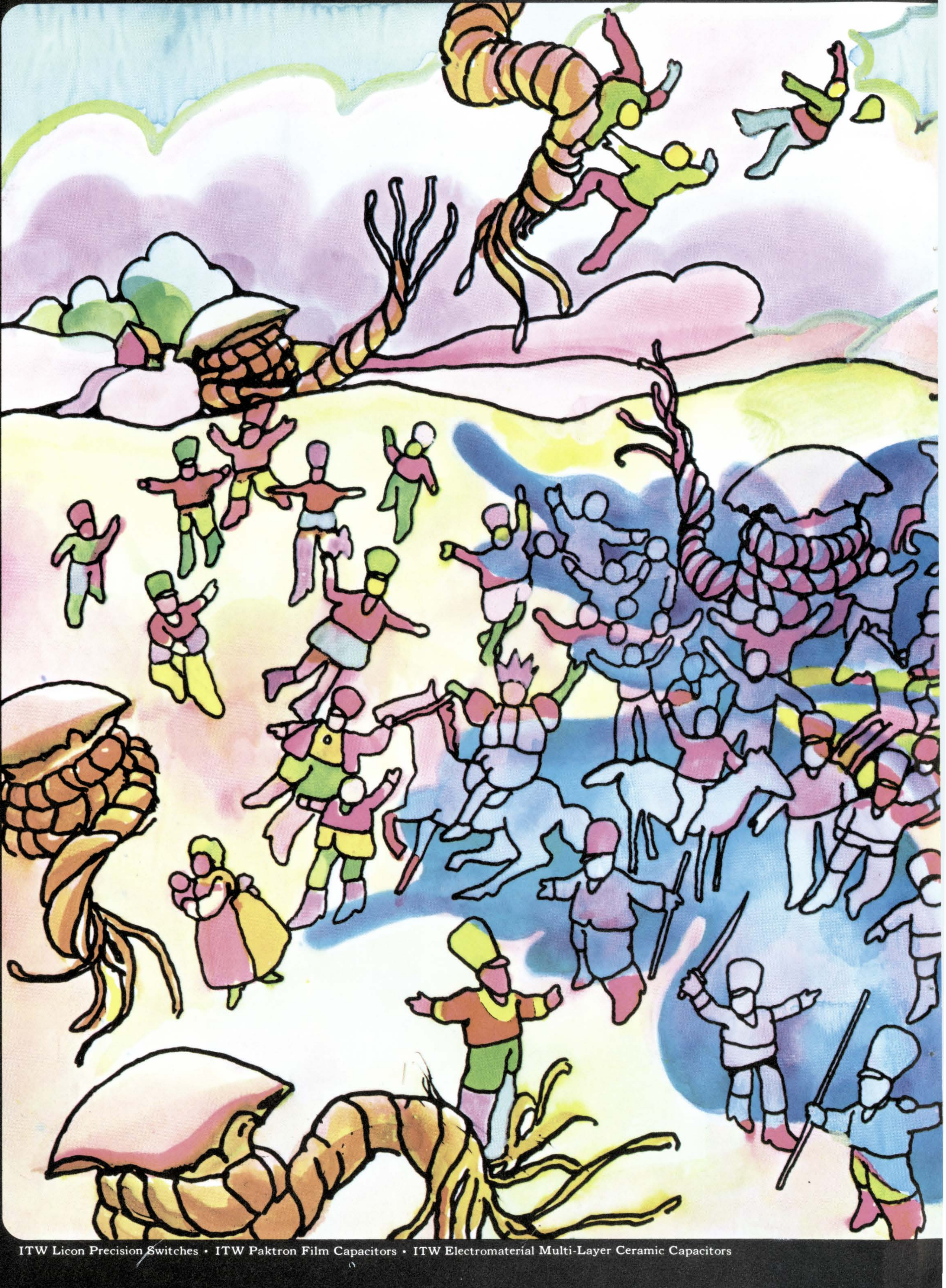

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Many years ago, (before cyclamates or even The Pill), the little Licon® people tried to invent a completely new kind of switch. It was to be a double-break switch no bigger than a single-break. Oh boy.

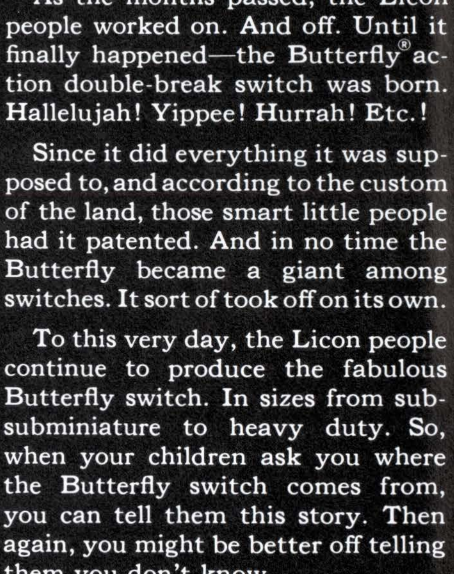
But seriously, this meant a lot to them. They wanted a switch with a life expectancy of over 20 million mechanical cycles without alteration of original switch characteristics. Two transfer blades instead of one. And twice as many contact surfaces. Generally speaking, that's double the electrical rating of a single-break switch of equal size. (If you're impressed by this, read on. If not, read on anyway, there's only a little left.)

As the months passed, the Licon people worked on. And off. Until it finally happened—the Butterfly® action double-break switch was born. Hallelujah! Yippee! Hurrah! Etc.!

Since it did everything it was supposed to, and according to the custom of the land, those smart little people had it patented. And in no time the Butterfly became a giant among switches. It sort of took off on its own.

To this very day, the Licon people continue to produce the fabulous Butterfly switch. In sizes from sub-subminiature to heavy duty. So, when your children ask you where the Butterfly switch comes from, you can tell them this story. Then again, you might be better off telling them you don't know.

Better yet, tell them to write for a catalog.



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Is there an operation breakthrough for electronic engineers?

Breaking through
the barriers to adequate
housing in this
country may
break loose new jobs—in
untried areas—for
electronic engineers.

Challenger: Harold B. Finger of HUD

By John McNichol, Assistant Editor

You probably live in a suburban community, in your own home with your own plot of land. It's mortgaged, of course, but only the bank shares it with you. And, there is a good possibility that your job is located in an industrial park outside the city limits.

Aside from mortgage payments and keeping your house in good repair, housing is probably not a major concern unless you have to face a move, motivated by transfer, layoff or just greener pastures. Then you may well face the payment of points, a very tight money market that makes it difficult to get a mortgage even at inflationary rates, and a genuine shortage of homes. Suddenly, you realize that housing can be a real and terrifying problem.

And as for being a suburbanite, you may have left the city or avoided it because of higher taxes, declining services, transit problems, racial tensions, air pollution and other problems that make Job's afflictions look like a minor psychosomatic skin disorder.

On May 9, 1969, Harold B. Finger took office as the nation's first Assistant Secretary for Research and Technology at the Department of Housing and Urban Development (HUD). So, how does this event affect you —working as you do as an electronic engineer for a large aerospace firm, a computer manufacturer, or an instrument maker?

Well, Harold B. Finger was formerly Associate Administrator for Organization and Management at NASA, and now sees some of the contractors he knew there—defense, aerospace, and other companies known for work in the physical sciences and engineeering—getting into the construction business. Companies such as GE, Westinghouse, Lockheed, Martin-Marietta, and others have made some commitment to develop housing on a scale never before attempted in the U.S.

Catalyst of change

Crystallizing this new emphasis is Operation Breakthrough—a multi-faceted attempt by all levels of government, industry and labor to try and catch up with America's increasingly serious housing shortage. Spearheading this effort, sponsored by HUD, is Harold B. Finger. Finger's hope for Operation Breakthrough is that it will produce quality housing, in large volume, at lower prices. Not a small hope in itself and complicated by having to juggle such diverse items as large land tracts, cutting through the red tape of so-called "snob" zoning law, labor restrictions, obsolete building code requirements, and financing sources.

Breaking through outdated and cumbersome constraints may seem a thankless task—except when you look at the magnitude of the need. The population of this country has been pegged at 300 million by the year 2000. Our urban areas will have 35 million people—and we will need 26 million more houses—in the next ten years. This will call for a building rate roughly double our present one. Instead of increasing, however, our building volume is being forced still lower by the tight money market. Proportionally, Finger states, "The countries of Western Europe (excepting England), as well as the USSR, are outbuilding the United States."

To meet this challenge, about 650 firms have shown an interest in Operation Breakthrough by submitting proposals for full prototype housing systems (called "Type A"), and proposals for components or specialized elements of a system (called "Type B"). Since some of the participating companies have names like General Electric, ITT, Lockheed, Martin-Marietta, TRW and Westinghouse, it is very likely that many of our readers will eventually work on some aspect of housing.

This may be a difficult transition. As Finger notes, very few respondees to the request for proposal (RFP) were purely aerospace firms. "I made a point of saying, 'Fellows, if you've never been in this business—watch it; it's really different.' " Most of the companies who have entered the field have acquired a construction capability.

Examples, though still not numerous, will suffice to show a developing trend, for example:

- GE will build 200 modular housing units at George AFB, Calif.
- Westinghouse, through its Urban Systems Development subsidiary, has built town houses for the inhabitants of a former slum in Montgomery County, Md., at a small, but satisfying, profit.
- Both Martin-Marietta and Lockheed have entered the housing field.
- Mitre Corp. has joined the National Association of Homebuilders.

The unifying communications network

Aside from direct opportunities in the housing indus-

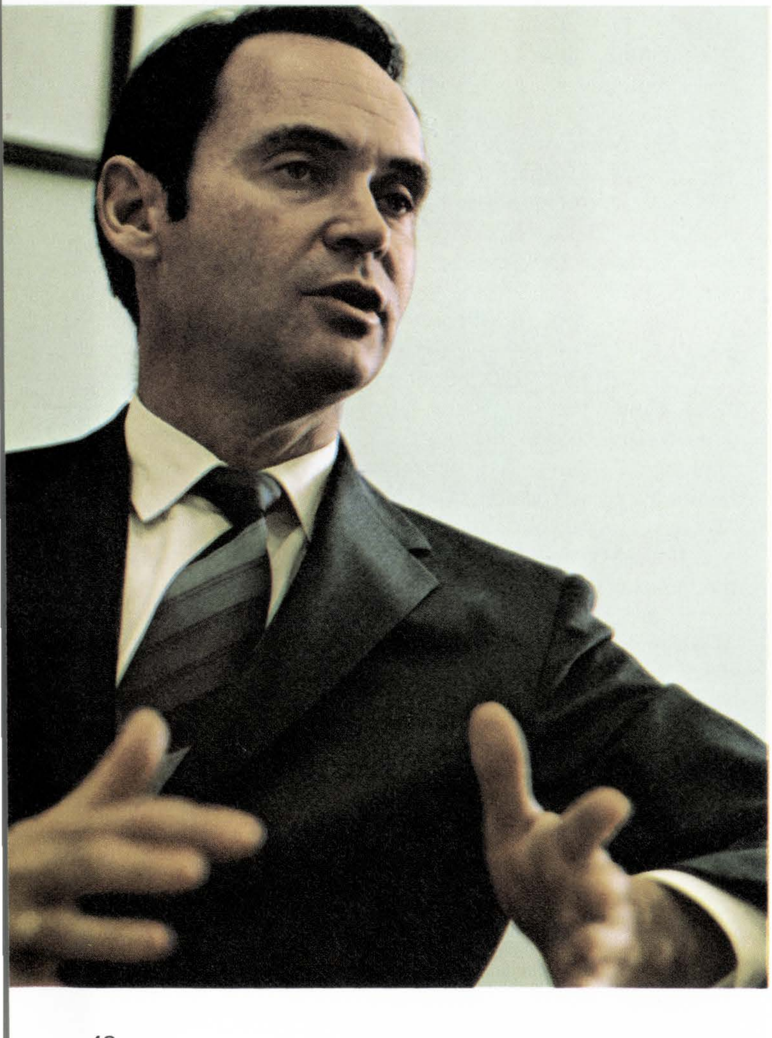
"Electronic engineers must think of . . . communications transfer requirements in

try, Assistant Secretary Finger visualizes an increasing need for broad urban communications. As he noted, "One of the difficulties we have today is that the police department, fire department, and medical and emergency facilities, all with separate communications systems, are frequently simultaneously required for an emergency. There is absolutely no reason why one call—that would define the nature of the problem—couldn't reach a central system that would take into account the area, the structures, and the traffic to dispatch the best emergency service. Your reader, the electronic engineer, must think in terms of the broad information and communications transfer requirements of our cities as a key element to the overall logical and efficient operation of our urban areas."

Systems analysis

Since he brought from NASA a reputation as a systems analyst, we asked Finger how successfully systems analysis might be applied to a program such as Operation Breakthrough. He cautioned "Don't oversell systems analysis and systems engineering in the urban field at this time. For one thing I believe that, although there are masses of data available in many cities that can be considered as experimental examples throughout the country, very little of that information is ordered or consistently acquired. Also, the existing systems for providing services or carrying out the operation expected of a city are not described well enough to develop clear simulation systems or comprehensive models based on real experience.

"There is nothing wrong with the engineer's way of thinking: he wants to know when he is being factual and when he is being subjective."



"The problem then is to obtain a good model of the system to work with. One approach we have been thinking of is to pull all the information together from such metropolitan functions as fire protection, police, etc. Then the data must be examined to discover what factors affect it. If this is done in discrete areas then, eventually, we may be able to tie together the various models and find the interconnecting loops between fire, crime, income levels and other factors. There is no question that they are connected!

"I believe in the techniques of systems analysis and know that they will apply—if you have the proper data pulled together in a sufficiently ordered way and data models you can rely on. It's a long term effort."

The engineering approach

Finger's background is certainly not the conventional one for such a government position. Does his experience help or hinder him? "Well," he replied, "I think my background has helped. With any job of this type, it's essential that you work on the significant areas—not the minor ones. You must be able to analyze the problem in all of its important areas and not get bogged down in trivia. I can't help thinking that some of the problems that have existed in the past with research in this area were the result of an incorrect approach. You have to ask, 'What is going to provide us with results that will really affect the operating programs and give us a better understanding of the problems we face?' Too often there has been a tendency to do research for research's sake; we must do research to solve a problem!

"Another aspect of the problem is that you must provide a very sound management approach to your task. On Operation Breakthrough we're setting up a management system that will track every action on a high level here and on another level for the field; in this way everyone knows where the program stands. I suppose this approach is borrowed from the aerospace field. Actually, this line of attack comes from the way an engineer has to think through a problem. There is nothing wrong with an engineer's way of thinking: he just wants to know when he is being factual and when he is being subjective. He wants to know when he has data and when he doesn't. Of course, you can't have facts for everything. The same thing is true here: you don't have to know everything; you just have to know

urban areas as a key element to the logical and efficient operation of urban areas."

enough to work out solutions or methods of attack."

The changing scene

As an engineer, Assistant Secretary Finger believes that engineers are aware of the social changes in this country. "I think they realize, however, that a great deal remains to be done. Inevitably, when you find a group of engineers together, you'll find them talking about social problems. Most importantly, I think everyone wonders how you attack problems of such complexity and whether they are capable of solution."

Continuing, he stated that improvements can be made. "I think the problems are solvable, or I wouldn't be here. What does concern me is whether a confrontation between the races or between the affluent and the poor can be avoided. This is a very basic issue that underlies all the normal urban problems, such as congestion, pollution, lack of housing, communications, education, job opportunities, etc."

The urban syndrome

Developing his thesis, which may have far-reaching

"Western Europe . . . is outbuilding the U.S."

New decades promise new challenges, and never before have there been more and varied areas to explore and develop for the electronic engineer. These new opportunities are not just the result of pushing forward the frontiers of state-of-the-art technology but totally new areas. To suggest some of the tremendous potential in new technologies, new markets and new fields, THE ELECTRONIC ENGINEER presents the second in our new series, CHALLENGE.

The Seventies will see our readers working on problems previously outside their specialty—such as mass and individual transit, pollution of water and air, and improved housing. One such example of divergence from the traditional paths for engineers is the former Associate Administrator for Organization and Management at NASA, Harold B. Finger, who has been since May 8, 1969, the first Assistant Secretary for Research and Technology at the Department of Housing and Urban Development (HUD). Assistant Secretary Finger is responsible at HUD in great measure for the success or failure of Operation Breakthrough—a program to encourage large-volume production and delivery of housing through the application of improved technologies and management methods. George Romney, the HUD Secretary, has characterized this concept as "not a program designed to see just how cheaply we can build a house, but a way to *break through* to total new systems of housing construction and marketing."

The man who shoulders this weighty assignment had been responsible at NASA for virtually all of the Agency's administration, organization and management activities since March 1967.

Prior to this, Finger had been Manager of the Space Nuclear Propulsion Office, a joint NASA/Atomic Energy Commission organization to develop and test nuclear propulsion systems for space rockets. This involved the responsibility for carrying out all areas of the nuclear rocket propulsion program.

During the same period that he served in the above capacity, Finger also held the positions of Director, Space Nuclear Systems Division for the AEC (June 1965 to March 1967) and Director, Space Power and Nuclear Systems for NASA (January 1964 to March 1967). In these positions he was responsible for the work of each agency aimed at the development of electric power systems to be used in space, including nuclear propulsion. His NASA responsibilities also included research and development on advanced solar and chemical electric power systems and space electric propulsion systems, as well as the application of all these systems to space propulsion and their development through flight testing.

Previously, Assistant Secretary Finger had been on the NASA Headquarters staff in varying capacities since its establishment in October 1958. Before this association, he had been with the National Advisory Committee for Aeronautics, the predecessor to NASA. During this period his research had been on reciprocating and advanced gas turbine engines, and, eventually, nuclear engineering.

A recipient of the Bachelor's degree in Mechanical Engineering from the City College of New York, Finger was awarded the M.S. degree in Aeronautical Engineering at the Case Institute of Technology. In 1957 he was co-winner of the Manley Memorial Award, given by the Society of Automotive Engineers, for the best paper on Aeronautics. He received the American Institute for Aeronautics and Astronautics James H. Wyld Propulsion Award in 1968 and the NASA Outstanding Leadership Medal in 1966.

implications for urban and surburban housing and working patterns, Assistant Secretary Finger elaborated on the historical basis for such a confrontation and what might be done to prevent it. "We should be planning ahead to see where our future growth will be, but, unfortunately, this is much easier said than done. First, we must know what are the factors that really influence urban growth and development. We do know that if you build a highway out from the city there will be a tendency for industries and housing growth to develop along that highway. Look at what happens to real estate values; we ought to be able to quantify this action.

"In the Twenties and Thirties, we started with central core cities with rail lines fanning out to the suburbs. It was difficult to get from the end of one suburban line to another with public transportation—there were relatively few automobiles. There were open areas of greenery between each of these wedges. As the automobile became more available, the open areas filled up with housing. At the same time, highways expanded their routes and beltways were extended from one wedge to another. Then industry developed along these beltways.

"In the meantime, the center city deteriorated and became a less pleasant place in which to live; the white middle class moved to the suburbs with their available mortgages. The center core cities were left to the poor and the Blacks who couldn't move out and didn't have ready mobility to get to jobs. Until there is an opportunity for choice and dispersion, the confrontation will exist and this is the major problem that we face in this country.

"We must set up an urban development policy that carries with it a requirement for better housing and schools located near job opportunities. This must be a publicly and privately supported objective. By privately supported policy, I mean that when a company that employs a wide range of skills is planning to build a plant in an area, the company should take action in that community to force the development of housing. This action should be taken before the firm develops the area and provides revenues for the community."

New Horizons

All this may seem far-fetched material for an engineer from NASA. However, Harold Finger has a reputation as a "get-it-done" guy and that's why he was chosen to steer Operation Breakthrough between such traditionally warring factions as the unions, private capital, industry, zoning regulations, and bureaucratic and public apathy. And that is part of the reason that opportunities for electronic engineers may be expanding into such unlikely areas as housing, urban communications systems and other fields previously unexploited.

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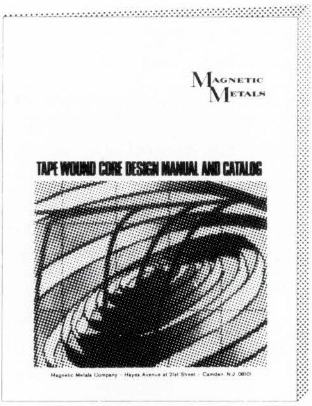

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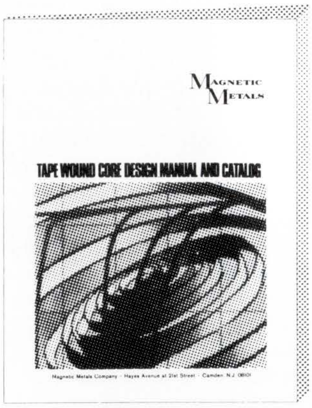

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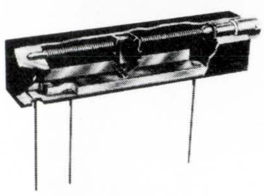

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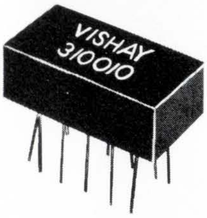

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Circle 27 on Inquiry Card

WELCOME

(Continued from page 43)

erations. Carey—also a Fairchild alumnus—is a specialist in MSI processing. And Sven Simonsen, director of engineering for complex digital functions, was very closely associated with the development of the 9300 MSI family.

Advanced Micro Devices was formed to build complex function ICS for the peripheral equipment, minicomputer and data communications markets. The company will use its special skills to build devices for the mainstream of these industrial markets. Advanced Micro Devices' mainstream concept means it will select its products from a wide group (originally spread amongst several manufacturers) in such a way as to form its own product families. These families will be pertinent to particular types of equipment. First products—to be announced in the second quarter of this year—will be monolithic, bipolar, TTL/MSI and linear devices of second-generation complexity.

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System development for mini-computers

Three former employees of Sperry Rand have banded together to form Custom Computer Systems, Inc., a company established to bridge the gap in system development created by the advent of the mini-computer. Located at 40 South Mall Drive in Plainview, L. I., N. Y., CCS was formed early in 1969. Specializing in both hardware (logic design, circuit design, and memory systems) and software (analysis and programming), the fledgling company has the capability of developing turnkey systems utilizing mini-computers. The hardware and software disciplines of the company provide a vehicle to take advantage of the potential of the mini-computer by diverse users with a variety of applications, made economically feasible by the low cost of the mini-computer.

At present Custom Computer Systems, Inc. is offering a hardware system which is a breakpoint generator designed to talk to the PDP-8L (a Digital Equipment mini-computer). The cost of the system is $590. An automatic bidding system, priced at $15,-000 is also being offered. Under development is an automatic tester for testing modules (A/D and D/A converters) which should be available for under $20.000 in January, 1970.

Competition for the new company comes from firms in the mini-computer field; however, only with those companies that can supply the system as well as the computer.

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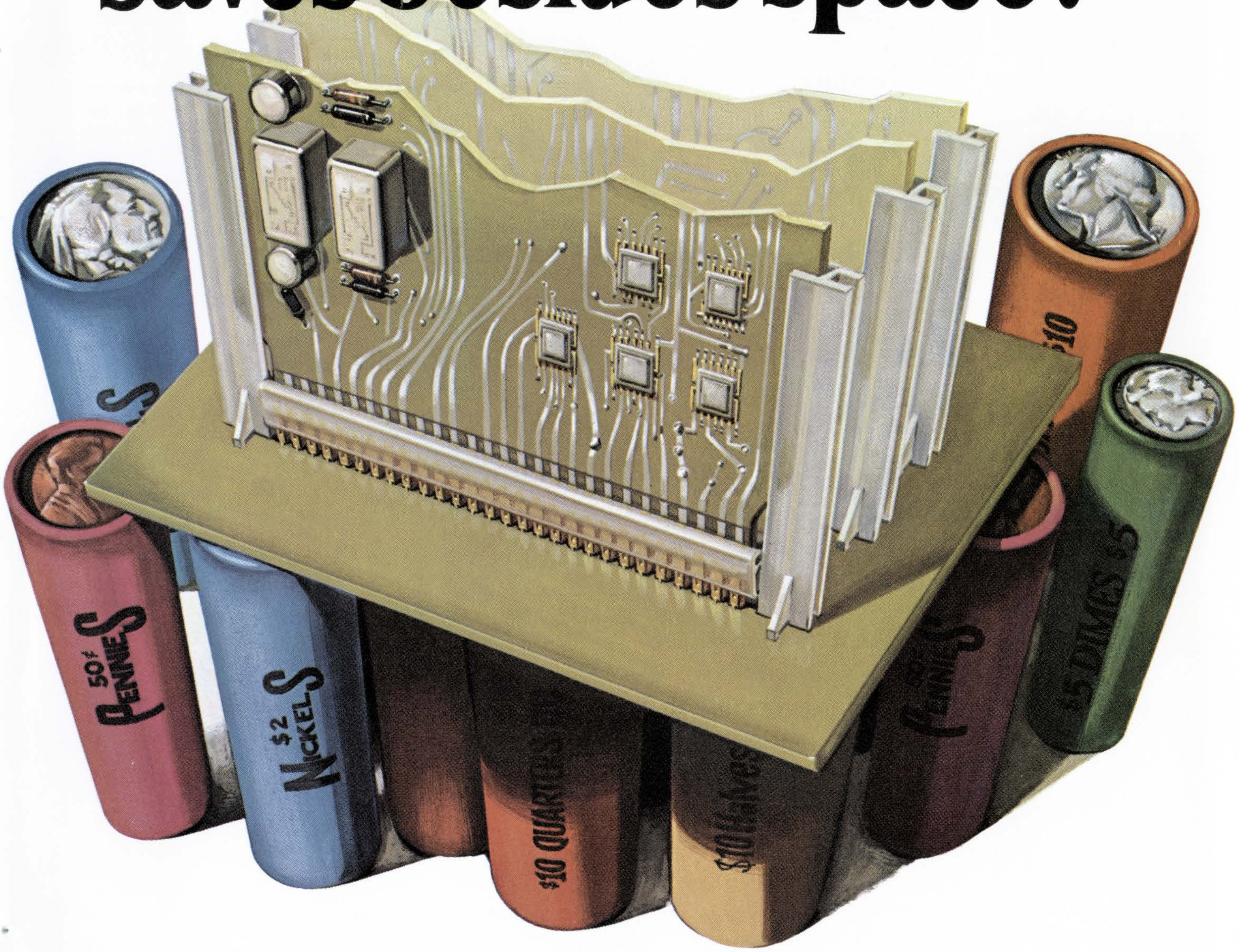

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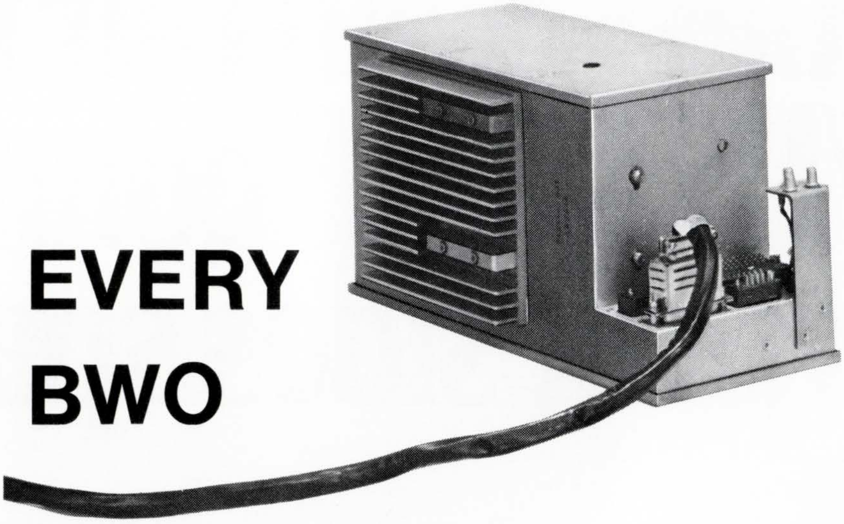

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MOS course—Part 2
The MOS circuits

In the first installment of our course on MOS integrated circuits, we described how the devices are made. Some of the problems associated with n-channel devices were discussed and although they hold a lot of promise, you saw that most of the MOS devices that you can buy today are p-channel.

We also pointed out in last month's issue that one of the major problems of MOS is threshold voltage. With a conventional MOS device, the designer needs different power supplies and logic voltages than he does with bipolar circuits. If he wants to use both types of devices in the same system, then he must add special interface circuits.

In an attempt to eliminate this problem, manufacturers have developed several different methods of making MOS devices that will have voltage levels directly compatible with bipolar voltage levels. These efforts have produced such devices as the p-channel MOS on $< 100 >$ silicon, the metal-nitride-oxide semiconductor layered structure, and the silicon gate device: the three types of low threshold MOS devices now on the market.

In addition, some other structures were also discussed last month. You saw that by using ion implantation to form the critical portion of the source and drain, parasitic capacitances are reduced. This means you can now operate the device at higher clock frequencies. Also shown was a different kind of device—complementary MOS. These units differ from the other structures because they combine both p-channel and n-channel transistors on the same chip.

This month

This installment of the course is concerned with how MOS devices are used. The circuits we discuss can be made with any of the structures described last month with the exception of complementary MOS which we will treat separately in a future issue.

The first part of this installment deals with how you can use the MOS device to do logic. It also discusses a different kind of logic, one particularly suited to MOS circuitry—dynamic logic.

Our second section this month describes MOS shift registers. You will see that they are not the same as bipolar registers and they may offer you a significant savings in power dissipation.

In this month's third part, you will find a detailed discussion of the multi-phased clocking schemes used with MOS circuits, particularly four-phase clocking. Also included is a comparison of the various clocking systems and where each can be used to best advantage.

To finish up this month's installment, we diverge a little. Instead of talking about circuits, we talk about how circuits are made. This part discusses computer-aided design and the role it plays in MOS manufacture. You will see how CAD can help turn a logic diagram into functioning hardware, and do it faster and cheaper than would be possible otherwise.

MOS Course—Part 2

Doing logic with MOS

While they work in conventional logic systems, MOS devices are particularly suited for a different application—dynamic logic.

By William Penney, Sr. Applications Engineer
American Micro-Systems Inc., Santa Clara, Calif.

Digital logic functions can be implemented by two general types of MOS circuits: (1) conventional dc or static logic that uses techniques similar to those used in bipolar integrated circuits; and (2) dynamic or ac logic that uses temporary memory and clocked load resistors.

Dc logic is probably the simplest to understand but it does not make full use of the unique advantages of the MOS device. Two-phase dynamic logic offers reduced size and power consumption while sacrificing only low frequency operation or dc storage. A quasi-dc storage function can be performed with dynamic logic if the two-phase clocks are allowed to run continuously at any frequency over 5 kHz.

Dc or static logic

In dc logic with MOS devices, a relatively high impedance MOS device which needs very little area is used in place of a diffused load resistor which requires much more area. This MOS load (or pull-up) device is held conducting at all times by returning its gate to a negative potential sufficient to overcome its gate threshold voltage. There are two methods of accomplishing this result: one uses a single power supply applied to both the gate and drain of the load device, while the other uses two supplies, with the more negative one tied to the gate. By using a second supply that is at least one gate threshold drop more negative than the drain supply (V_{DD}), the drop across the load device becomes essentially zero when the inverter is off.

The MOS logic inverter operates as follows: with the pull-down device on, the output node falls to ground. However, when the pull-down device is off, the output node goes to either V_{DD} or one gate threshold drop less negative than V_{DD} (depending on the potential on the gate of the load device). By defining the negative voltage and ground as opposite logic states, you can see that the input voltage is "inverted" to the opposite logical state at the output, thus satisfying the definition of a logical inverter.

The load and pull-down devices in a MOS inverter differ in size. The load device is designed to have an on impedance about 20 times that of the pull-down device. This ratio has been selected to assure that the output node goes to near ground when the inverter is conducting.

Using the convention of negative true logic, a two-input NOR gate differs from the logic inverter by having two pull-down devices in parallel, while the two-input NAND gate differs by having two pull-down devices in series. These two basic logic functions can be expanded and interconnected to perform many more complex logic functions.

Ac or dynamic logic

Dynamic logic uses clocked load devices in conjunction with the inherent gate capacitance of the MOS device to give you simpler circuits and greatly reduced power consumption. Since power is consumed only when the clocks are on, dynamic logic lets the designer trade off power consumption for speed of logic operations.

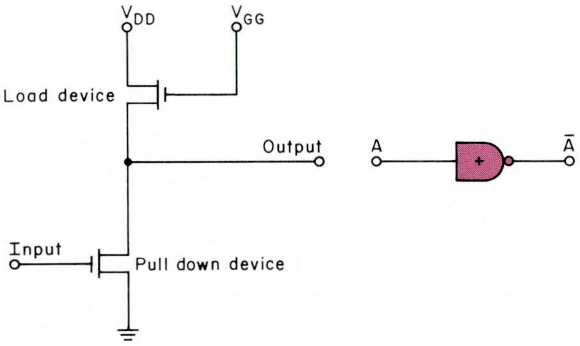

Fig. 1. The MOS inverter shown in schematic and logic diagram form. The node N is at or close to V_{DD} if the pull-down device is off and is close to ground if the pull-down device is on.

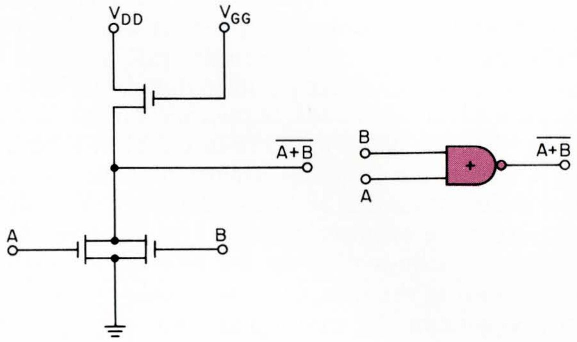

Fig. 2. The MOS NOR gate (dc) is similar to the inverter except that it has two pull-down devices in parallel.

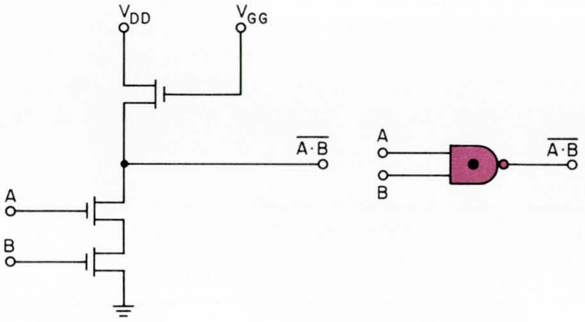

Fig. 3. The MOS NAND gate (dc) has two pull-down devices connected in series.

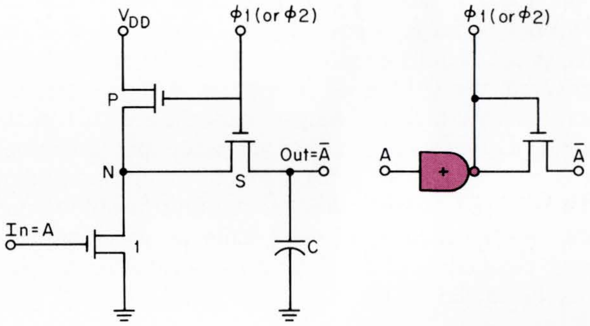

Fig. 4. The ac inverter. This logic gate shows the standard application of the three basic functions of MOS devices; the pull-up and coupling (series) devices are clocked at the same instant by a common phase, while the pull-down device is activated by the data (input).

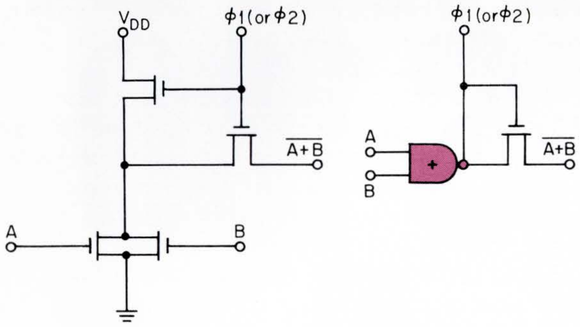

Fig. 5. An ac NOR gate

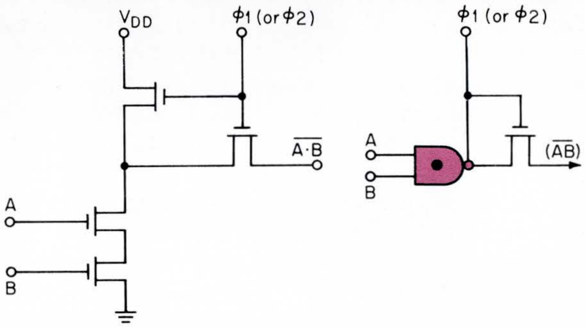

Fig. 6. AC NAND gate

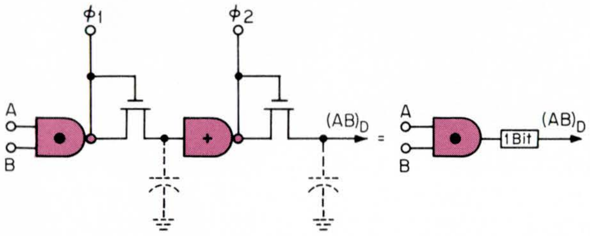

Fig. 7. A logic OR gate with delay is obtained by connecting a NOR gate clocked with ϕ_1 in series with an inverter clocked by ϕ_2.

The MOS device is uniquely suited for this application because its gate looks like a perfect capacitor with virtually no leakage. This intrinsic gate capacitance serves as temporary storage for incoming data. Dynamic logic takes advantage of this temporary storage in conjunction with two-phase clocking to establish a built-in delay in any gating structure. Unlike dc logic, in most cases you do not have to add extra devices to the intrinsic gate structure to provide delay. The function of the two-phase clocking is to direct the flow of information from one gate to the next. One bit-of-delay (one clock period) occurs in the case where two adjacent logic gates are clocked with alternate phases; no delay occurs in the case where two adjacent logic gates are clocked with the same phase.

The MOS devices that make up a single ac gating structure perform three operations: pull-up, pull-down, and transfer and store. These functions are shown in Fig. 4 (the terminology refers to node N). When the pull-up device is on, N goes to V_{DD}; when the pull-down device is on, N falls to ground; and as the series device is activated, the voltage on N appears at the output and is temporarily stored on the gate capacitance (C) of the following device. The ac inverter structure, combined with ac NOR and NAND gates, provide the basic building blocks required for logic design. A point to note is that a NOR gate clocked at phase 1 time in series with an inverter clocked at phase 2 time constitutes an OR gate with a bit-of-delay. On the other hand, a NAND gate followed by an inverter and clocked the same way give you a logic AND gate including the bit-of-delay. Essentially the input is clocked by ϕ_1 through the first series coupling device to the gate capacitance of the second inverter pull-down device, where it is stored between clock pulses. Next, ϕ_2 clocks the data through this inverter and stores it on the next gate until the subsequent ϕ_1 time.

If no delay is desired, you can return all the clocks to a common phase. In this case all series devices between gates of a common phase can be omitted since their main function is to isolate data until the alternate clock time. Thus a gating structure with no delay would need no series devices.

To insure the proper flow of data, the two clocks ϕ_1 and ϕ_2 should never be a logic 1 (V_{DD}) simultaneously. Also, the capacitive memory time constant must be greater than the time period between the trailing edges of ϕ_1 and ϕ_2 or vice versa, whichever is greatest, so that a logic 1 stored on the gate capacitor is not degraded by leakage to a voltage below the gate threshold level. High speed operation is limited by the ability to fully charge the gate capacitor to a 1 level during the clock on time.

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MOS Course—Part 2

MOS shift registers

Shift registers are an application where MOS can really shine.

George Landers, MOS and Memory Products Mgr.
Signetics Corp., Sunnyvale, Calif.

Common to all data-processing equipment is the ability to transfer digital data. The transfer of such data generally involves temporary storage combined with the ability to move the data by a prescribed number of bit positions.

Shift register fundamentals

A shift register holds *N* bits of data than you can enter, store and sample upon command. In addition, the register can shift the data from one storage position to an adjacent position. For an *N*-bit shift register, *N* clock pulses are necessary for the data appearing at the input to be transferred to the output.

A shift register can be serial- or parallel-in and serial- or parallel-out. For the sake of simplicity, we will treat only serial-in, serial-out registers here.

Shift registers can also be static or dynamic. Static registers let you stop the register and hold the data indefinitely while dynamic registers require continuous operation and you must refresh them for long-term storage. An example of a dynamic register is a glass delay line. Static registers give you more flexibility, but dynamic registers are cheaper to implement.

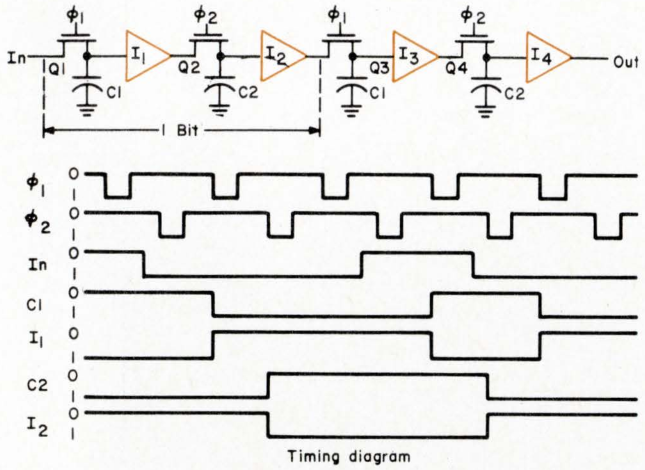
Dynamic shift registers

Dynamic shift registers made with MOS devices are simply inverter structures connected in series by clocked transmission gates. Because the information is held in the register by the charge on capacitors instead of in latched flip-flops, you need a minimum operating frequency. The discharge rate from the capacitors determines this frequency. If you operate the register at slower speeds, the data stored in the capacitors leaks off and is lost. A typical dynamic shift register needs a minimum frequency of at least 10 kHz. The output buffer of the register usually determines its maximum operating speed.

The inverters in a dynamic shift register can be static or clocked. With static inverters, the load devices are always biased on. Therefore, a register with static inverters dissipates power on a dc basis because one of the inverters in each stage is always conducting. Clocked inverters, however, reduce power dissipation in the register. In a clocked inverter, dc power is dissipated only during the 1 portion of the clock cycle.

So far, the inverters discussed have been the ratio type. The ratio name is derived from the fact that when the inverter is on, the load device and the pull-down device form a voltage divider between the supply voltage and ground. Therefore, the voltage that appears at the output of the inverter is determined by the ratio of the resistances of the pull-down device and the load device.

A circuit that has no dc current path regardless of the data stored or the state of the clock offers a significant savings in power dissipation even over that of the clocked inverter. Such a circuit has an even more important advantage, namely, a reduction in chip area. Since it is not necessary to maintain a ratio of resistances, all devices can be of minimum geometry. This



Timing diagram

Fig. 1. The basic dynamic shift register uses a two-phase clock system. When ϕ_1 is at a logical 1, Q_1 is turned on allowing C_1 to either charge or discharge depending on the state of the input. The inverted information on C_1 is then transferred to the output of inverter I_1. When ϕ_1 returns to 0, the input data is stored in C_1. The input data can now be changed without affecting the contents of the register. When ϕ_2 goes to a 1, Q_2 is turned on, allowing C_2 to charge or discharge depending on the information at the output of I_1. When ϕ_2 returns to 0, the inversion of the data on C_1 is stored in C_2. Inverter I_2 re-inverts the data to give true data at its output. The data at the input of the register has now been transformed through one full bit of the register in one full bit time of the clocks.

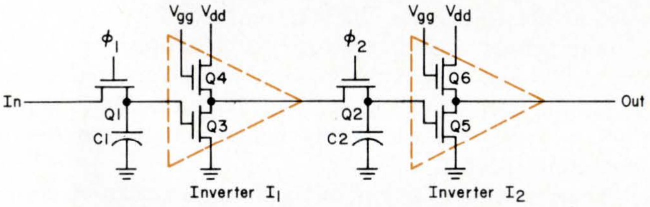


Fig. 2. A shift register with static inverters. Since the load devices (Q_4 and Q_6) are always biased on, the register dissipates power on a dc basis.

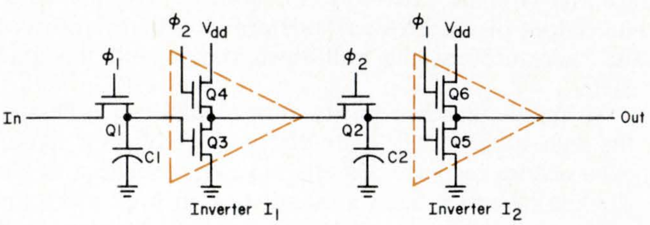


Fig. 3. By clocking the load devices (Q_4 and Q_6) the power dissipated in the register is reduced. Now, dc power is dissipated only during the 1 portion of the clock cycle.

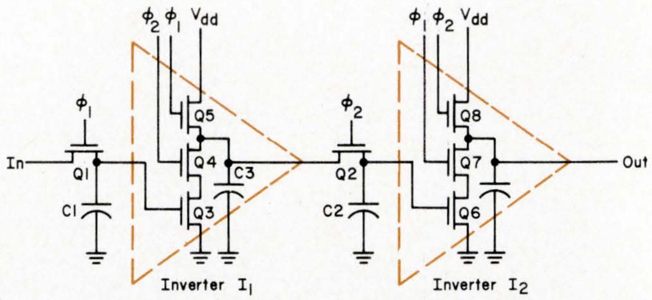


Fig. 4. Ratioless-powerless inverters. When ϕ_1 goes to a 1 state, C_3 charges to V_{DD} through Q_5. When ϕ_2 goes to a 1, C_3 either discharges through Q_3 and Q_4 or charges C_2 through Q_2 depending on the input. If Q_3 is turned on, C_3 and C_2 are discharged; if Q_3 is turned off, the charge is transferred from C_3 to C_2. In order to transfer the charge from C_3 to C_2, it is necessary that C_3 be much larger than C_2 to preserve the logic levels. Inverter I_2 operates identically except that the phases are reversed.

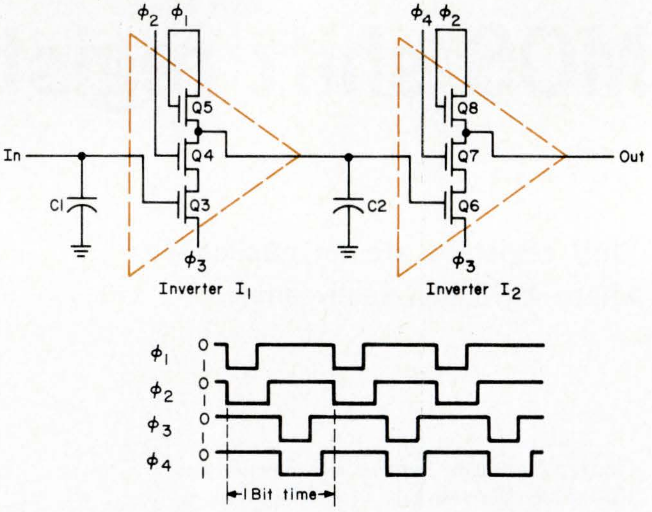


Fig. 5. Four-phase system. The ratioless-powerless scheme of Fig. 4 requires eight devices per bit instead of six devices per bit for the ratio circuit. The ratioless-powerless circuit, presented here, uses only 5 devices, but it requires four clock phases. The inverters (I_1 and I_2) are directly coupled, thereby eliminating Q_1 and Q_2 of Fig. 1. Operation of the circuit is as follows: When ϕ_1 goes to a 1, C_2 is charged through Q_5. When ϕ_1 returns to 0, grounding the source of Q_3, C_1 is discharged if Q_3 is turned on by a negative voltage stored in C_1. If Q_3 is off, C_2 retains its charge after ϕ_2 returns to 0. Operation of inverter I_2 is identical except that ϕ_3 and ϕ_4 replace ϕ_1 and ϕ_2. ϕ_2 and ϕ_4 can be generated on the chip since they are only expansions of ϕ_1 and ϕ_3.

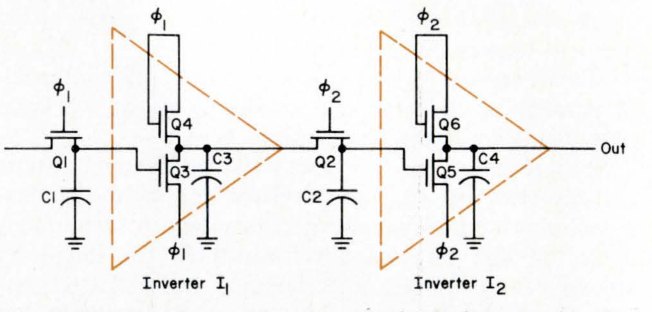


Fig. 6. This two-phase scheme uses six devices per bit. The circuit requires the transmission gates Q_1 and Q_2 of Fig. 1 but needs only two clock lines running through the bit matrix. The phase relationship is the same as Fig. 1. When ϕ_1 goes to a 1, C_1 charges or discharges through Q_1 depending on the data input. At the same time C_3 charges through Q_4. When ϕ_1 returns to 0, C_3 will retain its charge if C_1 is discharged, but will discharge through Q_3 if C_1 is charged. This circuit requires that C_3 be much larger than C_2 for level preservation during charge transfer.

