VOL. 19 NO.

Electronic Design 11

FOR ENGINEERS AND ENGINEERING MANAGERS

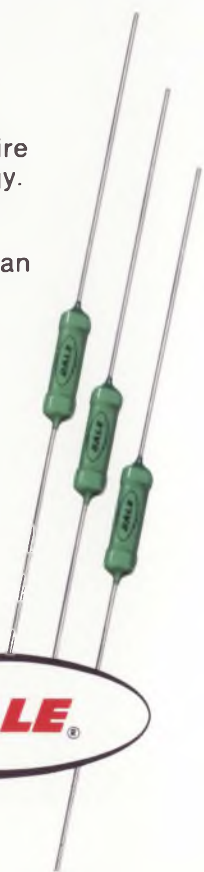
MAY 27, 1971

Optoelectronics arrives in 1971 as a powerful, new solid-state design discipline. Basic building blocks in this growing area of technology are radiation emitters and sensors – ranging from the near infrared to the ultraviolet. For design insight on these and other optoelectronic components, see the report beginning on p.44.

This illustration generated on a custom-built computer (containing Dale resistors, of course).

...all available now from Dale.

Nothing new in resistors? Forget it! Dale has just opened an entire new area of cost-saving, stability-improving metal film technology. From basic MIL-R-10509 configurations, you can get a multitude of broadened functions. They're standard, not special...and they're available now. Check today. No other metal film source can meet *all* your requirements as fast as Dale.



T.C.'s as low as 10 PPM – 10 PPM/°C standard for 1/10 to 1/2 watt (0 to +80°C), 100 ohms to 400K ohms. Broader ranges in 15 & 20 PPM. Complete 26-model line available with 25 PPM/°C (−55°C to +175°C); 15 ohms to 5.11 megohms.

Tolerance as low as .01% – In models from 1/10 to 1/2 watt with values from 49.9 ohms to 2 megohms, depending on size. Made on established reliability (MIL-R-55182) line.

Values as low as 1 ohm and as high as 1800 megohms – 1/10 thru 1/2 watt = 1 ohm (150 PPM); .25 thru 5 watts = 80 megohms to 1800 megohms, depending on size (1000 PPM); 1/10 thru 1/2 watt = 50 megohms (150 PPM).

Power as high as 10 watts – Coated and molded styles (2.188" L x .375" D max.) deliver 10 watts at 25°C, 5 watts at 70°C. Permit more power in less space and excellent stability and T.C. control.

To get more functions with less fuss, call 402-564-3131 today

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DALE ELECTRONICS, INC. In Canada: Dale Electronics Canada, Ltd.
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