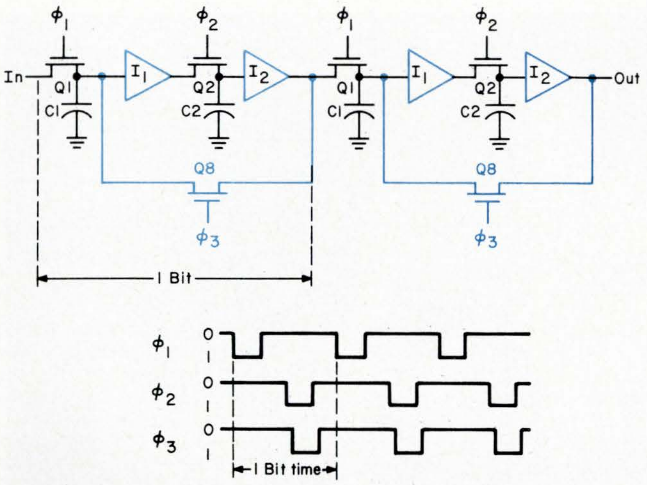


Fig. 7. The basic static shift register. The dynamic shift register, shown in Fig. 1, can be made into a static shift register by adding a feedback path around I_1 and I_2 (shown in color). If ϕ_3 is a 1 at the same as ϕ_2, then I_1 and I_2 along with Q_2 and Q_8 form a cross-coupled flip-flop. The timing shown allows this since ϕ_3 is a slowed ϕ_2 to prevent data racing from the output to C_1 before C_2 is in its final state. Both ϕ_2 and ϕ_3 must be at a logic 1 to hold information indefinitely.

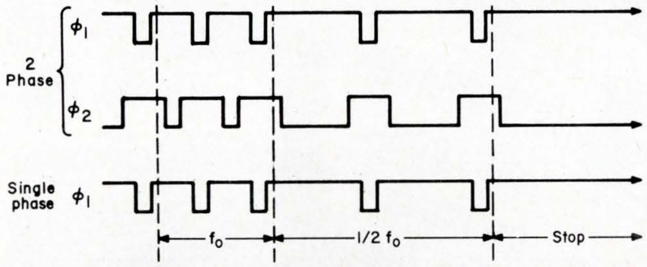


Fig. 8. Relative timing in single- and two-phase static systems. In the two-phase system, ϕ_2 must be a 1 while ϕ_1 must simply be returned to 0 to stop the register. In the two-phase system, the gap between ϕ_1 and ϕ_2 must be controlled. As the frequency changes, the pulse width of ϕ_2 must be changed. The single-phase system does this changing of ϕ_2 pulse width internally.

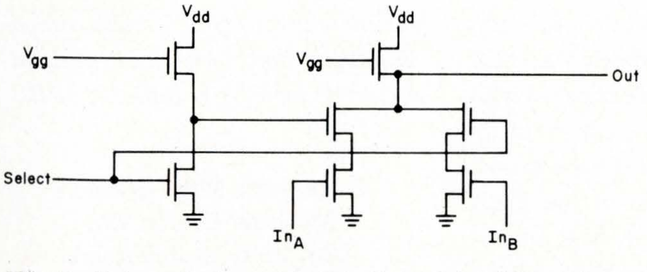


Fig. 9. Data selection structure for static shift registers. This circuit produces an inversion of the desired information which it must be corrected later in the register. The circuit shown is for static registers, but it can be used in slower dynamic registers also. Other variations can be constructed for modifications of inverters shown in the dynamic shift register section.

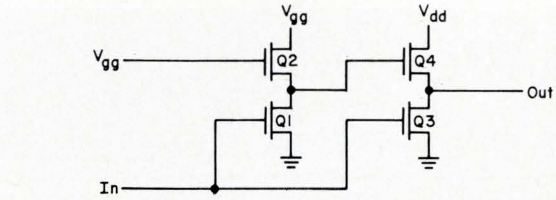


Fig. 10. Push-pull static buffer. This buffer has both source and sink capability. This buffer inverts data thereby correcting for the inversion of the data select structure in Fig. 9. A non-inverting buffer can be implemented by reversing the gate drive of Q_3 and Q_4.

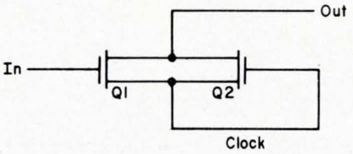


Fig. 11. Pre-charge dynamic buffer. In this buffer the output load capacity is pre-charged by the clock going to a 1. The output can be sampled after the clock returns to 0 and before the input data changes. This circuit is similar to Fig. 6 differing only in geometry. Other dynamic buffers can be constructed using variations of the inverters shown before.

type of circuit has been implemented and shift registers that use it are referred to as ratioless-powerless.

Static shift registers

You can make the basic dynamic shift register into a static shift register by adding a clocked feedback loop around the inverters. This type of circuit must use the static inverters discussed above.

While a static shift register uses three-phase clocking, either ϕ_3 or ϕ_2 and ϕ_3 may be internally generated. The single-phase system (with ϕ_2 and ϕ_3 being generated on the chip) has the obvious advantage of needing only one system clock. In addition, you only have to control the one clock phase to stop the register, and this clock can have a constant pulse-width regardless of frequency.

Input structures and output buffers

Up to now, we have dealt with the internal cells of a shift register only. At some time it is necessary to interface with the outside world. If no data selection or recirculation is required, the input can simply be expanded versions of the register's cells themselves. If you do need data selection, it can be accomplished with an AND/OR structure.

At the output of the register, it is necessary to transfer data from sources with very little drive capability to the high capacitive or low resistive loads of the external environment. To accomplish this, an output buffer is necessary. In some dynamic register applications, it is necessary to have a stable output for only a small portion of the clock cycle. In this case the output can be speeded up by providing a pre-charge buffer.

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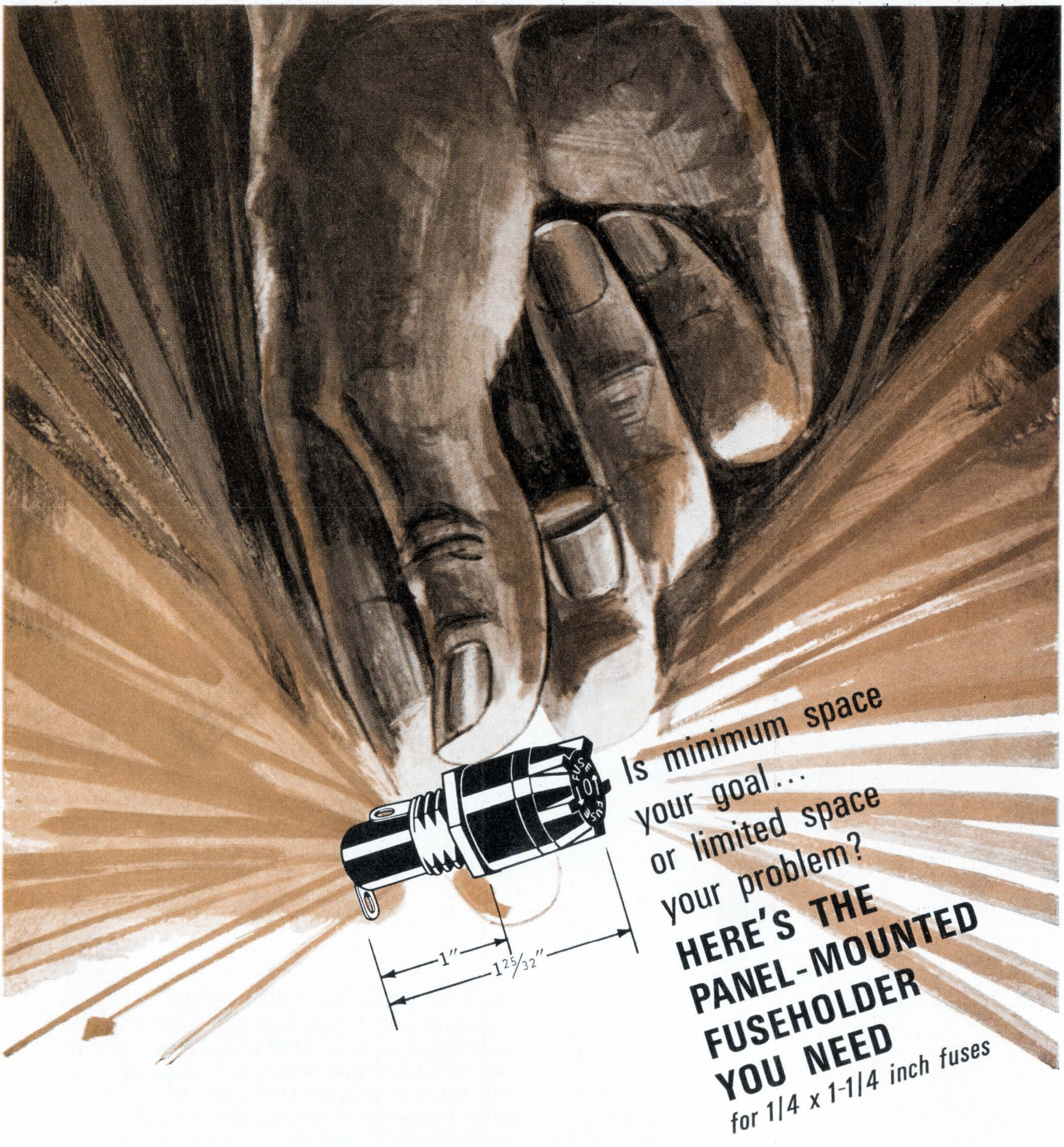

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MOS Course—Part 2

Four-phase logic

There is a lot of interest in LSI. Here is a discussion of the way to "very" LSI.

By Lee L. Boysel, Cloyd E. Marvin, Joe Murphy, Jim Sorenson
Four-Phase Systems, Inc., Cupertino, Calif.

The first MOS-LSI systems ranging from simple desk calculators and controllers to small computers have recently begun to appear. A majority of these systems employ some form of dynamic logic, usually four-phase. This article is a general discussion of the various approaches to four-phase logic design with minimum reference to equations.

Several years ago LSI had been defined as a single chip containing 100 gates or more. However, from a practical standpoint, the dramatic cost savings expected from LSI are not realized until these devices have 800 to 1200 gates per chip, MHz speeds, 100- to 200-mW power dissipation, and gate-to-pin ratios of 20-30 to 1. For the moment we'll call this complexity level "very" LSI. Now that MOS-LSI is producible, what are the possibilities? What type of circuit designs will be required in order for LSI to reach its full potential?

Where to begin an LSI design

The most natural course in designing MOS circuits is to retrofit familiar bipolar circuit designs using MOS devices. Typically, however, the pull-up resistor of the MOS gate is very large and rise times are slow. Reducing the size of this resistor reduces rise times, but increases power dissipation as well as the device area of the pull-down device, which results in larger physical size and increased capacitance for that gate. The practical limit for this type of design (commonly referred to as resistor or ratio logic) is a chip with around 100 gates operating at 1 MHz or less. Although many useful devices have and will be designed using this approach, new design techniques must be used to reach "very" LSI.

An approach which is proving to be very successful is the clocked or dynamic system in which small capacitors are used to temporarily store a voltage which represents a logical 0 or 1 level.

This type of structure has three advantages. First, the power required is only a few nanowatts of CV^2 power (the power to charge the capacitor). Second, rise and fall times are in the order of a few nanoseconds, e.g., a 20 KΩ MOS charging device (about the smallest producible gate) charging a ¼- to ½-pF load and parasitic capacitor would require only 5 to 10 ns. Third, the device or gate density is dramatically increased in dynamic systems. A device of only minimum size combined with versatility of very complex AND/OR gate functions gives you a device density increase of approxi-

COMPARISON OF CLOCKING METHODS FOR LSI

		MAX. SPEED (MHz)	POWER PER GATE AT MAX. SPEED (mW/gate)	GATE DENSITY ON AVERAGE 120 x 120 mil CHIP	AVERAGE NUMBER OF GATES PER CLOCK DRIVER ASSUMING 1000 pF/DRIVER	AVAILABILITY OF PROVEN DESIGN MATERIAL	BEST AREA OF APPLICATION	COMMENTS
dc, ratio internal clocks	SR ROM RAM	0.5–1	1–2	150–250	---	Good	Small systems with 100–1000 gates: D/A, A/D, small shift register memories, etc.	You can use this type in a bipolar system with no level shifters. All MOS circuit types can be interfaced with bipolar levels; however, only this type requires no high-voltage clock drivers.
	Random logic	0.1–0.3	1–2	100–200	---	Fair		
dc, ratio two phase external clocks	SR ROM RAM	1–3	1–2	400–500	1000	Good	Medium systems with 500–2000 gates: DDA, small controllers and desk calculators	Very low system power levels may be achieved by reducing clock speed and duty cycle.
	Random logic	0.3–0.8	1–2	150–250	1000	Good		
Dynamic two phase ratioless	SR	2–10	0.1–0.2	1000–1500	2000	Fair	Long, high-speed low-power shift registers	Ratioless two-phase shift registers can be used in both two-phase ratio and four-phase ratioless systems.
Dynamic four phase ratioless	ROM RAM	1–2	0.05–0.2	1000–1500	10,000–15,000	Poor	Large systems with 2000 gates and up: terminals, computers; expensive desk calculators	The large number of gates per clock results from the combination of 20 to 30 gates or bits in one logic block with one clock pull-up and one clock pull-down (conditional discharge gate).
	Random logic	0.8–1	0.1–0.2	500–1000	4000–8000	Poor		

mately 5-6 times that of static logic. There are, of course, disadvantages in dynamic logic designs. For one thing, the system must have synchronous clock lines and the related clock drivers. Obviously, the larger the system the easier it is to amortize the expense of the clock drivers. Also, dynamic logic has many design subtleties which can make it a high-risk development.

Assume for the moment, however, that the advantages outweigh the disadvantages and that the decision to use dynamic MOS logic has been made. The designer is now confronted with a wide variety of dynamic circuit schemes from which to choose, as well as the problem of satisfactorily representing the logic. It might be well at this point to examine some of the approaches and the many tradeoffs available to the designer.

Power clock vs. V_g system

The basic dynamic cell may be implemented physically in one of two ways. In the first, the power clock system, the phase 1 clock goes to a voltage equal to V_g, precharging the holding capacitor to the V_g or logic 1 level. The current which charges this capacitor comes from the phase 1 clock line. When phase 1 returns to 0 volts and phase 2 becomes active, the capacitor is conditionally discharged to 0 volts or logic 0 through the phase 1 clock line, which now acts as a ground path. In the second method, the "V_g System," the charging current is supplied by the V_g power supply rather than by the clock line. Likewise, the conditional discharge path is to true ground.

The power clock approach has an advantage in that it reduces the number of devices as well as gains additional space by eliminating ground and V_g lines running through the chip. The major disadvantage of the power clock approach is the addition of heavy clock-line capacitive loading. The V_g system overcomes this problem and reduces the load on the clock line by a factor of 7 to 10. A 1000-bit shift register or RAM using the power clock approach would have 200- to 300-pF per power clock line, while the V_g system would reduce this load to about 30-40 pF. Considering the high cost of high-speed clock drivers and the noise problems associated with 1- or 2-A clock pulses, this is an important point. As a general rule, designers use V_g systems except in special cases where overlapping clocks are desirable.

Overlapping vs non-overlapping clocks

There are two commonly used clocking schemes which we can use to charge and conditionally discharge our standard gate. We should consider first the overlapping scheme in which the clock pulses are grouped in twos. This scheme reduces logic power and flexibility but has one important advantage. The phase 2 and phase 4 clocks (slow clocks) may easily be generated on the chip. In addition to the obvious advantage of halving the number of clock drivers, removing the consecutively pulsed clock lines eliminates clock skew and clock overlap slivering problems associated with four external non-overlapping phases. The overlapping clock, unfortunately, precludes the use of a V_g system to reduce clock line loading. In a larger system the increased load on the two external clocks could result in the need for almost as many clock drivers as a full four-phase design.

The non-overlapping clock system has an advantage in that all the gates are capable of interfacing with the succeeding two time slot gates. In practice the increased interconnection flexibility of non-overlapping clocking, combined with the advantages of a V_g clock design, has proven particularly important in the design of complex system logic. In general, very complex logic system design usually requires four non-overlapping clock lines. However, some less demanding applications will profit by using overlapping clocks with two phases generated on the chip.

How many clock phases?

The decision to use four phases or time slots has not been an arbitrary one. The basic gate may be expanded to form any combination of AND and OR gates followed by an inversion. This means that any logic equation or transfer function, no matter how complex, may be constructed logically with one basic gate if all logic inputs and their complements are available. It is normally not practical, however, to construct one very complex gate, and usually large logic functions are divided into two gates in two consecutive time slots.

Thus in a typical circuit, one phase is used to obtain the required complements of the input signals; two slots are used to do the required logic, and the last phase is used to set up the output levels. A practical example of this would be the design and timing assignments of an arithmetic logic block found in an LSI computer. The first cycle selects, gates in, and forms the complements of the input data. While the second phase is used for the carry look-ahead circuits, the third performs the actual add, subtract, AND, OR, shift, etc., instructions. The fourth time slot gates out the results and/or latches the results back into the main register.

There are special types of devices, e.g., shift registers, which do not require an input inversion or two stages to perform logic. In these situations, a two-phase subset of four-phase logic is possible, which offers twice the speed and half the number of system clocks. Variations of the two-phase shift register may be useful for designs where shift registers are required to be on the same chip with full four-phase logic, e.g., a desktop calculator.

Which two phase?

The term, two phase, is also used in reference to ratio (as opposed to ratioless dynamic) circuits in which the load or pull-up resistors and lateral data-path gates are gated by the clocks. The ratio circuit offers a factor of two increase in the speed power product, but still suffers from the same basic static circuit limitations in speed, power, and density as well as the additional problems of any clocked system. Although this type of design was originally very popular, it is now losing

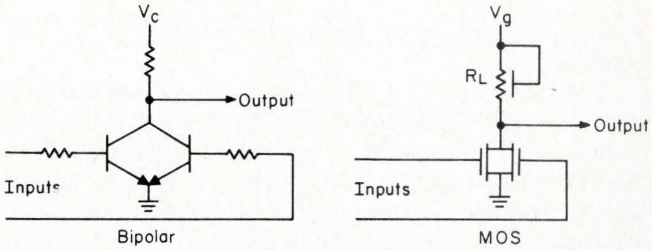

Fig. 1. Bipolar RTL two-input NOR gate and MOS two-input NOR gate equivalent circuit. This type of gate is known as ratio circuit logic because the output MOS voltage levels are dependent on the ratio of the pull-up resistor R_L and the resistance of the bottom or pull-down device. In the MOS circuit, R_L may be gated on and off with a clock to reduce chip power consumption, but the basic logic form is still ratio. Circuits where capacitors are charged and discharged and where no resistor ratio for voltage division exists are called ratioless.

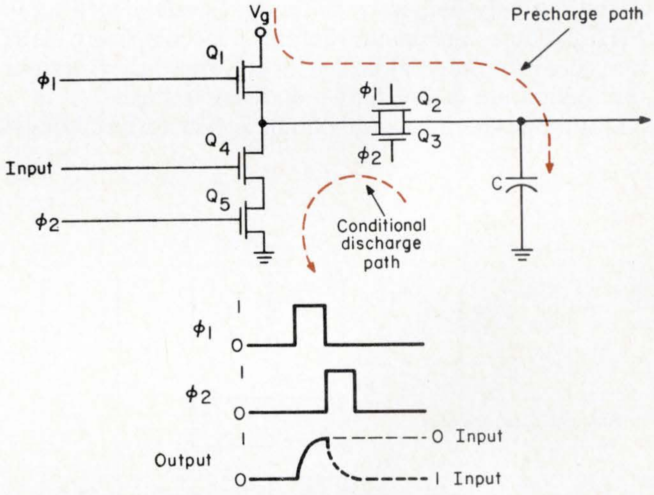

Fig. 2. Basic precharge inverter and the sequence of clock charging and conditionally discharging the output holding capacitor, depending on the input signal is shown.

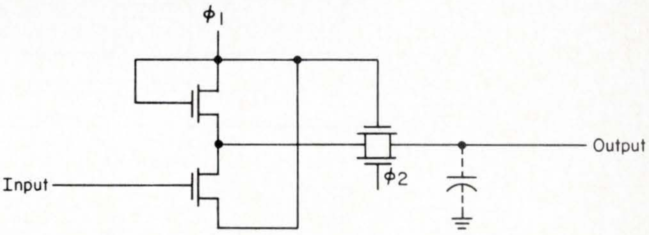

Fig. 3. Power clock with overlapping or non-overlapping phases.

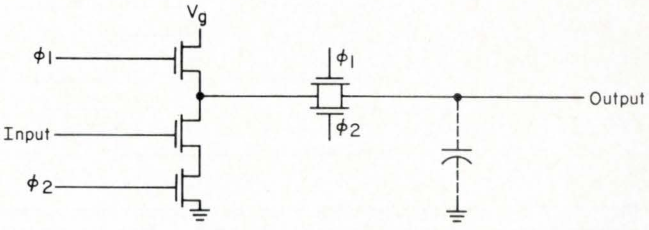

Fig. 4. V_g system with non-overlapping phases (overlapping clock phases cannot be used in a V_g system since this would short V_g to ground).

favor, and most new circuits are ratioless or true dynamic designs.

Two-phase ratio design does have an advantage in that it is well understood, and by following the well-defined, straightforward design rules the designer doing his first MOS design has an excellent chance of success on the first try. This is not true of complex four-phase designs which usually require some sensitive reworks of design or masks, even when done by experienced designers. Four-phase designs have a tendency to look great on paper, but may be unproducible in practice because of a variety of unexpected parasitics.

Static vs precharge output buffers

The designer has two basic output configurations available. Most of the early dynamic devices used the precharge output in one of various forms. The primary advantage of this approach is the increase in operating speed (usually limited by the output buffer) to 5 to 10 MHz. These precharge output concepts were later moved to the internal circuit areas where they became the foundation of precharge or dynamic logic.

Although the precharge output is very fast and draws

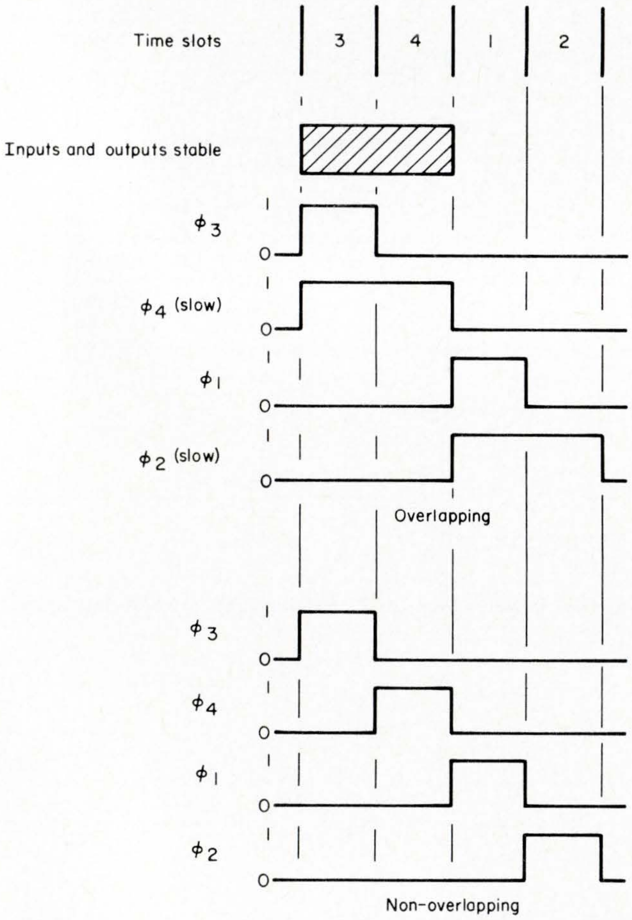

Fig. 5. The overlapping and non-overlapping four phase clocks are shown related to the four time slots. Note that the inputs and outputs of both types are stable during time slots 3 and 4. Thus, systems may have both types of clocks.

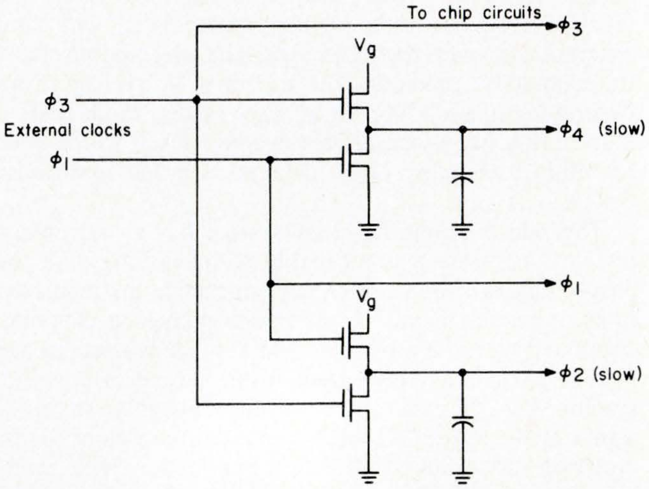

Fig. 6. This circuit located on the chip may be used to generate the two slow overlapping clocks, thus reducing the number of external clocks required.

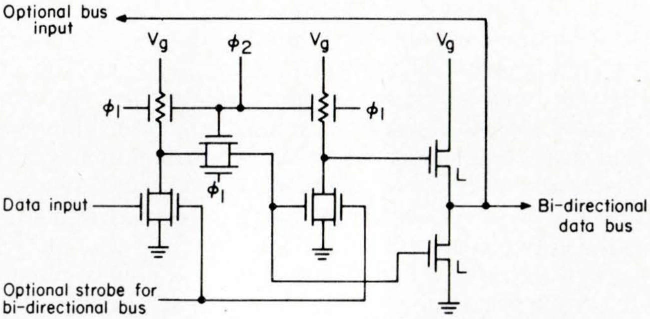

Fig. 7. Dc stable output does not precharge the output on odd clock cycles. Note bi-directional data buss strobe option used to reduce the LSI pin count.

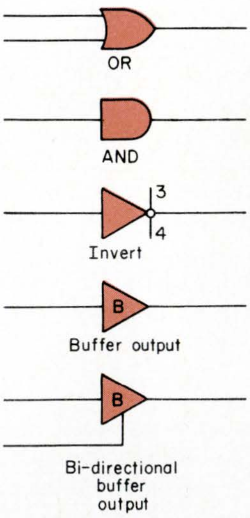

Fig. 8. The five basic logic elements are shown. The AND and OR gates are normally combined and fed into an inverter. The number 3 denotes the time slot in which the inverter precharge occurs and the number 4 at the bottom indicates that the conditional discharge occurs during the fourth time slot. The output is stable in time slots three and four.

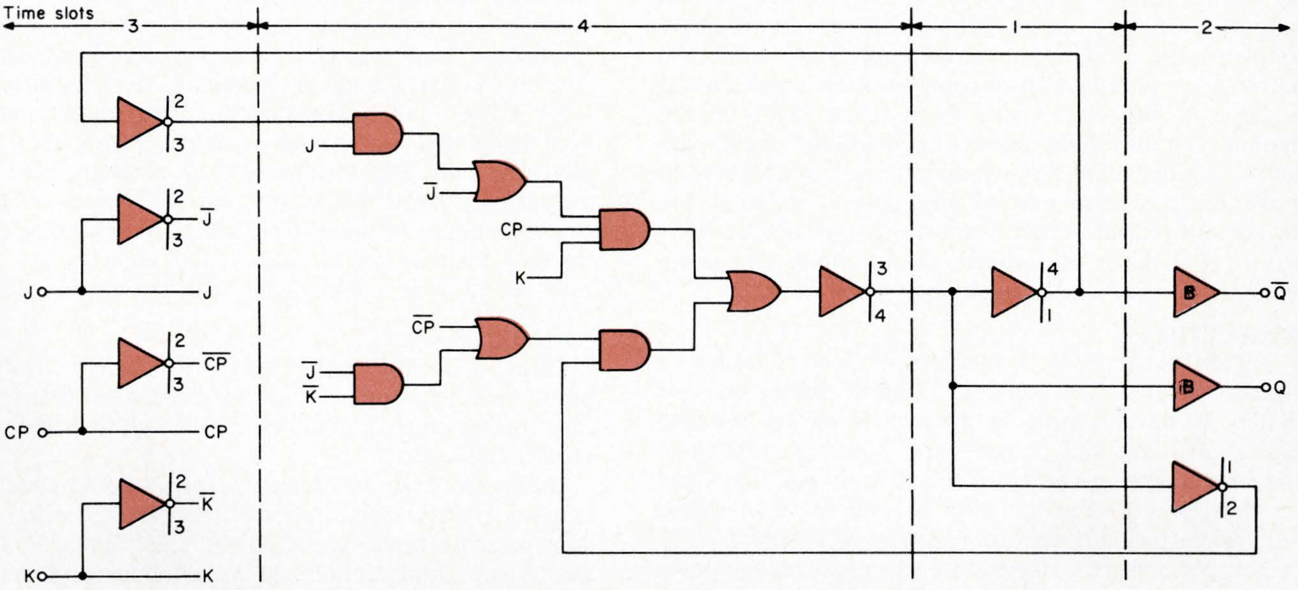

Fig. 9. Detailed logic and timing diagram for JK flip-flop.

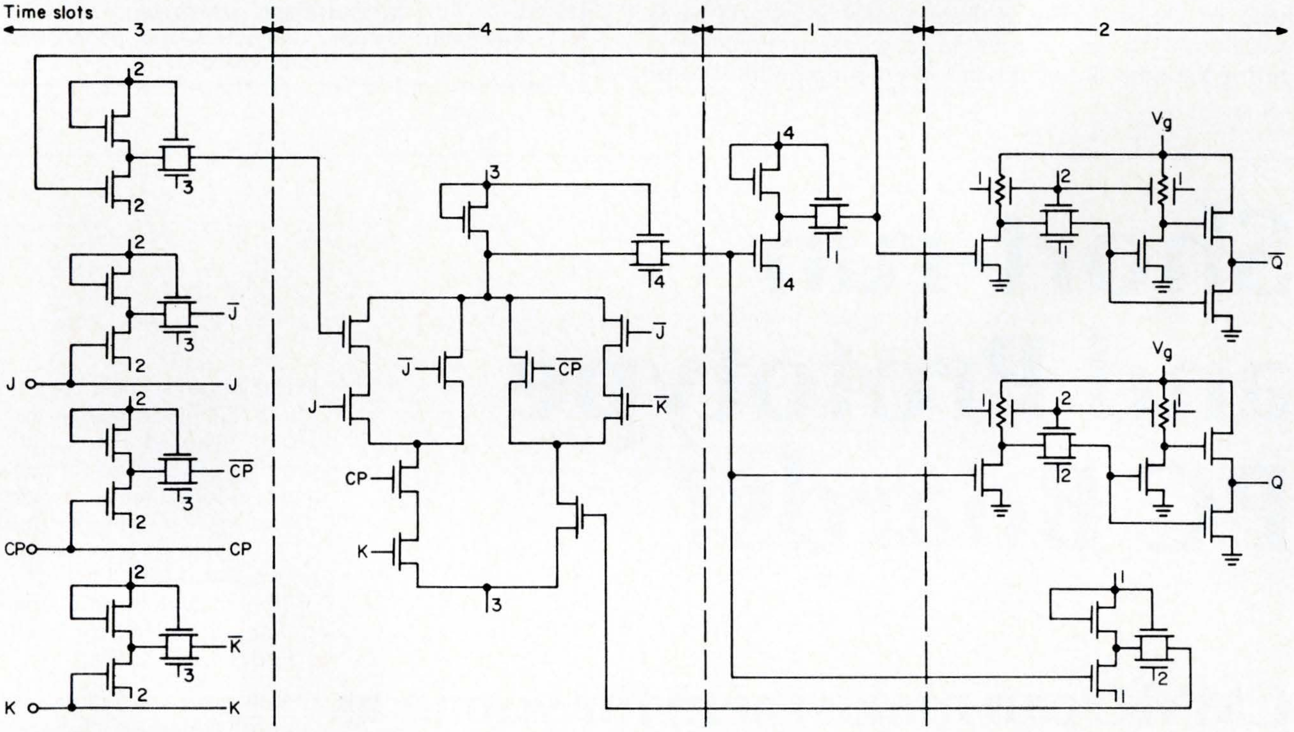

Fig. 10. Schematic diagram of JK flip-flop.

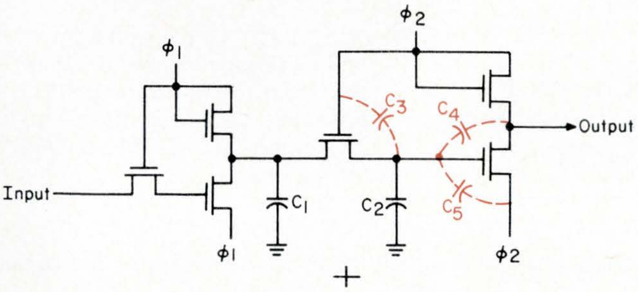

Fig. 11. This two-phase shift register shows the effect of parasitic coupling. A capacitor ratio of $C_1 = 6C_2$ is commonly used and $C_2 = 6(C_3+C_4+C_5)$ is a reasonably good approximation. First ϕ_1 precharges C_1, to a logic 1 (15 V) and then ϕ_2 shorts C_1 and C_2 together. Using the above capacitance values, when ϕ_2 returns to ground, the voltage left on C_2 is about 10 V, which in many systems is the minimum input level.

If the parasitic capacitors are 0.01 pF, then C_1 must be greater than 1.08 pF. This is a fairly large-area capacitor. For applications that require a fan-out of one this may be a fairly useful circuit. However, for applications requiring larger fan-outs, the area required for the capacitors would be prohibitive.

little power, working with it is difficult. Test lights or dc voltmeters are useless since the presence of a zero output means the output will be an ac square wave following the clock input. Oscilloscopes are not much better since examination of complex signals patterns on a scope is difficult at best. As a result, many recent dynamic circuits have incorporated limited speed, dc-stable output buffers (which operate at 1 or 2 MHz) to make complex dynamic devices appear static at the inputs and outputs. This is known as quasi-static four-phase. If speed is not critical, static outputs can make testing, servicing and maintenance much easier.

Overall timing

Before undertaking a multiphase clocked design, a concise statement on input and output timing must be made. If the resulting equipment is to be serviced easily, all input and output signals must be related to the master timing so that real and transient times can be determined. The temptation is great in a closed LSI system to interface various chips on different clock cycles, but beware of the testing and maintenance problems.

Logic representation

The five basic logic symbols required for four-phase logic are shown in Fig. 8. Each group of AND-OR gates is followed by an inverter stage which is precharged during the time slot noted on top (pull-up number) and conditionally discharged during the time specified by the lower number. Although the symbols are straightforward, the timing relationships of complex logic to multiphase feedback paths can become a nightmare. The only practical method of design is to simultaneously draw a logic and timing diagram with each time slot containing that logic which is active during that time slot. The only rule to remember is that any time slot output may input to the next two slots and multiples or submultiples of these slots. Thus, in a complex logic system, feedback paths from many logic cycles later may be fed back automatically with the correct timing.

Parasitic effects

Often, a dynamic logic design, which appears foolproof, becomes completely unworkable when first fabricated on the chip. In many cases, the culprit is parasitic capacitance effects.

In dynamic, ratioless logic, the signal-holding capacitances are of the same order of magnitude as the random parasitic capacitances on the chip. When you select a gate configuration for a particular application, you must simultaneously consider the physical layout and all parasitic effects.

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MOS Course—Part 2

Computer-aided design

Using a computer to help in the design and layout of a custom MOS circuit can give you the circuit faster and cheaper.

By Frank Schenstrom and Robert Williams
Fairchild Semiconductor, Mountain View, Calif.

Almost all of the large semiconductor houses have a CAD *program for custom* MOS *design and fabrication. This article traces a typical circuit through Fairchild's system.*

Naturally enough, before designing a custom MOS-LSI circuit, the customer must convey his requirements to the manufacturer. This input from a customer can be as basic as a truth table, Boolean expressions, or a timing diagram to describe the logic, or as detailed as a fully defined logic diagram, utilizing standard cells and submitted with complete test sequences and electrical specifications. No matter what form it takes, the starting point is a functional description of how the circuit must operate.

In the case of a multi-chip development, the first step in the design cycle is partitioning the system into individual chips. When partitioning has been completed logic diagrams of each chip are prepared using standard cells (or logic blocks). Once the logic for a chip has been defined, the network is then entered into the Computer-Aided Design (CAD) system for development. Every input and internally generated signal is assigned a alphanumeric name. The coding of the network consists of simply listing each cell name along with the type of cell and the names of the inputs to the cell. The coded network is then assembled in machine language and stored on a disk for use in other phases of the CAD process.

Next, the operation of the network is simulated with a logic simulator program. The inputs to this program are the assembled network description and a sequence of design verification tests, either supplied by the customer or developed by the manufacturer. The computer applies this sequence of tests to the input of the assembled network. When simulation is complete, a printout of the logic states of inputs, outputs and selected internal points as a function of time is obtained. In essence, the computer is performing a function similar to breadboarding the circuits but in this case a more concise picture of the circuit response versus time is achieved. A study of the simulation printout is made to verify the correctness of the stored network.

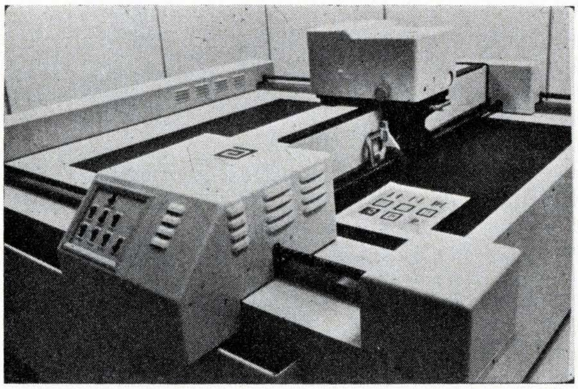
After the stored network is verified, a propagation delay program estimates the capacitance associated with each node in the network and calculates the propagation delay through each logic gate. The designer analyzes this information for possible speed problems and determines which interconnection paths must have minimum capacitance. When the chip layout has been completed, the exact node capacitances are automatically computed, based upon layout information. The results are then re-examined as a final check for proper ac performance.

Artwork generation

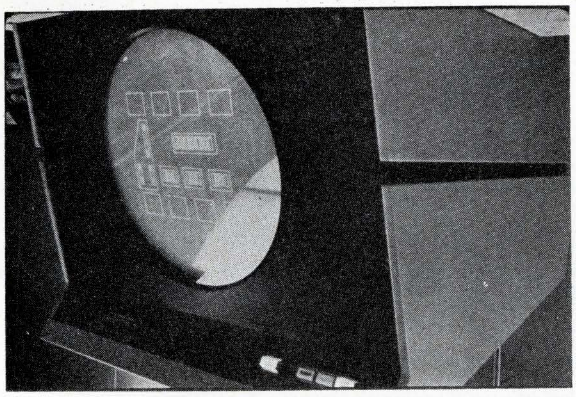
Once the circuit has been verified to be functionally correct and to meet all performance requirements, the artwork generation can begin. Standard cells are of uniform height and variable width so that they can be placed side by side in rows on a rectangular grid. Interconnections run along grid lines in the channels between the cells. Horizontal interconnections are usually made with aluminum, while vertical lines are usually p+

continued on page 73

The role of CAD in graphic design



Computer-controlled drafting machine produces artwork at 100 times actual size.



Interactive data terminal used in on-line CAD system. Several polycells can be seen in position.

One of the most economically pertinent and highly active use of CAD for ICS is graphic design. To prepare a production mask for an integrated circuit, master artwork is generated for a single circuit, reduced in size, and then stepped across the actual mask by automatic step and repeat equipment. Preparing the mask manually is a long and tedious procedure, particularly prone to human error.

A more up to date method uses a computer-controlled drafting machine to generate the mask masters directly. Not only is this method more accurate, but it also produces highly satisfactory work at 100 times final size instead of the 500 times required with the manual procedure.

The CAD system used at Motorola Semiconductor can operate in either an on-line or off-line mode. In the off-line mode, the designer sketches the circuit and then reduces his design to a dimensioned drawing on a worksheet. For all its apparant complexity, it is relatively straight-forward to describe a complex integrated circuit for drafting.

In the on-line system, a computer-controlled CRT display is used as an interactive sketch pad to try various geometric configurations. When an acceptable layout and metal routing has been designed, the computer is instructed to prepare drafting instructions.

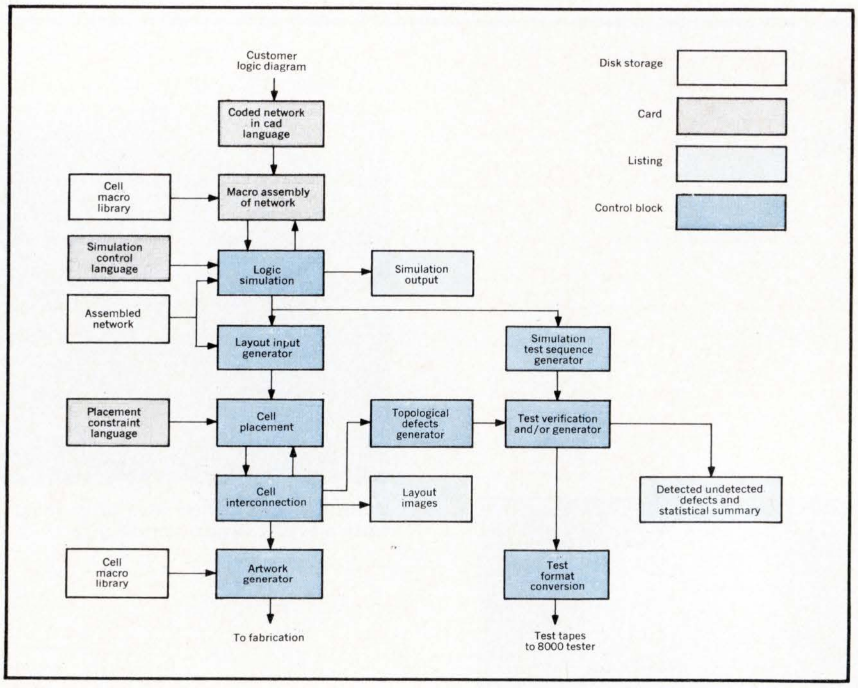
The off-line system runs on a small-scale computer with a 16k word memory and a disc pack storage unit. The on-line program requires the use of a cathode-ray console and the same type of computer. The on-line system represents a relatively inefficient use of the computer, since much of its time is spent waiting instructions.

The specific description of devices such as diodes, transistors, etc., including their shapes on each mask layer are stored in the disc library. These are the basic building blocks in both the on- and off-line systems. All shapes, no matter what layer they are on, are defined relative to the same point. When a device is moved, all shapes on all layers move with it.

These devices are often arranged into more complex structures (called polycells) such as gates or flip-flops. Those commonly used can also be stored, giving the designer a more powerful set of tools. A polycell is considered to be a logic entity. All the constituent parts are defined by one placement and need not be individually handled.

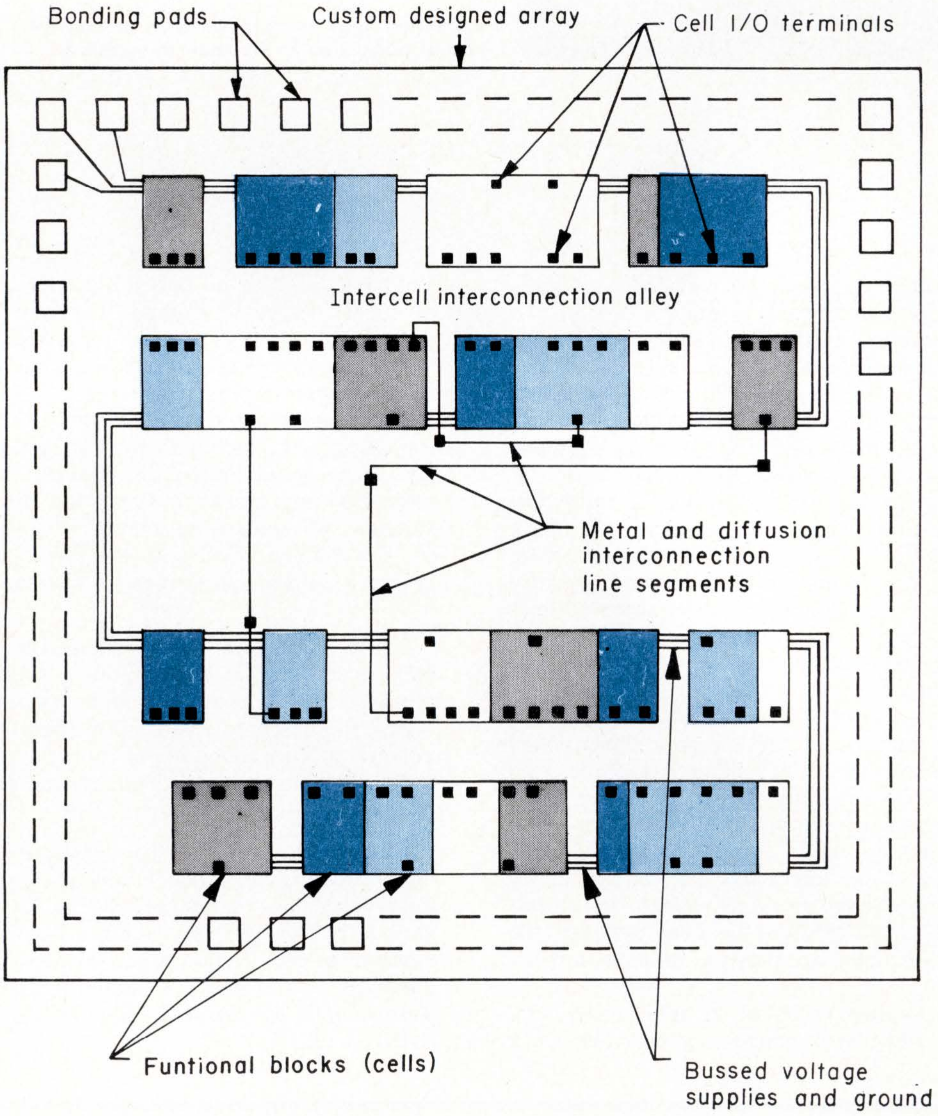
The application of CAD techniques to ICS is a major undertaking. The hardware requirements are impressive, but the major cost is in software, not hardware. However, CAD is not a luxury in the manufacture of ICS. Today, it is a highly useful tool and tomorrow it will be an absolute necessity.

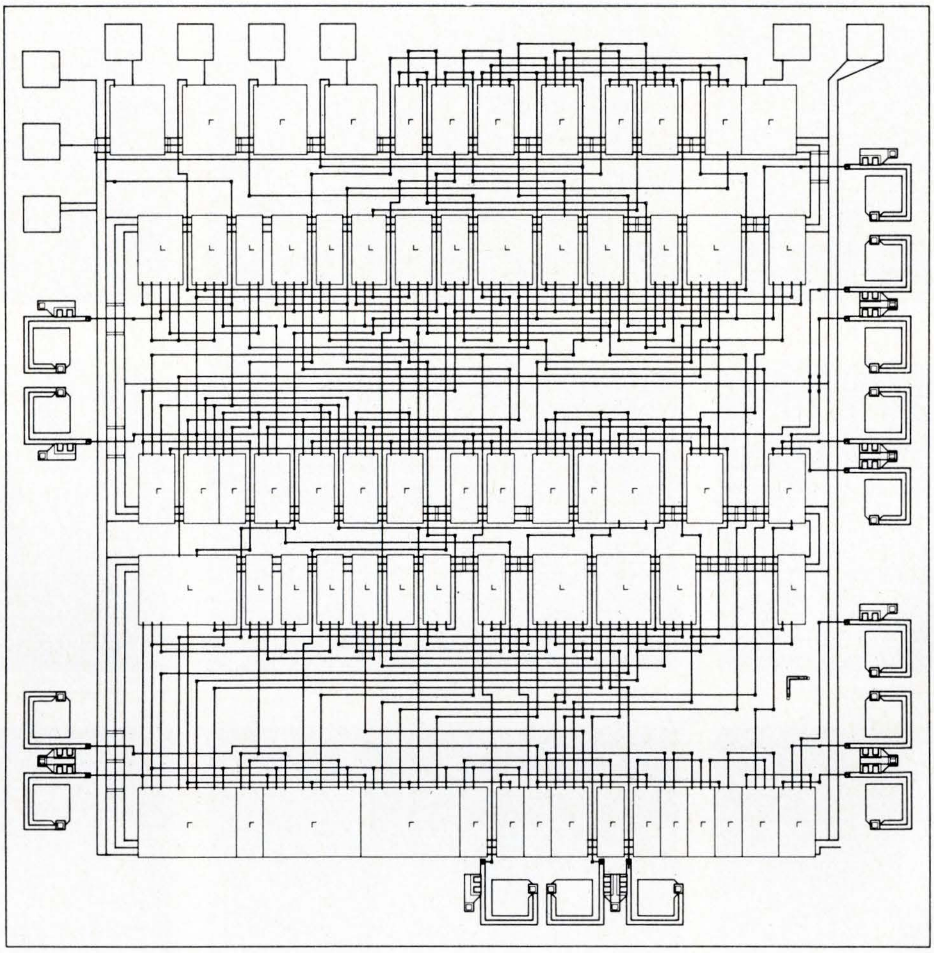
(Contributed by Motorola Semiconductor, Phoenix, Ariz.)



Flowchart for CAD subsystem design, test generation, simulation and artwork generation.

The organization of standard cells in a custom designed array.





Computer generated interconnection layout for a four-bit counter.

diffusions so that two layers of interconnection are available. During this phase, any constraints, such as pin configuration, critical speed paths, and any peculiarities of the circuit, are fed into the CAD system. Modifications to the automatic placement and wire routing can be manually entered to fulfill any special circuit constraints. These modifications are automatically checked for layout rule violations.

After all modifications have been made, a computer-driven plotter produces a symbolic drawing of the circuit. This final drawing is reviewed and artwork for the masks is then cut automatically by the same plotter.

Test generation

Functional test generation of a valid test sequence for LSI, especially random logic sequential networks with a few outputs, is an extremely difficult task without the aid of a computer. The starting point in developing a valid functional test sequence (if not supplied by the customer) is to determine how effectively the simulation exercises all of the logic in the circuit. In other words, does the simulation, used previously to verify the correctness of the logic, exercise all of the inputs and outputs of all gates?

This testing is accomplished by a subroutine of the test verification program. In essence, the network is resimulated with the original simulation and a printout is generated which shows all gate inputs and outputs not switched. This list is reviewed and additional simulation statements are added to ensure that all gate inputs and outputs are switched.

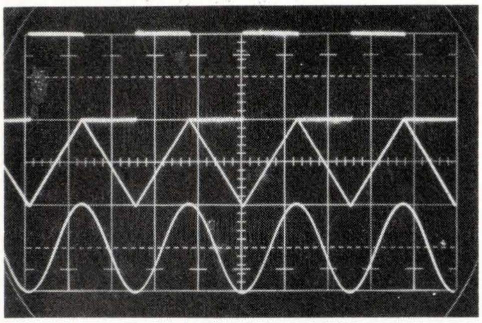
The above step is necessary, but is not sufficient to determine whether the simulation can be used as a valid test sequence. Although all gate inputs and outputs are exercised, the logic states of the circuit must be such that any defects are eventually allowed to propagate to an output pin without being masked by other signals. The verification program assures this by converting the simulation to a test sequence. The program then selects a defect to be checked and determines where in the test sequence the defect can be detected at an output pin.

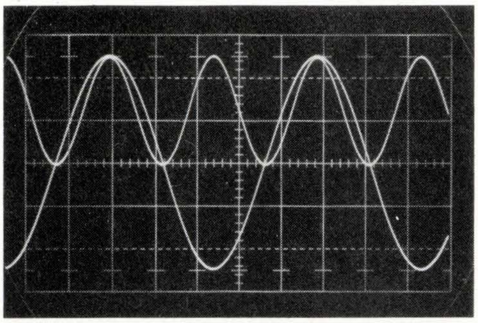
Computer-aided design is not a necessity for LSI. Many complex MOS arrays have been produced using conventional approaches. As a matter of fact, the CAD circuit is very often not *the* optimum solution to a design problem.

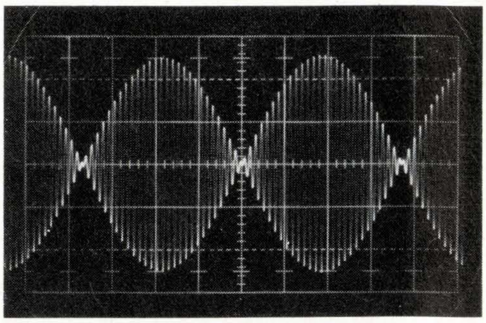
However, CAD makes LSI feasible for many applications that would otherwise be prohibitively expensive. When low engineering costs and fast turnaround time are prime considerations, CAD is the answer.

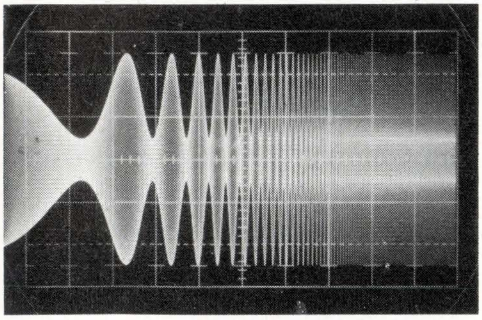
INFORMATION RETRIEVAL

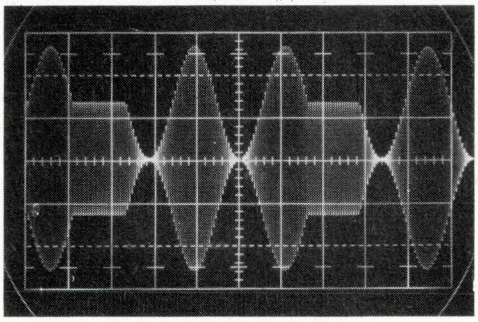
Integrated circuits, Computers and peripherals. Digital design

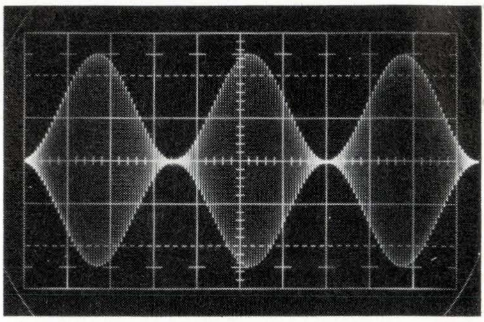

Sine, square & triangle

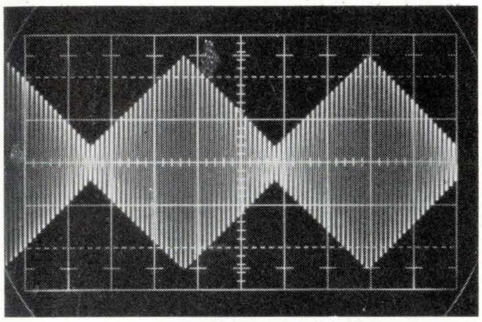

Sine squared

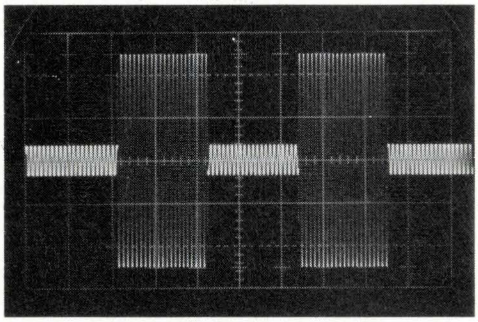

Suppressed carrier modulation

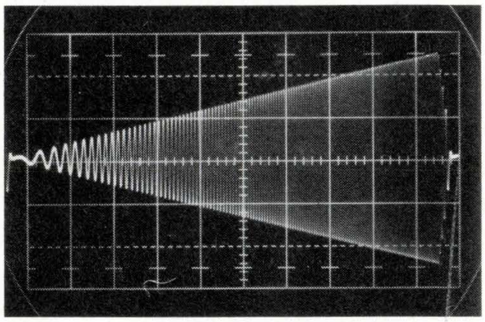

AM log swept envelope

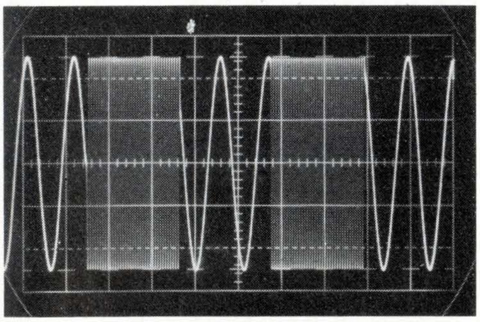

Tone burst AM

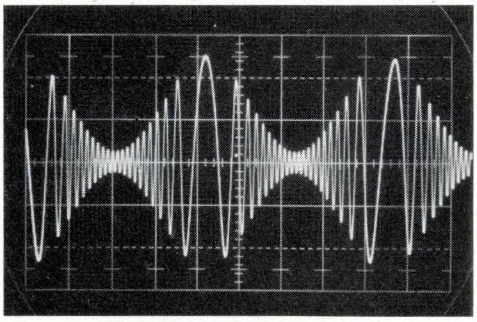

Sine wave amplitude modulation

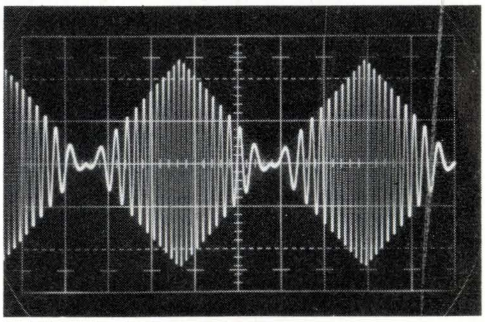

Triangle amplitude modulation

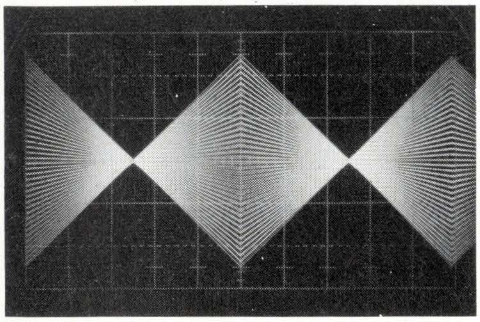

Square amplitude modulation

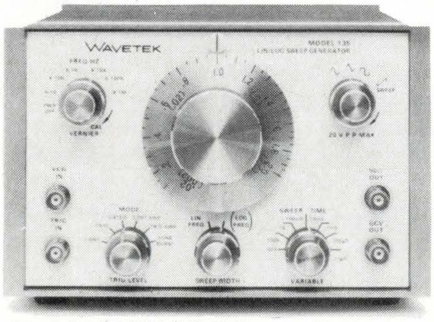

Swept AM - FM


Frequency shift keying

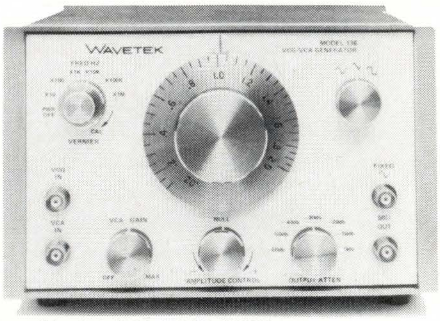

Linear AM - FM (sine wave)


Linear AM - FM (triangle)


Ultra low frequency AM



Model 135 LIN/LOG Sweep Generator



Model 136 VCG/VCA Generator

How do these waveforms grab you, generator fans?

WAVETEK®

9045 Balboa Ave., San Diego, Calif. 92123; Tel. 279-2200
P.O. Box 651, San Diego, Calif. 92112; TWX 910-335-2007

Circle 34 on Inquiry Card

Oscillators and function generators revisited

The accompanying charts let you compare at a glance the salient features of the most popular oscillators and function generators.

In the August 1969 issue of The Electronic Engineer we discussed, and illustrated in chart form, the significant features of new instruments that would make their first appearance at Wescon. Now, less than seven months later we have found that many more instruments have since been introduced, and, for your convenience, have updated our previous charts.

As in the previous charts we compare the main characteristics of the new instruments with those of the most popular oscillators and function generators that cover roughly the 1-mHz to 10-MHz field. To make the comparison meaningful, the charts exclude instruments whose upper frequency limit is below 1 MHz.

The greatest number of new entries on the chart comes from Interstate Electronics with five, closely followed by Wavetek with four. Interstate's instruments are all part of the company's new Series 50 line—F51, F52, F53, F54 and F55. Prices range from $595 for the F51 to $1195 for the F55. All five feature variable pulse width in addition to the standard sine, square, triangle, ramp and fixed duty cycle outputs. All have VCG (analog voltage control operating frequency) and PWM (analog voltage control of pulse duty cycle).

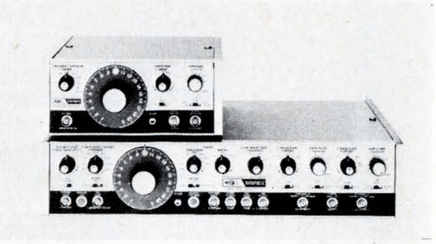
Wavetek continues to add to its 130 line with the addition of the Model 135 LIN/LOG sweep generator and the Model 136 VCG/VCA generator. The 135 is an extension of the Model 134, but offers a logarithmic sweep capability in addition to the other features of its predecessor. Either the linear or the logarithmic sweep function is available, with any of the outputs, in a continuous sweep or triggered sweep modes, using an internally generated sweep voltage.

The 136 combines true amplitude modulation (VCA) and voltage controlled frequency modulation (VCG). An internal four-quadrant multiplier makes it capable of flat amplitude modulation from dc to 10 MHz. These and other Wavetek models are shown on page 79.

Exact Electronics has introduced three new instruments in its 100 series. These instruments are covered in some detail on page 91. Although it is not covered in the charts because it is a modular building-block system, the company's 5000 Series Modular Waveform Generator is worthy of mention. It provides flexibility in the choice of both amplifier and generator modules. The common unit in all configurations is the P5001 cabinet-power supply. The cabinet has seven module spaces, and the power supply can provide power for any combination of modules. Heart of each system is one of three different modules that are being made available. One, two or three generators may be used in a system. Frequencies are controlled by a Kelvin-Varley divider.

A new entry in the function generator sweepstakes is the Datapulse division of Systron-Donner. The company is introducing their first two function generators at IEEE. Model 401 is a low cost ($395) unit which generates sine; triangular and square waves over a frequency of 0.02 Hz to 2 MHz in seven overlapping ranges. Model 410 is a direct extension of the Model 401, but with a broader range of capabilities and functions. It covers 0.2 mHz to 2 MHz in nine overlapping ranges. It features both am and fm inputs and a built-in sawtooth and triggerable sweep generator.

Another name new to the charts is Microdot. The company recently acquired the general purpose electronic test instrumentation product lines of Data Royal Corp. Thus, all models formerly listed for Data Royal will appear under the Microdot name. Model number suffixes have been changed in some cases and front panels have been redesigned.

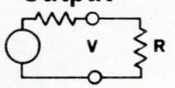


These two instruments mark the entry of the Datapulse Division, Systron-Donner Corp. into the function genenrator market. Model 401 (top) generates sine, square and triangular waves over a frequency of 0.02 Hz. to 2 Hz. Model 410 (bottom) will generate almost any waveform over a frequency range of 0.2 mHz. to 2 MHz. It can also be used as a precision oscillator, square wave generator, am or fm modulator, frequency shift keyer, and sweep and tone burst generator.

If after examining the charts you want additional information on any of these instruments, just circle on the inquiry card the numbers listed below.

Beckman Instruments	**213**
Exact Electronics	**214**
General Radio	**215**
Hewlett-Packard	**216**
Interstate Electronics	**217**
Krohn-Hite	**218**
Marconi Instruments	**219**
Microdot	**220**
Philips Electronic Instruments	**221**
Systron-Donner, Datapulse Div.	**222**
Waveforms	**223**
Wavetek	**224**

Oscillators and Function Generators



mHz Hz kHz MHz

0.1 1 10 100 1 10 100 1 10 100 1 10 100

Price	Waveforms					Frequency Range				Output			
$	Sine	Square	Triangle	Ramp	Pulse			Dial accuracy		V p-p	R Ω	Output Atten.	Offset
2995	●	●	●			0.1	Wavetek 157 (digital)		1	10	50	●	
1995	●	●	●	●		0.1	Wavetek 170 (digital)	±0.01%	1	10	50	●	
1545	●	●	●			10	Microdot F280A (digital)	±2%	1.1	11	50	●	●
1445	●	●	●			10	Microdot F270A (digital)	±2%	1.1	11	50	●	
1195	●	●	●	●	●	0.1	Interstate F55	±1%	10	15	50	●	●
1145	●	●	●	●		0.5	Microdot F250B	±2%	3	16.25	50	●	
1105	●	●	●	●		5	Microdot F240A	±2%	3	16.25	50	●	●
1095	●	●	●	●		5	Microdot F230B	±2%	3	16.25	50	●	●
1085	●	●	●	●	●	0.1	Interstate F54	±1%	10	15	50	●	●
1085	●	●	●	●		5	Microdot F220A	±2%	3	16.25	50	●	●
995	●	●	●			0.2	Systron-Donner 410	±1%	2	20	50	●	●
990	●					10	Hewlett-Packard 653A	±1 to 4%	10	1	75,124	●	
935	●	●				10	Marconi 1370A	±2%	10	7	75-600	●	
895	●	●	●	●	●	0.1	Interstate F53	±1%	10	15	50	●	●
895	●	●	●	●		0.5	Beckman 9030	±2%	1	15	600	●	●
875	●					10	Hewlett-Packard 654A	±4%	10	3	50-600	●	
845	●	●	●	●		1.5	Wavetek 116	±2%	1	10	50		
795	●	●	●	●	●	0.1	Interstate F52	±1%	10	15	50	●	●
795	●	●	●	●		1.5	Wavetek 114	±2%	1	10	50		
795	●	●				10	Microdot F324A	±3%	10	5	50	●	
785	●	●	●	●		5	Microdot F210B	±2%	3	16.25	50	●	

745	●	●	●	●		1.5	Wavetek 115	±2%	1	10	50		
725	●					10	Hewlett-Packard 652A	±3%	10	9	50	●	
720	●					10	Microdot F322A	±3%	10	5	50	●	
700	●	●				10	Waveforms 511A	±3%	12	3	50		
695	●	●	●			200	Wavetek 135	±2%	2	10	50		
695	●	●	●	●		1.5	Wavetek 112	±2%	1	10	50		
695	●					10	Hewlett-Packard 4204A (digital)	±0.2%	1	10	600	●	
660	●	●				10	Microdot F323A	±3%	10	5	50	●	
645	●	●	●			50	Wavetek 141	±3%	5	10	50		
645	●	●	●	●	●	0.1	Exact 505B	±3%	2	27	600		●
595	●	●	●	●	●	0.1	Interstate F51	±1%	10	15	50		●
595	●	●	●			200	Wavetek 136	±2%	2	10	50	●	●
595	●	●	●			1	Wavetek 142 HF VCG		10	30	50	●	
595	●	●	●	●		1	Wavetek 113 (digital)	±2%	1	10	50		●
590	●					10	Hewlett-Packard 651B	±3%	10	9	50	●	
585	●					10	Microdot F321A	±3%	10	5	50	●	
575	●	●	●	●	●	0.5	Hewlett-Packard 3310A	±3%	5	15	50		●
565	●	●	●	●	●	0.1	Exact 504B	±3%	2	27	600		●
550	●	●				10	Krohn-Hite 4100A (digital)	±0.5%	1	14	50	●	
545	●	●	●	●		1.5	Wavetek 111	±2%	1	10	50		
545	●	●	●	●	●	0.1	Exact 503B	±3%	2	27	600		●
495	●	●	●	●	●	100	Exact 126	±2%	3	10	50	●	●
495	●	●	●			5	Beckman 9010	±2%	1	15	600		●
495	●	●	●			200	Wavetek 134	±2%	2	10	50		
495	●	●	●	●	●	0.1	Exact 500B	±3%	2	27	600		●
490	●					10	Hewlett-Packard 241A (digital)	±1%	1	25	600		
450	●					1	Waveforms 402A	±2%	1.5	8	600		

0.1 1 10 100 1 10 100 1 10 100 1 10 100

mHz Hz kHz MHz

*Qty. discounts available

NOTE: New instruments are shown in color

next time you think **oscillator...** don't!

this new waveform generator outperforms oscillators to 3 MHz at oscillator prices

only 345^{00} *

THREE WAVEFORMS

GREATER BANDWIDTH — Dynamic frequency from 0.1 Hz to 3 MHz.

EXTERNAL VCF — Control voltage can be either DC programming or AC frequency modulation. 1000:1 range.

OUTPUT POWER—All waveforms at least 20 V P-P into open circuit, 10 V P-P into 50-ohm load.

MINIATURE SIZE—Only 2⅞″ high, 7⅜″ wide, 8½″ deep. Just 4 pounds.

Exact's new Model 123 VCF Waveform Generator not only outperforms oscillators in its range, but surpasses the performance of any waveform generator in the same league. And at a price you'd expect to pay for an oscillator!

EXACT
electronics, inc.

WHAT YOU GET FOR ONLY $345 IN THE MODEL 123:

- Kelvin-Varley Divider frequency control for greater accuracy.
- Variable ±5 V DC offset.
- db Step Attenuator.
- Floating output provision.
- Search mode for manually sweeping 1000:1.
- Combination tilt-stand and handle.
- Easy maintenance—single P.C. board with calibration procedure printed inside top cover.

*** Tight budget? Check Exact's new Model 120. Only $295.**

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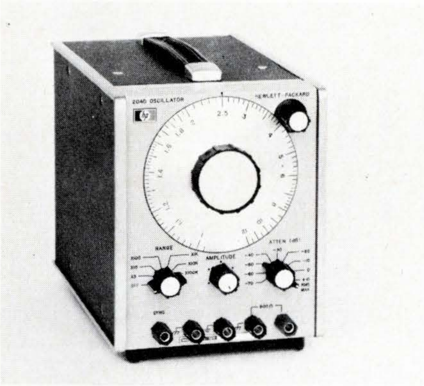
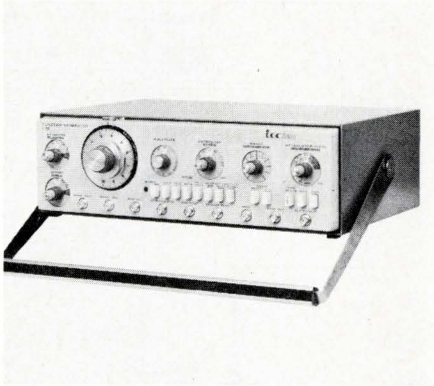
Circle 35 on Inquiry Card

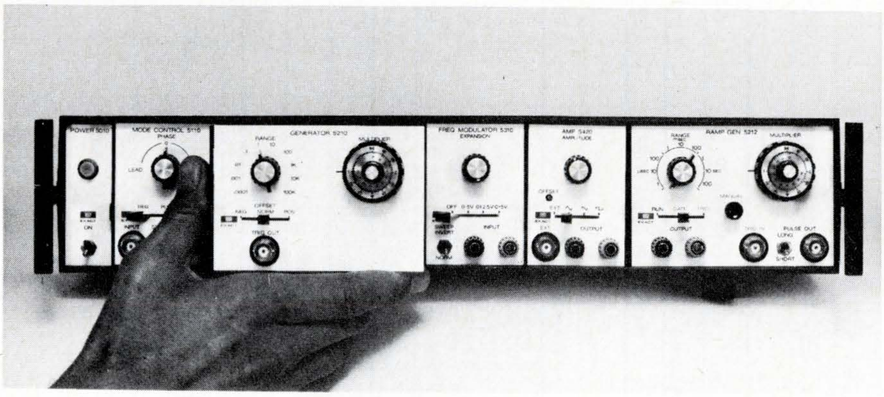
Function generators (Continued)

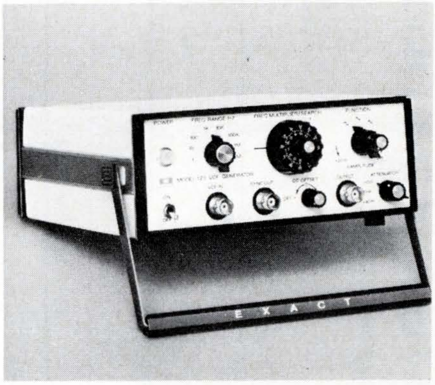


Hewlett-Packard's Model 204D oscillator is basically the same as the earlier Model 204C except that the 204C has a continuously adjustable amplitude control with range greater than 40 dB, and the 204D has an 80dB, 10dB/step attenuator with vernier. ◄

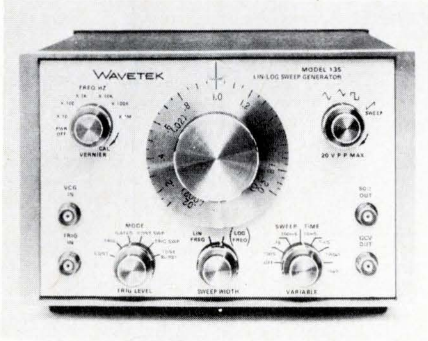
F55 generator from Interstate has all features of basic Series 50 units but also features variable offset independent of output signal level, calibrated attenuator with 70 dB range, triggered output of one complete cycle for each input, gated output, phase lock, and sweep width variable to 100:1 with a rep rate variable from 0.01 to 100,000 sweeps/s. ►

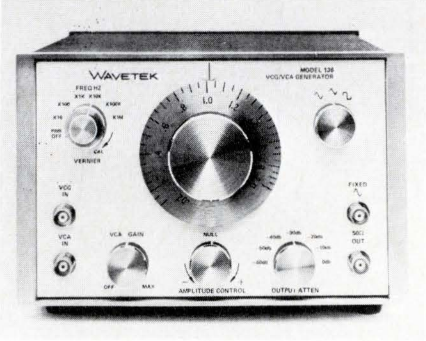




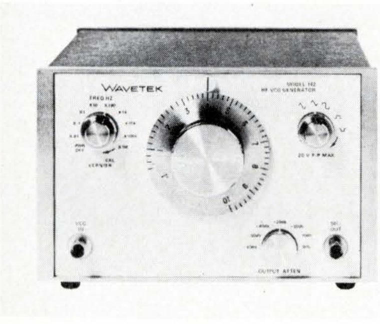


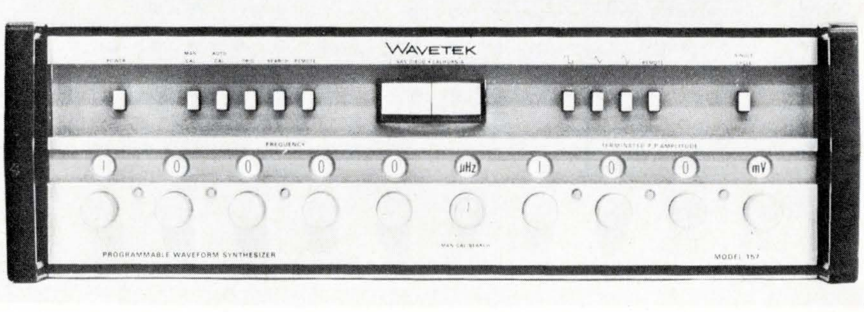
Building-block waveform generator system (Exact's 5000 Series) starts with a simple cabinet and power supply and lets you select its components. You can add, subtract or change functions to meet your needs. One square/triangle generator (G5210) and two ramp generators (G5212 and G54414) are now available. The company's low-cost ($345) Model 123 (rt. above) produces sine, square and triangular waveforms, as well as a sync pulse. Frequency is controlled by a Kelvin-Varley divider in the form of a multiplier with both digital and vernier adjustments.



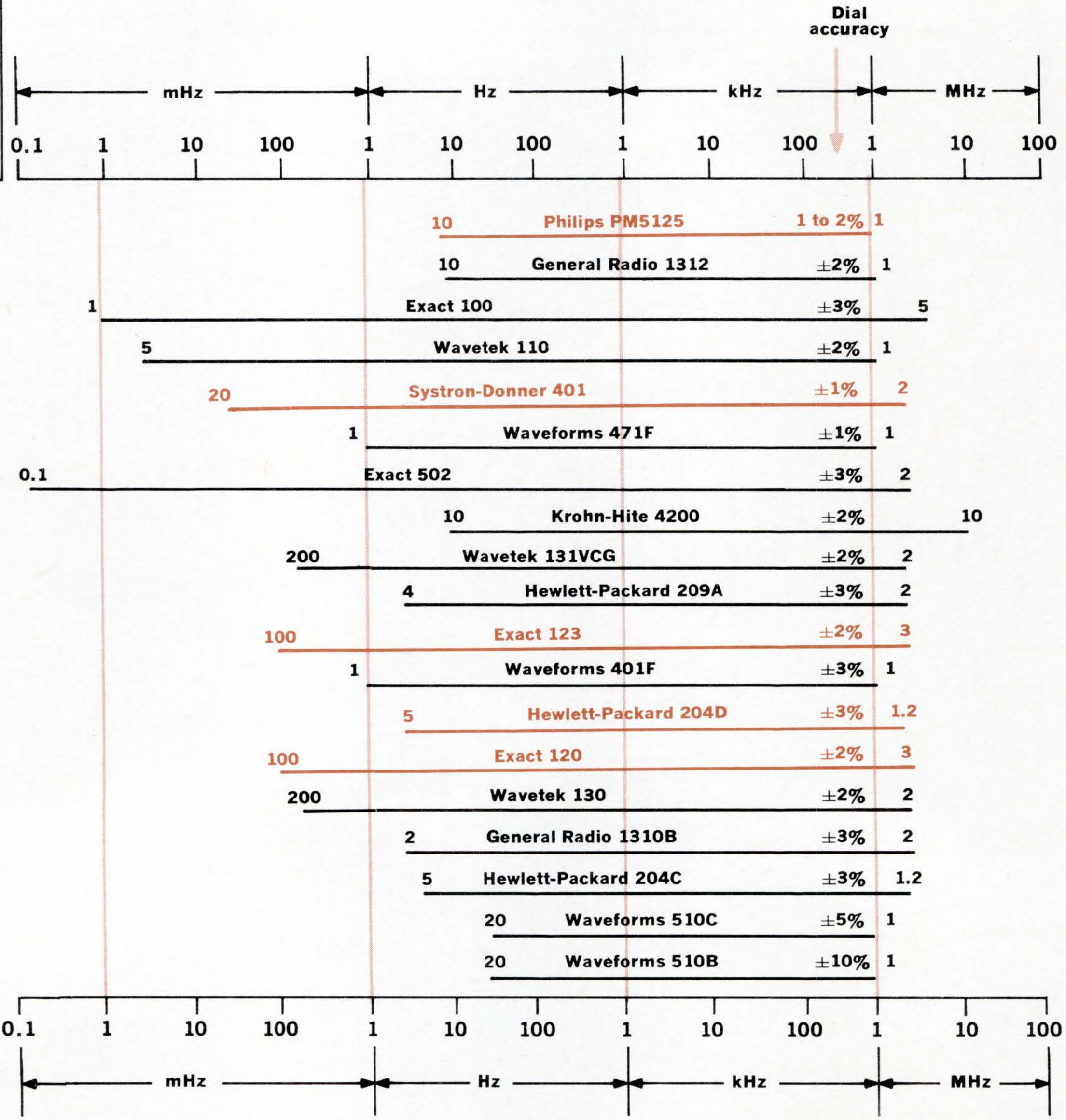


Models 135 and 136 (left) have been added to the Wavetek 130 series of low cost precision generators as described in the text. The company also recently introduced the Model 142 HF VCG genertor (left, below) and the Model 157 Programmable Waveform Synthesizer (below rt.). With the 142 you can make the output waveshape symmetrical, or assymmetrical by as much as 20 to 1. The 157's frequency can be controlled precisely by ext. voltage over a 1000:1 ratio; either dc programming or wideband ac freq. modulation. It can be synced to an ext. freq. and remotely triggered.





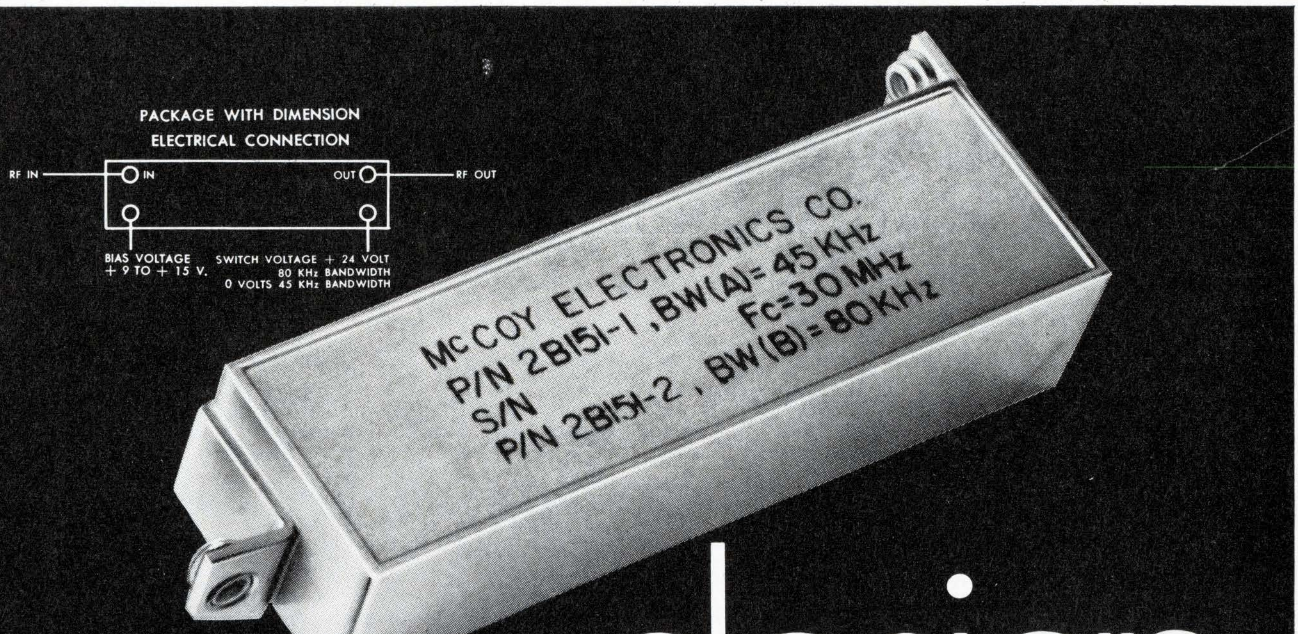
Oscillators and Function Generators



Price $	Sine	Square	Triangle	Ramp	Pulse	Frequency Range		Dial accuracy		Output V p-p	Output R Ω	Output Atten.	Offset
445	●	●				10	Philips PM5125	1 to 2%	1	28	600		
*445	●					10	General Radio 1312	±2%	1	10	600	●	
445	●	●	●	●	●	1	Exact 100	±3%	5	15	50		●
445	●	●	●			5	Wavetek 110	±2%	1	10	50		
395	●	●	●			20	Systron-Donner 401	±1%	2	10	50	●	●
385	●					1	Waveforms 471F	±1%	1	10	600		
385	●	●	●	●	●	0.1	Exact 502	±3%	2	14	600		
350	●					10	Krohn-Hite 4200	±2%	10	1 14	600 50	●	
345	●	●	●			200	Wavetek 131VCG	±2%	2	10	50		
345	●	●				4	Hewlett-Packard 209A	±3%	2	10	600		
345	●	●	●			100	Exact 123	±2%	3	10	50	●	●
325	●					1	Waveforms 401F	±3%	1	15	600		
325	●					5	Hewlett-Packard 204D	±3%	1.2	7	600	●	
295	●	●	●			100	Exact 120	±2%	3	10	50		
295	●	●	●			200	Wavetek 130	±2%	2	10	50		
*275	●					2	General Radio 1310B	±3%	2	10	600		
250	●					5	Hewlett-Packard 204C	±3%	1.2	7	600		
200	●					20	Waveforms 510C	±5%	1	2.5	600		
180	●					20	Waveforms 510B	±10%	1	5	600		

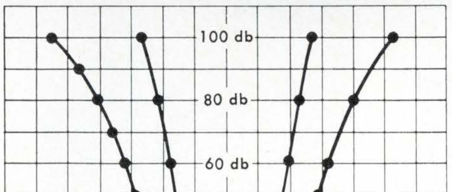
*Qty. discounts available

NOTE: New instruments are shown in color



design freedom

yours with the new switchable dual bandwidth crystal filters



SPECIFICATION	CENTER FREQUENCY 30 MHz
filter (A)	filter (B)
1 db Bandwidth 35 KHz Min.	1 db Bandwidth 64 KHz Min.
6 db Bandwidth 45 KHz Min.	6 db Bandwidth 80 KHz Min.
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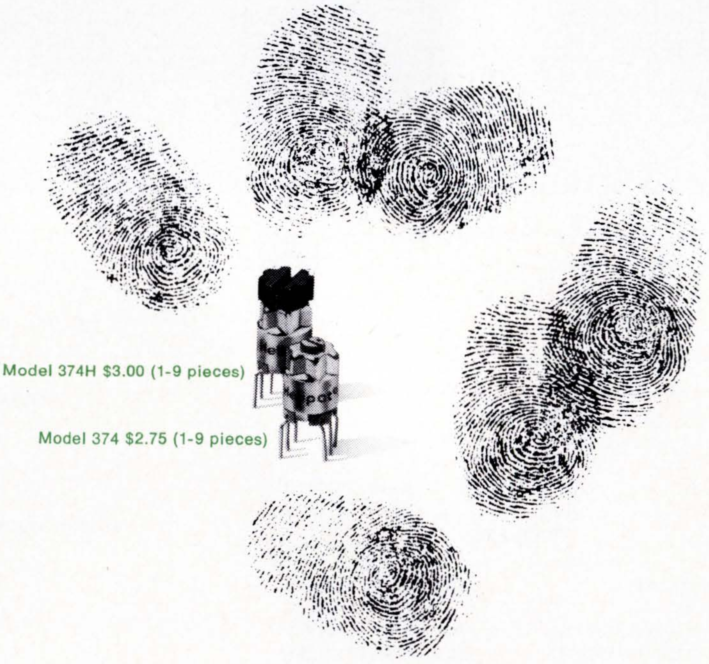

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IC IDEAS

This month's Ideas

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- After 12 issues our readers will vote on the best idea for all 12 issues. The winner gets his choice of either a Hewlett-Packard 1206A or a Tektronix 310A oscilloscope.

Submit your IC Ideas to:
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Here's how you voted

The winning Idea for the September 1969 issue is, "Simple-to-make toggling flip-flop."

Thomas Benzie, our prize-winning author, is an engineer at United States Steel Corp. in Monroeville, Pa. Mr. Benzie has chosen the Triplett Model 600 TVO multitester as his prize.

901 Simple one-shot multivibrator

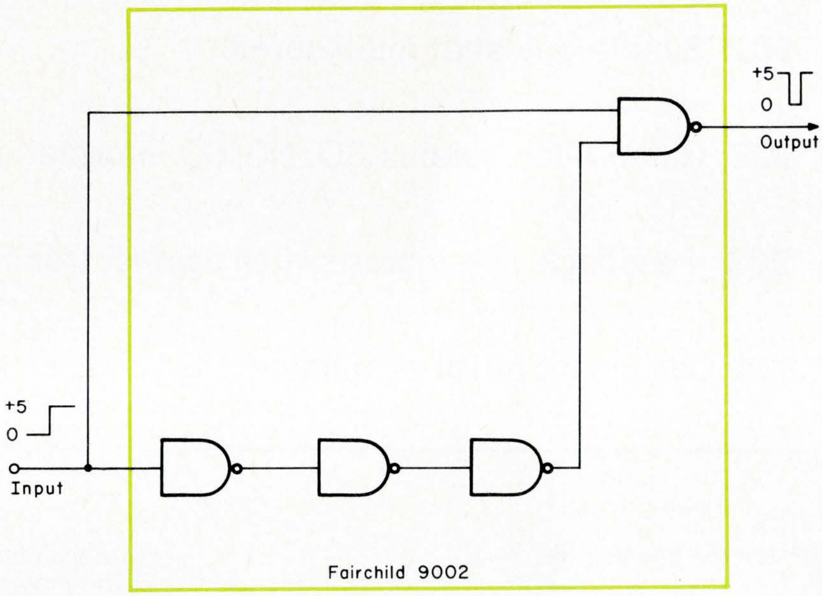
C. Musquetier

Philips V.d. Heem, The Hague, Holland.

Many times you run into the situation where you need a short pulse that is triggered off the leading edge of a longer pulse. In most applications there are no special requirements on the pulse width except that it be long enough to reset a flipflop.

You can make this inexpensive and reliable one-shot with just one quad, two-input gate. This particular circuit uses a Fairchild 9002.

When you change the input from 0 to +5 V, the circuit gives you a pulse output as shown. The pulse width is dependent on the delay through the gates and in this case is about 40 ns. Of course by changing the number of gates you can vary the pulse width.



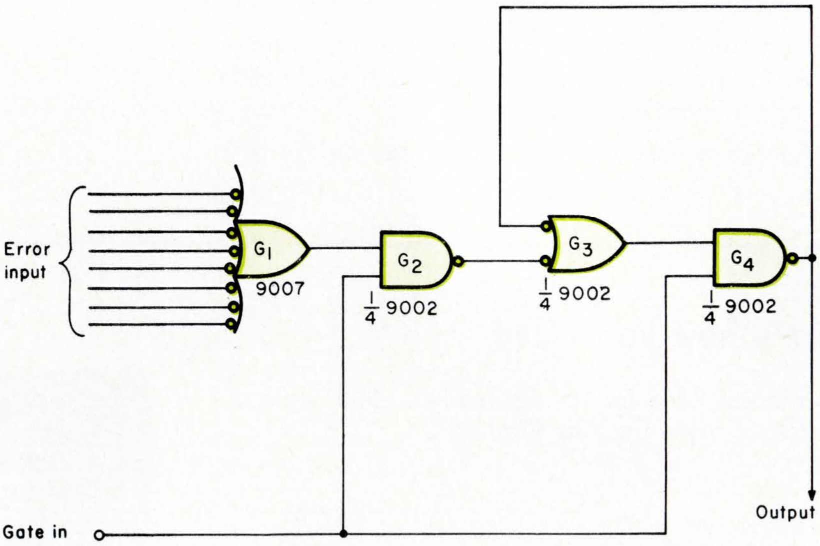
902 Gated latch retains GO/NOGO information

Aaron Mall and C. H. Doeller III

Bendix Communications Division, Baltimore, Md.

Here's a simple, reliable circuit that stores information for a gated interval. A good application is as an error detector during automated testing. This circuit will remember if an error occurred for the duration of the test.

At the start of the test, a positive gating signal is applied to both G_2 and G_4. Using a Fairchild 9007 as G_1 lets you monitor up to eight inputs. If any of the error inputs is a logic 0, the output of G_1 goes high. This enables both inputs of G_2 and causes the output of G_3 to go positive. Both inputs of G_4 are now high and the output drops to logic zero—indicating an error has occurred. Since the output is also tied to G_3 as a feedback signal, the circuit latches itself and will retain the information even if the error corrects itself. Cycling the gating signal to a logic 0 and back to logic 1 resets the circuit. The Fairchild TTL gates shown let the circuit latch on any error signal of 50 ns or longer.



903 Feedback eliminates switch contact transients

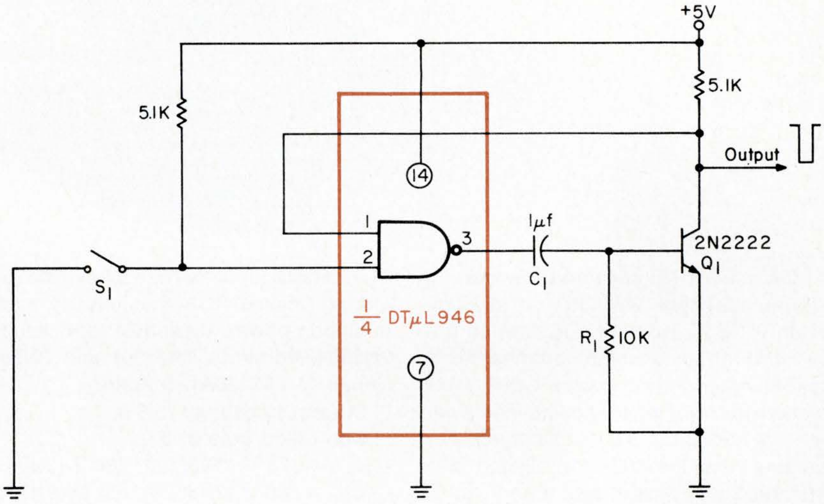
Veikko O. Jaakola

Teledyne Systems Co., El Segundo, Calif.

This monostable circuit lets you use a pushbutton or toggle switch to generate a single pulse without worrying about transients.

When S_1 is closed, it causes the output of the Fairchild DTμL 946 gate to go to +5 V turning on transistor Q_1. The feedback to the input of the gate keeps its output high for as long as Q_1 is on, despite any transients in the switch. You can even open the switch and still get the output pulse.

The pulse width is determined by the R_1C_1 time constant and you can get pulses from 1.5 ms to several seconds with this circuit.



904 Coincident Pulse Eliminator

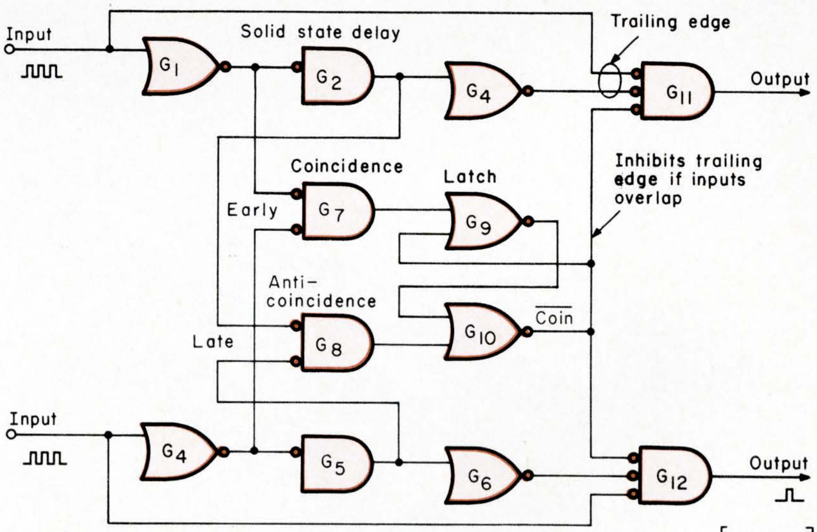
John M. Irwin

General Electric Co., Syracuse, N.Y.

Designing asynchronous logic can be made easier by using a circuit that eliminates overlapping pulses. You can then use simple latches without worrying about simultaneous set and reset pulses causing races or hazards.

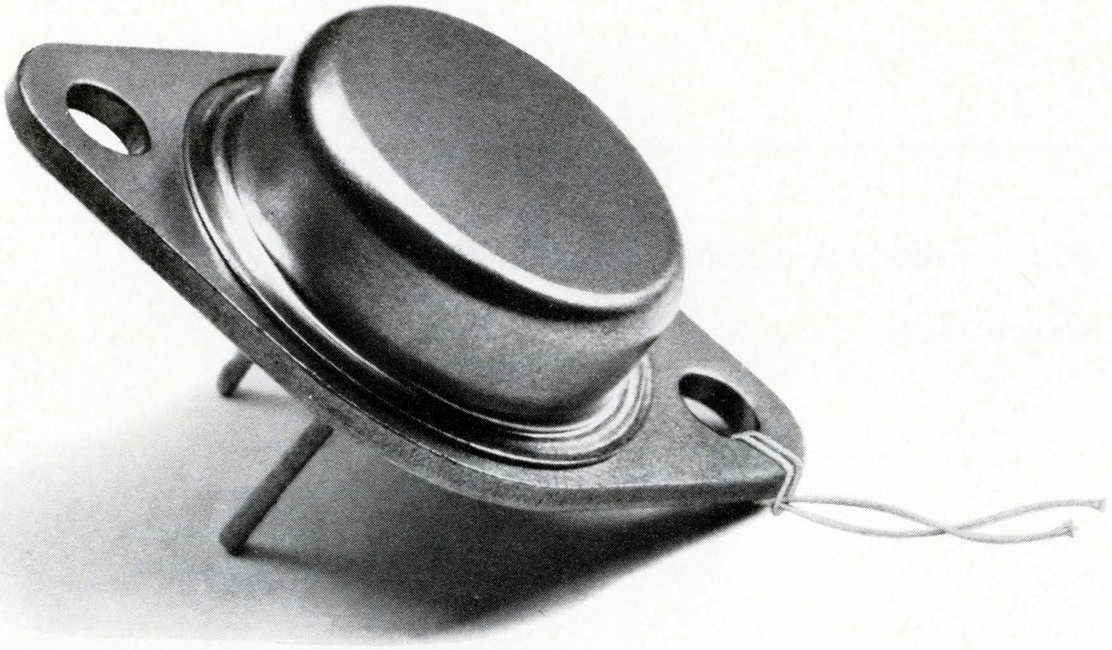
This circuit detects the trailing edge of each input by ANDing the pulse with its delayed and inverted counterpart. Any coincidence of input pulses sets a latch that inhibits the generation of the trailing edge of the output pulse. The latch is reset by anti-coincidence, that is when both pulses are not present.

Signals for the coincidence gate are taken as early in the delay chain as possible while anti-coincidence signals are taken as late as possible.



Gates G_1 thru G_{10}: MC1010 (1/4 each), Gates G_{11},G_{12}: MC1007 (1/3 each) [MECL II]

By using the propagation delay of the gates, you eliminate the need for capacitors which degrade rise times when used for delay. With high-speed logic families such as emitter-coupled logic, the propagation delay is predictable and only three gates are needed in each delay path, giving you output pulse widths of 13 ns. For slower logic, more gates (but always an odd number) may be necessary.



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

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

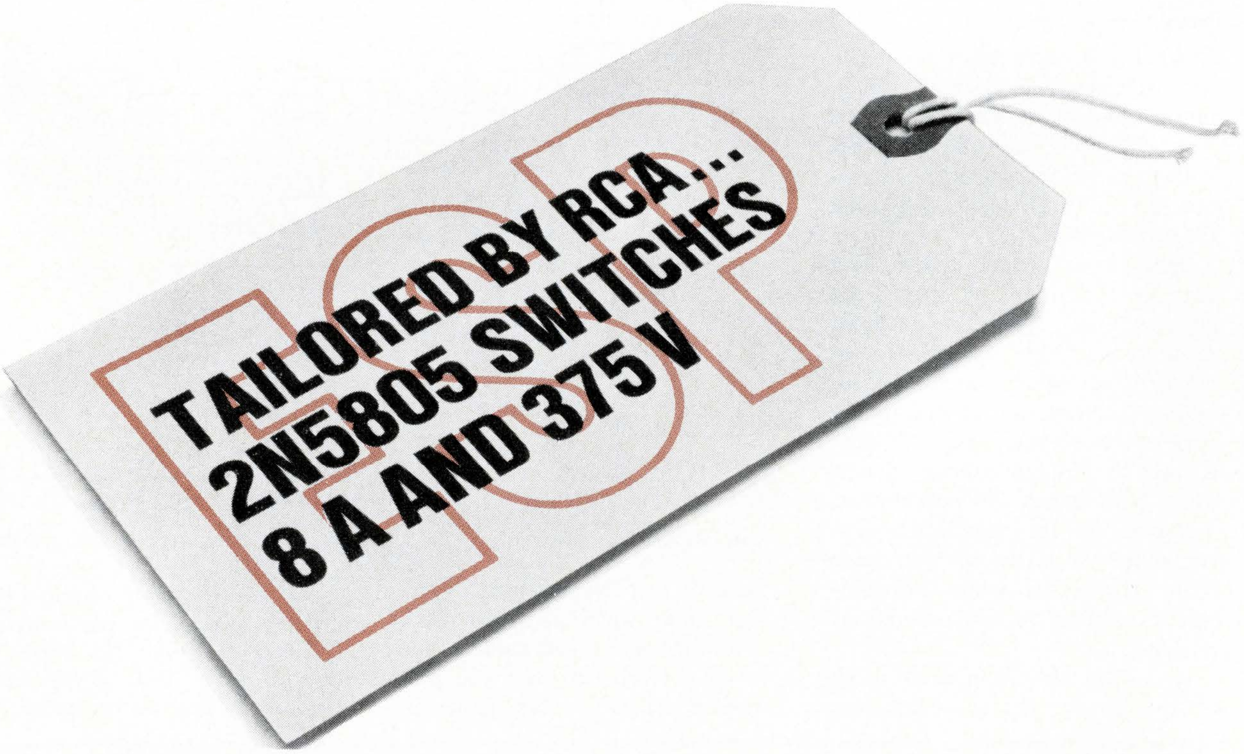
Rounding out a transistor line that already makes RCA the industry leader in silicon power, these ESP devices—the 2N5804 (formerly TA7130) and 2N5805 (formerly TA7130A)—feature:

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

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

For more information on these and other RCA silicon power transistors, just contact your local RCA Representative or RCA Distributor. For technical information, write: RCA Electronic Components, Commercial Engineering, Section No. I-J-3 /UT6, Harrison, N. J. 07029. In Europe: RCA International Marketing, S. A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

RCA



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Amplifiers

Stumped by wideband amplifiers? Mike Kennedy, Data Device Corp., "EDN," Vol. 14, No. 22, Nov. 15, 1969, pp. 53-59. To properly use a wideband amplifier, you must understand the significance of a 6-dB/octave rolloff and a large gain-bandwidth product. Kennedy discusses these parameters, and defines several terms—frequency for full output, gain-bandwidth product, and slew rate—which are sometimes difficult to interpret from spec sheet to spec sheet.

Circuits

"Perfect" regulator satisfies logic circuits, Robert C. Sanford, Electro-Optical Systems, "EDN," Vol. 14, No. 24, Dec. 15, 1969, pp. 51-53. This is a description of a 5-V power supply for logic circuits. The reference diode need not be lower in voltage than the output, so you can use Zener diodes with good temperature coefficients. The circuit uses positive feedback to establish an almost-zero output impedance.

Components

Take a second look at mercury switches, Fred W. Kear, Spartan Southwest, Inc., "EDN," Vol. 15, No. 2, Jan. 15, 1970, pp. 53-58. A view of the construction, switching parameters, and some current uses of the glass-enclosed mercury switch.

Timing module challenges relay designer's ingenuity, Peter A. Lajoie, Allegheny Ludlum Steel, "EDN," Vol. 15, No. 1, Jan. 1, 1970, pp. 56-60. A presentation of a timing module with an unlimited timing range, useful for dc relay-control systems. Various applications of the module are described.

The 7-segment and cold-cathode displays, Henry D. Olson, Research Engineer, Stanford Research Institute, "Electronic Products," Vol. 12, No. 9, January 1970, pp. 120-124. This article describes some of the seven-segment displays and drivers currently on the market.

Swift, sure design of active bandpass filters Norman T. Doyle, Fairchild Semiconductor, "EDN," Vol. 15, No. 2, Jan. 15, 1970, pp. 43-50. This article illustrates the design of bandpass filters for use to 100 kHz, using an op amp combined with RC components. A set of design curves accompanies the text.

Computers and Peripherals

Why semiconductor memories? Robert Graham and Dr. Marcian Hoff, Intel Corp., "Electronic Products," Vol. 12, No. 9, January 1970, pp. 28-34. This article looks at some of the advantages of semiconductor memories especially when compared against some of the more familiar magnetic types. Also included are some predictions of what's ahead for semiconductor memories.

Circus means versatility as a CAD program, C. D. Root of Raytheon Co., "Electronics," Vol. 43, No. 3, Feb. 2, 1970, pp. 86-96. Circus, a digital computer-aided program for transistor analysis, promises to be a very versatile medium. With this program you only need one model based on the physical makeup of the semiconductor, rather than on an arbitrary boundary condition. Initial conditions and transient solutions for networks containing bipolar and field effect transistors, as well as tunnel, zener, four-region devices, and conventional devices are easily handled. This program works for silicon and germanium devices, both small and large signal circuits.

Applying the versatile MOS ROM, John Wunner and Ron Colino, General Instrument Corp., "Electronic Products," Vol. 12, No. 9, January 1970, pp. 35-40. The authors review some of the features that have made MOS read-only-memories one of the busiest areas in the integrated circuit field. They also show some examples of an ROM being used as a microprogrammer and in an LSI testing operation.

Integrated Circuits

***Computer aided design,** Frank Schenstrom and Robert Williams, Fairchild Semiconductor, "The Electronic Engineer," Vol. 29, No. 3, pp. 69-72. Using computers to help in the design of LSI has made it feasible for a variety of applications. The authors show how the computer saves time, effort and money in turning out LSI circuits.

***Four-phase logic,** Lee L. Boysel, Cloyd E. Marvin, Joe Murphey, and Jim Sorenson, Four-Phase Systems, Inc., "The Electronic Engineer," Vol. 29, No. 3, pp. 63-68. There has been a lot of discussion about multiple clocking schemes. Here's a description of how to design with four-phase logic.

***MOS shift registers,** George Landers, Signetics Corp., "The Electronic Engineer," Vol. 29, No. 3, pp. 59-61. The MOS technology has found

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ABSTRACTS

widespread usage in shift registers. Mr. Landers shows the different ways that these registers are constructed.

***Doing logic with MOS,** William Penney, American Micro-systems, Inc., "The Electronic Engineer," Vol. 29, No. 3, pp. 56-58. This article looks at how the MOS transistor is used to form the various logic functions. The author also discusses the two logic types found in MOS systems; dynamic and static.

Integrated fm detectors, W. F. Allen, Jr., and L. H. Hoke, Jr., Philco-Ford Corp., "EEE," Vol. 17, No. 12, December 1969, pp. 56-63. The authors point out how desirable it would be for the semiconductor industry to standardize on an integrated limiter-detector circuit suitable for fm receivers. They then describe seven circuits that could lend themselves to integration. The first one, the Foster-Seeley discriminator, is already available as a monolithic integrated circuit from several manufacturers. The others are; two more discriminators (crystal and RC phase-shift), and four detector circuits (ratio, pulse-counting, quadrature, and synchronous). Some of these circuits, like the pulse-counting detector, can be implemented with existing IC i-f limiters. In addition, the authors show two ICs, one with a ratio detector, the other with a quadrature detector.

Analog switching—high complexity with MOS, E. Floyd Kvamme, National Semiconductor, "EDN," Vol. 15, No. 2, Jan. 15, 1970, pp. 33-37. Progress in MOS technology has given us the low-threshold FET for analog switching applications. The author investigates factors which control the performance of these switches.

Decoder/Drivers for digital displays, Bill Hillenbrand, Assoc. Editor, "Electronic Products," Vol. 12, No. 9, January 1970, pp. 114-118. Here's a description of the different types of decoder/driver assemblies available. Included is a table listing data on monolithic units.

Designing with super-beta transistor op-amp ICs (Part I of a series), Robert J. Widlar, National Semiconductor Corp., "EEE," Vol. 17, No. 12, December 1969, pp. 70-73. The author makes a case for using super-beta transistors—bipolar transistors optimized for high gain—instead of field-effect transistors, in the input stage of an operational amplifier. Since he has incorporated in one of his company's products, the LM108, he shows the improvement in characteristics such as offset voltage and drift by comparing them to those of op amps with FET inputs, as well as with those of op amps that use standard bipolar transistors in their input stage. The author then analyzes the application of the LM108 to a sample-and-hold circuit, a circuit that is very sensitive to the type of op-amp errors that super-gain transistors tend to correct.

Grounded-load drivers, John Vennard, National Semiconductor Corp., "Electronic Products," Vol. 12, No. 9, January 1970, p. 119. Because of recent developments in high voltage monolithic chips, the author suggests you take another look at the grounded load configuration in digital drivers.

What's ahead in ICs, Glen Madland, President of Integrated Circuit Engineering Corp., "Electronic Products," Vol. 12, No. 9, January 1970, pp. 14-18. Here's a crystal ball look at what you can expect in the integrated circuit industry during 1970. Mr. Madland sees some perplexing problems facing the smaller companies trying to carve a portion of the market for themselves.

Semiconductors

Analog switching—high speed with JFETs. Donald L. Wollesen, National Semiconductor, "EDN," Vol. 15, No. 2, Jan. 15, 1970, pp. 38-40. Junction-FET switches toggle to about 10 MHz, and switch analog signals to beyond 100 MHz. The author covers the requirements for JFETs to switch high-frequency signals, and shows how to build the circuits.

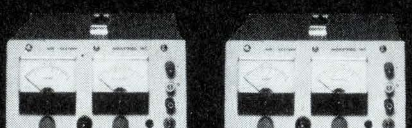
Test and Measurement

Digitized thermocouple compensation yields direct reading for data logger, Jacek H. Kollatai, Finland's Nokia Electronics, "Electronics," Vol. 43, No. 3, Feb. 2, 1970, pp. 116-119. With about $30 worth of ICs and a little designing, you can have a digital temperature reading that has the thermocouple's reference value added to the measured value. By the method described you work into a digital voltmeter and automatically supplies corrected process temperatures for display in actual temperature units.

What to look for in a DVM, Charles Newcombe, John Fluke Manufacturing Co., "EDN," Vol. 14, No. 24, Dec. 15, 1969, pp. 37-40. When buying a DVM, Newcombe cautions you to make sure that its assumed capabilities are really there. The instrument should make measurements with a minimum of limiting conditions. In particular, you should examine the instrument's interference rejection, method of ratio measurements, input characteristics, overload protection scheme, and system compatibility.

Miscellaneous

Arc-plasma deposits may yield some big microwave dividends, D. H. Harris and R. J. Janowiecki, Monsanto Research Corp., "Electronics," Vol. 43, No. 3, Feb. 2, 1970, pp. 108-115. Arc-plasma spray (APS) can accommodate a wide variety of deposition and substrate materials for making microwave hybrid ICs. With this system there is no heat, meaning that depositions could even take place on a plastic substrate. The new system features uniformity of deposition, high density of films, alternate feeds for building up various material layers, and simultaneous feed on the same substrate, with good resolution.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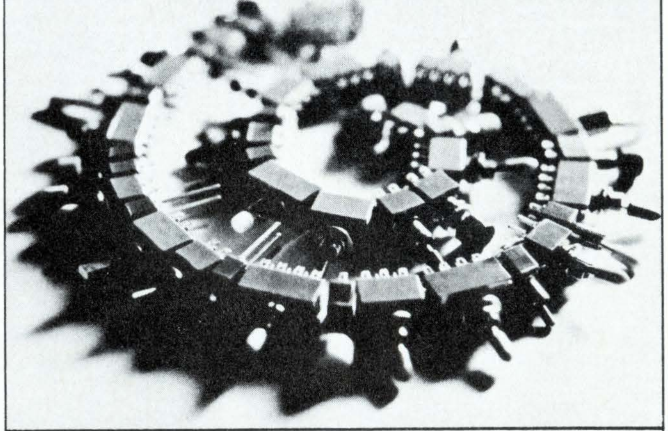
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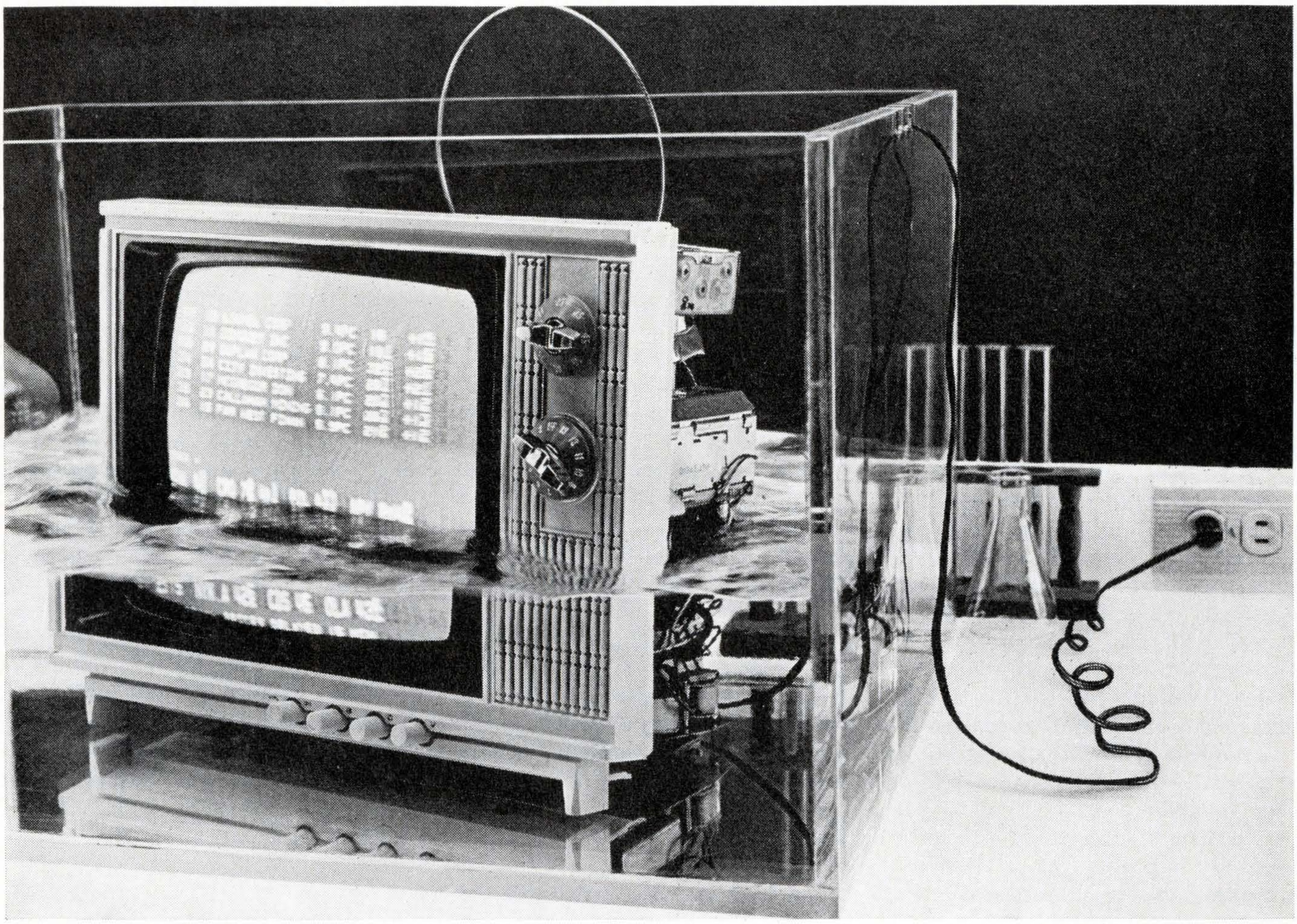

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All of us have been making rms readings of ac voltages for years. We know we have, it says so right on the front of the meter.

If someone were to ask what we mean by rms voltage, we could quickly explain the concept of "root mean square." In the interest of accuracy we might add that the rms voltage indication on most meters is true only for a sinusoidal wave. Unfortunately, most measurements are not made on true sinusoidal waves. However, for many applications, average responding meters are adequate.

But it would seem logical, where accuracy is important, to use a meter that measures true rms voltage no matter what the wave shape—a true rms voltmeter.

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Now Hewlett-Packard has adapted the thermocouple concept used in standard laboratories; added protective amplifiers to insure overload protection (800 V p-p); and reduced final-value step function response to less than 5 seconds.

When you combine these features with a low price of $575, it adds up to the HP 3400A—the first practical true rms voltmeter for general use in the 10 Hz to 10 MHz range. And, a high crest factor (ratio of peak to rms) allows you to measure noise and other non-sinusoidal wave forms at a ratio of 10:1 full scale or 100:1 at 10% of full scale. You get accurate noise and pulse measurements — without having to make non-standard corrections.

The 3400 isn't just a fine true rms voltmeter—although that's plenty in itself. It can also be used as an ac/dc converter and a current meter. Typical dc output accuracy is 0.75% of full scale from 50 Hz to 1 MHz. Use the HP 456A AC Current Probe ($250) and you get quick dependable current measurements. The 456A probe has a 1 mA to 1 mV conversion allowing direct readings up to 1 amp rms.

So, if all your measurements aren't made on true sinusoidal wave shapes and if you like direct accurate rms voltage indication no matter what you're measuring, it's time to check into the HP 3400A true rms voltmeter. For more information, contact your local HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

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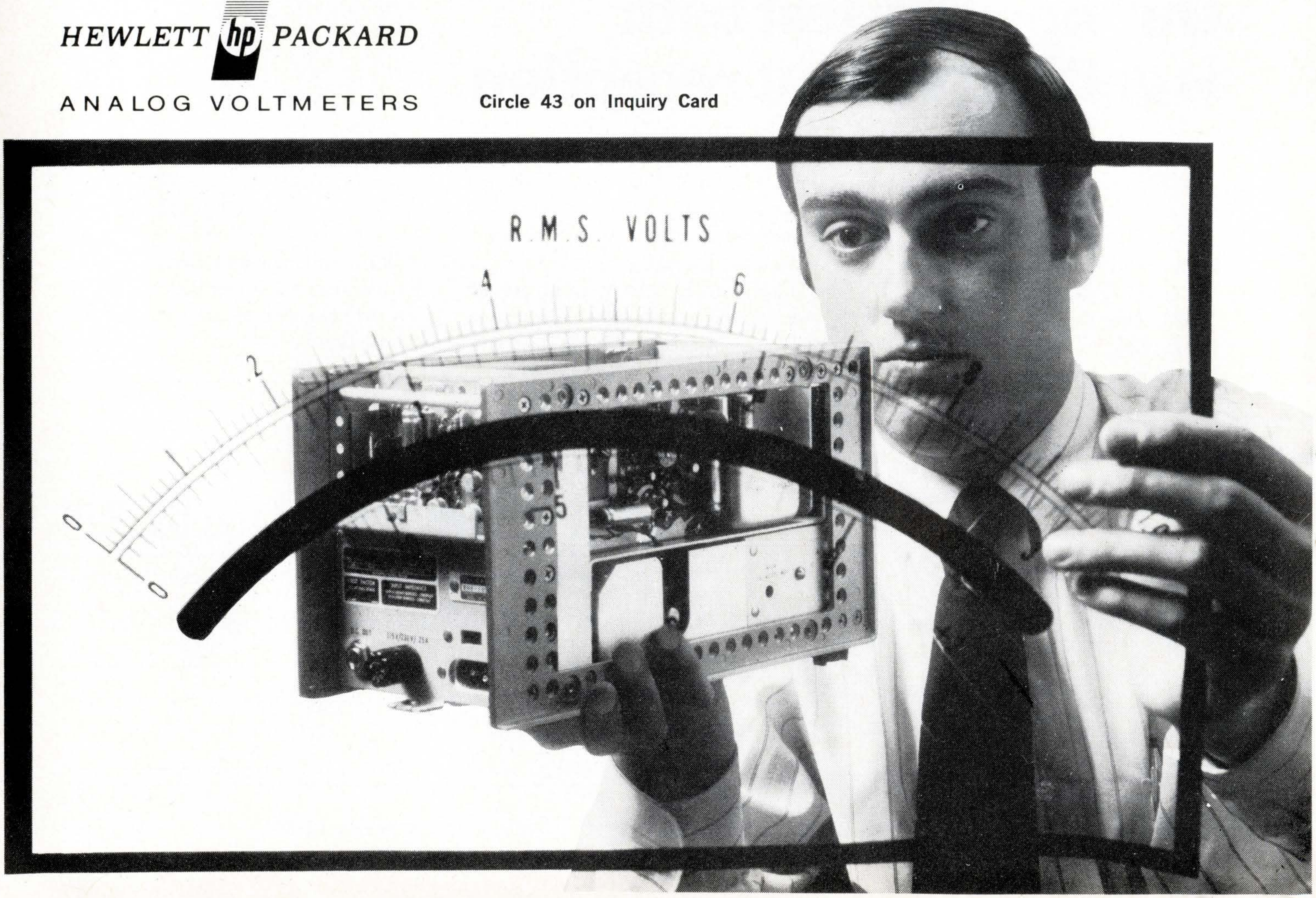
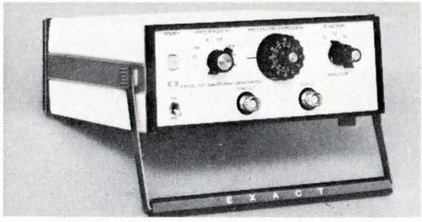


Waveform generator has sweep capability

The latest entry from Exact Electronics in the waveform generator sweepstakes is the Model 126. The 126, together with two other recently introduced generators — Models 120 and 123—considerably broaden this manufacturer's line of miniature waveform generators.

While the Model 120 is perhaps comparable to the $345-priced 123, it lacks certain of the 123's operating features, such as voltage-controlled frequency, calibrated output step attenuator, dc offset control, and a third decade of manual sweep range. But the Model 126 represents a more sophisticated waveform source, because it is two generators in one package.

In addition to the sine, square, triangle, and sync pulse outputs common to the 120 and 123, the 126 includes a sweep generator that produces a linear ramp output.



The addition of the ramp output, which is variable in duration from 10 μs to 100 s, gives the main generator several modes of operation: GATE, TRIGGERED, BURST, PULSE, and SWEEP. These modes are available because you can use the ramp source to sweep the main generator, or to gate or trigger it for tone bursts and pulse generator operation. So, you can consider the Model 126 to be a combination of voltage-controlled frequency, sweep, tone, burst, pulse, and ramp generators all in a single package, one which you can have for $495.

The frequency range of the 126's main generator (sine, square, triangle, and sync waveforms) is 0.1 Hz to 3 MHz, and the frequency multiplier dial accuracy is typically ±2% of setting. A 5-V input gives you three decades of voltage-controlled frequency operation.

Sine wave distortion is less than 0.5% to 100 Hz, and harmonics (100 kHz to 3 MHz are more than 30 dB down. Rise and fall times for the square waveform are <60 ns, with overshoot and ringing <5%. Triangle linearity is 99% to 100 kHz, 95% to 3 MHz. Exact Electronics, Inc., Box 160, . Hillsboro, Ore. 97123. (503) 648-6661.

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New printed circuit manufacturing process

Normally, when making a printed circuit, about 90% of the laminated copper foil is etched away, leaving the remaining copper as the circuit itself. Undesirable aspects of this process are wasted material and the problem of disposing of spent etching solution.

To overcome these faults, the new RICO PC+™ system integrates a newly developed board material and additive circuit process which effects considerable savings of time and material. In addition, it eliminates the separate through-hole plating process. Circuit and through-hole plating are accomplished simultaneously, as is plating of both sides of the board.

This way, the copper is not etched away to form the circuit pattern but is instead deposited on the board, eliminating the need for a copper-clad board. The system uses laminated paper and glass board based on the company's RICON resins. These boards have good electrical properties, high tensile and flexural strength, good mechanical characteristics over broad temperature and humidity ranges, and low moisture absorption.

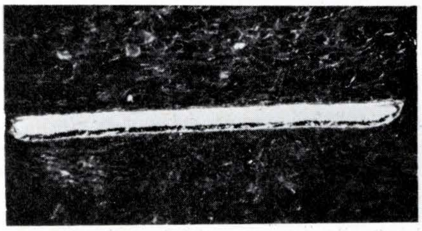


Photo (188x) shows a cross-section of a line, 1 mil thick and 20 mils wide, illustrating the minimal undercut achieved with RICO PC+.™

Other advantages are the virtual elimination of undercut, great reduction of circuit noise, and closer placing of conductor lines than is possible with current systems.

With other systems, 5-mil lines with 5-mil spacings were possible, but special and expensive production precautions were needed. Now 5-mil lines with 5-mil spacings are possible at normal production rates. Also, only the conductor thickness required by the design is deposited on the substrate.

Since this system uses electroless nickel instead of electroless copper, the co-deposits of copper oxide are eliminated. These deposits tend to affect electrical properties and to produce a high noise-to-signal ratio.

The Richardson Co., Allied Research Products Inc., 4004 East Monument St., Baltimore, Md. 21205. (301) 732-9070.

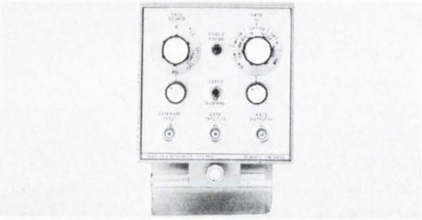
Circle 276 on Inquiry Card

Pulse system components reach 125-MHz rep rate

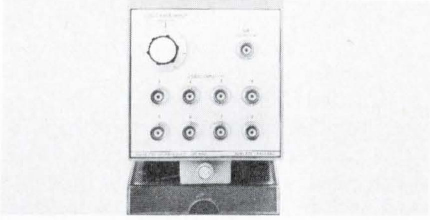
Here are three new plug-ins for Hewlett-Packard's Model 1900 pulse system. The 1900 system, introduced more than a year ago, consists of a high-speed main frame and a number of plug-ins. This concept lets you put together the pulse system you need *now*—whether it is to be a pulse generator for general testing, or a digital formatting equipment—and its flexibility lets you change it as you need to do so, and economically.

The system plug-ins have been predominately 25- and 50-MHz units, but all of the new components are for 125-MHz rep rates. For example, the Model 1906A rate generator gives you a clock source that is variable to 125 MHz. Triggering is either internal or from an external source; the external trigger may be sinusoidal or pulse. And there is a GATE input which lets you generate bursts of clock signals.

The output pulse amplitude is more than 1.5 V across 25Ω (which means that you can use this plug-in to drive two other 1900-series plug-ins), with a rise time faster than 3 ns, and width of less than 5 ns. Output impedance is 50Ω, dc-coupled. The Model 1906A costs $275; there is an analog programming option that adds another $100 to the price.

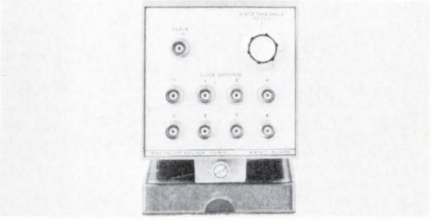


The other 125-MHz plug-ins are the Model 1927A fan-in amplifier and the Model 1928A fan-out amplifier. The fan-in unit provides a positive logic, inclusive-OR function for eight input signals. The inputs can range in amplitude from 1-V minimum to 4-V maximum, with a 4-ns minimum width. You set the threshold simultaneously for all eight inputs, and you can vary it from +0.5 to +3 V; propagation delay is <8 ns.



The logic one of the inclusive-OR output is current-sourced at 45 ±10 mA. Rise times, fall times and pulse stretch are all <3 ns.

The input and output specs for the Model 1928A fan-out amplifier are the same as those of the fan-in unit (threshold and logic levels, amplitudes and widths, and so forth). But with the 1928A, you can drive 16 1900-series plug-ins, because each of the 1928A's eight outputs can drive two other plug-ins.



The Model 1927A fan-in amplifier costs $150, while the Model 1928A fan-out unit is somewhat higher at $225. Inquiries Manager, Hewlett-Packard, 1501 Page Mill Road, Palo Alto, Calif. 94304. (415) 326-7000. (Booths 2F25-2F36.)

Circle 303 on Inquiry Card

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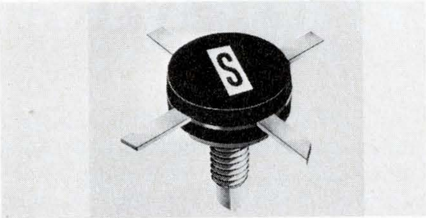
This high performance amplifier comes in TO-8 (12-lead); DIP (14-lead); and modular flat pack (7 lead). Designations are: ZA801M1, modular flat pack, epoxy; ZA801D1, DIL, epoxy; ZA801E1, DIL, hermetically sealed; and ZA801T1, TO-8. Specs: dc gain (@rated load), 100,000 min.; unity gain, 4 MHz; full power freq. output, 200 kHz; voltage drift, 50 μV/°C, max.; output rating, ±10 V @ 5 mA, min; and CMR (±10 V). 10,000: 1. Zeltex Inc., 1000 Chalomar Rd., Concord, Calif. 94520. (415) 686-6660. Booths 2H19, 2H21.

Circle 304 on Inquiry Card

RF POWER TRANSISTOR

With 60 W at 150 MHz.



This transistor can deliver 60 W of output power at 150 MHz with 28 V V_{CE} and a min. 6 dB gain. It can also deliver 50 W of output power at 175 MHz with a min. of 6 dB gain. The SRD54117 comes in a TO-128 setup. Intended for use primarily in vhf communications systems, it guarantees a 3:1 VSWR capability. $66 (1 to 99). Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404. (305) 848-4311.

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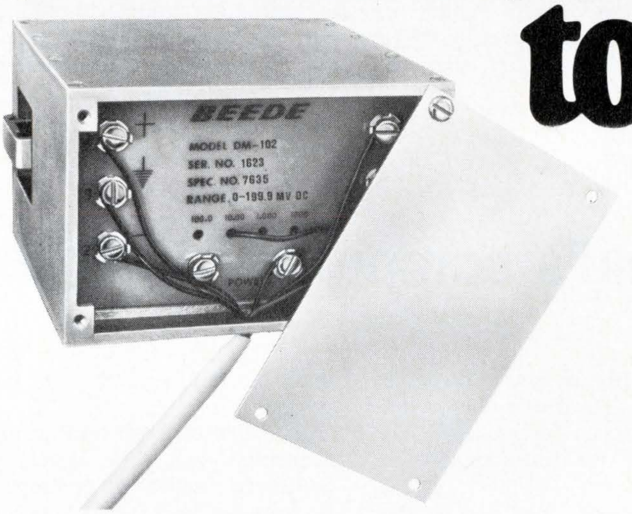
LEAD WELDER

Makes 14,000 welds/h.

Model 6.11 welds axial wires to resistor bodies at 7,000 components/hr. Cylindrical bodies are vibrated into a magnetic feeder, through a channel and then to the welding position via a magazine. Wire is simultaneously spool fed from both sides of the welder. B. Freudenberg, Inc., 50 Rockfeller Plaza, New York, N. Y. 10020. (212) 757-9130. Booths 1H09-1H11.

Circle 306 on Inquiry Card

take a look at our backside, too



Beede's DPM's feature a rugged die cast aluminum case that totally encloses the unit, (for RFI & dust). A covered terminal board with just the leads you need brought out in clearly marked #6 screws (or a multi-pin terminal strip for BCD output). A panel clamp that lets you install or remove the unit from the panel front, (and the glass protected meter front can be customized to your specifications). That other little lead lets you plug-in the decimal point where it's needed. Write for all the details or a demonstration.

BEEDE

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DIGITAL PANEL METERS
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Circle 45 on Inquiry Card

Will the circuits keep up with the testers?

Are you using large-scale integrated (LSI) circuits today? If so, chances are that the highest number of terminals you are likely to find in one package is about 64. If you are using only a few of these circuits per day, several suitable testers are available.

This month however, Fairchild Systems, Teradyne, and Macrodata (a new company) are introducing computer-controlled LSI testers. The first two handle not only 64-pin packages, but may be expanded to accept packages with hundreds of pins. While we have not yet seen anybody using 120-pin LSI packages in quantity, there is no question that there are many mass-produced packages with between 20 and 60 pins, creating a need for such testers.

All three models can test both sequential and combinatorial circuits, and perform both functional and dc parameter testing. They can test not only LSI packages, but also LSI wafers by interfacing directly with the wafer prober.

Since it is difficult to make a one-to-one comparison of the capabilities of computer-controlled testers that may cost between $100,000 and $200,000, we present their main features below, and suggest that you look up Teradyne's and Fairchild's at the IEEE Show. Macrodata will not exhibit at the Show, but you can get in touch with them via our reader service card. Here are the numbers:

Fairchild Systems Technology—Sentry 400. IEEE Booths M17-M24: Circle Reader Service No. 210.

Teradyne—SLOT (Sequential LOgic Tester). IEEE Booths 2B03-2B07: Circle Reader Service No. 211.

Macrodata Co.—Diagnostic test system: Circle Reader Service No. 212.

Fairchild's computer-controlled array test system

Production testing is now the name of their game. To prove the point, Fairchild Systems Technology has spotlighted their new test system—the Sentry 400.

Because it was designed around the known and projected needs of LSI/MOS houses, Fairchild feels that its Sentry series will fulfill testing requirements for at least the next three years.

Expandable

The Sentry 400 is a flexible system. For a start, each test station can test devices with between 30 and 240 leads; for future needs, the station is expandable beyond this. Each station can operate from the wafer-probe level all the way to final test and classification, quality control, and high-reliability examinations of the circuits.

Right now, Sentry runs at about a 300-kHz rate for functional tests; however, a program raising this to 20 MHz is already under way. To increase through-put in production, you can expand Sentry to four full test stations multiplexed from the central processor and the instrumentation chassis. These stations are independent and each can test unique arrays. Automatic LSI/MSI handlers are being developed.

You can test both combinatorial and sequential logic. The system includes additional automatic features which let you log test results, control automatic die-sort stations, and control automatic final package handlers.

While LSI may not yet be here in volume, printed-circuit cards are. So, besides testing semiconductors per se, Fairchild's new instrument also does nicely as a card tester. It satisfies the urgent need for a large-volume, PC-card exerciser.

Rolled its own

Though outside purchase of the CPU and software was considered, this approach was discarded because of the difficulty of adapting standard programs to the special needs of array testers.

Instead, Fairchild Systems built its own 24-bit central processor. Sentry's CPU uses a machine language which knows how to talk to circuits. The test program language—called USERS—is, according to Fairchild, reasonably simple to learn and use.

Now, once you write and debug a program it becomes a permanent document, which both the array manufacturer and the array user must be able to understand. So a systems compiler encodes the USERS language into an object-code-set of tester instructions. This process is analogous to that of compiling a FORTRAN program, and then assembling it into a list of computer operation instruction codes.

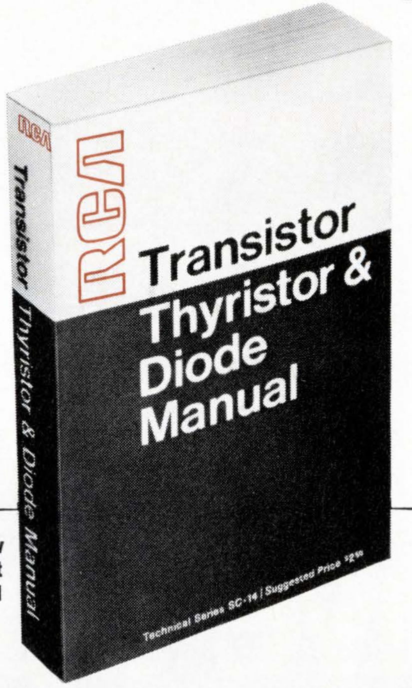
Organization

Sentry tests arrays *functionally* (for the intended logic operation), and *absolutely* (for dc parameters). Since the logic and timing for the dc tests are implemented primarily in Sentry's software, the system runs through its logic tests at the 300-kHz rate, but performs its dc tests one pin at a time at 4 ms/pin. This approach sacrifices some speed to save hardware costs and to add flexibility. The system can force and/or measure a dc voltage or current on any pin of the device being tested.

The central processor has a segmented memory capability, with a 4096-word area for the operating system, and another 4096-word area for

(continued on page 97)

solid state...up to date



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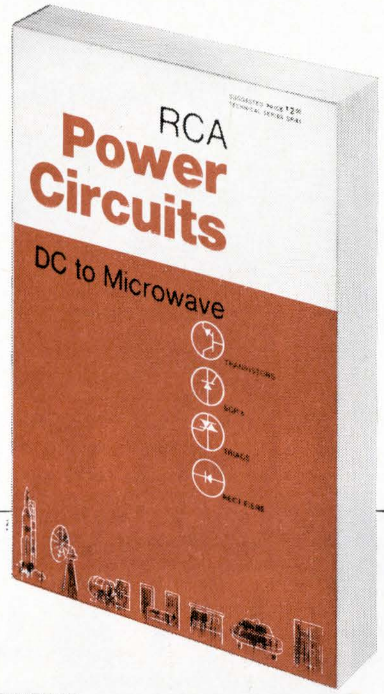
CONTENTS	PAGE
MATERIALS, JUNCTIONS, AND DEVICES Semiconductor Materials, P-N Junctions, Current Flow, Types of Devices	3
BIPOLAR TRANSISTORS Design and Fabrication, Basic Circuits, Characteristics, Biasing, Bias Stability, Coupling, High-Frequency Operation, Switching, Transient Effects	11
MOS FIELD-EFFECT TRANSISTORS Theory of Operation, Fabrication, Electrical Characteristics, General Circuit Configurations, Handling Considerations	33
THYRISTORS Silicon Controlled Rectifiers, Triacs, Diacs, Gate Characteristics, Switching Characteristics, Ratings, Critical Rate of Rise of On-State Current, Holding and Latching Currents, Critical Rate of Rise of Off-State Voltage, Transient Protection, Radio-Frequency Interference	40
SILICON RECTIFIERS Thermal Considerations, Characteristics, Ratings, Overload Protection, Series and Parallel Arrangements	59
OTHER SEMICONDUCTOR DIODES Tunnel Diodes, Varactor Diodes, Compensating Diodes, Photoconductive Diodes, Light-Emitting Diodes	65
LINEAR SYSTEM APPLICATIONS Detection, Amplification, Oscillation, Frequency Conversion, Automatic Frequency Control, Frequency Multiplication	74
TV DEFLECTION AND COLOR DEMODULATION Scanning Fundamentals, Sync, Vertical Deflection, Horizontal Deflection, Color Demodulation	128
POWER SWITCHING AND CONTROL Nonsinusoidal Oscillators, Switching Regulators, Converters and Inverters, Automobile Ignition System, Pulse Modulators, Light, Heat, and Motor Controls	144
COMPUTER CIRCUITS	174
DC POWER SUPPLIES Rectification, Filtering, Regulators	183
TESTING AND MOUNTING	191
SYMBOLS	211
SELECTION CHARTS	217
TECHNICAL DATA	223
OUTLINES	564
MOUNTING HARDWARE	576
CIRCUITS	582
INDEX	653



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CONTENTS	PAGE
SEMICONDUCTOR MATERIALS, JUNCTIONS, AND DEVICES Semiconductor Materials, Current Flow, N-P-N and P-N-P Structures, Types of Devices	3
SILICON RECTIFIERS Theory of Operation, Characteristics and Ratings, Series and Parallel Rectifier Arrangements, High-Voltage Rectifier Assemblies, Packaging	10
THYRISTORS Theory of Operation, Construction, Ratings and Characteristics, Series and Parallel Operation, Transient Protection	29
SILICON POWER TRANSISTORS Design and Fabrication, Basic Transistor Parameters, Maximum Ratings, Thermal Considerations, Second Breakdown, Safe-Area Ratings, Small-Signal Analysis, Large-Signal Analysis, Switching Service	65
RECTIFICATION	149
POWER CONVERSION	162
POWER REGULATION Linear Voltage Regulators, Switching Regulator, General Triggering Considerations, Phase-Control Analysis of SCR's, Motor Controls, Incandescent Lighting Controls	200
THYRISTOR AC LINE-VOLTAGE CONTROLS General Considerations, Motor Controls, Heater Controls, Incandescent Lighting Controls	226
HIGH-FREQUENCY POWER AMPLIFIERS Design of RF Power Amplifiers, Matching Networks, Marine Radio, Citizens-Band Transmitters, Mobile Radio, SSB Transmitters, Aircraft Radio, Community-Antenna TV, UHF Military Radio, Microwave Amplifiers and Oscillators, Frequency Multipliers	262
CONTROL AND LOW-FREQUENCY POWER AMPLIFIERS General Considerations, Audio-Frequency Power Amplifiers, Ultrasonic Power Sources, Servo Amplifiers	379
BIBLIOGRAPHY	438
INDEX	440
RCA TECHNICAL PUBLICATIONS	444

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Fairchild Camera and Instrument Corporation, 464 Ellis Street, Mountain View, California. 94040.
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the test program. If a larger memory is required, you may add two more 4096-word storage units.

The CPU interfaces with the tester in the three functional areas of *control data transfer* to and from the tester (under direct control of software), *decision control* through a priority interrupt system (initiated by failures or improper operating conditions), and *high-speed data transfers* through a direct memory access channel (to maintain an average functional test rate greater than 100,000 tests per second).

Peripheral equipments include a teletype, card reader, disc, and a magnetic tape system.

Use tested

Fairchild Systems points out that it enjoys the luxury of an excellent in-house debugging facility for its test systems—Fairchild Semiconductor; so that software and hardware have already gone through extensive checkout procedures.

Available in May, the Sentry 400 will sell for about $170,000. This price includes installation and checkout, an 18-megabit Burroughs disc, a teletype, one test station, all software, and a training course. A projected change from core memory to semiconductor memory may allow this price to drop. Fairchild Systems Technology, 974 E Arques Ave., Sunnyvale, Calif. 94086. (408) 735-5331.

Circle 210 on Inquiry Card

Macrodata's diagnostic test system

The Series 200 is a computer-controlled test system that performs parameter and digital functional testing of MOS/LSI arrays. Capable of handling up to 64 leads (in 16-lead increments), it can test both wafers and packaged devices.

The system accommodates both high- and low-threshold MOS and dc, two- or four-phase clocking requirements. You can select input/ouput data rates from dc to 2 MHz and a phase rate up to 8 MHz.

For wafer testing, the interface electronics of the Series 200 can be placed to within about 2 in. of the device under test. It also controls all the mechanical functions needed at the wafer probe station, including probe-down sensing, off-wafer detection, and inking.

TOIL spoken here

To make the software as simple as possible, Macrodata has created TOIL—Test Oriented Interactive Language. This language incorporates into the test program all necessary parameter and functional tests plus mechanical functions. Because TOIL formats the test sequence, the actual programming becomes a series of questions and answers between the operator and the test system.

For production testing, with its fixed test sequences, the system needs only the identification information for a particular sequence. In a lab application where you want to vary the sequences, the manufacturer stresses the time-saving value of the interactive feature.

It does more

The Series 200 gives you more than a LSI production checkout system. It helps you to evaluate the entire design and production cycle. You can use the system to evaluate individual test transistors on every chip and to log these test results for diagnostic evaluation. It also performs wafer-yield mapping for statistical analysis. In addition, design aids such as a test pattern generation program, a logic simulation program and a circuit analysis program are available.

System organization

The basic diagnostic system includes a performance analyzer (PA), a pattern synthesizer (PS), an interrogation unit (IU) and a matrix.

The PA inputs, stores, and performs the tests. It contains both the input pattern and the expected output pattern for each device. You can store the actual output in the pattern synthesizer or compare it with the desired output to give an immediate error signal if a failure is detected. The PA can give you either a GO/NO GO output or a printout of the error position and all revelant information.

Data buffering between the PA and the interrogator unit is provided by the pattern synthesizer. It receives test information at a 1-MHz rate and transmits this pattern data to the IU at the 8-MHz maximum frequency.

The interrogator unit is the front end which interfaces with the device under test. It is mounted on either the probe head or under the device connector. You can add, in increments of four, input/output channels to the IU to provide a maximum of 64 I/O channels. This unit also includes the clock generators; the prober step, ink and control functions; and a relay matrix for parameter testing.

The system matrix is contained partly in the IU and partly in the pattern synthesizer. While the IU matrix is needed for all systems, the PS matrix is required only for complete automated testing of different configurations.

The Series 200 is modularized; among the options you can get are an expansion of core memory to 64k bytes, a floating point multiply-divide option, and disc storage. This storage is expandable in 7.2M, or 1.3M bytes for a small disc option. The system will interface with a variety of peripherals including a line printer, high-speed paper tape reader/punch, card punch, CRT display, or magnetic tape unit.

A multi-station system of four test stations has an average cost of about $125,000 per station. Macrodata Company, Test Systems Division, 20440 Corisco St., Chatsworth, Calif. 91311. (213) 882-8880.

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Teradyne's SLOT for both MOS and bipolar LSI

Teradyne calls it the SLOT Machine (Sequential LOgic Tester) and expects it to pay off. Their hopes for this LSI tester are based on the experience gained with its successful computer-controlled IC tester, the J259. Like the J259, the SLOT can test functions and dc parameters, packaged integrated circuits, and wafers of ICs—both bipolar and MOS.

Inputs? Outputs? No, 'in/outs'

Since today's LSI circuits defy standardization, it is next to impossible to predict which test pins go to the inputs of the circuits being tested, which to outputs (inputs and outputs are usually called "active" pins), and which to ground and bias voltages. Teradyne solved the problem in the most universal way, allowing each pin to serve as *either* an input *or* an output. The answer was to provide four logic levels and two digital comparators for each active pin.

During any one test, the machine connects two of these levels to any number of active pins, while it "parks" the other two for subsequent tests.

Remember the previous level

The availability of these four logic levels, plus the fact that switching from one logic level to another is performed by transistors and diodes, was planned specifically to make the SLOT suitable for sequential testing. In sequential logic, some of the circuits incorporate storage elements. Therefore, while the voltage at some of its terminals depends on its present logic state, the voltage at others depends on the *previous* state.

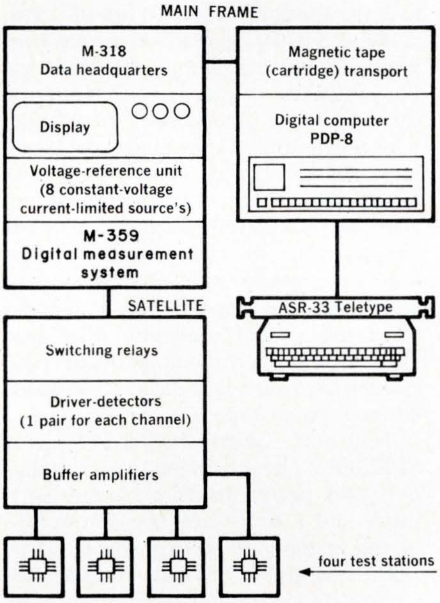
In sequential circuits, it is important to go from one voltage to another directly, rather than through the type of discontinuity introduced by relay switching. For this reason, the machine uses solid-state components to switch from one logic level (such as 5 V) to another (such as 1 V).

Designed for multiplexing—and expansion

The simplest version of the SLOT consists of a main frame, a PDP-8 digital computer with an ASR-33 teletypewriter and magnetic tape system, and a "satellite" rack that handles up to four test stations. Each test station accepts 40-pin packages (36 active plus four bias pins). With one test station, such system costs around $125,000, plus $5,500 for each additional station.

The system's capability can be doubled by adding a second satellite, also with four stations. In addition, these stations can be expanded to accept 64 or 124-pin packages. Teradyne, 183 Essex St., Boston, Mass. 02111. (617) 426-6560. Booth No. 2B03-07.

Circle 211 on Inquiry Card



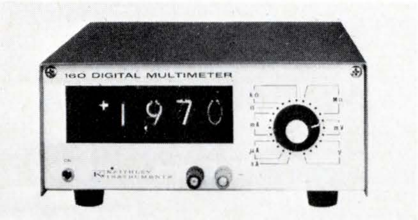
SLOT Machine. Teradyne's Sequential LOgic Tester (SLOT) consists of a main frame, a PDP-8 computer, and one or two satellite frames which control up to four test stations each. Note the CRT display (in the main frame), which permits quick debugging, and the tape cartridge unit, which allows loading a master operating program into the computer in seconds. Since the power supplies cover a ± 30 V range, the SLOT can test both bipolar and MOS ICs. The rate for functional tests is 20 to 50 kHz, depending on the number of pins, length of test sequences, etc. For parametric testing, the rate depends on the parameters tested.

A satellite can test different devices on each station—simultaneously. In addition, all pins at the test stations can accept either inputs or outputs from the units under test. As shown, with four test stations this SLOT costs $141,500.

Digital multimeter offers 1-µV/digit resolution

This 3½ digit multimeter, Model 160, has seven voltage ranges that let you read from ±1 µV/digit up to ±1000V full scale. Accuracy over all ranges is ±1 digit or 1% of reading.

Instead of the usual chopper front end, the Model 160 uses a buffer amplifier. This approach gives the unit a *constant* input impedance of 10-M Ω on all but the lowest range (here it is 1 M Ω). The normal-mode rejection ratio is 80 dB at line frequency or twice line frequency on the most sensitive scale and 60 dB on the 1-kV scale. Common-mode rejection is better than 140 dB on all ranges.



More than a voltmeter, the 160 takes resistance and current readings. Using it as an ohmmeter, you can read from 0.1 Ω/digit up to 2000M Ω full scale. The accuracy is ±3% or ±1 digit up to 1 M Ω.

As an ammeter, the unit will measure from ±1 nA/digit up to 2A full scale. Input impedance ranges from 100 k Ω on the 0.1 µA range to 0.1 Ω on the 1A range.

The instrument sells for $545 with quantity discounts offered on five or more. A companion unit, the Model 163, gives you the same voltmeter performance for $475. Keithley Instruments Inc., 28775 Aurora Rd., Cleveland, Ohio. 44139. (216) 249-0400. IEEE booths 2H19-2H21.

Circle 319 on Inquiry Card

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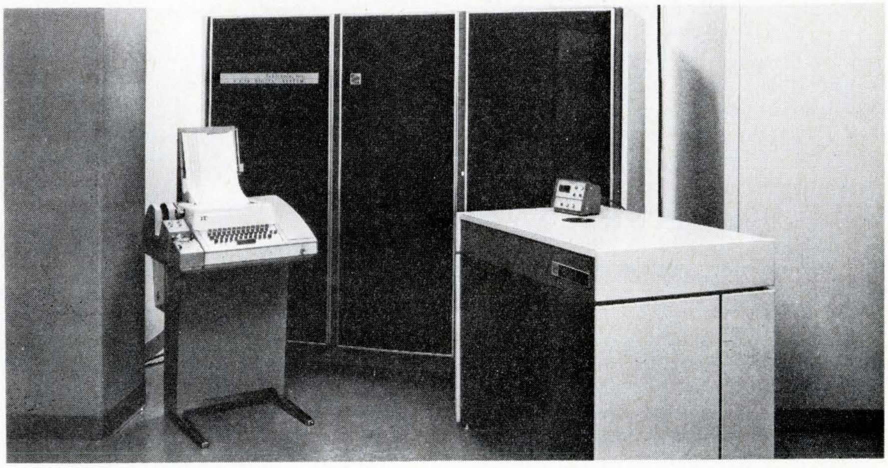
Digital IC measurement system



Tektronix, Inc.'s Type S-3150 is a high-speed, disc-programmed, dynamic dc tester for digital ICs. Self-contained, you can program it to perform either GO/NO GO or diagnostic testing at rates to 100 measurements per second.

The system uses a Digital Equipment Corp. PDP-8/L computer for on-line data acquisition and off-line data reduction, and to write programs for dc and dynamic tests (interactive software is supplied).

Basically an S-3130 with a small computer and a programmable IC test station added, the S-3150 gives you *fixture flexibility*—while most changes within a family are under program control you need change only a single load board to accommodate most other logic families; *dc capability*—you can measure dc levels to better than 1% in most cases in the same socket as that used for dynamic measurements; *computer-controlled data acquisition*—there is no loss in test rate; a *special interactive computer program*—a plain English program that interacts with the programmer to generate measurement programs at the keyboard; and a *disc memory*—you can use the measurement system for GO/NO GO and diagnostic tests while you use the computer for batch data reduction or interactive program compilation.

All of the many pieces of equipment that make up the S-3150 may be mounted in a three-bay enclosed cabinet. There is an operator's table with a programmable test station at one side, and a Teletype ASR33 free-standing at the other side.

The programmable test station can test ICs with up to 16 leads in dual in-line, flat pack, and TO-5 packages. The measurement system controls this test station during the test sequence. Each lead of the IC may be independently connected to power supplies (three voltage supplies and one current source), signal sources (two pulse generators), load networks or buffer drive circuits (48 total), and measurement probes (16 sampling heads) as required. Voltage and current forcing capabilities (dc) are 0 to ±100 V, and ±1 mA to ±200 mA, respectively.

Dynamic measurement characteristics feature a measurement system rise time of <1 ns for a device source impedance of 25Ω or less, a voltage measurement range from 3 mV to 16 V, time measurements from 100 ps/div. to 500 ms/div. (5-s full scale), and delays from 0 to 1 ms.

The measurement-word format is 144 characters of 4 bits each (576 bits) plus parity. There is storage for 1080 measurements, and test sequences can be any length from one to 1080 measurements; test results can alter the sequence. Minimum-access-time programming can reduce the 17-ms average random access to about 1 ms.

Type S-3150 comes with three programs. The *translator* program lets you write test sequences either on-line for immediate debugging, or off-line, which lets the 3150 make measurements while other tests are being written. A *record test result data* program gives you the test results on either magnetic tape or teletype printout. The *disc test sequences to paper tape* program transfers selected test sequences from the system magnetic disc onto paper tape for permanent storage. And system hardware lets the disc be loaded from paper tape.

Tektronix sells the S-3150 for $120,000. The price includes installation and performance checkout software, and a four-week training course in Beaverton. Another version, Type S-3150 Model 651B, sells for $80,000 without the computer, computer interface unit, and computer software. Tektronix, Inc., Box 500, Beaverton, Ore. 97005. (503) 644-0161. (Booths 2G25-2G34.)

Circle 277 on Inquiry Card

POWER SUPPLY

Output reg., line or load is ±0.2%.

Model 527 provides two 15 V supplies capable of common ext. connections with an accuracy of 1%. Each separately regulated supply provides a full 50 mA output. Rated input is 115 or 230 V rms, but it will accept ac voltage from 105 to 125 V or from 210 to 250 (rms), and from 47 Hz to 420 Hz. $39 in unit quantities. Burr-Brown Research Corp., Internat'l Airport Ind. Park, Tucson, Ariz. 85706. (602) 294-1431.

Circle 278 on Inquiry Card

DELAY LINE

Used in TV broadcast and radar.

02151UDL low loss acoustic delay line can be supplied in the range of 15 to 20 μs with a stability of 10 ns over a temp. range of 0° to 60°C. It has a center freq. of 60 MHz, a BW of 20 MHz min. and an insertion loss of 25 to 30 dB. Ripple is < 0.1 dB over the band, input imp. 50 Ω, and it can drive a 50 Ω load. Walther M. A. Andersen & Assoc., 4 Main St. Ext., Tariffville, Conn. 06081. (203) 658-7666.

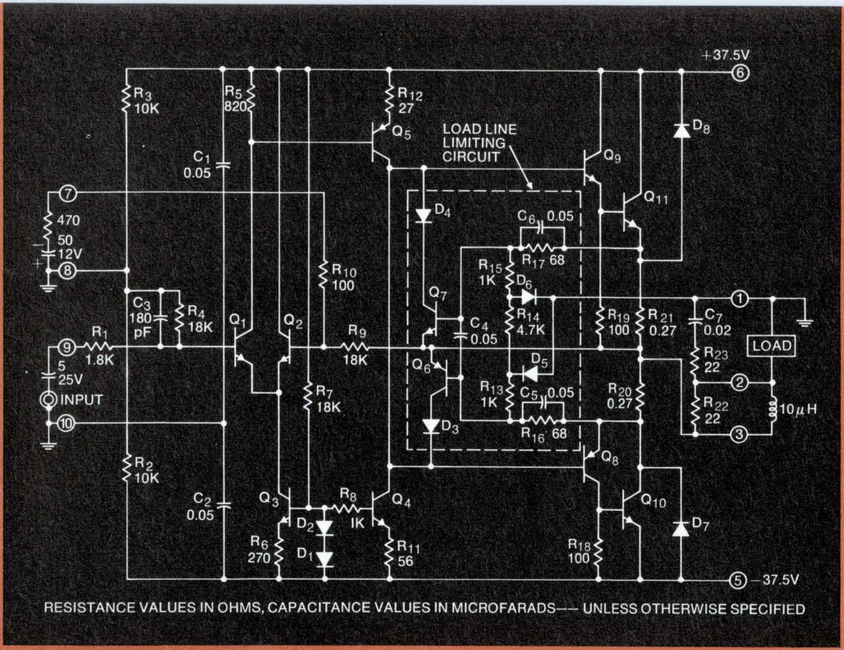
Circle 279 on Inquiry Card

COAXIAL MAGNETRON

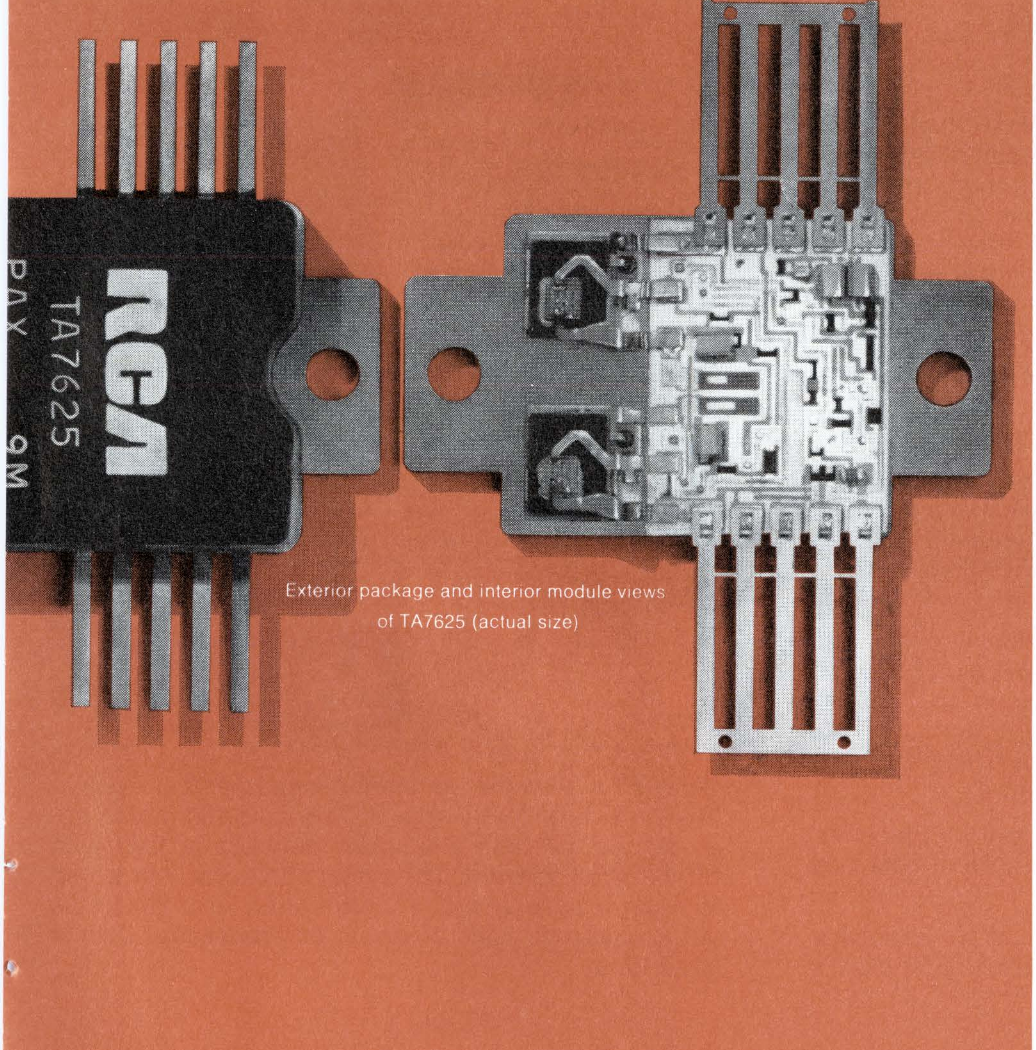
For remotely-tuned systems.

SFD-383, mechanically-tuned CEM® magnetron delivers a pk. output of at least 1 MW over the range of 5.25 to 5.40 GHz. Maximum pulling factor is 6 MHz with a 1.5:1 VSWR, and max. pushing factor is 50 kHz/A. It can handle pulse durations between 0.35 and 3.2 μs, and duty capabilities between 0.001 to absolute ratings of 0.0011. Varian, Eastern Tube Div., 800 Rahway Ave., Union, N. J. 07083.

Circle 280 on Inquiry Card



Schematic diagram of unencapsulated TA7625



Exterior package and interior module views of TA7625 (actual size)

New–from the industry leader in Solid-State Power:

TA7625 Hybrid Power Circuit

From the latest advances in power hybrid technology, RCA introduces the TA7625 7A linear amplifier—a complete, all-silicon power module for industrial, military and commercial applications.

The solid-state TA7625 is ruggedly packaged...so small it fits in the palm of your hand. It will offer you new opportunities in design—new economies in systems production. As for design features:

- 7 amperes of peak load current capability
- single or split power supply (30-75 volts)
- load line limiting
- >60 dB power gain
- provision for external feedback control

The RCA developmental TA7625 is now available for your engineering evaluation. Its potential uses are numerous and challenging:

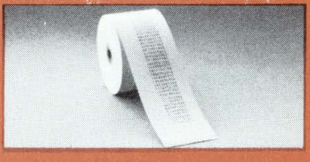
- servo-motor driver (AC, DC, or pulse-width modulated)
- positive and negative output power supply
- self-excited and driver inverter
- linear amplifier
- power Op Amp
- bridge amplifier
- audio power amplifier

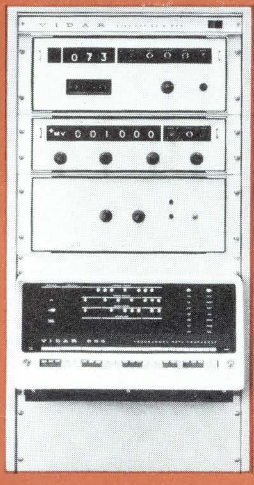
For more information on RCA Hybrid Power Circuits, see your local RCA Representative. For technical data, write RCA Electronic Components, Commercial Engineering, Section IJ-3 /UC1, Harrison, N. J. 07029. In Europe: RCA International Marketing S.A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

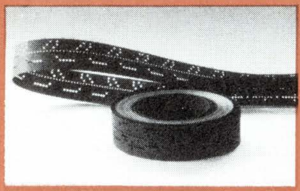
RCA

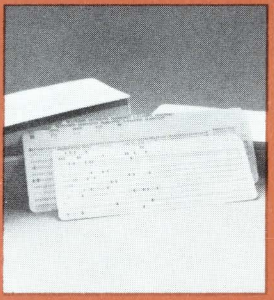
Circle 46 on Inquiry Card

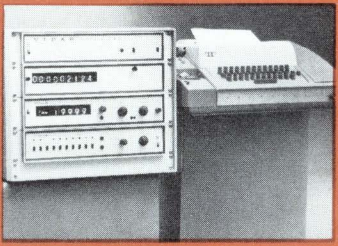
how to pick the right **automatic measurement** system when you have 14 choices

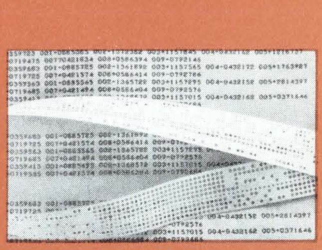


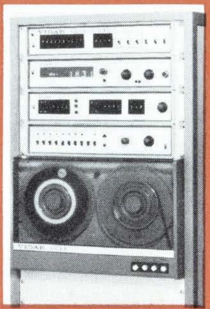


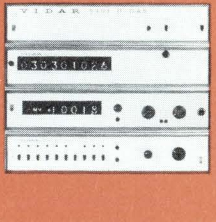


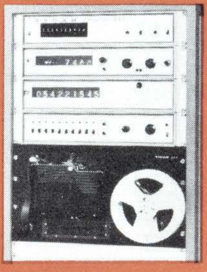


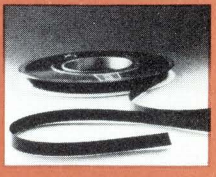












Automatic measurement with a VIDAR digital data acquisition system can make a dramatic difference in your operation. You can record data more precisely, in computer-compatible form. You can speed up data acquisition / reduction, so that the information you need is instantly available during and at the end of the test. You can reduce your data-handling costs and get a rapid payout on your instrumentation investment.

But *which* digital acquisition system should you consider when VIDAR gives you all these choices? Among the features of the fourteen standard systems are:

Automatic measurements: Vidar systems measure 1 to 1,000 data points . . . resistances from 1 milliohm to 12 megohms . . . frequencies from 10 to 2,000,000 Hz . . . 5 to 1,000 AC volts, and 5 microvolts to 300 volts DC.

Output: You get visual numerical display *and* a permanent record — on printed tape, punched tape, magnetic tape, Teletype, punched card . . . or processor-controlled with built-in mini-computer for real-time reports, and test or process control from basic physical measurements.

Scanning modes: Single scan, continuous scan, manual, single-channel monitor, or remote random access.

Interfaces: Any BCD output from shaft encoders, counters, other digital voltmeters, digital clocks.

It's easy to select an automatic measurement system. That's the time to call in a VIDAR instrumentation engineer: he will help you select the best system, with off-the-shelf delivery. The system he helps you select is sure to save valuable engineering time and help you to improve your products or processes. Call or write today.

VIDAR®

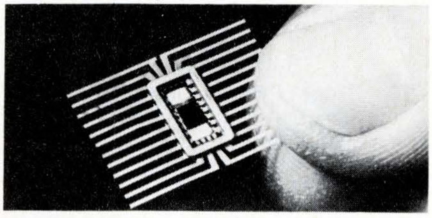
77 Ortega Avenue, Mountain View, California 94040 (415) 961-1000

the automatic measurement people

NEW MICROWORLD PRODUCTS

THIN FILM RESISTOR LADDER

With accuracy of ±½ LSB.

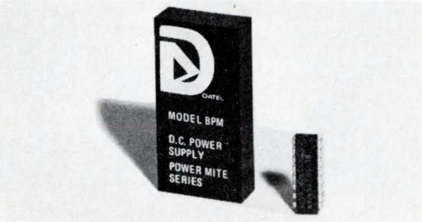


This ladder network is reportedly the first to be made with 12 bits on a single chip. The Model HC100 comes in either a 24 lead flat pack or DIP. The hermetically sealed version is $175 ea. (1-24 pcs), with two-week delivery. Also available are 8- and 10-bit units. HyComp, Inc., 146 Main St., Box 250, Maynard, Mass. 01754. (617) 897-4578.

Circle 201 on Inquiry Card

DC POWER SUPPLY

For digital ICs.

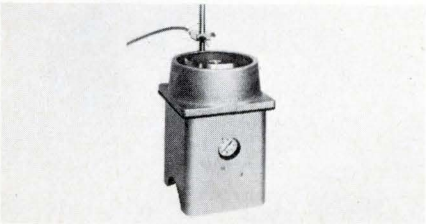


The Model MPM5-300 gives you 300 mA at 5 Vdc. The unit is about four times the size of a 24-lead DIP and is completely self contained, including input isolation transformer. It connects directly to the 115 Vac power line and will provide a ±0.05% regulated output. $59. Datel Corp., 943 Turnpike St., Canton, Mass. 02021. (617) 828-1890.

Circle 202 on Inquiry Card

SPIN CLEANER

For semiconductor wafers.

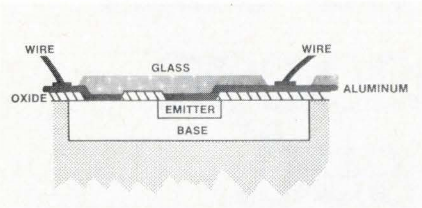


Model SC45 cleans silicon wafers prior to the deposition of epitaxial layers or diffusion processes. The unit uses a high energy "scrubbing" action while the surface is rinsed and cooled by a clean pure fluid. Process cycle time is 10-15 s and the wafers are ready for immediate processing. Headway Research, Inc., 3713 Garland, Tex. 75040. (214) 272-1566.

Circle 203 on Inquiry Card

PASSIVATION GLASS

For planar junctions.

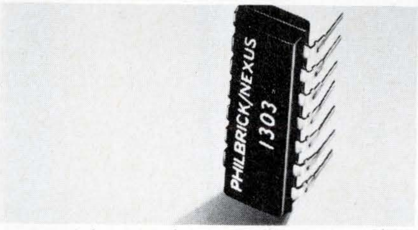


You can apply IP 550 passivation glass either as a frit or as a target for sputtering. Applied as discrete particles following normal wafer fabrication, it is glazed at 550°C prior to dicing. It can be as thin as one micron making it particularly suited for multilayer devices. $15 to $35 per pound. Innotech Corp., 181 Main St., Norwalk, Conn. 06851. (203) 846-2041.

Circle 204 on Inquiry Card

OPERATIONAL AMPLIFIER

General purpose unit.

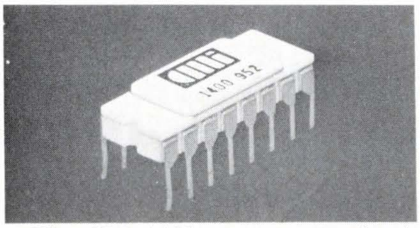


Model 1303 is a single, integrated-circuit amplifier in a 14-pin, silicone plastic DIP. It has a typical voltage offset of ±2 mV, a drift of +5 μV/°C and an input impedance of 200 kΩ. The unit price is $3.50 (1-9) and $3.10 for 100 units or more. Teledyne Philbrick Nexus, Allied Dr. at Rte 128, Dedham, Mass. 02026. (617) 329-1600.

Circle 205 on Inquiry Card

ONE-OF-EIGHT DECODER

With bipolar to MOS level shift.

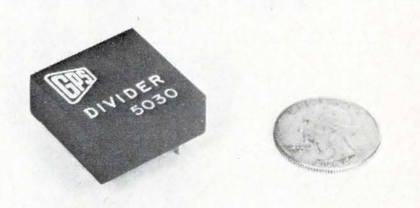


The CM 1400 accepts TTL levels (fan-in of 1) and gives you a 1-9 V output for low-threshold MOS devices. It has two chip-inhibit inputs for ease of expansion and a short circuit protected output. Typical propagation delay into a 100 pF load is 50 ns. Price, (1-24 pcs.) is $15.25. Computer Microtechnology Inc., 610 Pastoria, Sunnyvale, Calif. 94086.

Circle 206 on Inquiry Card

MINIATURE DIVIDER

Does not need external amplifier.

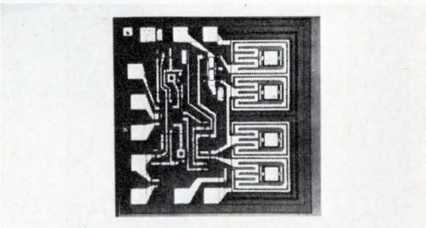


This hybrid unit, Model D 5030, gives you the instantaneous quotient of two variables. It accepts an X input of ±10 V and a Y input of <0 to −10 V, and will supply up to 10 mA at ±10 V out. Full scale accuracy is 1%. The price is $105, with delivery within one week. GPS Instrument Co., 14 Burr St., Framingham, Mass. 01701. (617) 875-0607.

Circle 207 on Inquiry Card

DRIVER SWITCHES

Monolithic bipolar/MOS.

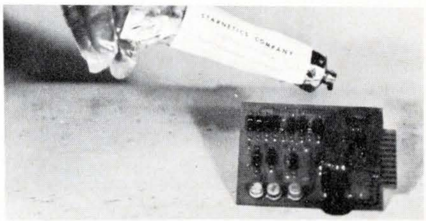


The DG122 is a two-channel differential switch with driver; the SI3001 is a special function driver switch and the SI3002 is a SPDT switch with driver. Immediately available, the DG122 is $31 in hundred quantities; the SI3001 and SI3002 are $18 in the same quantities, Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, Calif. 95054. (408) 246-8000.

Circle 208 on Inquiry Card

COPPER-EPOXY ADHESIVE

For hybrid circuits.

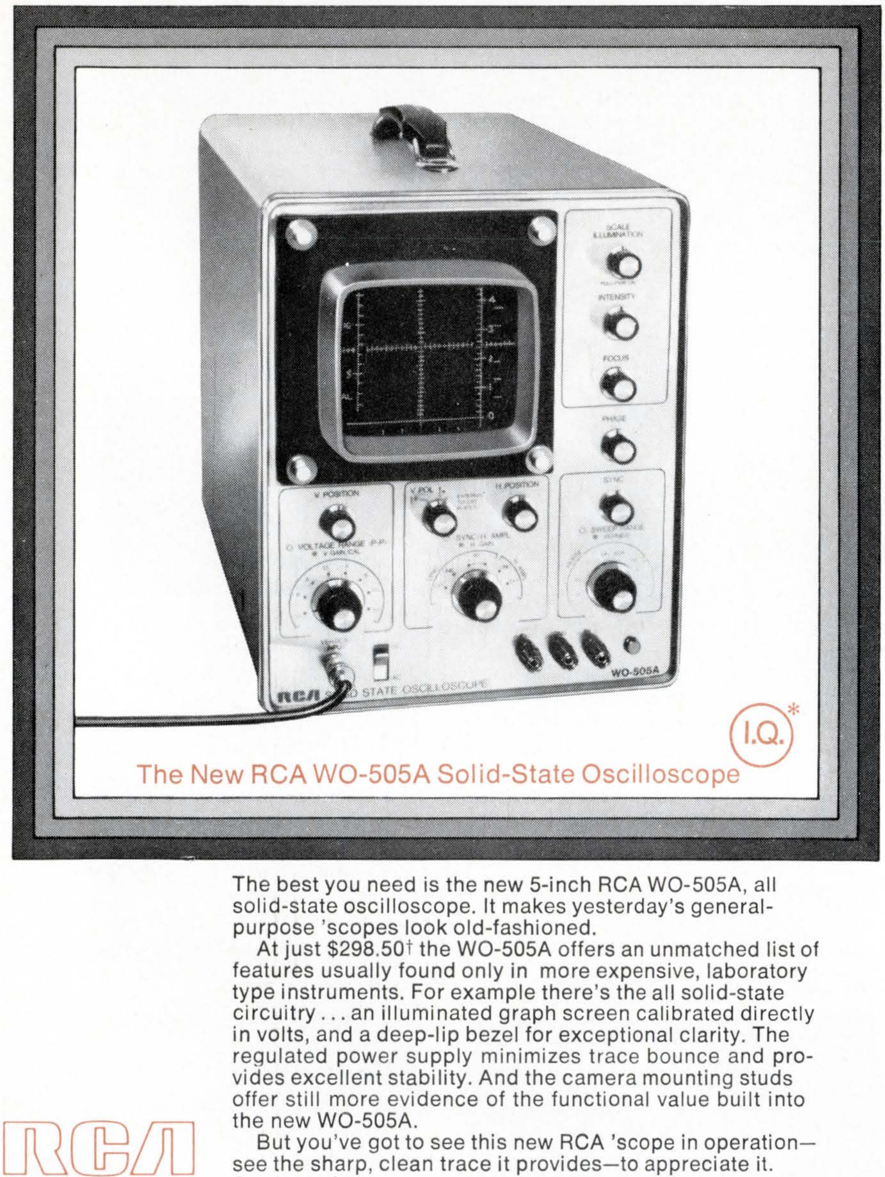


Fritz-Copper is a two-component, air-drying, adhesive that develops a tensile strength of 5000-6000 psi. Its chief use is to attach active devices to passive, metallized alumina substrates, but you can also use it as an electroplating base or for ceramic and plastic PC repairs. Starnetics Co., 10639 Riverside, North Hollywood, Calif. 91602. (213) 769-8437.

Circle 209 on Inquiry Card

←Circle 47 on Inquiry Card

Now it costs less to own the best oscilloscope you need.



The New RCA WO-505A Solid-State Oscilloscope

The best you need is the new 5-inch RCA WO-505A, all solid-state oscilloscope. It makes yesterday's general-purpose 'scopes look old-fashioned.

At just $298.50† the WO-505A offers an unmatched list of features usually found only in more expensive, laboratory type instruments. For example there's the all solid-state circuitry . . . an illuminated graph screen calibrated directly in volts, and a deep-lip bezel for exceptional clarity. The regulated power supply minimizes trace bounce and provides excellent stability. And the camera mounting studs offer still more evidence of the functional value built into the new WO-505A.

But you've got to see this new RCA 'scope in operation—see the sharp, clean trace it provides—to appreciate it. Some statistics:

- High-frequency response, usable to 8 MHz.
- High Sensitivity (.05 V p-p range).
- DC vertical amplifier; DC/AC input.
- Return trace blanking . . . Trace polarity reversal switch . . . Phase control.
- High-frequency horizontal sweep; solid lock-in on 5 MHz.
- Preset TV "V" and "H" frequencies for instant lock-in.
- Built-in square-wave signal for calibrating P-P voltage measurements.
- Provision for connection to vertical deflection plates of CRT.

Some statistics! For complete details, contact your RCA Distributor.

RCA | Electronic Components | Harrison, N. J. 07029

RCA

*Inexpensive Quality

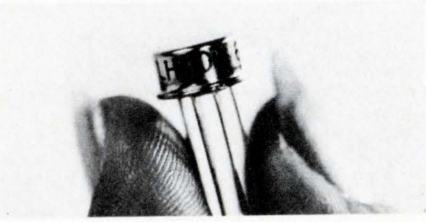
†Optional Distributor Resale Price

Circle 48 on Inquiry Card

Products with Booth Numbers will be exhibited at IEEE

MONOLITHIC OP AMP

Replaces hybrid unit.

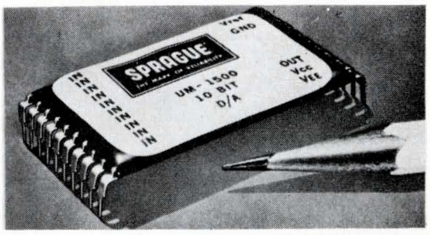


This device, the LH101, was first introduced as a hybrid circuit (with a 30 pF MOS capacitor chip). It is now available in monolithic form with the same operating characteristics. In quantities of 1-24, the LH101 (−55 to 125°C) is $22.50 and the LH201 (0 to 70°C) is $11.25. National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. 95051.

Circle 243 on Inquiry Card

D/A CONVERTERS

Hybrid, thin-film units.

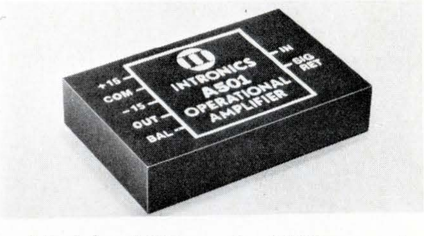


You can get this series, the UM-1400, in 4-, 8-, or 12-bit versions all with an accuracy of ±½ LSB. They come in a modified DIP and are specified from 0 to 70°C. Also available is the UM-1500, a 10-bit converter with ±½ LSB accuracy. Technical Literature Service, Sprague Electric Co., North Adams, Mass. 01247. (413) 664-4411. Booths 3D11-3D12.

Circle 244 on Inquiry Card

SPECIAL PURPOSE OP AMP

Called the industry's fastest.

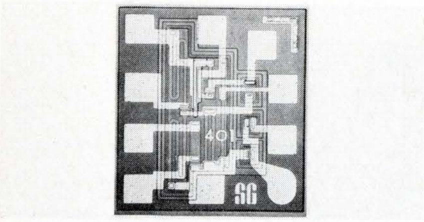


Models A501 and A502 are designed for high frequency inverting applications. They feature a slew rate of 1000V/μs and a 100 MHz gain bandwidth product. Also, Model A502 offers a 0.1% settling time of 60 ns. In quantities of 1 to 9, the A501 is $105 and the A502 is $125. Intronics Inc., 57 Chapel St., Newton, Mass. 02158. (617) 332-7350. Booths 2A17-2A19.

Circle 245 on Inquiry Card

HIGH FREQUENCY VIDEO AMPS

Dissipate 100 mW at 12 V.

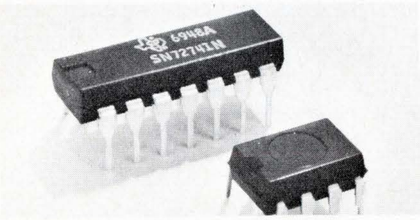


A voltage gain of 20 dB at 100 MHz, 5 ns rise- and fall-times, and fixed or variable gain are features of this group of monolithic amplifiers. The Series 401 also offers single supply operation and symmetrical limiting. Prices range from $1.10 to $2.25 (1000 pcs.). Silicon General Inc., 7382 Bolsa Ave., Westminister, Calif. 92683. (714) 839-6200.

Circle 246 on Inquiry Card

OP AMP

With internal freq. compensation.

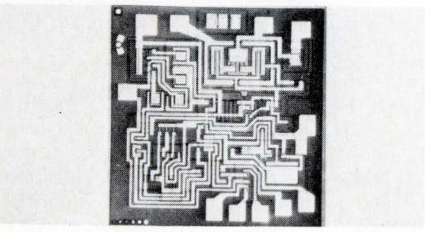


This unit, SN72741 is particularly suitable for voltage follower applications. The device is short-circuit protected and has a typical power dissipation of 50 mW. Prices, in 100-piece lots, are $2.95 for a 14-pin plastic DIP, and $2.40 for an 8-pin unit. Delivery is 2 weeks. Texas Instruments Incorporated, Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-2011.

Circle 247 on Inquiry Card

VOLTAGE REGULATOR

Output adjustable from 2 to 37 V.

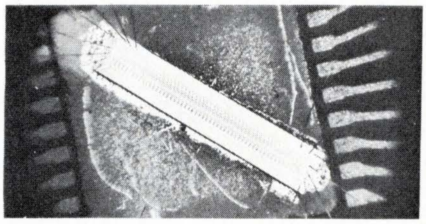


The ICB8723 includes a temperature compensated reference amplifier, series pass power transistor and current limiting circuitry. You can add NPN or PNP pass elements when you need more than 150 mA out. It also has provisions for adjustable current limiting and remote shutdown. $4.85 ea. (1-99). Intersil Inc., 10900 N. Tantau Ave., Cupertino, Calif. 95014. (408) 257-5450.

Circle 248 on Inquiry Card

LIGHT SENSITIVE ARRAY

For optical sensing applications.

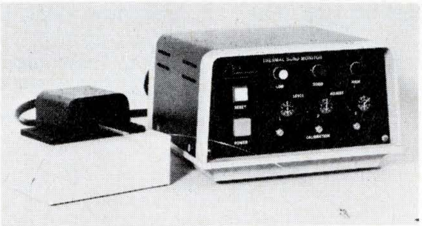


The IPL 20 consists of a linear configuration of 50 silicon planar photo diodes integrated with a 51-bit shift register on a single chip. The shift register lets you multiplex the diode sensors at the frequency of an external clock. It comes in a 40 lead round package. $205. Teknis House, 31 Stoke Rd., Guildford, Surrey, England. Booth 3B30.

Circle 249 on Inquiry Card

THERMAL BOND MONITOR

Measures IR emitted by chip.

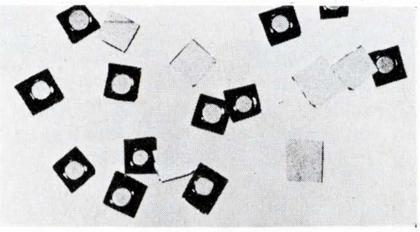


Model 1010 has three threshold sensors; the first to warn that bonding temperature has been reached and "scrubbing" should begin; the second, to signal that a good bond has been made; and a third, that indicates overheating—thereby spotting bad bonds. $2,985. Vanzetti Infrared & Computer Systems, Inc., 515 Providence Hwy, Dedham, Mass. 02026.

Circle 250 on Inquiry Card

SILICON GLASS DICE

With double passivation.



This line of mesa dice is thermally oxidized and passivated with five μm of pyrolytic glass. Pad dimensions range from 0.16 x 0.16 in. to 0.035 x 0.035 in. and they meet Mil-S-19500 and Mil-Std-202 without further treatment or encapsulation. Cost is less than $.09 ea. in 1000 piece lots. MicroSemiconductor Corp., 11250 Playa St., Culver City, Calif. 90230. (213) 391-8271.

Circle 251 on Inquiry Card

save
chassis
chamfering!

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Sealectro**

Rivet-Loc™
PAT. PEND.

**semi-assembled
Teflon*-Insulated
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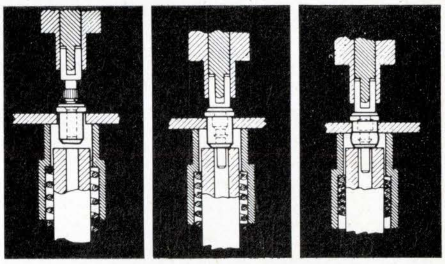
SIMPLE FAST ECONOMICAL INSTALLATION



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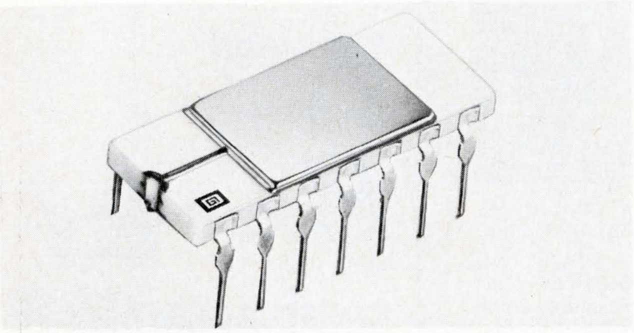
Circle 49 on Inquiry Card

MOS STATIC SHIFT REGISTERS

In both 25- and 32-bit lengths.

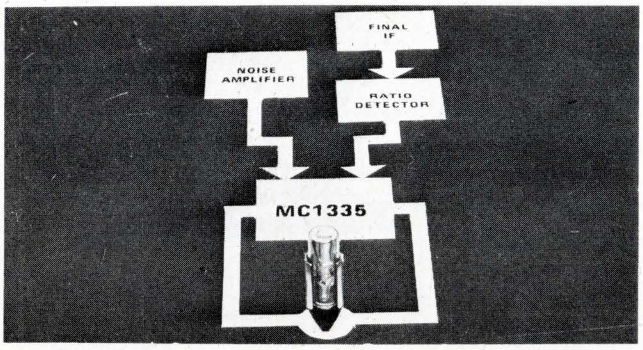


These quad shift registers give you the choice of interfacing directly with TTL/DTL or MOS. Each register has one serial input and one serial output and the clock input is common to all four registers. You can drive all inputs, including the clock, directly from TTL/DTL logic levels and each output can drive TTL/DTL without external interfacing components. The devices are rated over the full military temperature range of −55 to 125°C and they come in a 14-lead, ceramic dual-in-line package. The SL-6-4025 (25-bit) is $18.20 ea. in quantities of 100. The SL-6-4032 (32-bit) is $26 ea. in the same quantities. General Instrument Corp., 600 W. John St., Hicksville, N.Y. 11802. (516) 733-3333.

Circle 267 on Inquiry Card

MONOLITHIC TUNING INDICATOR

For color TV and fm receivers.

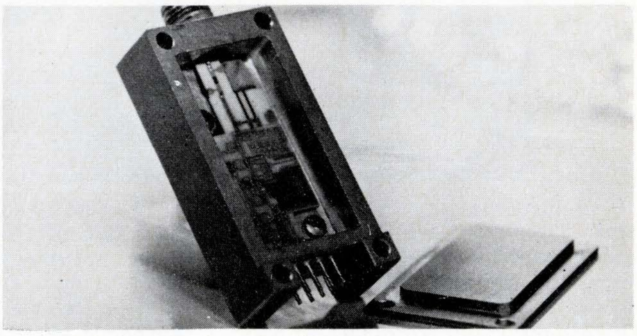


This device, Type MC1335 saves mounting cost and space over discrete tuning indicators, and provides increased reliability. You add a miniature bulb and the device indicates proper fine tuning of color TV and fm receivers. When the receiver is correctly tuned, a ratio detector provides two equal input voltages and the lamp is turned on. Unequal voltages cause a voltage drop that turns off the bulb and indicates the need for retuning. The device comes in an 8-lead DIP, and operates from 0 to 75°C. It dissipates 625 mW and has a typical standby current of 5.5 mA. $2.75 ea. (100-999 pcs.). Technical Information Ctr., Motorola Semiconductor Products Inc., Box 20924, Phoenix, Ariz. 85036. (602) 273-3466.

Circle 268 on Inquiry Card

MICROWAVE IC NOISE SOURCES

Constant noise power output from −55 to 100°C.

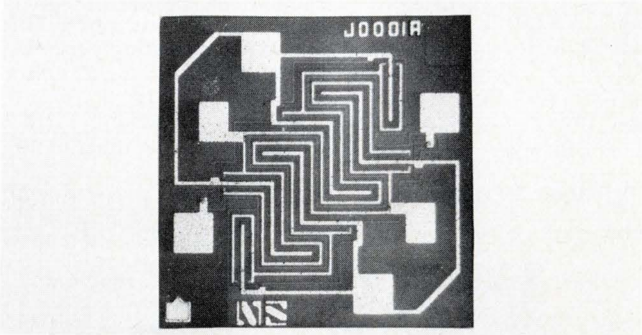


The MIC-93 series of noise sources can give you power output levels of up to 25 dB above KT_0B. Each source has a silicon avalanche noise diode that is biased to produce constant noise voltage from 1 to 20 GHz. Combining guard ring construction with low power dissipation, gives this diode very stable operation. They have < 1 μs turn-on and turn-off times so you can pulse them on during radar dead-time intervals for continuous monitoring of performance. The sources were designed to replace argon gas tubes and meet MIL-E-5400. The series includes five units and covers from 2 to 12.4 GHz. $700 ea. in quantities of 1-9. Texas Instruments Inc., Box 5012. M/S 16, Dallas, Tex. 75222. (214) 238-3741. Booths 2F08-2F20.

Circle 269 on Inquiry Card

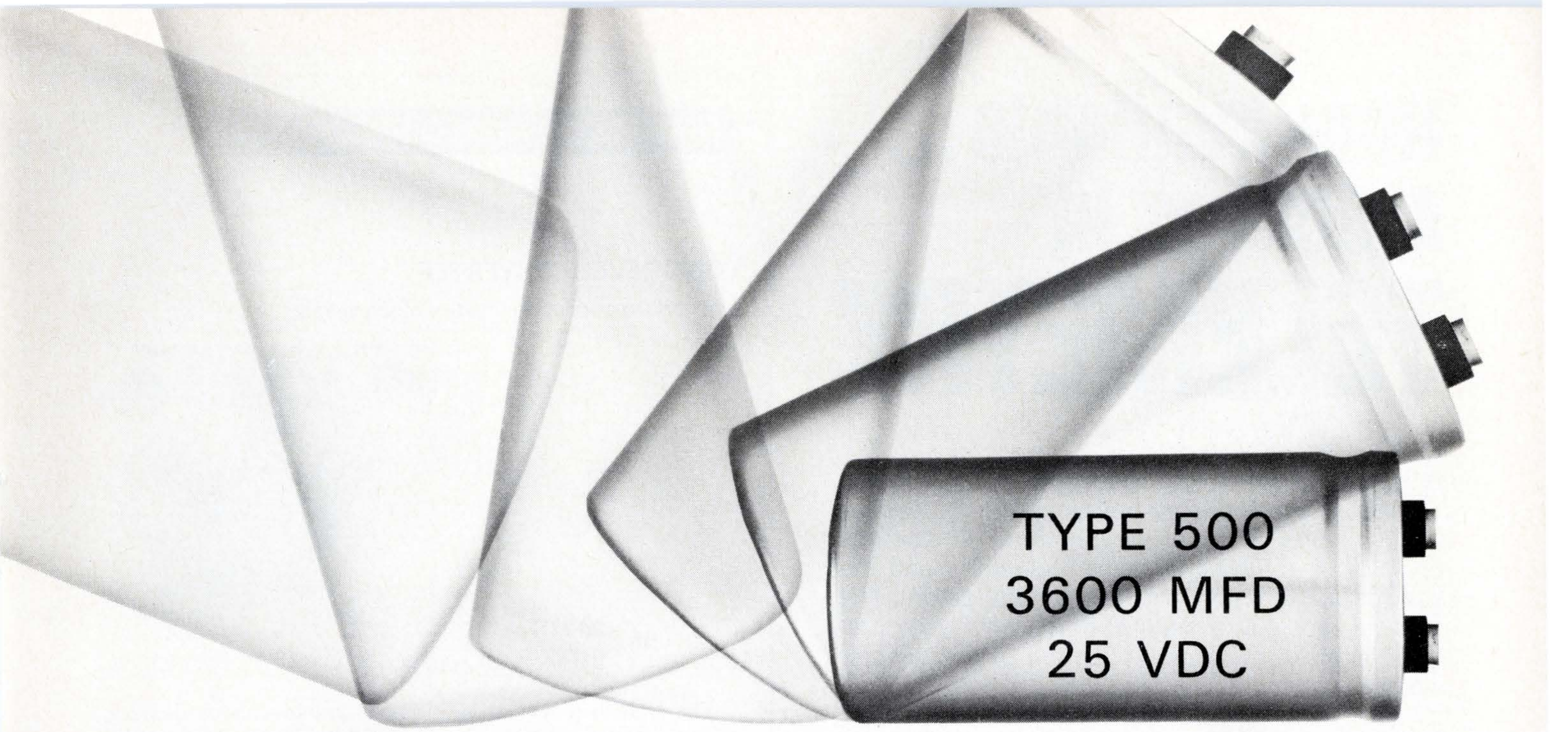
N-CHANNEL DUAL FET SERIES

Features intertwined geometry for precision matching.

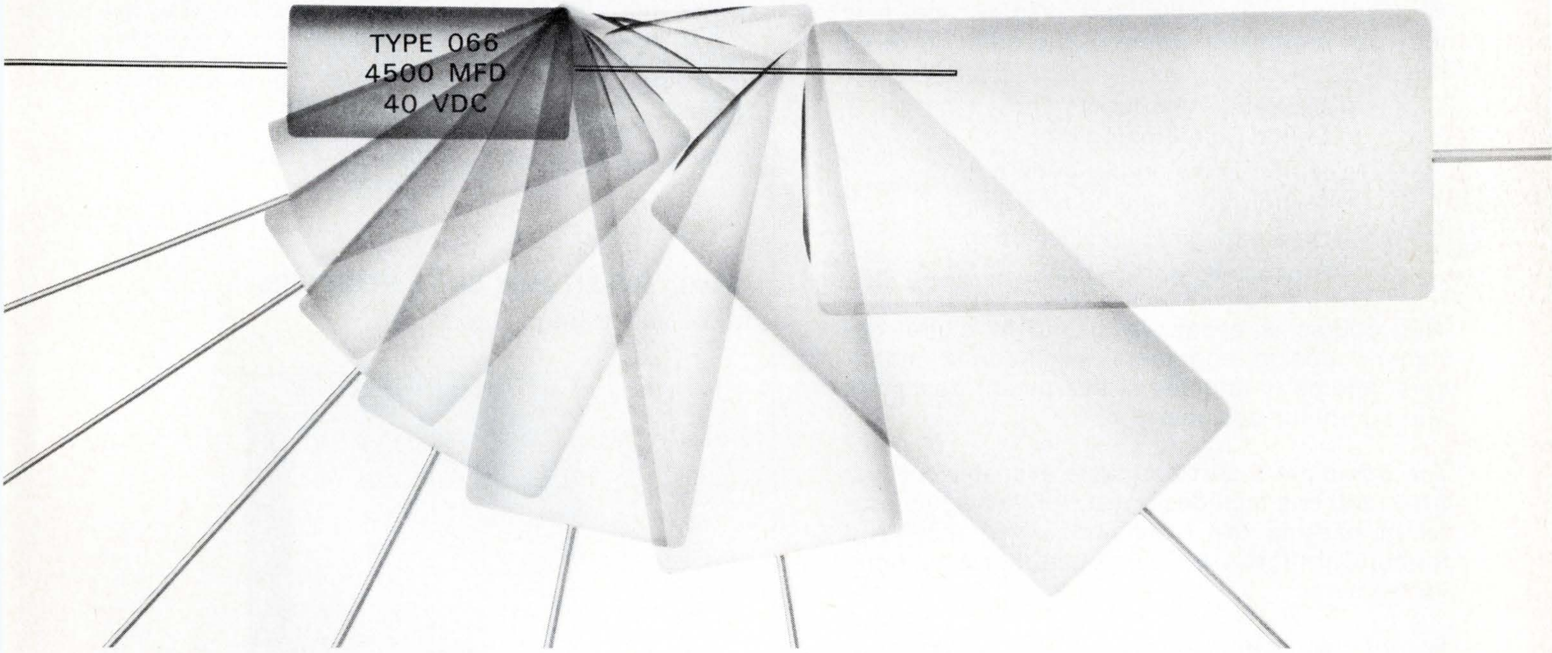


The National Semiconductor FM3954 series are monolithic dual JFETS made with special processing and a new approach in geometry. They eliminate the problem of complicated testing in wafer and die form because each dual die is matched by design. Features of the series include close tracking regardless of bias point, from 50 μA to 500 μA, leakage of 100 pA and a gain of 1000 μmhos. You can use these FETS in balanced modulators and mixers, analog switching, multiplexers, AGC, rf applications up to 30 MHz and in high slew rate op amps. In quantities of 100-999, prices range from $2.40 to $12.70. National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. 9501. (404) 245-4320.

Circle 270 on Inquiry Card



SANGAMO SIZE RANGE



The Big Plus in our "Designer Line" of Computer Grade Capacitors

The family resemblance is obvious. Both are "computer grade" aluminum electrolytic capacitors . . . made by Sangamo. Both offer high ripple current, low ESR, and a voltage range up to 450 wvdc. Both operate at temperatures from -40° C to +85° C for over 10 years. And, as you can see, both offer a wide range of core sizes.

Our type 500 delivers from 55 μF to 500,000 μF capacitance in case sizes ranging from 1-3/8" x 2-1/8" to 3" x 8-5/8".

But if you're looking for the same kind of performance and stability in a smaller, axial lead unit, our Type 066 is the answer. For example, a 1" diameter Type 066 can replace a 1-3/8" Type 500 to save space and provide easier mounting on a printed circuit board.

This is possible thanks to the Type 066's high ripple current capability. Which is why our Type 066 is so popular with designers of small equipment such as power supplies.

Type 066 offers you up to 24,000 μF capacitance in cases ranging from 1/2" x 1-1/8" up to 1" x 3-5/8". And if that's not small enough, chances are we can even cut these dimensions down to size for you.

Give us a try. Contact us for samples and catalogs, and get acquainted with our "Designer Line" of computer grade capacitors.

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Circle 50 on Inquiry Card

EC70-1

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E-3

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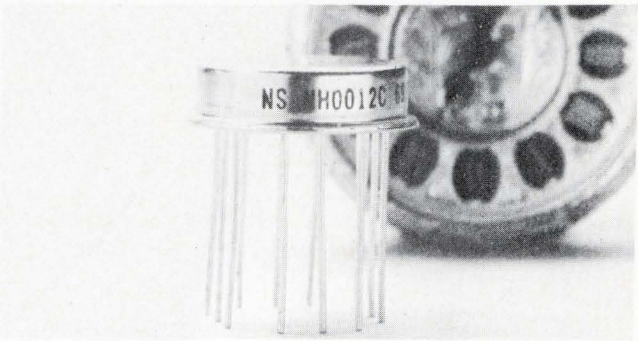
NEW MICROWORLD PRODUCTS

LOGIC LEVEL CONVERTER

Converts DTL or TTL to MOS clock levels.

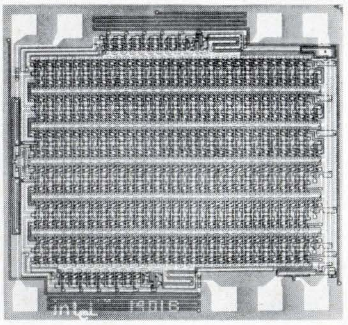


The NH0012, will drive high- or low-level MOS devices, since it has an output swing from 12 to 30 V. This hybrid device can drive MOS shift register clocks at up to a 10 MHz rate. It is designed to be driven by a TTL or DTL line driver or high current buffer such as the manufacturer's DM7830/DM8830 and will provide a fixed width output with a 1000 mA max. current capability. The circuit is useful where you want extra speed out of MOS shift registers, such as high speed buffer memories or long serial delay lines. The military version, (NH0012) is $37.50 ea. 1-24 pcs. while a commercial version (NH0012C) is $27. National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. 95051. (408) 245-4320.

Circle 261 on Inquiry Card

DUAL, 100-BIT MOS SHIFT REGISTERS

Guaranteed clock rates to 2 MHz.

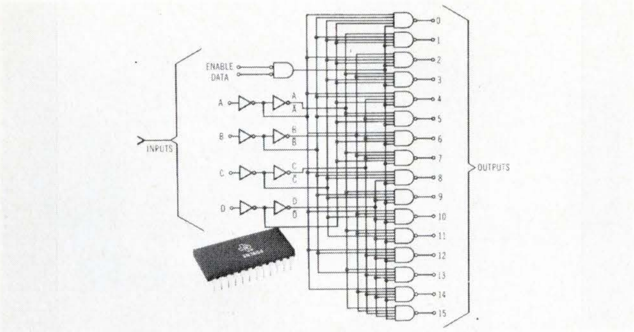


These units feature an input capacitance of 35 pF on the clock line and use 15 mA of power supply current at 10 V. Two models operate over the military range of −55 to 125°C. One of these has an open drain output (Model 1-406) and the other has a 20 kΩ output pull-up resistor (Model 1-407). Two similar models are specified from −25 to 70°C; open-drain Model 1-506 and 20 kΩ Model 1-507. All units are DTL/TTL compatible. Prices, 1-24 pcs., are $60 ea. for the 1-406 and 1-407, and $45 for the 1-506 and 1-507. In quantities of 100, the prices drop to $40 and $30 respectively. Delivery is from stock. Intel Corp., 365 Middlefield Rd., Mountain View, Calif. 94040. (415) 969-1670.

Circle 262 on Inquiry Card

TTL 4-16 LINE DECODER/DEMULTIPLEXER

In both military and industrial versions.

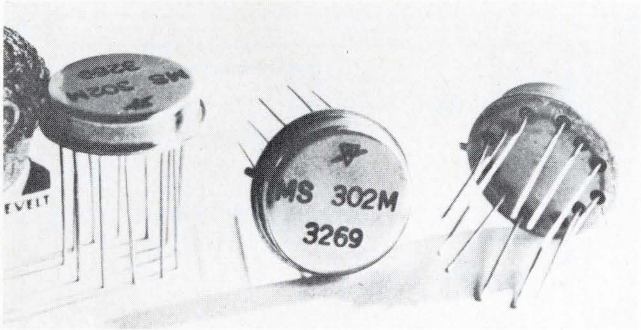


This MSI circuit, SN54154/SN74154, has four binary coded inputs which are coded internally to address one of the 16 output gates. Applications include demultiplexing serial data to parallel; decoding BCD and binary codes and sequentially distributing serial word data. You can also use it as a clock-time or minterm generator. The device has a typical propagation delay of 20 ns and a typical power dissipation of 170 mW. The unit comes in a 24-pin plastic package and is available in one week. The SN54154N is $8.96 (100-999 pcs.) and the SN74154N is $7.14 in the same quantities. Texas Instruments Inc. Inquiry Answering Service, Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-2011.

Circle 263 on Inquiry Card

TWO-PHASE MOS CLOCK DRIVER

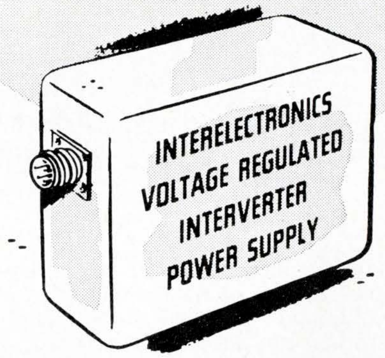
Dual drivers in a TO-8 package.



You can use these devices with TTL circuits to provide fixed width, two-phase clock pulses for MOS registers. They are also useful in independent translator/driver applications. These hybrid circuits feature output voltage swings of up to 30 V and output currents as high as 500 mA. They can deliver clock pulses with widths variable from 100 to 300 ns with an external capacitor. Typical timing characteristics are 10 ns delay, and 50 ns rise and fall times. The MS302, the industrial rated version, is $27 ea. in lots of 1-9. The MS302M, the military version, is $38 in the same quantities. Both are available immediately. Sylvania Electric Products Inc., 730 Third Ave., New York, N.Y. 10017. (212) 551-1403. Booths 3G01-3G02.

Circle 264 on Inquiry Card

PROVEN RELIABILITY—
SOLID-STATE POWER INVERTERS,
over 260,000 logged operational hours—
voltage-regulated, frequency-controlled,
for missile, telemeter, ground support,
135°C all-silicon units available now—



Interelectronics all-silicon thyratron-like gating elements and cubic-grain toroidal magnetic components convert DC to any desired number of AC or DC outputs from 1 to 10,000 watts.

Ultra-reliable in operation (over 260,000 logged hours), no moving parts, unharmed by shorting output or reversing input polarity. High conversion efficiency (to 92%, including voltage regulation by Interelectronics patented reflex high-efficiency magnetic amplifier circuitry.)

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Complies with MIL specs. for shock (100G 11 mlsc.), acceleration (100G 15 min.), vibration (100G 5 to 5,000 cps.), temperature (to 150 degrees C), RF noise (I-26600).

AC single and polyphase units supply sine waveform output (to 2% harmonics), will deliver up to ten times rated line current into a short circuit or actuate MIL type magnetic circuit breakers or fuses, will start gyros and motors with starting current surges up to ten times normal operating line current.

Now in use in major missiles, powering telemeter transmitters, radar beacons, electronic equipment. Single and polyphase units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics—first and most experienced in the solid-state power supply field produces its own all-silicon solid-state gating elements, all high flux density magnetic components, high temperature ultra-reliable film capacitors and components, has complete facilities and know how—has designed and delivered more working KVA than any other firm!

For complete engineering data, write Interelectronics today, or call 914 ELmwood 8-8000 in New York.

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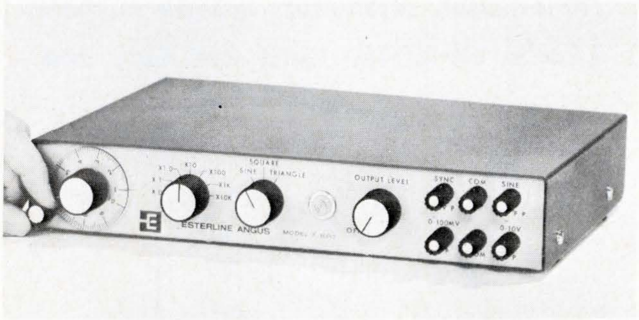
Circle 51 on Inquiry Card

Products with Booth Numbers
will be exhibited at IEEE

FUNCTION GENERATOR

Has a 0.01 Hz to 100 kHz frequency range.



Model F-1000 function generator performs with <1% amplitude change over the 0.01 Hz to 1 kHz range. Even at 100 kHz, amplitude is down <4%. Sine, square or triangle waveforms can be switch selected. Its voltage level is adjustable within the range of 0-100 mV or 0-10 V pk-to-pk. A sine wave of fixed level 10 V pk-to-pk and a 10 V sync pulse of 5 μs duration can be obtained simultaneously. Applications include timing pulses and ramp drivers. Also used for amplifier, freq. response, IC and vibration testing. Its l-f capability (with low-level 0-100 mV output) is useful for testing closed-loop servo systems. $310. Esterline Angus, div. of Esterline Corp., Box 24000, Indianapolis, Ind. 46224. (317) 244-7612.

Circle 271 on Inquiry Card

DUAL-TRACE SAMPLING OSCILLOSCOPE

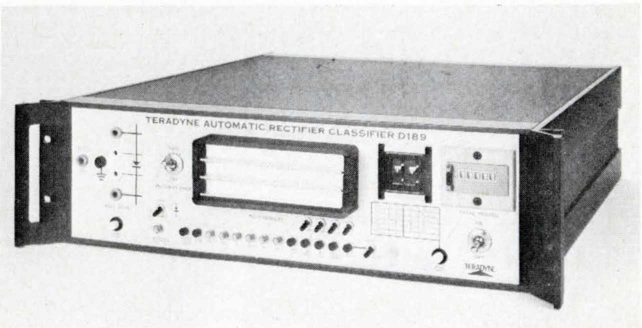
Has variable sampling speed ontrol.

This unit has a vertical amplifier rise time of 200 ps for an equivalent bandwidth of 1.7 GHz. The PM 3400 provides for continuous rather than fixed sampling speed between the preset speeds of 10, 100 and 1000 samples/cm. Manual scanning of the waveform and "one-shot" scan at sweep speeds in the range of 5 to 60 s/sweep are also possible. To solve the problems of internal triggering usually encountered with sampling scopes, the manufacturer has used delay lines in both vertical channels, ensuring that the time-base generator starts before the signal is applied to the sampling gate. Philips Electronic Instruments, 7505 S. Fulton Ave., Mt. Vernon, N.Y. 10550. (914) 664-4500. Booths 2E03-2E09.

Circle 272 on Inquiry Card

DIODE CLASSIFIER

Tests over 10,000 diodes/h.

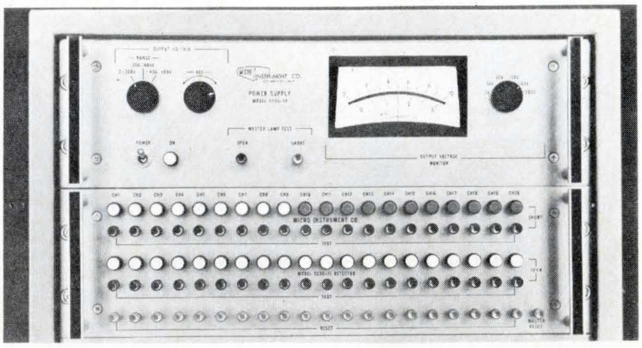


The type D189 tests for peak inverse voltage, makes a ΔV test to determine the degree of sharpness of the reverse-breakdown characteristic, tests for reverse leakage and makes two forward voltage tests. The unit will also automatically check for correct polarity and polarizes the test connections before testing. The entire test process takes 180 ms, or you can omit some of the tests, if desired. The instrument measures reverse voltage to 1200 V in two ranges and can deliver up to 10 A for forward voltage tests. Reverse-leakage current range is 0.005 to 1000 μA. Plug-in PC boards program all biases and test limits. $13,500. Teradyne Inc., 183 Essex St., Boston Mass. 02111. (617) 426-6560. Booths 2B03-2B07.

Circle 273 on Inquiry Card

CAPACITOR TEST SYSTEM

Tests for short- and open-circuit failures.



This system can test up to 100 capacitors simultaneously and it gives you a lighted indication if any fail for a period exceeding 0.5 ms. The system meets all requirements of Mil-C-39022A-3.14, Section 4.7.10. The Model 5330 system consists of a dc bias supply, an ac signal source and internal reference supply, individual channel circuit cards and a reset switch. Capacitance range is 100 pF min./channel to 1000 μF max. for all channels in a system. A basic system comprised of the ac signal source, reference and system power supply capable of testing 20 channels, is $4200. Additional channels are $120 ea. Delivery is 6 weeks. Micro Instrument Co., 12901 Crenshaw Blvd., Hawthorne, Calif. 90250. (213) 772-1275. Booth 3A50.

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Circle 52 on Inquiry Card ⟶

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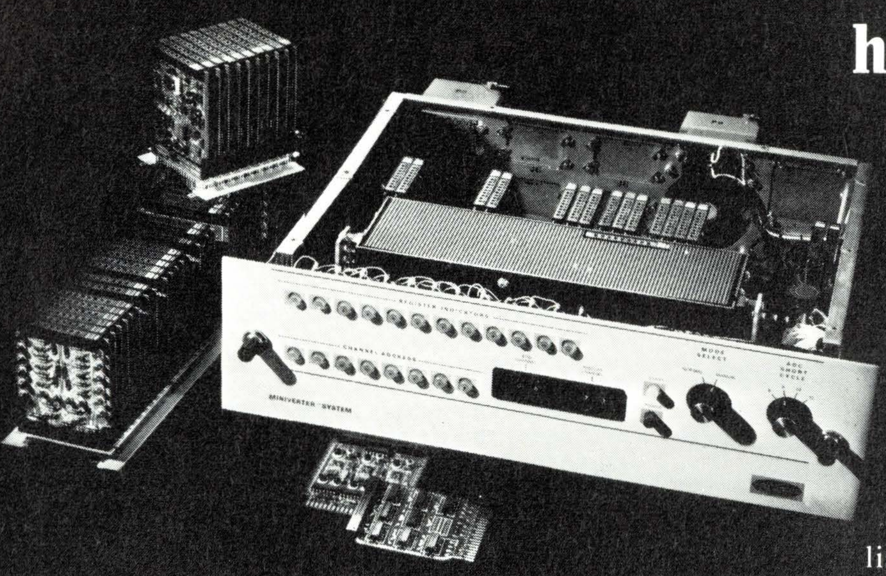

Analog/digital interfaces and conversion can end up costing you more than any other portion of your system.

So we've come up with a system of our own. Instant conversion in a range of prices and performance levels. All with the best price/performance ratio in the industry.

For analog-to-digital conversion, $1,220 buys you our 10-bit A-to-D converter and a 50kHz word rate. $1,790 buys our 12-bit high-speed 100kHz Miniverter™. $4,095 gets our 100kHz, 15-bit Multiverter® III. Each of these analog-to-digital converters has 8 multiplexed channels (expandable to 128) and a short-cycle control for even higher through-puts with shorter words.

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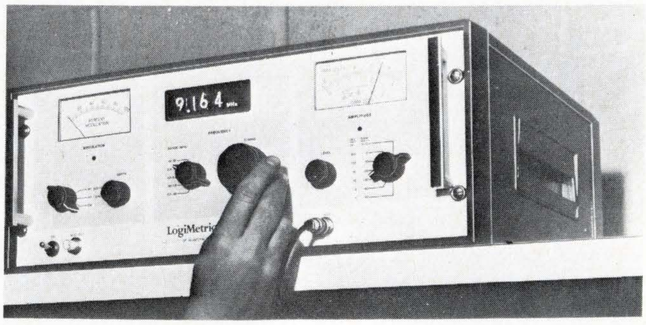
NEW LAB INSTRUMENTS

RF SIGNAL GENERATOR

With continuously viewable display.

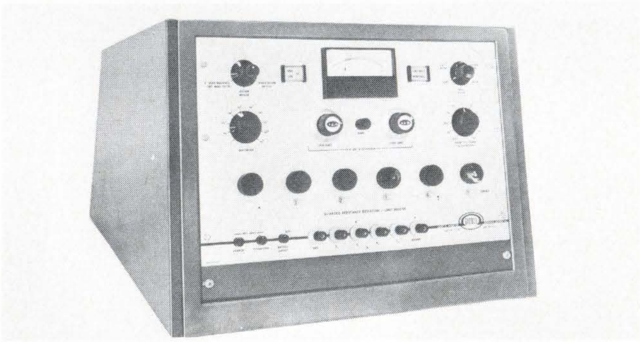


This line of signal generators covers the range of 100 kHz to 80 MHz with an accuracy of 0.006%. The 900 series displays the frequency by directly counting the generated signal. Because the unit uses a variable time base for the counter, and changes it for each frequency band the four-digit readout is completely filled on all bands and at all frequencies. It also uses a prescaling system that makes the least significant digit accurate to within ½ digit—or 50 ppm. Other features include a stability of better than 20 ppm, output leveling better than ±½ dB, spurious am lower than 70 dB, and incidental fm less than ±1 ppm. LogiMetrics, Inc., Subs. of Slant/Fin Corp., 100 Forest Dr., Greenvale, N.Y. 11548. (516) 484-2222.

Circle 265 on Inquiry Card

RESISTANCE MEASURING SYSTEM

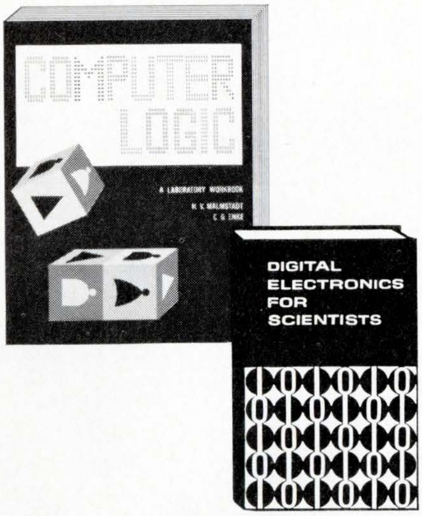
With NBS traceability.

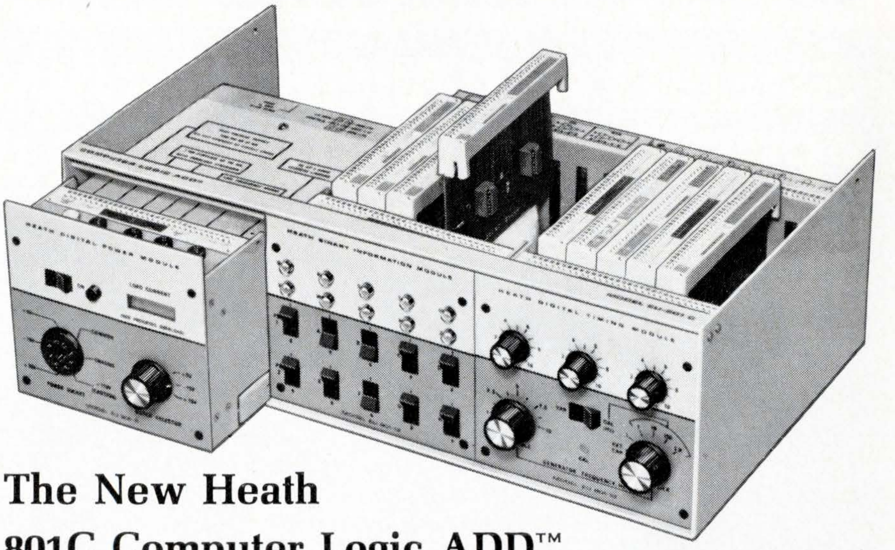


The Model 71-131 is a self-contained resistance measurement system, consisting of a Kelvin and Wheatstone Bridge, a guarded regulated bridge voltage supply and a solid state null detector. Bridge voltage and detector sensitivity are automatically controlled so that the meter is calibrated to indicate the exact deviation of the resistor tested. You can also use the meter for measuring temperature coefficient of resistors. The instrument can be used as a prime resistance measuring instrument with 6-digit readout for dc resistance measurements from 0.1 Ω to 11,111 MΩ. James G. Biddle Co., Township Line & Jolly Rds., Plymouth Meeting, Pa. 19462. (215) 646-9200. Booths 3A20-3A21.

Circle 266 on Inquiry Card

Is Your Computer Doing Things For You... Or To You?





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What Is Your General Purpose Computer Doing? Is it doing things for you in your problem solving that make the job easier, faster, more accurate? Things like analyzing, processing, measuring . . . working as an integral, active part of your design process? Does your knowledge of how your computer works, and what it can do, enable you to significantly alter your view of the problem . . . to the point of finding a better solution? Or is your computer, by being something of an enigma, doing things to you . . . like wasting your valuable time . . . increasing costs . . . degrading the accuracy and repeatability of your results? Is your computer doing things for you . . . or to you? The New Heath 801C System Can Help You Find Out . . . by broadening your understanding of computer logic. The Computer Logic ADD is designed to give you the basic knowledge of computer logic you need to effectively use the computer as a functional part of your designing and problem solving methods. The 801C System consists of the new EU-801C Computer Logic Analog-Digital Designer (ADD), a pioneering new text, "Digital Electronics For Scientists", by Drs. Malmstadt & Enke, and a Workbook keyed to the text and written to lead the newcomer a step at a time through basic logic functions and methods of manipulating data.

The EU-801C Computer Logic ADD is a precision teaching and design device composed of three Modules . . . Digital Power, Binary Information and Timing. Plug-in circuit cards in the Modules contain discrete logic functions such as AND, OR, NOR, NAND, INVERT etc., and the solderless connectors on the top of each card allow the user to patch the cards together with ordinary hook-up wire to form logic subsystems and systems identical to those used in present computers. Standard logic symbology is used throughout the system so the cards can be connected according to common logic diagrams. The ADD is also completely open-ended . . . more complex circuit cards are available from Heath to provide design & self-teaching capability for computer interfacing, digital instrumentation and control functions.

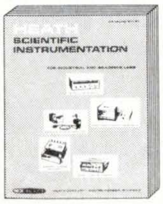
The Workbook, written by Drs. Malmstadt & Enke, is applicable to anyone interested in learning basic computer logic concepts and functions. The Workbook contains descriptive summaries, textbook references and specific instructions for 50 experiments. The experiments systematically "open up" the computer so that its basic logic functions and data handling methods become clearly understood. The format, experiments and presentations are designed for self-teaching and self-checking of one's comprehension. Table Of Contents by chapter: (1) Gate Logic . . . the student becomes familiar with logic levels, truth tables, Nand/Nor gate logic, Boolean Algebra, and encoder, adder, subtracter, decoder, multiplexer, comparator, parity and relative magnitude detector circuits and functions. (2) Flip-Flops . . . one of the most basic logic functions, used in all types of registers, for buffer storage, counting, converting, scaling and many other computation and measurement applications. (3) Counters & Scalers . . . including BCD counting, decade counters, scalers, variable modulus counters and preset counters. (4) Shift Registers . . . this set of experiments illustrates all the basic shift register circuits and applications. (5) Counting Measurements . . . this chapter demonstrates the use of counters to measure frequency, period and time interval. (6) Binary Computation . . . including serial and parallel addition and subtraction, which are the basis for all types of computation in actual computers.

Text—"Digital Electronics For Scientists" is a complete, up-to-date reference and study text for modern digital logic techniques. Although only the non-electronic portions of this text are used with the 801C System, the complete text offers an invaluable source of information for those interested in probing further into the nature and uses of current digital techniques.

The New Heath 801C System . . . can be the key to making your small computer an active, functional part of your design process. Order your 801C System now . . . and discover that your computer can be doing things for you, instead of to you.

EU-801C, complete system **$365.00***

FREE Heath Scientific Instrumentation Catalog



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Circle 53 on Inquiry Card

LOGIC DESIGNERS WHO SPEND ALL NIGHT DRAWING "FROM-TO" WIRE LISTS AREN'T LOGIC DESIGNERS

EECO'S LOGIC-WARE COMPUTER AUTOMATED SYSTEM WILL GET YOU HOME ON TIME.

In a typical logic design project, you can spend over 200 hours generating "from-to" wire lists, and other routine activities. That's work designers shouldn't have to do; and that's why EECO developed Logic-Ware, a computer automated system for design, hardware and production.

Logic-Ware takes the dirty, sticky, unrewarding monotony out of logic design, but it's more than just a design aid. It's software, hardware, production and final test. It's a total package available at any level of design or manufacturing. It can become "involved" in the initial circuit development, during hardware selection or the production phase. We've even worked from schematics. You give us a pin list — that's all — we do the rest.

Our computer will simulate your logic and help goof-proof your design. It will compute optimum wire routing and produce machine wiring instructions. From there EECO will automatically wire wrap on two levels, leaving the third for any later design changes. And, provide operational hardware with a lifetime warranty in a standard drawer or on planes. 30 days after getting your pin list.

Write for our Logic-Ware do-it-yourself kit: The Emancipator. We'll get you home on time.

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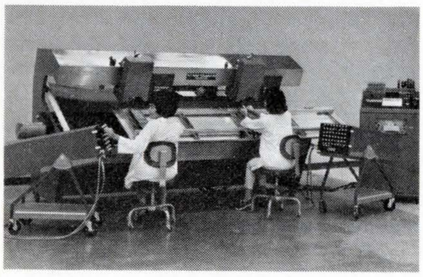
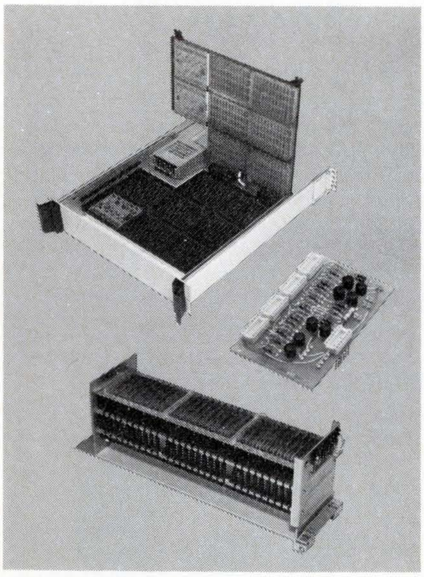
EECO'S LOGIC-WARE.

It's a full service system for the logic designer.

Computer automated design aid — logic simulation, error checking exception reports, string list and documentation.



Computer automated production system — wire routing, component placement and wire wrapping.



Hardware — boards, chassis, cards, connectors, power supplies, IC's, racks, frames, sockets, panels and drawers. Final assembly and checkout.

Electronic Products Division
Electronic Engineering
Company of California
1441 East Chestnut Ave.
Santa Ana, Calif. 92701
Ph: (714) 547-5651

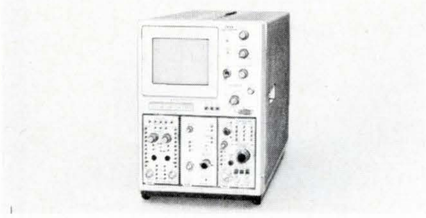
Circle 54 on Inquiry Card

NEW LAB INSTRUMENTS

Products with Booth Numbers will be exhibited at IEEE

THREE PLUG-IN OSCILLOSCOPE

Two vertical, one time-base.

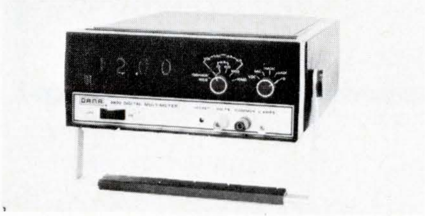


Type 7503 is a 90-MHz oscilloscope in which vertical-mode switching gives a dual-trace amplifier in the mainframe. You can simultaneously measure widely different waveforms. $1775. Type 7B52 time base has NORMAL, INTENSIFIED, DELAYED, and MIXED sweeps. $900. Tektronix, Inc., Box 500, Beaverton, Ore. 97005. (503) 644-0161. Booths 2G25-2G34.

Circle 252 on Inquiry Card

THREE DIGIT MULTIMETER

With 100 MΩ input resistance.

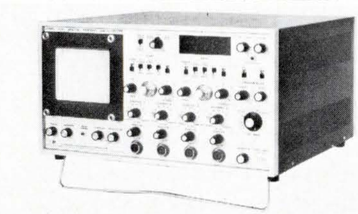


Model 3800 has full multimeter capability; 5 dc, 4 ac, 6 Ω, and 6 dc current ranges, and BCD output as an option, and sells for $425. Model 3860 provides dc and ohms measurement capability for $350. Both instruments have a dc accuracy of 0.1% of measured reading. Dana Laboratories, Inc., 2401 Campus Dr., Irvine, Calif. 92664. (714) 833-1234. Booths 2H39-2H47.

Circle 253 on Inquiry Card

DIGITAL READOUT SCOPE

Four-trace, four-channel unit.

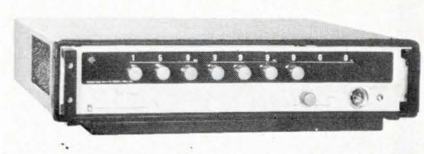


Model 1100 lets you simultaneously view both input and OR/NOR outputs from digital ICs or 1 and 0 flip-flop outputs. Using remote sampling units with either a high-impedance or 50-Ω input, the instrument bandwidth is better than 1 GHz. E-H Research Laboratories, Inc., 515 11th St., Box 1289, Oakland, Calif. 94604. (415) 834-3030. Booths 2C29-2C35.

Circle 254 on Inquiry Card

FREQUENCY SYNTHESIZER

Has range of 10 kHz to 160 MHz.



Model 1165, a sine-wave oscillator and tunable frequency standard, comes in both master and slave versions. Both feature 1 x 10^{-9} parts/day stability, phase modulation capability, and remote programming. The master unit (with internal oscillator) is $5900 and the slave is $5300. General Radio Co., West Concord, Mass. 01781. (617) 369-4400. Booths 2E26-2E36.

Circle 255 on Inquiry Card

DIGITAL COUNTER/TIMER

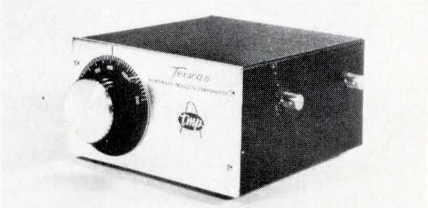
Count rate from dc to 20 MHz.

The Model 461 will measure frequency, period, multiple period, frequency ratio, multiple frequency ratio, time intervals and will totalize. The instrument gives you a seven-digit display with storage and a sensitivity of 10 mV. Instrument Systems Div., Dynasciences Corp., 9601 Canoga Ave., Chatsworth, Calif. 91311. (213) 341-0800. Booth 2K33.

Circle 256 on Inquiry Card

TUNABLE BANDPASS FILTERS

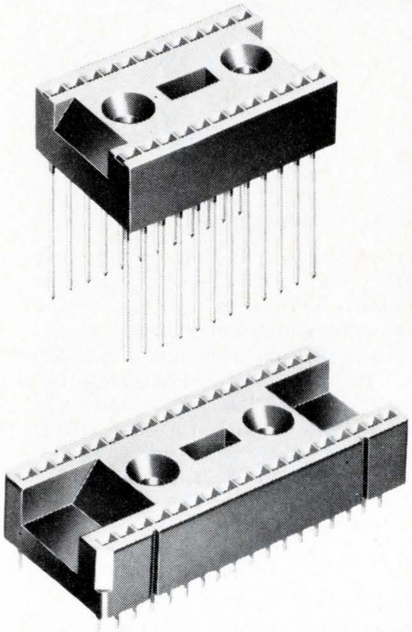
Series covers 50 to 4000 MHz.



The VF series comes with either a three- or five-section response. They have a 3 dB bandwidth of 5%, an insertion loss of from 0.2 to 1.5 dB, and VSWR less than 1.5:1. Prices range from $320 to $510 with delivery two to three weeks. Texsan Microwave Products Corp., 4610 N. Franklin Rd., Indianapolis, Ind. 46226. (317) 454-6481. Booths 2F03-2F07.

Circle 257 on Inquiry Card

L.S.I. SERIES
IC PACKAGING SOCKETS



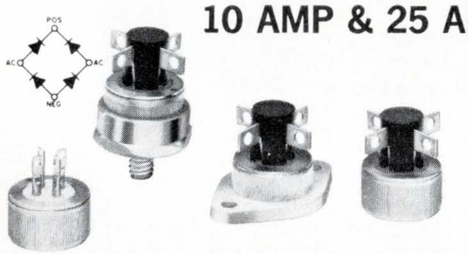
- Designed for use with 24 and 36 lead I.C.'c on .600" between rows.
- Accepts packages with round or flat leads.
- Contoured entry holes for easy, damage free I.C. insertion.
- Available in Diallyl Phthatate with gold plated contacts.
- Wire Wrap or printed circuit termination.

Request Data Sheet 166D

AUGAT INC. TEL: 617/222-2202
39 PERRY AVENUE, ATTLEBORO, MASS. 02703

Circle 55 on Inquiry Card

Available in production quantities now!
10 AMP & 25 AMP IBR®



ELECTRICAL CHARACTERISTICS at $T_C = 25°C$ (Unless Otherwise Specified)	SYMBOL	200V	400V	600V	UNIT
Minimum Avalanche Voltage	$V_{(BR)}$	250	450	650	VOLT
Maximum Avalanche Voltage	$V_{(BR)}$	700	900	1100	VOLT
RMS Reverse Voltage	$V_{R(RMS)}$	140	280	400	VOLT
Average Rectified Output Current at $T_C = 100°C$ (Fig. 2)	I	10 or 25			AMP
Nonrepetitive Peak Surge Current (Fig. 3)	I_{FM} (surge)	100/250			AMP/ LEG
Max. Surge Current, 1 sec. at 60Hz and $T_C = 100°C$ (Nonrep.)	$I_{F(RMS)}$	30/50			AMP
Power Dissipation in $V_{(BR)}$ Region for 100μ sec., Square Wave (Fig. 4)	P_{RM}	600/1500			WATT
Insulation Strength, Circuit-to-Case	2000 (MIN)				VDC

Varo Integrated Bridge Rectifiers offer single-phase full-wave rectification in an electrically insulated case.

Controlled avalanche characteristic permits selection of decreased PRV safety factor without greatly reduced transient voltage vulnerability.

The IBR® is ideal for use where space, current and cost requirements disallow use of discrete semiconductor devices.

VARO

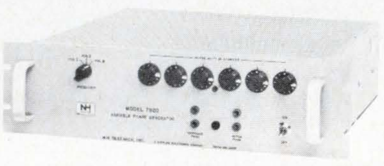
SEMICONDUCTOR DIVISION, 1000 N. SHILOH ROAD, GARLAND, TEXAS 75040 (214) 272-4551

Circle 56 on Inquiry Card

NEW LAB INSTRUMENTS

VARIABLE PHASE GENERATOR

With an accuracy of ±0.05°.

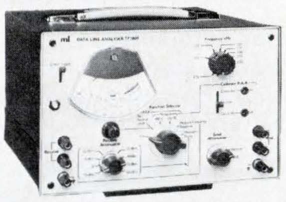


The Model 7920 provides two low-distortion, fixed voltage, sine wave outputs. You can vary the phase angle between the two outputs from 0 to 360° by front panel controls or optional, remote BCD programming. Price is $3695. N H Research, Inc., 1510 S. Lyon St., Santa Ana, Calif. 92705. (714) 835-1616. Booth 2G11.

Circle 258 on Inquiry Card

DATA LINE ANALYZER

Measures distortion in data links.

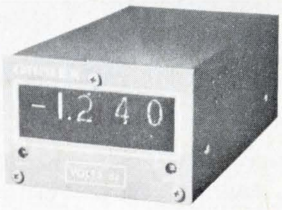


Model 2809 is a self contained test set for testing the suitability of voice band transmission systems and microwave links for data transmission. The unit makes three types of measurements, peak-to-average rating, frequency response and system noise level. $1295. Marconi Instruments, 111 Cedar Lane, Englewood, N.J. 07631. (201) 567-0607. Booths 2D02-2D08.

Circle 259 on Inquiry Card

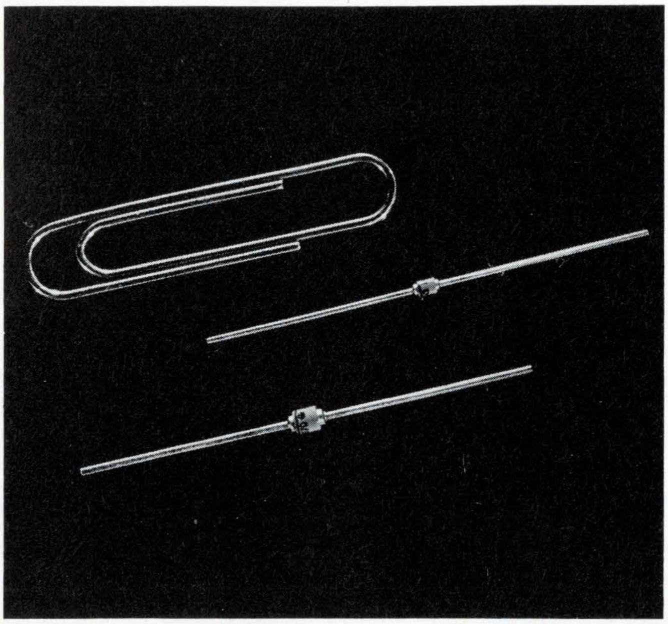
DIGITAL PANEL METERS

Measure 4.25 x 2.75 in.



Series DM-30 have a three-digit display, together with overrange and negative polarity symbols. A choice of five input ranges is available for full scale readings of 100 mV, 1 V, 10 V, 100 V, or 1000 Vdc. Gralex Industries, Inc., 155 Marine St., Farmingdale, N.Y. 11735. (516) 694-3607. Booths 3K20-3K21.

Circle 260 on Inquiry Card



now 1N SERIES mini-size power glass zeners ...from COMPONENTS

AVAILABLE NOW!

- 1.5 Watts (1N4461-1N4496)
- 3 Watts (1N5063-1N5104)
- 5 Watts (1N4954-1N4989)

Double stud construction . . . Special fused glass bonding . . . now make it possible to pack big power in tiny "match head size" cases . . . ¼ the size of comparable conventional zeners.

• Rugged, reliable Power Glass Zeners from Components mount in any position. • Operate from −65°C to + 200°C. • Surge capability up to 40 amps. • Leakage current down to 50 nanoamps. • Order now in voltages from 6.8 to 200.

Write or call today. Data sheets on request.

COMPONENTS INCORPORATED

Biddeford, Maine 04005

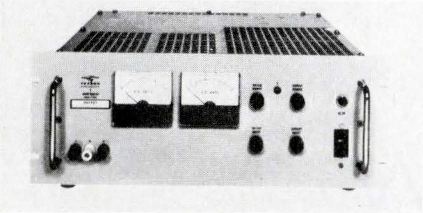
Circle 77 on Inquiry Card

NEW PRODUCTS

Products with Booth Numbers will be exhibited at IEEE

PRECISION POWER SUPPLY

For high current applications.

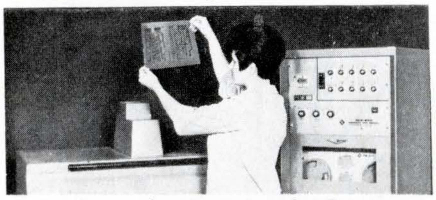


Model M7C5-130 0 V is a 0 to 5.25 V, 0 to 130 A, regulated supply. It has provisions for both constant voltage/constant operation and master-slave programming. Other features are: 0.005% reg., 0.015% stab., full power to 60°C without derating, ripple < 1 mV rms and automatic load share paralleling. $995. Trygon Electronics, Inc., 111 Pleasant Ave., Roosevelt, L.I., N.Y. 11575. (516) FR 9-2800. Booths 2B49 & 2B47.

Circle 281 on Inquiry Card

ARTWORK GENERATOR

Tape controlled system.

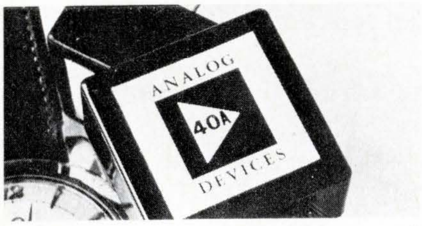


Slo-Syn Photo Artwork Generator eliminates manual drafting and photo reduction of PCB artwork. Working from a grid paper sketch, the tape can be programmed manually, by a digitizer or by computer. It produces, on film, an accurate circuit pattern to finished board size without the need for photo reduction. The Superior Electric Co., Bristol, Conn. 06010. (203) 582-9561. Booths 3B03-3B07.

Circle 282 on Inquiry Card

DIFFERENTIAL OP AMP

With low-current-drift FET-input.



Model 40 op amp features 10^{11} Ω input imp., 50 pA and 5 pA/°C bias current and bias current drift (at room temp.). Also, 50 µV/°C voltage drift, 5000 CMR, 200,000 open loop dc gain, 100 kHz full response, and ±10 V, 5 mA rated output. List price —$12 and $19 ea. for the 50 µV/°C and 20 µV/°C versions. Analog Devices, Inc., 221 Fifth Ave., Cambridge, Mass. 02142. (617) 492-6000. Booths 3F16-18.

Circle 283 on Inquiry Card

PHOTOTRANSISTORS

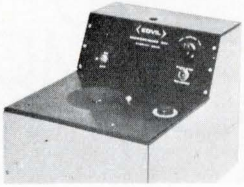
Extra sensitive.

New silicon planar Darlington light sensor is suitable for use where the available light is below normal industry stds. At irradiance of 1 mW/cm^2, the Type OP 300 phototransistors will generate light currents of over 10 mA. Peak spectral response is between 0.80 and 1.0 µm. Maximum power diss., 50 mW. $3.95 ea. (1-99); $2.65 ea. (100-999). Optron, Inc., 1201 Tappan Circle, Carrollton, Tex. 75006. (214) 242-6571.

Circle 284 on Inquiry Card

MULTI LEAD SPREADER

For TO-5 semiconductor devices.

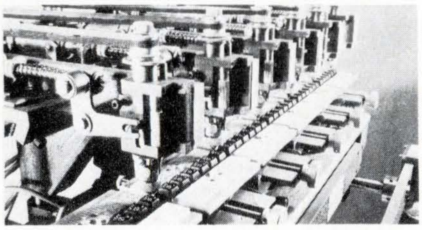


Model MS-15 provides fast and accurate lead spreading for multi leaded TO-5 headers. It is available in four models: for 6, 8, 10, and 12 leaded headers. Easy to operate, it does 2400 pieces/h. Header height adjustment is from 0.200 to 0.375 in. It is small (portable) 10 x 13¼ x 9⅝ in. Edvil Microscience Div., Mill Plain Rd., Danbury, Conn. 06810. (203) 744-1574. Booth 1J07.

Circle 285 on Inquiry Card

ENGRAVING MACHINE

Useful for key operated equipment.



Multi-spindle engraving machine has solved the problem of how to permanently mark concave typewriter keys with up to 3 lines of identification. The machine is operated pneumatically on the tracer-guided principle. An operator without any previous experience can engrave 36 keys with one setup. New Hermes Engraving Machine Corp., 20 Cooper Sq. New York, N.Y. 10003. Booth IB12.

Circle 286 on Inquiry Card

HIGH PRESSURE BLOWER

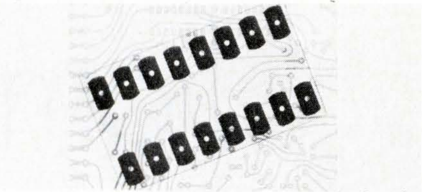
Provides efficient cooling.

This centrifugal blower is for use in equipment having a vertical profile of no more than 1¾ in. The Biscuit™ blower features inverter motor construction and resiliently mounted, permanently lubricated sleeve bearing system. For this reason, it has a design life of 10 yrs at room amb. without maintenance. Rotron Inc., Hasbrouck Lane, Woodstock, N.Y. 12498. (914) 941-2401. Booths 3F11—3F13—3F15.

Circle 287 on Inquiry Card

CIRCUIT SYMBOLS

Speed circuit master artwork.

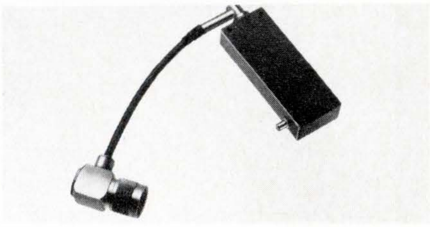


Self-sticking drafting symbols in pre-spaced configurations are for ICs. transistors and contact fingers. Called precision pad connectors, they are dimensionally stable with tol. of ±0.002 in. at 4:1. Image size and spacing are absolutely uniform from one set to another so that dimensions never vary. W. H. Brady Co., 726 W. Glendale Ave., Milwaukee, Wis. 53201. (414) 332-8100. Booths 1D12-14.

Circle 288 on Inquiry Card

COMMUNICATIONS FILTER

Passes 200-400 MHz band.

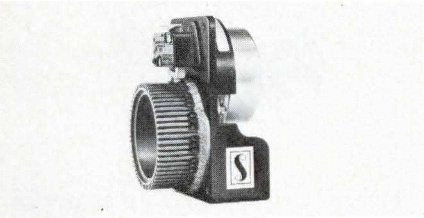


Model 2424-1 low pass filter passes the 200-400 MHz communications band with < 0.3 dB loss and rejects 520-1500 MHz, 60 dB. Power capability is 50 W average. The 3⅜ x 1¼ x ¾ in. filter mounts one SM connector (Microdot #51-258) and one type N elbow. $150.00. Microwave Filter Co., Inc., 135 W. Manlius St., East Syracuse, N.Y. 13057. (315) 437-4529.

Circle 289 on Inquiry Card

LOW COST TIMER

With a 60-position drum.

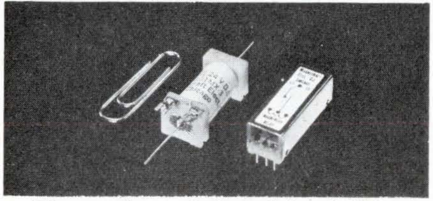


New LCT has a numerical drum-position indicator which provides instant visual recognition of program progress, and aids in making quick program changes. LCT's 15 A contacts are individually field adjustable and replaceable. $18.50 with a 1rpm motor and single contact. $22.50 (with two contacts). Sealectro Corp., Mamaroneck, N. Y. 10543. (914) 698-5600. Booths 4H03 and 4G04-4G10.

Circle 290 on Inquiry Card

REED RELAYS

They are IC compatible.

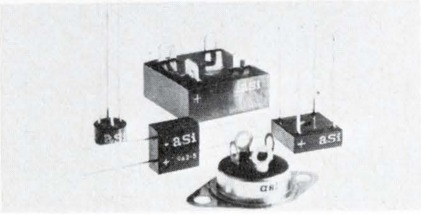


These relays, designed for 5 V logic systems, come in two package styles—PC mounting and in-line axial leads. These low profile, PC relays have a typ. coil wattage of 40 mW at 4 Vdc. The SPST-NO Class "101" has a contact rating of 10 VA at 0.25 A max. or 28 Vdc max. resistive load. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, Ill. 60630. (312) 282-5500. Booth 3E11.

Circle 291 on Inquiry Card

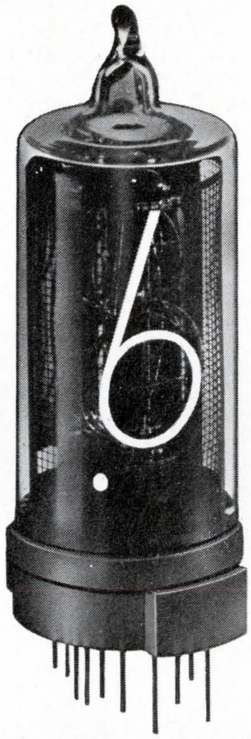
RECTIFIER BRIDGES

Miniature, medium power units.



These full wave bridge assemblies are made in current ranges of 1, 1.5, 2, 6 and 10 A. PIV's from 50 to 1000 V are available with std. and fast recovery characteristics. Packages range from a miniature 1 A epoxy unit to the 10 A with JEDEC TO-3 mounting. Atlantic Semiconductor, Div. of Aerological Research, 905 Mattison Ave., Asbury Park, N.J. 07712. (201) 775-1827. Booths 4D27-4D29.

Circle 292 on Inquiry Card



THE AVAILABLES

NL-950 Readout Tube
available in quantities you need

- also for immediate delivery NL-940 a direct replacement for the B-5750.
- made in U. S. A. (Geneva, Illinois)

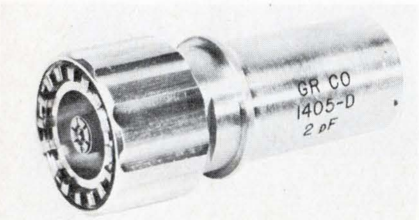
For additional information and application assistance, write or call National Electronics, Inc., a varian subsidiary, Geneva, Illinois 60134, Phone (312) 232-4300.

NATIONAL ELECTRONICS, INC.
a varian subsidiary

Circle 57 on Inquiry Card

COAX CAPACITANCE STDS

Range in value from 1 to 20 pF.

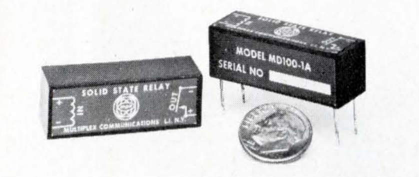


Type 1405 standards extend the available values of rf capacitance downward. These two-terminal stds. let you calibrate impedance-measuring instruments at even higher freqs accurately and with traceability to NBS. A certificate of calibration supplied with each unit gives the measured capacitance at 1 kHz and at a specific temp. and rel. hum. General Radio Co., 300 Baker Ave., West Concord, Mass. 01781. (617) 369-4400.

Circle 225 on Inquiry Crad

SOLID STATE RELAYS

Well suited for PC card use.

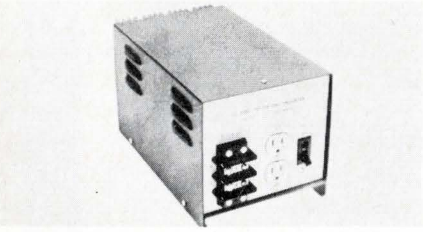


MD Series devices are designed to work as a relay or switch in computers, communications and aviation equipment. They will operate with current input of 800 μA and up, and voltage input from 2.5 V and up. They handle speed ranges from dc to as high as 6000 baud. Multiplex Communications Inc., 70-C Bell St., W. Babylon, N. Y. 11704. (516) 694-5225.

Circle 226 on Inquiry Card

DC TO AC INVERTER

For severe loads.

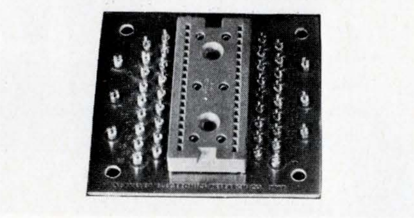


Model 1076 inverter can handle high transient overloads and hard-to-handle loads normally incompatible with inverters. Rated output is 500 V, 115 Vac, 60 Hz, single phase, square wave with a surge capability of 1000 VA. Input may fluctuate from 11 to 14.5 Vdc, but it is designed for 12 V operation. $188.00 (1-9). Wilmore Electronics Co., Inc., Box 2973, West Durham Sta., Durham, N. C. 27705. (919) 489-3318.

Circle 227 on Inquiry Card

TEST MODULE CARDS

Breadboard for ICs

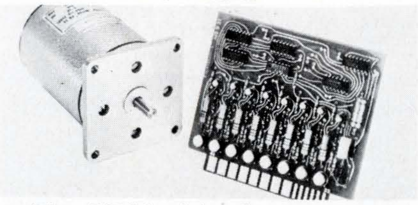


CmII cards contain an IC socket in any of the popular configurations including 24 and 36 pin. Each pin is brought out to a numbered terminal. Other terminals are available as tie points. Solder is used to make connections, and there is a ground plane around each terminal. The modules weigh about 1.2 oz ea., are 2½ x 2½ in. and cost from $9.50 to $13.50. Berkeley Electronics Research Co., Box 1021, Berkeley, Calif. 94701.

Circle 228 on Inquiry Card

STEPPER MOTOR

With TTL drive circuit.

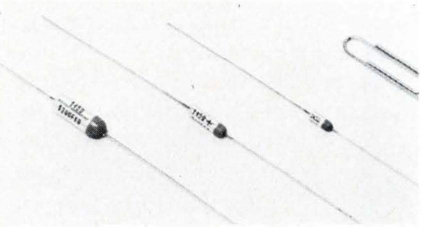


The PD24 eight-phase permanent magnet motor and logic operate off one common +5 Vdc supply. Features include high speed (pull-in rate 350 steps/s, pull-out rate 3500 steps/s), 7½° step angle, low power-11 W, heavy duty ball bearing construction and working torque to 15.3 oz.-in. The A. W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. (203) 756-4481.

Circle 229 on Inquiry Card

TANTALUM CAPACITORS

High volumetric efficiency featured.

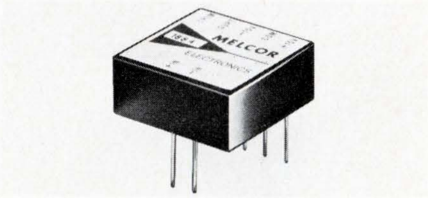


Designed to operate from −55 to +85°C without voltage derating, Type 145D sintered-anode Tantalex capacitors are for use in packaged circuit modules, l-f filters, printed wiring boards and allied uses. They have an elastomer end-seal capped with a plastic resin to protect the nickel-tantalum weld and to insure against electrolyte leakage and lead breakage. Sprague Electric Co., Marshall St., North Adams, Mass. 01247. (413) 664-4411.

Circle 230 on Inquiry Card

INVERTING OP AMP

With fast settling time.

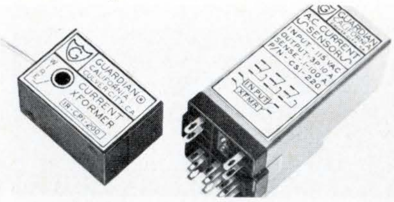


Model 1884 FET input op amp with a max. settling time of 3 μs to 0.01% operates over the temp. range of −55°C to +85°C. Gain is 100,000 min.; freq. response 25 MHz small signal, 2 MHz full power; voltage drift 50 μV/°C max. and 100 pA max. offset current which doubles every 10°C increase. Output is ±10 V at 20 mA. $70.00. Melcor Electronics Corp., 1750 New Highway, Farmingdale, N.Y. 11735.

Circle 231 on Inquiry Card

AC SENSOR

Versatile protective devices.

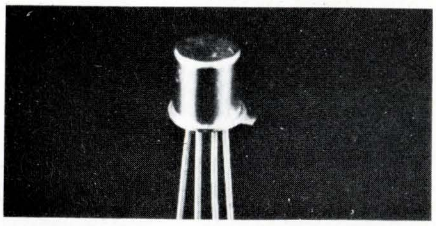


A 90-125 Vac 50-60 Hz input powers the current sensor which contains the sensing circuitry, adjustment pots and a 3 pole 10 A output relay. Current sense point, output relays response time (1-25 cycles) and differential are externally adj. Series CS1-200 sensors provide sensing ranges from 0.1 thru 100 A. Guardian Electric Mfg. Co. of Calif., Inc., 5755 Camille Ave., Culver City, Calif. 90232. (213) UP 0-4642.

Circle 232 on Inquiry Card

HIGH FREQUENCY FET'S

For vhf amplifier & mixer uses.

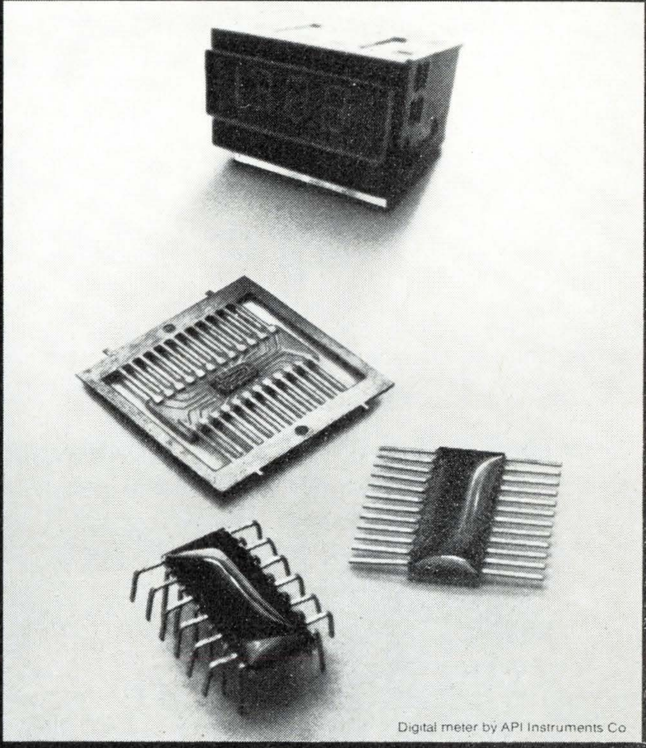


The 2N4416 and 2N4416A silicon epitaxial junction N-channel FETs have high power gain (10 dB min. at 400 MHz), low NF (4 dB max. at 400 MHz), and low output capacitance (0.8 pF max.). The 2N4416A has slightly higher voltage ratings (35 compared to 30 V) than the 2N4416; otherwise they are the same. Crystalonics, a Teledyne Co., 147 Sherman St., Cambridge, Mass. 02139. (617) 491-1670.

Circle 233 on Inquiry Card

Circle 58 on Inquiry Card ⟶

LAST YEAR THE TOMORROW MOSFETS.


Digital meter by API Instruments Co.

The complex LSIs are Tomorrow-minded, too. These Metal Oxide Semiconductor Integrated Circuits are loaded with Tomorrow features. Low-voltage threshold and nitride passivation have been production processes for more than a year. The advanced Mosinc device pictured is our new up-down counter with seven-segment decoder, Hughes Part No. HCTR0107. It includes 512 Mosfets; performs up to 100 functions; and serves as a universal, presettable counter and a storage register. We'd like to tell you more about our total capability in microelectronics—including our custom CMOS (Complementary MOS) and IMOS (Ion-Implantation MOS) logic, shift-register and memory capability. Check pages 1606-1620 in the 1969 EEM Catalog. Or write to us at this address: Hughes MOS Division, 500 Superior Ave., Newport Beach, Calif. 92663.

HUGHES

HUGHES AIRCRAFT COMPANY
MOS DIVISION

THIS YEAR THE HUGHES MOSINCS.

COUNTERS

HCTR 0107: Reversible Decade Counter with Seven-Segment Decoder and Drivers
HCTR 0507: Seven-Stage Binary Counter, 7 Outputs
HCTR 0102: Commercial/Entertainment Binary Divider
HCTR 0201: RST Flip-Flop

STATIC SHIFT REGISTERS

HSSR 2016: Dual-16 Bit
HSSR 2064: Dual-64 Bit

DYNAMIC SHIFT REGISTERS

HDSR 2025: Dual-25 Bit
HDSR 2050: Dual-50 Bit

ION-IMPLANTED MOS (IMOS)

LISR 0064: 20MHz/64-Bit Dynamic Shift Register

MULTIPLEXERS

HMUX 1756: 4-Bit D-to-A Converter
HMUX 1784: 4-Bit D-to-A Converter
HMUX 2542: Dual 2-Bit Commutator
HMUX 2641: 4-Bit Commutator

LOGIC ELEMENTS

HLOG 2304: Triple 3, Dual 2 NOR Gates
HLOG 2306: Dual J-K Flip-Flop

MULTIPLES

HMUL 1441: General Purpose Quad
HMUL 1444: General Purpose Quad
HMUL 1445: General Purpose Quad
HMUL 1446: General Purpose Quad
HMUL 1447: General Purpose Quad
HMUL 1463: Quad Dual-Switch
HMUL 1884: Quad Dual-Switch
HMUL 2661: Six-Channel Switch
HMUL 3362: Triple Differential Pairs
HMUL 3551: Five-Channel Switch
HMUL 3651: Five-Channel Switch
HMUL 3661: Six-Channel Switch

DUALS

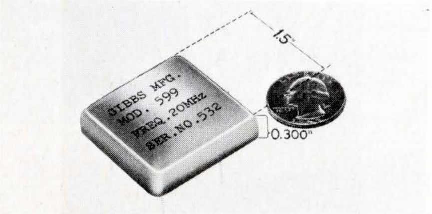
HDIG 8049: Low-Level Modulator
HDIG 8551: Amplifier
HDSW 8050: Modulator-Demodulator
HDSW 8550: High-Level Switch

DISCRETE MOS TRANSISTORS

HDIG 1030: General Purpose
HDIG 1886: Electrometer
HDSW 2106: Low-Resistance 20 Ohm Switch, General Purpose
HDSW 3005: Low-Leakage Switch
HDSW 8300: 30-Volt Switch
HDSW 8318: Switch, General Purpose
HDSW 8338: Chopper Switch
HDSW 8346: Linear Amp
HDSW 8348: 50-Ohm Switch, General Purpose

CLOCK OSCILLATORS

For computer applications.

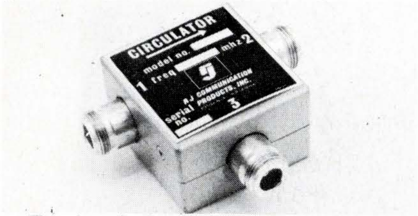


These crystal controlled oscillators feature output waveform parameters compatible with DTL, TTL, and RTL logic ICs, eliminating the need for interface circuitry. Output freq. range is between 50 Hz and 30 MHz. Sizes range from about 0.5 in.^{3} (Model 606) to 1.7 in.^{2} (Model 562). The 599 (shown) is a low profile unit only 0.300 in. high. Gibbs Mfg. Research Corp., Subs. of Hammond Corp., 450 N. Main St., Janesville, Wis. 53545.

Circle 234 on Inquiry Card

ISOLATORS/CIRCULATORS

Cover 150 to 460 MHz bands.

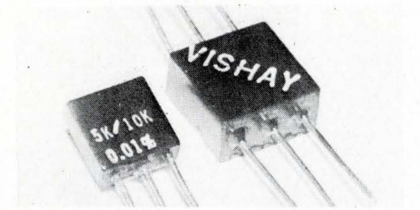


Ferrite isolator/circulator line includes seven new models in the low and medium power range. Available in 20, 50, 100 and 125 W capacities, they have direct applications for low power transmitters used in mobile communications. Isolation is 20 dB min. with a max. insertion loss of 0.7 dB. RJ Communication Products, Inc., 9827 N. 32nd St., Phoenix, Ariz. 85028. (602) 948-6310.

Circle 235 on Inquiry Card

RESISTOR NETWORKS

With 2 and 4 elements.

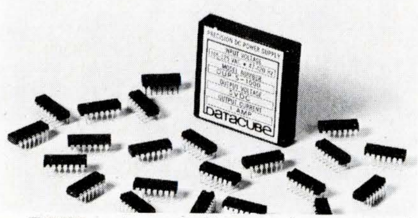


These networks extend the performance of amplifiers, voltage dividers, and R-2R ladder networks. They feature TCs of 1 ppm and tracking of ½ ppm, for all resistance values, and tol. matching to ±0.005% with rlse times of < 1 ns. Model 300144 (2 element) is 0.320 x 0.295 x 0.100 in., and Model 300145 (4 element) is 0.200 x 0.375 x 0.375 in. Vishay Resistor Products div. of Vishay Intertechnology, Inc., 63 Lincoln Hwy., Malvern, Pa. 19355.

Circle 236 on Inquiry Card

PRECISION PWR SUPPLY

Only 2 x 2 x 0.4 in.

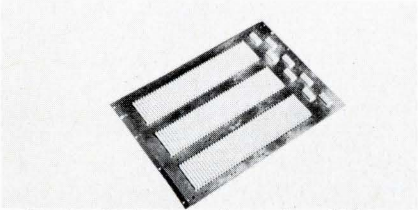


DUP series supplies can be mounted on PC boards on 0.5 in. centers, or they can be plugged into an optional mating socket. All models connect directly to 115 Vac line power and provide 5 W of reg. output power. The 5 W model can power 100 DTL-830 dual quad gates or 25 each SN7490 decade counters. There are models for all available digital IC types. Datacube Corp., Box 676, Salem, N. H. 03079. (603) 898-9400.

Circle 237 on Inquiry Card

CONNECTOR ASSEMBLIES

For solderless-wrap applications.

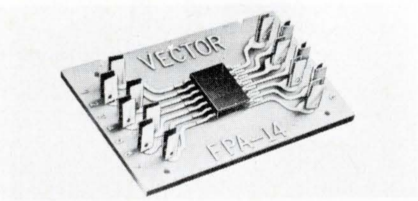


Basic design consists of a 6061-T6 aluminum back-plate, 0.080 in. thick, on which multiple-contact header modules are arranged. Typical modules take 1/16-in. PC boards with 5/32-in. circuit spacing. Minimum pin spacing on the back-plate is a 0.050 in. x 0.150 in. or 0.100 in. x 0.100 in. grid with 0.025 in.^{2} pins. Masterite Industries Inc., 2841 Lomita Blvd., Torrance, Calif. 90505. (213) 775-3471.

Circle 238 on Inquiry Card

FLATPACK ADAPTERS

For mounting ICs on ckt boards.

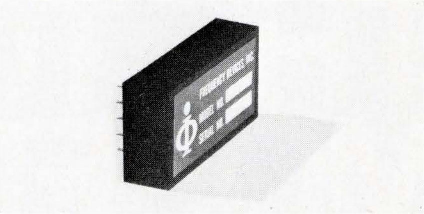


This adapter makes it easier to solder and handle flatpack ICs in breadboard and prototype construction. It is a 1/16 in. epoxy paper wafer with a 2 oz. copper etched pattern which matches the 0.05 in. spaced lead pattern on flatpacks. Leads are "fanned" out to an alternate 0.1 in. spacing at each end of the wafer where 0.125 in. pads with 0.042 in. dia. holes are located. Vector Electronic Co., Inc., 12460 Gladstone Ave., Sylmar, Calif. 91342. (213) 365-9661.

Circle 239 on Inquiry Card

ACTIVE FILTERS

Cutoff freqs. to 0.001 Hz.



Series 100 filters are unity-gain and non-inverting. Standard models have 2—6 pole—low pass, high pass, bandpass or band reject—Butterworth, Bessel, Tchebyscheff or Twin-T transfer functions. Specs include ±0.02 dB passband gain tol., ±5% cutoff freq. accuracy, 100 kΩ typ. input imp. 10 Ω output imp. and adj. volt. offset. Frequency Devices, Inc., 25 Locust St., Haverhill, Mass. 01830. (617) 372-6930.

Circle 240 on Inquiry Card

SOLDERING SYSTEM

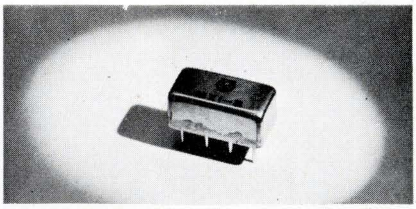
For hybrid circuits.

Model 150 autopulse soldering system features two newly developed micro point hand soldering probes. The power supply has a continuous range from 0 to 60 W of instant pulse heating energy. Plug-in hand probes feature soldering tips as small as 0.010 in. in dia. $175.00. Browne Engineering Co., 1120 Coast Village Circle. Santa Barbara, Calif. 93103. (805) 969-2268.

Circle 241 on Inquiry Card

WIDE-BAND MIXERS

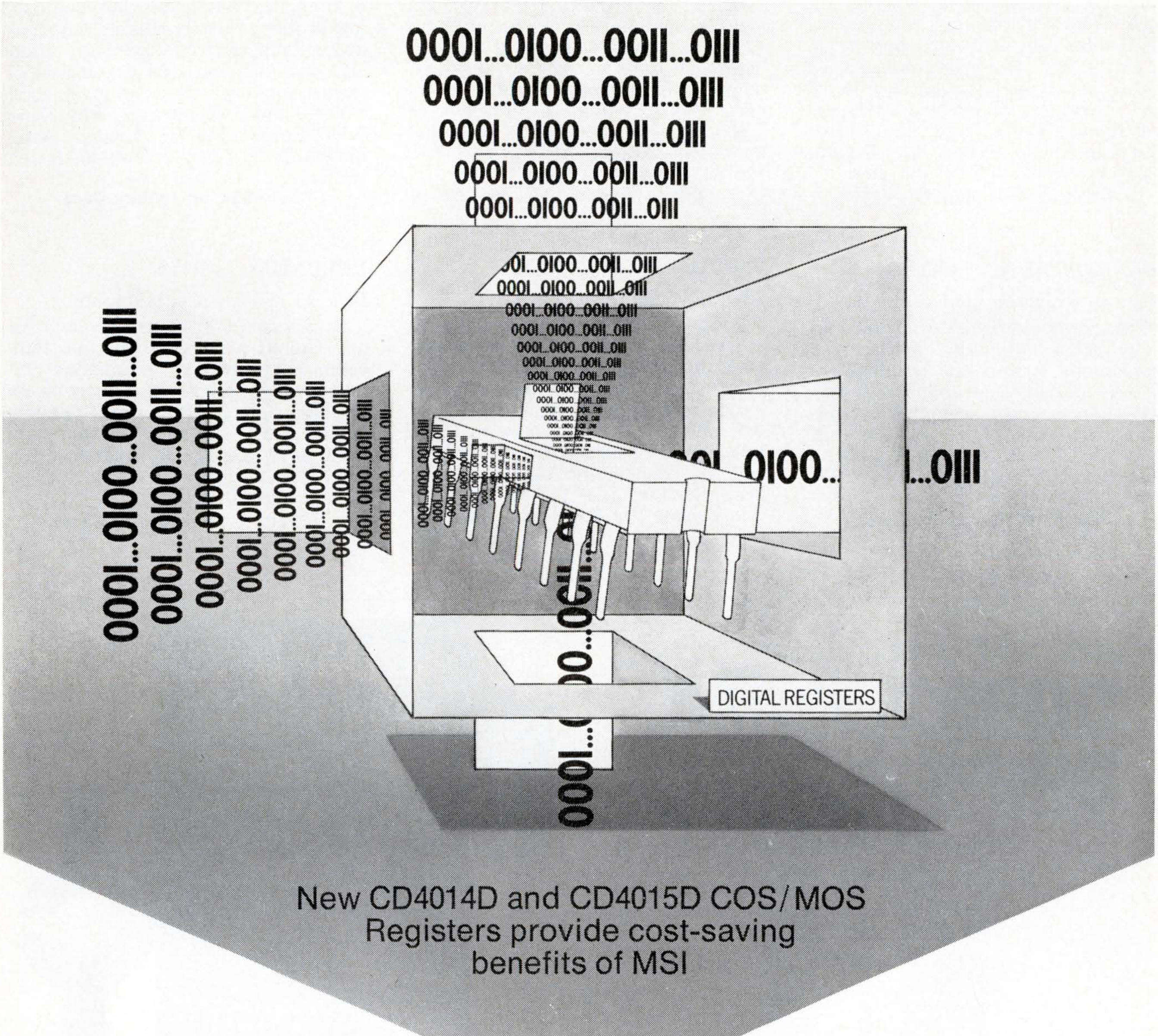
In the 0.05 to 500 MHz range.



MX Series double-balanced mixers feature low noise, flat response and a careful balance of ports. The MX1 and MX3 models use Schottky barrier diodes for low noise and high conversion efficiency, while the MX2 model uses low-capacity, high speed diodes for less critical applications where economy is a prime consideration. From $15 to $25. Vanguard Electronics Div. of Wyle Laboratories, 930 W. Hyde Park, Inglewood, Calif. 90302.

Circle 242 on Inquiry Card

RCA COS/MOS makes MSI also mean multiple-saving integration



New CD4014D and CD4015D COS/MOS Registers provide cost-saving benefits of MSI

RCA COS/MOS digital IC's provide:

- ☐ Operation from a single power supply—6 to 15 V
- ☐ Low quiescent power dissipation—5 μW (typ)
- ☐ High noise immunity—45% of V_{DD} (typ)

Think of these characteristics in terms of system reliability, minimum package size and elimination of extra circuits and components. Low power means simpler, less expensive power supply circuits; tighter packaging density (no special cooling devices required). COS/MOS IC's mean greater tolerances to power-supply voltage and signal amplitude variations. And the high noise-immunity characteristic eliminates the need for special noise-suppressing circuits. COS/MOS has other logic system design advantages, too: medium speed operation [$f_{CL}=2.5$ MHz (typ) at $V_{DD}-V_{SS}=10$ V]; fully static operation; full military temperature range, and single phase clocking.

CD4014D (formerly Dev. No. TA5578) is an 8-stage synchronous parallel-input/serial-output register; CD4015D (formerly Dev. No. TA5579) is a dual 4-stage serial-input/parallel-output register. Each device is available in 16-lead DIL ceramic packages at $13.60 (1000 or more units).

For further details on the two new COS/MOS Registers and RCA's growing COS/MOS line, see your local RCA Representative or your RCA Distributor. For the technical data bulletins on the new Registers (File Numbers 415 and 416) and a new COS/MOS Reliability Report (RIC-101), write to RCA Electronic Components, Commercial Engineering, Section ICJ-3/CD30, Harrison, N. J. 07029. In Europe: RCA International Marketing S.A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

RCA Integrated Circuits

Circle 59 on Inquiry Card

MOTOR DRIVEN SWITCH

Only $2\frac{1}{2}$ x $1\frac{1}{4}$ x $1\frac{1}{4}$ in.

This plug-in, self-contained unit can be mounted directly to a PC board. Long life reed switches and hermetically sealed contacts make it very reliable. Many switching arrangements are available as std., including a 10, 12 or 24 pole channel scanner, 10, 12 or 24 pole stepping switch, 5, 6 or 12 pos. two-pole, three-pole stepping switch and a 6 or 12 pole relay. Ansley East Corp., Old Easton Rd., Doylestown, Pa. 18901. (215) 345-1800.

Circle 307 on Inquiry Card

THERMOPLASTIC PARTS

Washers, insulators and bushings.

These precision molded nylon and acetal screw insulators, washer-type components, spacers and bushings are for use in electronic and a wide variety of mechanical assemblies. Gries Reproducer Co., Div. of Coats & Clark Inc., 151 Beechwood Ave., New Rochelle, N.Y. 10802. (914) 633-8600. Booths 1C09-1C11.

Circle 308 on Inquiry Card

MULTI-OCTAVE L.O.

For broadband systems.

Multi-Octave Local Oscillator (MOLO) replaces the four single-octave LOS normally used in broadband systems. Key specs for the WJ-5060 include continous coverage of 1 to 12.4 GHz, tuning linearity of ±0.1%, harmonic rejection of 40 dB, and power outputs from 2.5 mW to 65 mW. Watkins-Johnson Co., 3333 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. 94304. (415) 326-8830. Booth JO3/05.

Circle 309 on Inquiry Card

VACUUM PICKUP TOOL

With interchangeable tips.

LAB-69 tool connects directly to any vacuum source and has fine screen wires to prevent tiny particles from being sucked into the tool. Metal or Teflon tips are available in sizes from 0.5 mm to 6.0 mm. The item to be transported or held is merely touched with the vacuum tip. $20.00 (24 or less), $18.00 (25 +). Labtron Scientific Corp., 100 Smith St., Farmingdale, N. Y. 11735. (516) 293-4898.

Circle 310 on Inquiry Card

ENGRAVER

Many other applications.

Model SR21 bench type engraver is for 1:1 reproduction, down to 4:1 reductions and up to 1:1 enlarging. Multiple applications: engraving, contouring, profiling, master making, numbering, milling electronic parts, PC drilling, diamond and carbide engraving, electro-marking, stamp cutting, stencil making, and beveling. Scripta Machine Tool Corp., 575 E. Linden Ave., Linden, N. J. (201) 925-4940. Booth 1H07.

Circle 311 on Inquiry Card

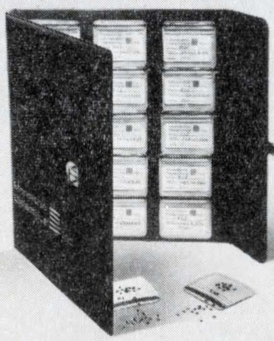
INDICATOR LIGHTS

Low 20 mW pwr. consumption.

Miniaturized lights can be used for applications such as logic state indication in computers. The smallest unit in the range is 0.25 in. long with an outside diameter of 0.09 in. Operating voltage is 6 V and power consumption is 20 mW. Oxley Developments Co. Ltd., Priory Park, Ulverston, Lancashire, England. Booth 3B28.

Circle 312 on Inquiry Card

GOOD BUY, MR. CHIPS BY MONOLITHIC DIELECTRICS



CHIP KIT NO. 1 consists of 300 monolithic ceramic capacitor chips for hybrid circuits. Browse, examine, and test. There are 10 chips of each standard RETMA values from 1.2 pf to 330 pf in ±10% tolerances at 50 VDCW.

CHIP KIT NO. 2 consists of 300 sample chips, 10 chips each of all standard RETMA values from 390 pf to .1 MFD in ±10% tolerances at 50 VDCW.

KIT NO. 1 or KIT NO. 2—$49.50 ea. A GOOD BUY!

Delivery from stock. Call direct and ask for Jim Waldal.

Monolithic
Dielectrics Inc.

P.O. Box 647, Burbank, Calif. 91503 • (213) 848-4465

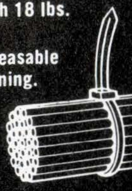
Circle 60 on Inquiry Card

NOW PANDUIT *PENNY-TY*™ cable tie at 1¢ each

THE PANDUIT SST1M PENNY-TY Miniature Cable Tie is now available for 1¢ each in quantities of 50,000* or more.

- Meets Military Standards MS-3367-4, MS-17821-4 and MS-18034-4.
- Harness diameter range 0 to ¾"; loop tensile strength 18 lbs. minimum.
- Self-locking and releasable prior to final tightening.

*In accordance with standard conditions of PANDUIT Price Sheet effective 12/1/69



At your PANDUIT Distributor.
FREE SAMPLES.

PANDUIT® CORP.

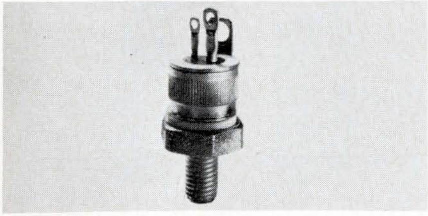
Tinley Park, Ill. 60477 • Phone: 312—532-1800 • Telex 25-4560

VISIT PANDUIT I.E.E.E. SHOW BOOTH 1B 15

Circle 61 on Inquiry Card

ISOLATED STUD SCRs

Four 35 A units.

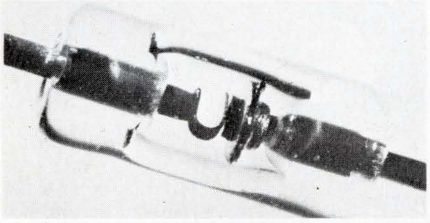


New SCRs are for uses requiring isolation from the chassis, or housing. They are RCA 40680 l-y power supplies (100 V_{DROM}), RCA 40681-120 V line operation (200 V_{DROM}), RCA 40682-240 V line operation (400 V_{DROM}), and RCA 40683 hv power supplies (600 V_{DROM}). Prices in 1000 lot quan. are $3.30, $3.75, $4.70 and $6.00 respectively. RCA/Electronic Components, Commercial Engineering, 415 S. 5th St., Harrison, N.J. 07029. (201) 485-3900. Booths 3D01-3D02-3D07-3D08.

Circle 313 on Inquiry Card

PIN DIODE RESISTOR

Atten./switches 1MHz to 1 GHz.



The long minority-carrier life-time of this PIN diode assures you a maximum distortion of only 0.05% at 1 MHz. Useful as a current-controlled resistor in agc circuits for CATV amplifiers (12-channel cross-modulation products are down 50 dB), T-R switches, etc., Type 5082-3080 costs 99¢ ea., in 10,000- to 25,000-pc. lots. Inquiries Manager, Hewlett-Packard 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 326-7000.

Circle 314 on Inquiry Card

TERMINATING SYSTEM

Is self-contained.

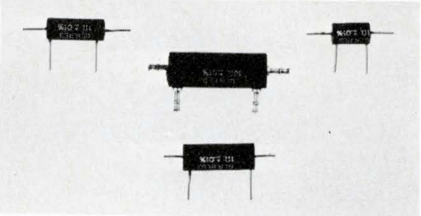
Model 8636 self-cooling Moduload^{TM} rf load resistor module eliminates the need for the usual 4-8 gal./min. required to dissipate the heat from 10 kW transmitter output. It terminates a 50Ω line with a low VSWR of only 1.1 from dc to 1000 MHz and 1.15 to 1400 MHz. It is for cw, a-m, TV, fm transmissions up to 10,000 W avg. pwr. $2300. Bird Electronic Corp., 30303 Aurora Rd., Cleveland (Solon) Ohio 44139. (216) 248-1200. Booths 2E40-2E42.

Circle 315 on Inquiry Card

Products with Booth Numbers will be exhibited at IEEE

PRECISION RESISTORS

Current sensing.

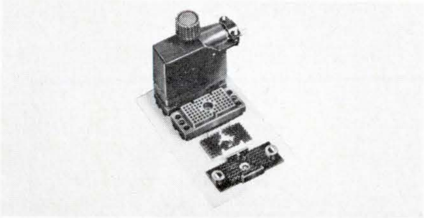


Curristors are available from stock in decade steps and in tolerances including ±0.01% with TCs of 1, 2, 5, 10, and 20 ppm/°C available. You may specify transfer characteristics from 1 mV/A to 10 V/A, up to and including 6 W. Applications include: sensors in analog process control systems, constant current supply sensing elements, metrology lab working stds., or any precision current sensing and control requirement. General Resistance, 500 Nuber Ave., Mt. Vernon. N.Y. 10550. (212) 292-1500.

Circle 316 on Inquiry Card

HI-DENSITY CONNECTORS

For solderless-wrap backpanels.



Designed as an integrated line of complementary rack-and-panel connectors and I/O devices for solderless-wrapped computer backpanels, this series is available with 33, 75 or 117 contacts on 0.100 in. spacing, and 55 or 79 contacts on 0.125 in. spacing. Hermaphroditic Mini-Varilok^{TM} contact, developed specially for this use, is nearly twice as small as its predecessors. Elco Corp., Willow Grove, Pa. 19090. (215) 659-7000. Booths 4G07-09.

Circle 317 on Inquiry Card

INSTRUMENTATION CASE

Dual-purpose unit.

Nomad carry case is used as an electronic console and transit case. The plastic outer case encloses an aluminum inner case. The aluminum case is isolated from the outer case and is shock-mounted in two polyurethane cradles. It accepts 19 in. wide RETMA panel mounting devices, and provides 15¾ in. of panel space. Outer shell has guide rails for stacking. B & F Instruments, Inc., Cornwells Heights, Pa. 19020. Booth 2K27.

Circle 318 on Inquiry Card

power module users:

DON'T ORDER ANOTHER POWER MODULE !

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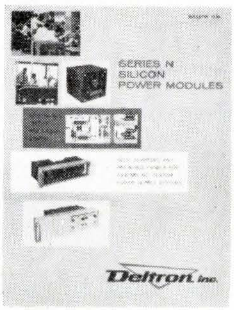

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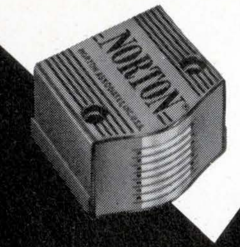
Circle 62 on Inquiry Card



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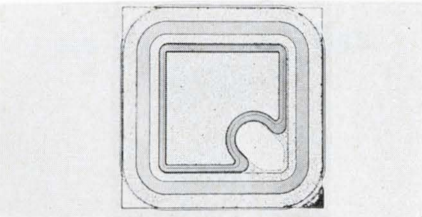
Circle 63 on Inquiry Card

NEW PRODUCTS

EPOXY SCRs

With 30 to 400 V ratings.



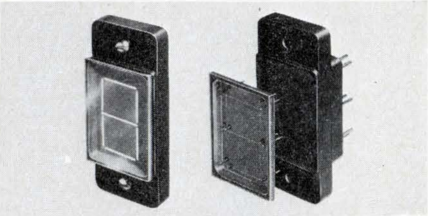
New lead-mount SCRs are registered as 2N5787 through 2N5792. Offered in an epoxy TO-106 package, they conform to electrical specs. of the registered TO-92 series, 2N5060 through 2N5063, and are electrically equivalent to the Texas Instrument series, TIC-44 through TIC-47. Operation is guaranteed at junction temps. of −65° to +125°C. They have a high gate sens. (10 μA typ.) and a low on-state voltage drop (1.0 V typ. at 200 mA). All have max. current ratings of 500 mA rms. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. (415) 962-3563.

Circle 293 on Inquiry Card

Products with Booth Numbers will be exhibited at IEEE

READOUTS

Digital and Alphanumeric models.

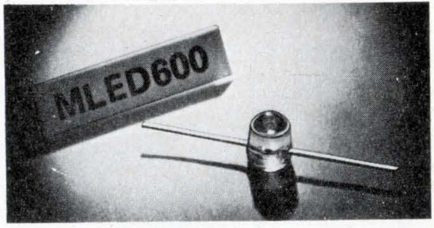


Maxi-Lites, Model 12-50 D is a seven segment ¾ in. digital readout. Individual segments are directly viewed incandescent tungsten filaments, for max. brightness and most efficient display. Viewing angle is 150°. Only ½ in. thin front to back, including connector. Alpha Model 12-50 A has 16 segments for undistorted characters. Pinlites Inc., 1275 Bloomfield Ave., Fairfield, N.J. 07006. (201) 226-7724. Booths 3H01-3H03.

Circle 294 on Inquiry Card

LIGHT-EMITTING DIODE

Plastic-packaged.

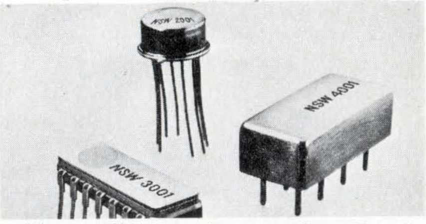


Type MLED600 emits in the visible red wave band with typ. peak emission at 660 nm. The gallium arsenide-phosphide photodiode exhibits a min. brightness of 50 ft-L at 10 mA and typ. brightnesses as high as 700 ft-L at drive currents above 40 mA. $1.45 (1000-up). Motorola Semiconductor Products Inc., Box 20912, Phoenix, Ariz. 85036. (602) 273-3466.

Circle 295 on Inquiry Card

SOLID-STATE RELAY

Low power/high speed.



True solid-state 2-PDT relay (break before make) uses conventional semiconductor components in a hybrid microelectronic assembly. Nanoswitch™ is a plug-in replacement for electromechanical relays in many applications. Because of low power driving requirements, it can be used in areas previously requiring amplifier stages. Nanotron, Inc., 8720 Woodley Ave., Sepulveda, Calif. 91343. Booths 2E39-2E43.

Circle 296 on Inquiry Card

DIGITAL PROCESS CONTROL SEMINAR

A 5-day course for engineering personnel

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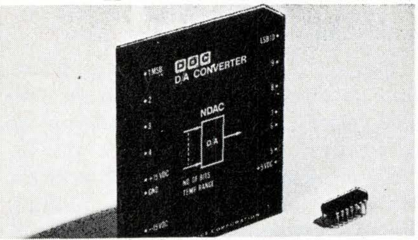
Bala-Cynwyd, Pa. 19004
215/835-2044

SYSTEMS EQUIPMENT

D/A CONVERTER MODULES

Drive 50 Ω coax lines.

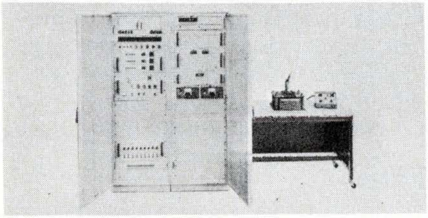


Nanodac Series converters are complete with an output amplifier providing up to 5 V at 100 mA. NDAC-8 (8 bit) provides accuracies of ±0.2% of full scale, with settling times of 50 ns. Accuracy of the NDAC-10 is ±0.05% of full scale, and its settling time is 100 ns. From $250 (1-9). DDC, div. of Solid State Scientific Devices Corp., 100 Tec St., Hicksville. N.Y. 11801. (516) 433-5330. Booths 3B11-12.

Circle 297 on Inquiry Card

TEST SYSTEM

Automatic testing.

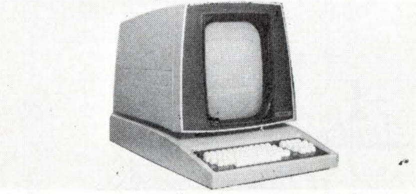


System (5000DC) energizes the circuit under test, measures its performance, and if out of tolerance, turns the circuit off and hunts for component errors by actual in-circuit measurements. Basic measurement capabilities include dc voltage, current, ac voltage, in-circuit impedance, resistance, diode/transistor orientation, and in circuit beta tests. Optimized Devices, Inc. Pleasantville, N.Y. 10570. (914) RO 9-6100. Booth 2C15.

Circle 298 on Inquiry Card

TERMINAL/PROCESSOR

With a 4 k expandable memory.

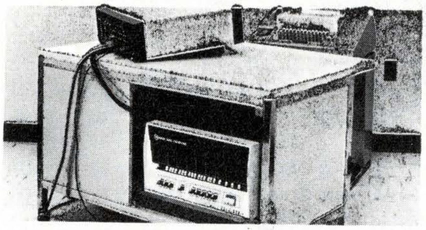


As a communications terminal, the PDS-1 system can replace any on-line, electromechanical device without modifying the central system nor the present communications facilities. It can function from 1 to 9600 baud using any bit structure or code level. PDS-1 is also a mini-processor. Imlac Corp., 296 Newton St., Waltham, Mass. 02154. (617) 891-1600.

Circle 299 on Inquiry Card

SIGNAL PROCESSOR

Computes fast Fourier transforms.

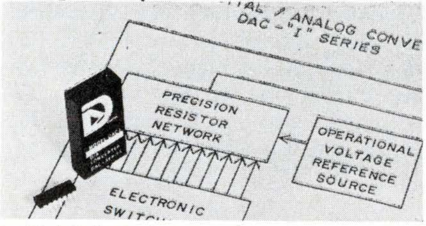


New digital signal processors use high-speed minicomputers to allow fast Fourier transforms in real time. The CompuSignal System — 3 (CSS-3) processing package applies digital techniques to any complex frequency waveform, performing various on-line, real time processes at sampling rates to 2 kHz, and with sample block sizes over 128. Varian Data Machines, 2722 Michelson Dr., Irvine, Calif. 92664. (714) 833-2400.

Circle 300 on Inquiry Card

D/A CONVERTER

Occupies only 0.8 cubic inches.

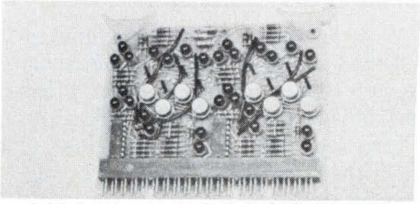


DAC-I Series are completely self-contained plug-in units. They are available with resolutions to 12 binary bits or 3 digit BCD and have an output current settling time of 150 ns to within 0.025% of full scale. Digital inputs are comparable with DTL or TTL logic. Full scale ouput current can be either bipolar (±1.2 mA) or unipolar (2 mA). Prices start at $115. Datel Corp., 943 Turnpike St., Canton, Mass. 02021. (617) 828-1890. Booth 3B29.

Circle 301 on Inquiry Card

MEMORY SYSTEM

Uses MOSFETS.



MOS Memory, MM 602 comes on one 3.5 x 4.3 in. circuit card and has a max. storage capacity of 3200 bits. It is designed for serial storage and random access application. Random address systems require a second card to perform the control logic functions. The system is DTL/TTL interface compatible. Standard Logic, Inc., 1630 S. Lyon St., Santa Ana, Calif. 92705.

Circle 302 on Inquiry Card

designer's keyswitch

Build your own keyboard by using new ALCOSWITCH Keyswitch Modules. A highly reliable reed and magnet combination is employed to provide extremely long life and a low operating force simulating the action of a fine electric typewriter. Modular switches fit into standard 3/4″ centers and have a 10° slanted base for "step up" key formation.

Quantity prices quoted upon request!

Read all about it in this 20-page catalog!

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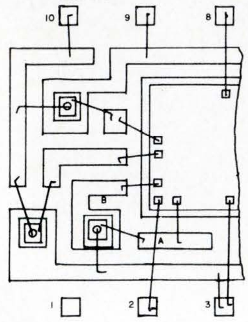
LITERATURE

Thin-film hybrid microcircuits

More than just an interesting brochure, this 6-pager contains basic information about suggested items to use in hybrids. It also provides the reader with guidelines and basic design rules for thin-film designs. While the hybrid business is generally custom, some available circuits are listed with necessary specs: 6-bit ladder network; dual negative reference D/A switch; quad power driver; 4-bit current summing D/A converter; voltage regulator; differential input amplifier; quad attenuator; and analog switch. Micro Networks Corp., 5 Barbara Lane, Worcester, Mass. 01604.



MN202 circuit diagram

Circle 361 on Inquiry Card

Operational amplifier

An 8-page data sheet introduces the Model FS-125 operational amplifier, designed for fast settling on step function input signals. With a closed loop gain of 1, the unit will settle to within 0.1% of full scale in less than 80 nanoseconds after the input is applied. It can be accurately calibrated with dc and remain within 0.1% of its dc accuracy at rates up to 12 MHz. Computer Labs, 1109 S. Chapman St., Greensboro, N.C. 27403.

Circle 362 on Inquiry Card

Relays and coils

A 48-page catalog describes a full line of relays and coils. All units utilize a miniaturized, ruggedized design and are recommended for military and industrial applications. Application notes accompany several of the product write-ups as do schematics and/or pictures for all models. Among the products included are solid state relays, optoelectronic relays, miniature transistor transformers and toroidal inductors. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343.

Circle 363 on Inquiry Card

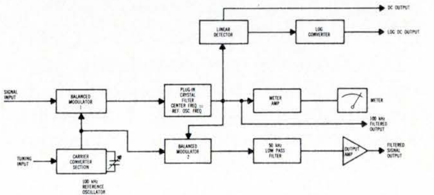
Connectors

A colorful wall chart introduces you to an expanded line of pin and socket connectors. Four new families have been added to the original Poke-Home® and hard dielectric standards —fixed contact, high density, encapsulated contact and power/coax. And they'll mate with the ones you're buying now. The "min-rac six-pac" wall chart outlines and illustrates six connectors, giving contact arrangements, dimensions, contacts, specs and ordering information. Last, but not least, is a section on accessories to help you make the right selection for your needs. Amphenol Industrial Div., The Bunker-Ramo Corp., 1830 South 54th Ave., Chicago, Ill. 60650.

Circle 364 on Inquiry Card

Analysis and control systems

Thirty different applications for the "Dynamic Analyzer" are described and diagrammed for you in this 12-page applications manual. A step-by-step explanation of the instrument's operation helps you to understand its use as the basic instrument in many types of analysis systems. The manual also shows you how the analyzer studies transient or periodic waveforms and plots the energy distribution of random data signals. Spectral Dynamics Corp., Box 671, San Diego, Calif. 92112.



SIMPLIFIED BLOCK DIAGRAM: SD101B DYNAMIC ANALYZER

Circle 365 on Inquiry Card

Facilities and capabilities

With background information established early in this 12-page booklet, you then meet the board of directors, officers and staff. A guided tour follows, showing you the facilities of the plant in action. Finally, you become acquainted with several IC products—the SG402, a self-contained wideband amplifier and multiplier, second source products, and custom circuits utilizing Master-Chips, monolithic devices containing a large number of component types and values for fast circuit fabrication. Silicon General Inc., 7382 Bolsa Ave., Westminster, Calif. 92683.

Circle 366 on Inquiry Card

Field-effect transistors

Dual-gate MOSFETS in color television receivers are evaluated in two application reports. In addition to schematics and performance details, the 8-page report shows how FETS are as effective as vacuum tubes in eliminating cross modulation in tuners. A 16-page report discusses considerations involved in designing an IF amplifier using dual-gate MOSFETS. Again, schematics and functional design curves are included. Texas Instruments Incorp., Box 5012, M/S 308, Dallas, Tex. 75222.

Circle 367 on Inquiry Card

Condensed capacitor catalog

A handy foldout brochure features various styles of capacitors, including porcelain, ceramic and chip types. Each style is identified by capacitor range, voltage rating, temperature coefficient, tolerances available, dimensions, lead spacing, and wire size where applicable. Vitramon Inc., Box 544, Bridgeport, Conn. 06601.

Circle 368 on Inquiry Card

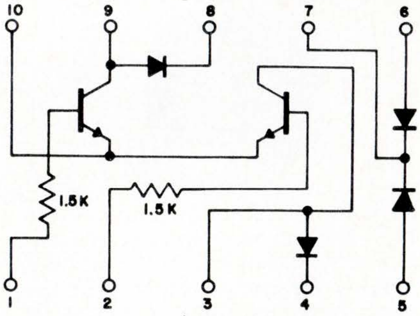
Relays

Drawings and specs are presented for basic and hybrid military TO-5s, industrial TO-5s and industrial solid state relays in this 6-page brochure. Special features and applications are included. Teledyne Relays, 3155 W. El Segundo Blvd., Hawthorne, Calif. 90250.

Circle 369 on Inquiry Card

Resistor networks

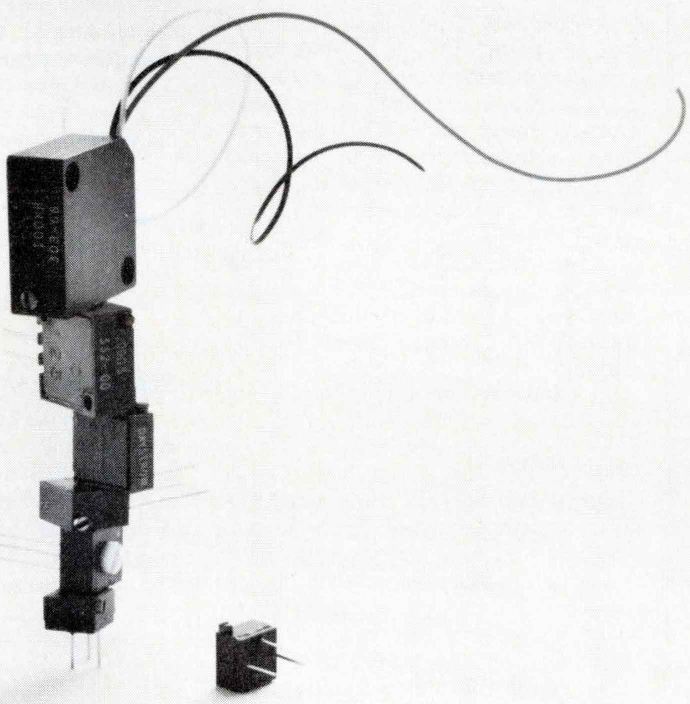
Three separate data sheets cover ladder switches, ladder networks and scale factor networks. A short description of each is provided, as are maximum ratings and operating characteristics. Schematics for each are included in bulletins 29032, 29033 and 29034, respectively. Sprague Electric Co., 115 Northeast Cutoff, Worcester, Mass. 01606.



Circle 370 on Inquiry Card

Circle 65 on Inquiry Card ⟶

How can such a little guy uphold the family reputation?



Our new 561/562 series are true Squaretrim® potentiometers down to the last quarter inch. As the smallest members of this distinguished family, they have to live up to a bigger reputation than other pots their size.

They do. We made sure.

We gave them the same high quality element that makes our military pots so reliable . . . the same tight ±5% tolerance . . . the same wide 10 ohms to 20K standard resistance range and −55°C to +150°C temperature range. We even designed them to meet all environmental requirements of MIL-R-27208, like their larger military brothers.

Models 561 and 562 ¼″ Squaretrims are available in three configurations, top or side adjustable, and they give you a generous 13:1 adjustment ratio. You wouldn't expect a general-purpose pot to have all these features and still be reasonably priced. But it's just another example of how our Squaretrim family supports its reputation as the biggest name in value for the smallest thing in pots.

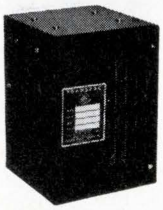
They're in stock now at Weston Potentiometer distributors. Or ask us about special resistance values, data sheets, evaluation samples.

The little guys.

WESTON COMPONENTS DIVISION,
Archbald, Pennsylvania 18403, Weston
Instruments, Inc. a Schlumberger company

WESTON®

GREAT NEW WAY TO BUY DC POWER



ERA's Wide-Range, Variable, All-Silicon DC Power Modules at Low, Low Prices

ERA's new Value-Engineered DC Transpac® power modules provide all-silicon, DC power in a wide-range, variable, low cost module.

Stocking problems are reduced to a minimum and power module obsolescence is practically eliminated. Design changes are easily accomodated since all units can be set to desired voltages by a simple external tap change.

Output Voltage (DC)	Current (71°C)	Model	Price
4-32	0-750 ma	LC32P7	$ 89.00
4-32	0-2 amps	LC322	$115.00
4-32	0-5 amps	LC325	$179.00
4-32	0-10 amps	LC3210	$215.00
30-60	0-1 amp	LC601	$145.00

Over-Voltage Protector Option: Add $35.00 to above prices and Suffix V to Model No. (i.e. LC325V, etc.).

SPECIFICATIONS

Input: 105-125 VAC, 50-400 cps
Ripple: Less than 800 microvolts RMS or .005%, whichever is greater
Line Regulation: Better than ± 0.01% or 5 mv for full input change
Load Regulation: Better than 0.05% or 8 mv for 0-100% load change
Voltage Adjustment: Taps and screwdriver adjustment
Short Circuit Protected: Automatic recovery
Vernier Voltage: External provision
Transient Response: Less than 50 microseconds
Operating Temperature: -20°C to + 71°C free air, full ratings
Maximum Case Temperature: 130°C
Temperature Coefficient: Less than 0.01% per degrees C or 3 millivolts
Long-Term Stability: Within 8 millivolts (8 hours reference)

Write Today for Catalog #147

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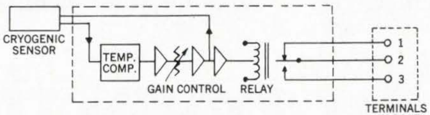
ERA Dynamics Corp. • ERA Pacific, Inc.

Circle 66 on Inquiry Card

LITERATURE

Ultrasonic controls

Divided into three sections, this 28-page catalog discusses two-sensor systems, liquid level systems and a new proximity control which can sense, without contact, the presence of any conducting metallic object within range of the sensing head. Dimensional drawings and block diagrams, as well as photos, accompany many of the instrument descriptions. Delavan Mfg. Co., 811 Fourth St., West Des Moines, Iowa 50265.



Amplifier block diagram

Circle 371 on Inquiry Card

Amplifier transistors

A complete listing of all standard dual, Darlington and differential amplifier transistors available on today's market is contained in an 8-page cross-reference guide. The guide provides electrical specs for all registered devices, allowing easy selection of the appropriate device for a specific application. It designates the package associated with each transistor type and provides dimension diagrams for these packages. Fairchild Semiconductor, Box 1058, Mountain View, Calif. 94040.

Circle 372 on Inquiry Card

Delay relays

Solid state variable time delay relays featuring external knob adjustment for various delay ranges are described in an 8-page bulletin. Photographs, line drawings, electrical characteristics, plug wiring diagrams and mechanical specs accompany the descriptions of four relay families. Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill. 60076.

Circle 373 on Inquiry Card

Regulated power supplies

A selection of ac-dc and dc-dc power supplies designed to provide system or component operating power for various industrial applications are discussed in a 4-page data sheet. Operational configurations and specs are provided as are tables showing characteristics common to each configuration and significant differences. Quindar Electronics Inc., 60 Fadem Rd., Springfield, N. J. 07081.

Circle 374 on Inquiry Card

Fluidic modules

A very readable 28-pager describes in detail Corning's family of fluidic industrial control modules. A basic introduction to fluidic technology is offered as is application data. A handy foldout chart provides symbols and truth tables for each element and gives their corresponding symbols in other technologies. Performance specs and installation instructions for the modules are included, as are performance curves and charts for the various gates. Corning Glass Works, Corning, N. Y. 14830.

Circle 375 on Inquiry Card

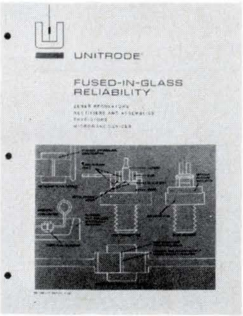
DC measurements

Fundamental techniques of precise dc measurement using four basic instruments are outlined in this 31-page application note. To ensure your understanding of the methods described, calibration terms are clearly defined. After reading of dc measurements and the basic techniques, the subject matter is divided into three sections for your better understanding of the instruments, measurements and problems involved. Hewlett-Packard Co., 195 Page Mill Rd., Palo Alto, Calif. 94304.

Circle 376 on Inquiry Card

Reliability report

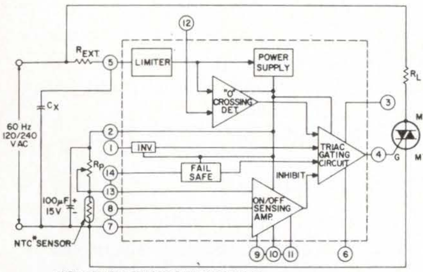
An 11-page booklet covers fused-in-glass reliability as applied to zener diodes, rectifiers and rectifier assemblies, thyristors and microwave pin diodes. A discussion of product design and construction as it affects reliability, failure analysis and corrective action procedures, process control procedures, and acceptance testing procedures is included. One section dealing with reliability engineering as related to the effectiveness of stress screening is provided, as is a summary of operating life test data. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172.



Circle 377 on Inquiry Card

Zero voltage switch

The application of RCA's CA3059 (high voltage switch) in thyristor circuits is covered in application note ICAN-4158. The switch is a monolithic IC used as a trigger circuit for thyristors. The operation of the circuit is discussed in detail with specific reference to its application in thyristor power switching and control circuits. RCA Electronic Components, Commercial Engineering, Harrison, N. J. 07029.



* NTC = NEGATIVE TEMPERATURE COEFFICIENT

Functional block diagram of IC zero-voltage switch.

Circle 378 on Inquiry Card

Control handbook

Specifiers, designers and users of electronic or mechanical logic should find this 288-page manual quite informative. Hardware specs, application notes and product data pertaining to the manufacturer's products, designed for industrial and control applications, are provided. An introduction to solid state logic is included in the guide. Dept. P, Digital Equipment Corp., Maynard, Mass. 01754.

Circle 379 on Inquiry Card

A/D Converter

Series ADC-U converters were designed to provide accurate performance at low cost. An 8-page application manual describes the instruments and offers basic theory, definition of key parameters and operating information. Also included are circuit details and a schematic supplement. Analog Devices, Inc., Pastoriza Div., 221 Fifth St., Cambridge, Mass. 02142.

Circle 380 on Inquiry Card

Tubular filters

Feed thru, L section, T section, Pi section and double L section filters are the subject of a 20-page catalog. Eight graphs show insertion loss characteristics of various types, and drawings and spec tables give technical characteristics. Hopkins Engineering Co., 12900 Foothill Blvd., San Fernando, Calif. 91342.

Circle 381 on Inquiry Card

TTL data selectors

Bulletin CA-132 devotes itself to series 54/74 TTL data selectors. The use of three data selectors or multiplexers that provide selective access to information sources is described in the 18-page report; suggested applications are provided. Various block diagrams are included, illustrating how the selectors function in different applications. Texas Instruments, Inc., Box 5012, M/S308, Dallas, Texas 75222.

Circle 382 on Inquiry Card

Power supply catalog

Power supplies for systems, laboratory, test equipment and OEM applications are described in a 72-page catalog. All-silicon dc power modules, power instruments and power systems are included. Power components include military and industrial models, as well as new lines of ac line regulators and transformers. Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, N.Y. 11746.

Circle 383 on Inquiry Card

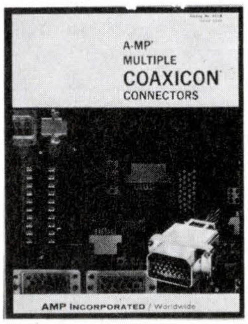
SCRs

A complete line of silicon controlled rectifiers is listed for you in this 16-page selection guide and is accompanied by condensed technical information. Those listed range in current values from 16 to 470 A and −25 to 1300 V. Specs are given in chart form according to type number, and outline drawings accompany all models shown. National Electronics Inc., Subs. Varian, Geneva, Ill. 60134.

Circle 384 on Inquiry Card

Coax connectors

Multiple coax connectors for rack and panel/cable applications are discussed in Catalog 467-8. Selection information is provided in the 52-pager as are updated specs, and application data. Housing configurations and a numerical index lend themselves to making this a useful reference. AMP Inc., Harrisburg, Pa. 17105.



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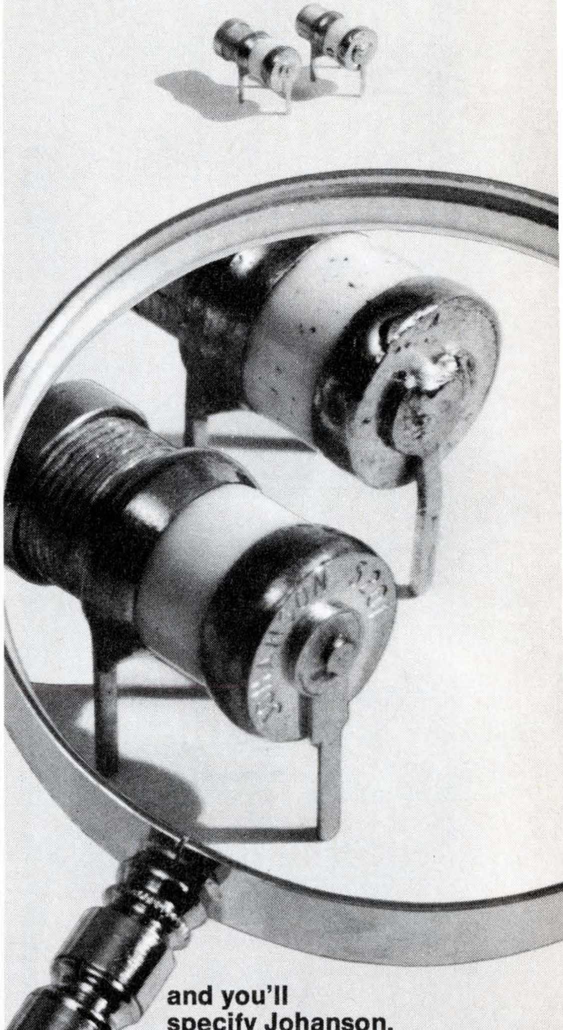

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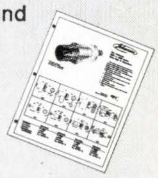

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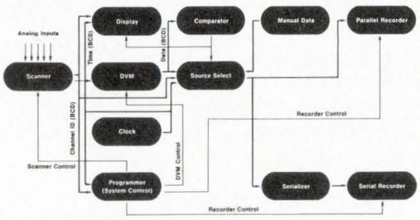
LITERATURE

Data acquisition system

Besides providing you with complete information on the 8000 series data acquisition system, this 16-page brochure helps you to plan a system to fit your particular requirements. After reading about the design, specs, construction, applications and available selections, you simply trace the applicable equipment blocks in the system planning guide on the inserted overlay, fill in the basic systems considerations form and mail it in. Cimron Div., Lear Siegler Inc., 1152 Morena Blvd., San Diego, Calif. 92110.



Circle 386 on Inquiry Card

Connector catalog

New styles are listed in this 48-page catalog and include the SHP 40, a modular PC connector. Also new are two edgeboard additions—the EBTL 050 for 1/32- and 1/16-in. boards with 0.050-in. centers, and the EBT 156 for circuit boards from 0.054- to 0.070-in. thick. Altogether, 18 connector types are included, with dimensional and ordering information provided for all models. Dale Electronics Inc., Box 609, Columbus, Neb. 68601.

Circle 387 on Inquiry Card

Precision and power resistors

A 1970 version of a precision and power wire-wound resistor handbook includes advancements in the resistor field along with updated technical information on various wire-wound resistors. Both precision and power types are discussed and specs for the entire series are provided. Typical curves are included as is a cross-reference chart for Mil spec resistors. RCL Electronics Inc., 700 South 21st St., Irvington, N. J. 07111.

Circle 388 on Inquiry Card

Speed controls

Stock motors and speed controls are the subject of a 20-page catalog. You will find data on more than 325 fractional motors and gear motors ranging from 1/2000 to ¼ hp, and on adjustable speed/torque drive systems. The line of motor speed controls listed includes both chassis and enclosed types. Bodine Electric Co., 2500 W. Bradley Place, Chicago, Ill. 60618.

Circle 389 on Inquiry Card

Filters and modulators

Passive and active electronic filters and modulators comprise this 12-page brochure. Filter specification and solid state modulator specification forms are enclosed for you, and room is left for you to sketch size and terminal requirements and attenuation requirements. You become familiar with the company's test facilities and capabilities as well as its product line. KDI Navcor West, 15551 Cabrito Rd., Van Nuys, Calif. 91406.

Circle 390 on Inquiry Card

Rectifier round-up

A range of high voltage selenium and silicon rectifiers are discussed in bulletin RB3001. The devices have been designed for use in X-ray equipment, radar ovens, precipitators, radar, and oscilloscopes. Descriptions of puck type, cartridge and block rectifiers are provided in the 4-pager, along with diagrams and formulas which should prove useful to the circuit designer. General Instrument Corp., 65 Gouverneur St., Newark, N. J. 07104.

Circle 391 on Inquiry Card

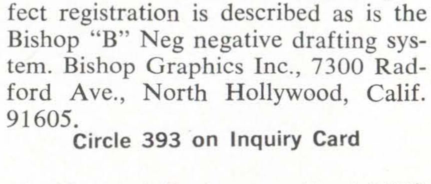
Diode assemblies

Methods for improving discrete diode designs by means of multifunctional diode assemblies and monolithic arrays are discussed in this 24-page designer's guide. Diode charts are provided, containing electrical parameters, thermal ranges and matching data needed for the evaluation of assembly and array designs. Fairchild Semiconductor, Box 1058, Mountain View, Calif. 94040.

Circle 392 on Inquiry Card

Technical manual

To aid you in the preparation of artwork for printed wiring boards, this 68-page manual describes more than 15,000 pressure-sensitive electronic component drafting aids, techniques and systems. A photographically compatible method of preparing artwork for two-sided boards in perfect registration is described as is the Bishop "B" Neg negative drafting system. Bishop Graphics Inc., 7300 Radford Ave., North Hollywood, Calif. 91605.



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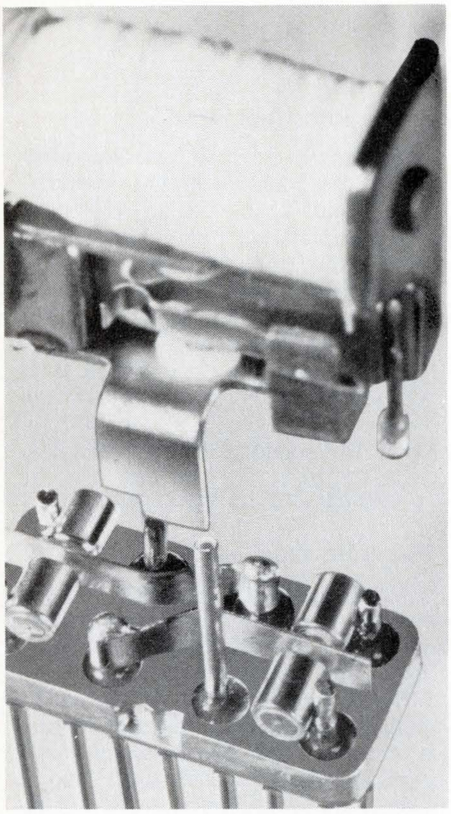

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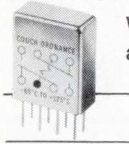

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LITERATURE

Silicon power transistors

To help you choose silicon power transistors for your new equipment and to find suitable replacements for devices used in older designs, this 8-page selector guide and cross-reference chart provides a listing of a complete line of PNP and NPN silicon power transistors. About 200 devices rated at currents between 100 mA and 30 A, and at voltages up to 400 V, are included. Motorola Semiconductor Products Inc., Box 20912, Phoenix, Ariz. 85036.

Circle 394 on Inquiry Card

Power supplies

An updated supplement of a power supply catalog covers modules for IC systems, dual modules for linear circuits and a new extension of the company's ferroresonant regulators, featuring voltage selection by internal taps. Also listed and described are bipolar power amps up to ±72 V at ±5 A, and high voltage operational power supplies at 0-500 V, 0-1000 V and 0-2000 V at 20 W. Kepco Inc., 131-38 Sanford Ave., Flushing, N. Y. 11352.

Circle 395 on Inquiry Card

Systems and capabilities

Several of the products featured in this booklet include packaged drives for use in industrial environments, solid state inverters for variable frequency power, IC digital products for industrial and process applications and engineered systems coordinating system components into a custom control panel. Technical and operating capabilities are illustrated. Emerson Electric Co., Industrial Systems and Controls Div., 540 New Haven Ave., Milford, Conn. 06460.

Circle 396 on Inquiry Card

Microwave products

Complete information on microwave products, including connectors, cable assemblies, adapters, instruments and components, is offered to you in this 84-page catalog. Facilities and capabilities are described for you, and the location of your nearest distributor or representative is provided. Products are also conveniently indexed by model number, and dimensional diagrams accompany nearly every model described. Omni Spectra Inc., Michigan Div., 24600 Hallwood Ct., Farmington, Mich. 48024.

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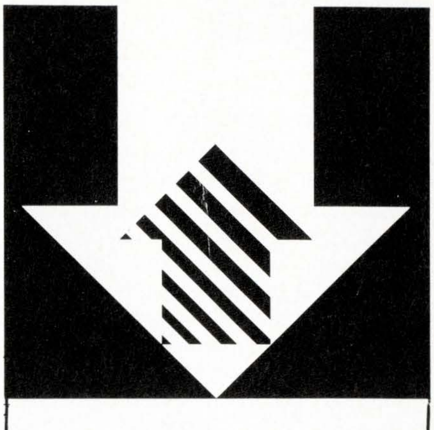

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Circuits compendium

Catalog WR-125A provides salient information for a line of thin-film hybrid circuits and transistor chips. The devices discussed include TTL and high-speed TTL ICS, MSI integrated circuit arrays, linear ICs 3:, thin-film hybrid circuits, transistors and chips, and flat-pack hermetic packages. All listed circuits are indexed by type numbers, and schematics are provided throughout the literature. Sprague Electric Corp., Marshall St., North Adams, Mass. 01247.

Circle 398 on Inquiry Card

Design guide

A 20-page short form catalog and design guide describes SSPI-product-group thyristors, high-power transistors, gate turn-off SCRS, photo SCRS and hybrid power ICS. For your convenience SCRS are categorized by Mil, high speed and industrial types and transistors by power, power switching, and high voltage power and power switching types. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172.

Circle 399 on Inquiry Card

Noise figures

A variety of methods have been used to measure and specify noise characteristics of amplifiers. A 3-page booklet titled "How to use noise figure contours" briefly describes the sources of amplifier noise and provides a method for determining it. Examples of typical amplifier matching problems are included. Princeton Applied Research Corp., P.O. Box 565, Princeton, N. J. 08540.

Circle 400 on Inquiry Card

Variable resistors

Electrical and mechanical specs for commercial composition variable resistors 15/16 in. in diameter and with a power rating from ¼ to ¾ W are listed in this 20-page catalog. Mechanical characteristics are outlined and diagrammed, and dimensioned drawings illustrate construction features. Information on available rotary switches is included, and additional diagrams illustrate terminal configurations. CTS Corp., 905 N. West Blvd., Elkhart, Ind. 46514.

Circle 401 on Inquiry Card

Hermetic connectors

"Solderless Miniature Hermetic Connectors Join Integrated Termination System" is the title of a 14-page article explaining why industry has moved away from the use of solder in terminating resilient connectors. The article promotes the advantages of the NAS-type rear release/rear insertion termination method which does not sacrifice sealing capabilities or add weight. Deutsch Co., Electronic Comp. Div., Municipal Airport, Banning, Calif. 92220.

Circle 402 on Inquiry Card

Magnetic tape heads

Detailed specifying information on magnetic heads for audio, mastering, duplicating, instrumentation and mini-digital applications is provided in this 24-page catalog which serves as a guide to solving head design problems. It contains technical data and full physical and electrical specs and a wall chart of recording track configurations. Nortronics Co. Inc., 8101 Tenth Ave. North, Minneapolis, Minn. 55427.

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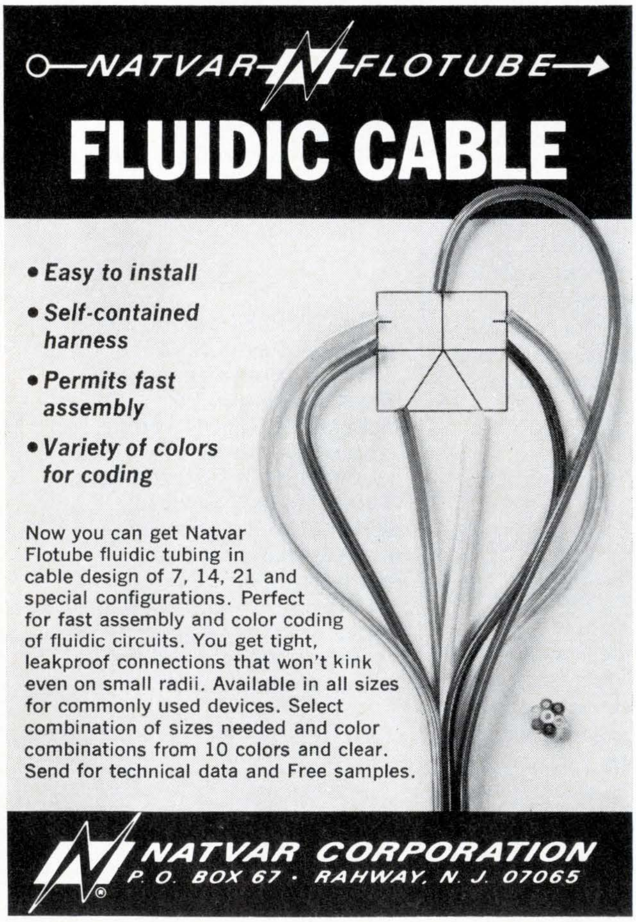
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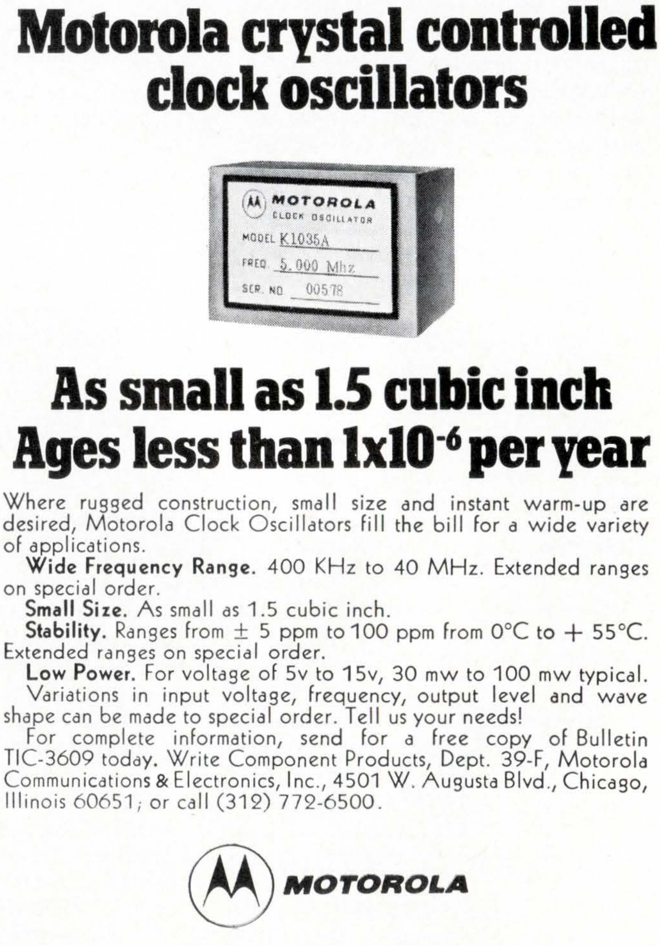
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Minireed relays, −55° to +125°C, utilize single-pole, single-throw normally open contacts. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343.
Circle 404 on Inquiry Card

Resistive terminations consist of coaxial resistor in matched housing and type N male or female connectors—2 pages. Maury Microwave Corp., 8610 Helms Ave., Cucamonga, Calif. 91730.
Circle 405 on Inquiry Card

Pulse instrumentation, 4-page, condensed catalog features pulse generators and data generators. Systron-Donner Corp., 10150 W. Jefferson Blvd., Culver City, Calif. 90230.
Circle 406 on Inquiry Card

Stacking connector with staggered, balanced contact eliminates intermittent connections in interconnecting PC boards; it has been designed primarily for use in the computer industry—2-page data sheet. Hugh H. Eby Co., 4701 Germantown Ave., Philadelphia, Pa. 19144.
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Liquid cooling system for removing heat from high current devices—4 pages. Thermalloy Co., 8717 Diplomacy Row, Dallas, Tex. 75247.
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Variable dc voltage standard has 1 μV resolution and 0.005% accuracy — 2 pages. Esterline Angus, Box 24000, Indianapolis, Ind. 46224.
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Jack receptacle, incorporating a 3-slot female contact to prevent mismating, is constructed of gold-plated stainless steel, Teflon, and gold-plated beryllium copper — product bulletin CX-602. Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. 10543.
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Residual gas analyzer features all solid state electronics—2 pages. Varian, 611 Hansen Way, Palo Alto, Calif. 94303.
Circle 411 on Inquiry Card

Semiconductor packaging for hybrid microcircuits — 1 page. Circa Tran Inc., Box 832, Wheaton, Ill. 60187.
Circle 412 on Inquiry Card

Filter holder, made of inert polyvinyl chloride, was designed for microfiltering deionized water without compromising its ionic purity—product bulletin PVC-142. Millipore Corp., Bedford, Mass. 01730.
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Synchro-to-digital converter accepts angular data from remote synchros and resolvers and converts it to a true digital display — engineering bulletin 67-11B. Theta Instrument Corp., Fairfield, N. J. 07006
Circle 414 on Inquiry Card

Cermet resistor network increases packaging flexibility with a 16-lead dual-in-line package—2 pages. CTS of Berne Inc., Berne, Ind. 46711.
Circle 415 on Inquiry Card

High performance op amps designed for use in precise servo applications as building blocks in a control system (models PA-101 and PA-102)—bulletins 101-01 and 102-01. Torque Systems Inc., 225 Crescent St., Waltham, Mass. 02154.
Circle 416 on Inquiry Card

Plastic bonding adhesives, a 4-page catalog, designates the proper adhesive for each plastic bonding application. 3M Co., 3M Center, St. Paul, Minn. 55101.
Circle 417 on Inquiry Card

Pressure sensitive transistor can provide a linear output voltage, amplify or switch other electrical signals, or can be used as the active element in an oscillator for FM or PWM outputs—7 pages. Stow Labs., Inc., 152 Kane Industrial Dr., Hudson, Mass. 01749.
Circle 418 on Inquiry Card

Tunnel diode detectors with frequency ranges from 0.1 to 26.5 GHz. The 4-pager includes a connector table and specs. Aertech Ind., 825 Stewart Dr., Sunnyvale, Calif. 94086.
Circle 419 on Inquiry Card

Flexible cables for use in instrumentation, transducers and miniaturized computer memories—4 pages. Caltron Ind., 2015 Second St., Berkeley, Calif. 94710.
Circle 420 on Inquiry Card

Diagnostic computer for functional testing of logic devices identifies and isolates defects — 4 pages. Digital General Corp., 11000 Cedar Ave., Cleveland, Ohio 44106.
Circle 421 on Inquiry Card

MOS memory tester for wafer-probing and final test applications of MOS and LSI memories—4 pages. Redcor Corp., Box 1031, Canoga Park, Calif. 91304.
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Instrumentation recorder, portable or rack mounted — 6 pages. Ampex Corp., 401 Broadway, Redwood City, Calif. 94063.
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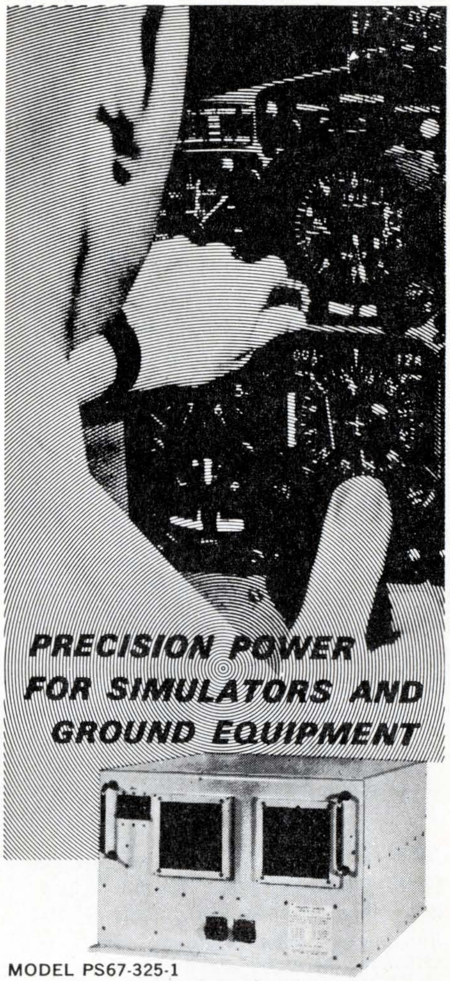

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LITERATURE

TTL 54/74 series performance guide gives hints on preset and clear pulses, expanders and decoupling—1 page. National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. 95051.

Circle 424 on Inquiry Card

Filters, notch and highpass, for eliminating 60-Hz and 400-Hz frequencies and their harmonics. Genisco Technology Corp., 18435 Susana Rd., Compton, Calif.

Circle 425 on Inquiry Card

Miniature power converters in a 4-page catalog giving features, specs, modifications and mounting dimensions. Arnold Magnetics Corp., 11264 Playa Court, Culver City, Calif. 90230.

Circle 426 on Inquiry Card

Microminiature chip resistors for breadboard designs, hybridizing of circuits and strip-line applications—2 pages. CTS Microelectronics Inc., West Lafayette, Ind. 47906.

Circle 427 on Inquiry Card

MOS/LSI functional test system-PAFT II—4 pages. Redcor Corp., Box 1031, Canoga Park, Calif. 91304.

Circle 428 on Inquiry Card

Extended arithmetic unit, its features, programming, specs and equipment—4 pages. Rolm Corp., 10925 N. Wolfe Rd., Cupertino, Calif. 95014.

Circle 429 on Inquiry Card

Cross-over power inverter intercepts power failure and supplies voltage through a storage battery and inverter with capacities to 1000 W—1 page. Terado Corp., 1068 Raymond Ave., St. Paul, Minn. 55108.

Circle 430 on Inquiry Card

Gravity sensitive electrolytic transducers with drawings and recommended circuit parameters—2 pages. Hamlin Inc., Lake & Grave Sts., Lake Mills, Wis. 53551.

Circle 431 on Inquiry Card

Four-bit transfer register module contains 12 integrated circuit J-K flip-flops—2 pages. Information Control Corp., 1320 East Franklin Ave., El Segundo, Calif. 90245.

Circle 432 on Inquiry Card

Dc amplifier is an all solid state silicon differential dc amplifier designed primarily for application as a dc or ac op amp—4 pages. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343.

Circle 433 on Inquiry Card

Plastic hot-carrier diode may be used in UHF mixer applications, detector and ultrafast switching circuits—2 pages. Motorola Semiconductor Products Inc., Box 20912, Phoenix, Ariz. 85036.

Circle 434 on Inquiry Card

Op amps, wideband FET operational, designed specifically for fast settling to step inputs—2 pages. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706.

Circle 435 on Inquiry Card

Proximity controls and sensors for edge guide control, jam-up, void and run-out control, etc.—2 pages. De-Tec-Tronic Controls, 2512 North Halsted St., Chicago, Ill. 60614.

Circle 436 on Inquiry Card

Dip test sockets designed for high-speed hand testing of dual-in-line devices, technical bulletin TB 543. Barnes Corp., 24 N. Lansdowne Ave., Lansdowne, Pa. 19050.

Circle 437 on Inquiry Card

Power supply, ±15-V regulated power at 60 mA—1 page. California Electronic Mfg. Co. Inc., Box 555, Alamo, Calif. 94507.

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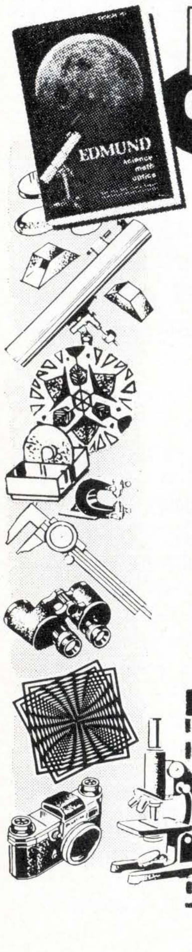

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Monda McCarter & Smith
AMERICAN MACHINE & FOUNDRY CO.,
POTTER & BRUMFIELD DIV. ....32 & 33
Grant, Wright & Baker, Inc.
AMP, INC. 53
Aitkin-Kynett
AUGAT, INC. 116
Horton, Church & Goff, Inc.

BECKMAN INSTRUMENTS, INC.
EID DIV. 16
HELIPOT DIV. 82
N. W. Ayer/Jorgensen/Macdonald, Inc.
BEEDE ELECTRICAL INSTRUMENT CO. 93
Weston Assoc., Inc.
BUSSMANN MFG. DIV. 62
Henderson Adv. Co.

CENTRALAB, DIV. OF GLOBE UNION 22
The Brady Co.
CHEMICAL MICRO MILLING CO. 68
Robert H. Kiefreider Assoc.
C & K COMPONENTS, INC. 88
Van Christo Assoc., Inc.
C. P. CLARE CO. 19
Reincke, Meyer & Finn
COMPONENTS, INC. 117
Owens & Assoc. Adv., Inc.
COMPUTER DESIGN CONFERENCE 98
Kiver Publications, Inc.
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FAIRCHILD CAMERA & INSTRUMENT CORP. 96
John Meade, Inc.
FAIRCHILD SEMICONDUCTOR ....28 & 29 &
Inside Back Cover
Chiat/Day, Inc.
FERROXCUBE CORP. 15
W. H. Schneider, Inc.

GENERAL INSTRUMENT CORP.
SEMICONDUCTOR ASSEMBLY DIV. ..6 & 7, 43
Norman Allen Assoc., Inc.
GLENAIR, INC. 4
T. F. Murray & Assoc., Inc.
GRAYHILL, INC. 136
Carr Liggett Adv., Inc.

HANOVER FAIR 1970 133
German American Chamber of Commerce
HEATH CO. 113
Advance Adv. Service
HEWLETT-PACKARD ASSOCIATES 51
Lennen & Newell/Pacific
HEWLETT-PACKARD CO.
COLORADO SPRINGS DIV...Inside Front Cover
LOVELAND DIV. 90
Tallant/Yates Adv., Inc.
HUGHES AIRCRAFT CO. NPB/MOSFET DIV. 121
Foote, Cone & Belding

IDEAL PRECISION METER CO., INC. 30
Fein, Silver & Soloway, Inc.
INSTRUMENT PRODUCTS DIV. OF 3M CO.. . 20
Reach, McClinton & Co., Inc.
INTERELECTRONICS, INC. 109
Samuel H. Meyer Adv., Ltd.

JOHANSON MFG. CO., INC. 131
Josephson, Cuffari & Co.

LICON DIV. ILLINOIS TOOL WORKS ...44 & 45
Hurvis, Binzer & Churchill, Inc.
LITTELFUSE, INC. 92
Burton Browne Adv.

MAGNETIC METALS CO. 50
Robert H. Kiefreider Assoc.
McCOY ELECTRONICS CO. 81
Buchen Adv., Inc.
MID-EASTERN INDUSTRIES,
DIV. EANCO, INC. 88
Halloff & Caine Assoc.
MILLER-STEPHENSON CO. 58
Michel-Cather, Inc.
3M CO., INDUSTRIAL CHEMICAL DIV. 89
Young & Rubicam, Inc.
MONOLITHIC DIELECTRICS 124
Eastman Adv.
MOTOROLA COMMUNICATIONS &
ELECTRONICS, INC. 134
Brand Adv., Inc.

NATIONAL ELECTRONICS, INC. 119
Connor-Sager Assoc., Inc.
NATVAR CORP. 134
Sanger-Funnell, Inc.
NORTON ASSOCIATES, INC. 126
J. J. Coppo Co., Inc.

PANDUIT CORP. 124
Donald L. Arends, Inc.
PHILCO FORD CORP. 69
Aitkin-Kynett Co., Inc.
POTTER & BRUMFIELD DIV.
AMERICAN MACHINE & FOUNDRY CO.
32 & 33
Grant, Wright & Baker, Inc.

RCA ELECTRONIC COMPONENTS
CIRCUIT MODULES DIV. 101
DIGITAL INTEGRATED CIRCUITS DIV. ... 123
DISTRIBUTOR PRODUCTS DIV. 95
POWER TRANSISTORS DIV. 86
POWER TUBES DIV. ....Back Cover
TEXT EQUIPMENT DIV. 104
Al Paul Lefton Co., Inc.
RAYTHEON COMPUTER 111
Durel Adv.

SANGAMO ELECTRIC CO. 107
Winius-Brandon Co.
SEALECTRO CORP. 105
Lescarboura Adv., Inc.
SPRAGUE ELECTRIC CO.
CAPACITOR AND RESISTOR DIV. 1
The Harry P. Bridge Co.
SYLVANIA ELECTRIC PRDTS., INC. 11, 35-42
Doyle Dane Bernbach, Inc.

TELEDYNE RELAYS 13
S. Michelson Adv.
TERADYNE, INC. 8
Quinn & Johnson, Inc.
TRYGON ELECTRONICS, INC. 132
Technical, Industrial & Scientific Mktg., Inc.

UNITRON 135
Warren Assoc.

VARO, INC., SEMICONDUCTOR DIV. 116
Tracy-Locke, Inc.
VIDAR CORP. 102
Bill Fisher Adv.
VIKING INDUSTRIES, INC. 2
Jansson Adv., Inc.
VISHAY RESISTOR PRDTS., INC. 52
Larwin Adv.

WATKINS-JOHNSON CO. 54
William C. Estler
WAVETEK 74
Chapman Michetti Adv.
WESTON INSTRUMENTS, INC.
ARCHBALD DIV. 129
Arndt, Preston, Chapin, Lamb & Keen, Inc.

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Index to Product Information

Listed below are all products and new literature that appear in this issue, along with the page number they appear on and their Reader Service Numbers (RSN). For more information, see the appropriate page and circle the corresponding number on the reader service card.

LINEAR

Linear Integrated Circuit technology is happening so fast, it's difficult to determine which development to advertise first. So, we've decided to advertise everything at once. As it happens.

Every month, you'll see this weird-shaped ad in the trade press. It will include new product announcements, applications, marketing decisions, assorted breakthroughs, a design contest, what-have-you. Sort of a something-for-everybody compendium of LIC information. If you see something you like, write us and we'll tell you more about it.

New Product Digest

In addition to the μA715 and μA725, Fairchild is introducing the following new Linears:

μA731 **Dual Channel Sense Amplifier**
2mV Threshold Accuracy
5nSec Strobe Time Variation
Internal Memory Data Register
Reader Service Number 122

μA735 **Micro Power Amplifier**
100μW Power Consumption
2nA Offset Current
±3V to ±18V Supply Voltage
10MΩ Input Resistance
Reader Service Number 123

μA739 **Dual Low Noise Op Amp**
$1\mu V_{rms}$ Noise (20Hz to 150KHz)
50μA Offset Current
20,000 V/V Voltage Gain
Reader Service Number 124

μA742 **Zero Crossing AC Trigger**
Operates from AC or DC Supply
2 Amps Peak Output Current
Time Proportioning Operation
Adjustable Hysteresis
Reader Service Number 125

μA747 **Dual Internally Compensated Op Amp**
Short Circuit Protected
Latch-up Proof
Offset Voltage Null Capability
± 30V Differential Input Voltage
200,000 V/V Voltage Gain
Reader Service Number 126

μA748 **High Performance Op Amp**
Short Circuit Protected
Latch-up Proof
±30V Differential Input Voltage
200,000 V/V Voltage Gain
Reader Service Number 127

μA749 **Dual Op Amp**
92dB Voltage Gain
20MHz Bandwidth
Latch-up Proof
Short Circuit Protected
Reader Service Number 128

EDITORIAL

If We Can't Sell You Ours, We'll Sell You Theirs.

For a long time, Fairchild built only linears designed by Fairchild engineers. We didn't think anything else was worth the effort. People said we had an NIH (Not Invented Here) complex. And, they were right.

However, it's been brought forcefully to our attention that a couple other guys in this business know what they're doing. The competition is coming out with some pretty worthwhile linears. Our customers have noticed too, because they're talking to other manufacturers about linears we don't make. They're even talking to sole sourcers!

To keep things even, we've decided to give our wandering customers something they're going to need if they start dealing with a sole source linear maker: A second source. Us. (Just in case the original supplier's factory blows up or they lose the formula or whatever it is that happens when you can't get delivery.)

Starting now, Fairchild is introducing a new line of linears. We call them IT circuits (Invented There). The first two are available today: The LM101 and the MC1495. Soon we'll add the LM101A, MC1496 and the SN7524. Of course, we've given them Fairchild part numbers. Here's a conversion chart:

μA795	Analog Multiplier	MC1495
μA796	Modulator	MC1496
μA748	Operational Amplifier	LM101
μA777	Operational Amplifier	LM101A
μA761	Sense Amplifier	SN7524

There will be other additions to the IT line soon. So be sure you contact your local Fairchild Sales Engineer before you drop a design for lack of a reliable alternate source. Just give him the part number you want and ask him to check the IT line. Farewell NIH.

Reader Service Number 129

Contest

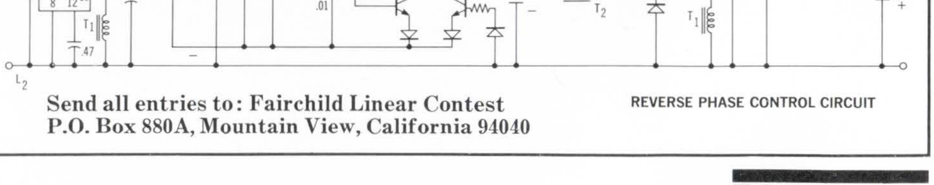
Last year, Fairchild gave a series of seminars on Linear Integrated Circuits in which we introduced 12 new products. One device, the μA742 TRIGAC Zero-Crossing A.C. Trigger, was so significant we offered a free sample to anyone who came up with an original application for it. We got hundreds of replies. The most ingenious was sent in by Richard M. Burkhart, a graduate student at the University of Illinois. We liked Richard's application so much, we decided to give him $100. Then, we liked the $100 idea so much, we decided to make it a contest.

Here's how it works:

1) Get all the facts on a Fairchild Linear IC.
2) Design the world's greatest application for it.
3) Send the application to us.

All entries will be judged by the editors of EEE Magazine. Every month, they will select the most fantastic application and give us the designer's name. We'll publish the winning design here and give the winner $100 upon publication.

To give you an idea of what we're looking for, here's Richard Burkhart's design:



REVERSE PHASE CONTROL CIRCUIT

Send all entries to: Fairchild Linear Contest
P.O. Box 880A, Mountain View, California 94040

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

FAIRCHILD
SEMICONDUCTOR

New Op Amp has Gain of 3,000,000.

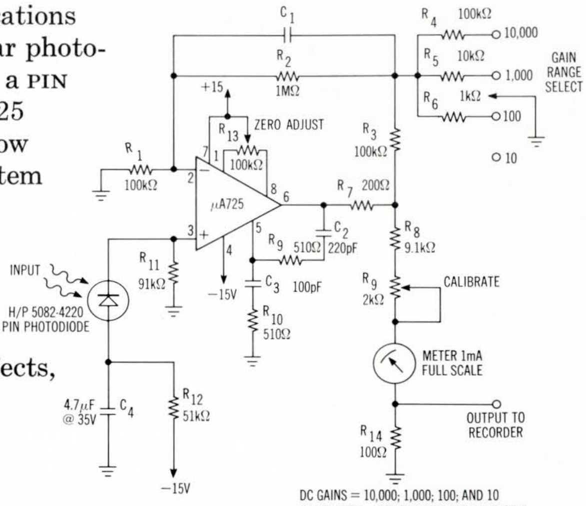
Fairchild's new μA725 Instrumentation Operational Amplifier can do the same jobs that used to require expensive chopper-stabilized or complex discrete component amplifiers. The μA725 is ideally suited for use in Low Level Signal Conditioners, Instrumentation Amplifiers, Precision Measuring Equipment, Process Control Systems and Data Acquisition Equipment.

Electrical Performance/Features

Low Input Noise Current	0.6pA/ Hz
High Open Loop Gain	3,000,000
Low Input Offset Current	3nA
Low Input Offset Voltage Drift	0.5μV/°C
High Common Mode Rejection	120dB

One of the many applications for the μA725 is in Linear photodetection systems. Use of a PIN Photodiode with the μA725 provides the user with a low noise linear detection system which operates from low voltage supplies and has none of the inherent disadvantages of photomultiplier tubes (high voltage supplies, aging effects, large physical size, high power dissipation).

Reader Service Number 120



DC GAINS = 10,000; 1,000; 100; AND 10
BANDWIDTH = DETERMINED BY VALUE OF C_1
GAIN ACCURACY × 1000 0.03%

μA725 PIN PHOTODIODE AMPLIFIER

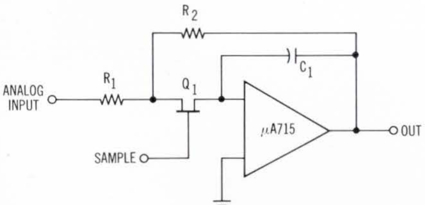
μA715 Basis of Fast Sample / Hold Circuit.

Many data acquisition systems require a sample and hold circuit to improve analog-to-digital conversion accuracy. The requirements of a good S/H circuit are:

1. minimum droop during the hold period
2. high open loop gain for good closed loop gain accuracy
3. high speed
4. minimum temperature drift

A basic sample and hold circuit configuration looks like this:

In the sample mode, the sampling switch Q_1 is turned on and the circuit functions as an inverting operational amplifier.



BASIC OPERATIONAL SAMPLE AND HOLD CIRCUIT

When Q_1 is switched off, the circuit functions as an integrator, holding the output voltage constant at the sampled value.

The acquisition time when going from the hold mode to the sample mode is a function of the time constant R_2C_1 and the required accuracy, and is given by:

$$t_a = R_2C_1 \ln \left(\frac{100}{\%\ \text{accuracy}}\right)$$

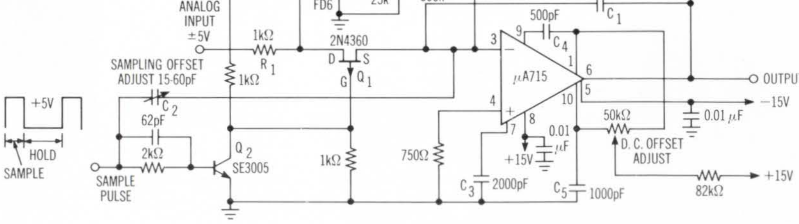
A complete sample and hold circuit is shown below. It includes the components necessary to compensate for the DC and AC errors inherent to the basic configuration. The DC offset is adjusted to zero by a 50k potentiometer (R_4). C_3, C_4, and C_5 provide unity gain frequency compensation.

A junction field effect transistor is used as the sampling switch Q_1. Because there is some capacity from the gate to the source of Q_1, a portion of the gate signal to the switch is coupled through the device onto the holding capacitor C_1 causing an offset error which is bucked out by an opposing signal, coupled by C_2, from the sample pulse input onto the holding capacitor.

Holding Accuracy. During the hold time the output voltage will tend to drift as the holding capacitor integrates the input bias current of the amplifier. This drift is compensated by supplying temperature compensated bias current from a separate source, R_5, R_6, R_7 and D_1.

With a 10 volt step input (±5 volts to ∓5 volts) the settling time to ±0.05% is 10μsec. This is slightly longer than that given by equation 1 due to the finite "on-resistance" of the sampling switch Q_1. If C_1 is decreased to 100pF the settling time is about 1μsec. Temperature drift of the output in the hold mode is approximately 0.001% per degree Centigrade for a hold time of 100μsec.

Reader Service Number 121



μA715 SAMPLE AND HOLD CIRCUIT

Four power levels for SSB

Now . . .
four tubes for SSB. And four power levels—500 W, 1 kW, 5kW, and 10 kW. These rugged Cermolox® tubes, developed from proved, in-use designs, feature new low in feedthrough capacitance and screen and cathode inductance plus superb IM characteristics. Their rugged construction makes them suitable for mobile service in shipboard and airborne equipment as well as in fixed stations.

Available at surprisingly low cost, the four are: 8791, 8792, 8793, and 8794. In addition to their efficient use in SSB service, the tubes are attractive for FM, VHF-TV, and VHF/UHF communications.

See your RCA Representative for details, including prices and delivery. For technical data on specific types, write: RCA Electronic Components, Commercial Engineering, Section **CT-50**, Harrison, N.J. 07029. In Europe: RCA International Marketing S.A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

RCA

Circle 76 on Inquiry Card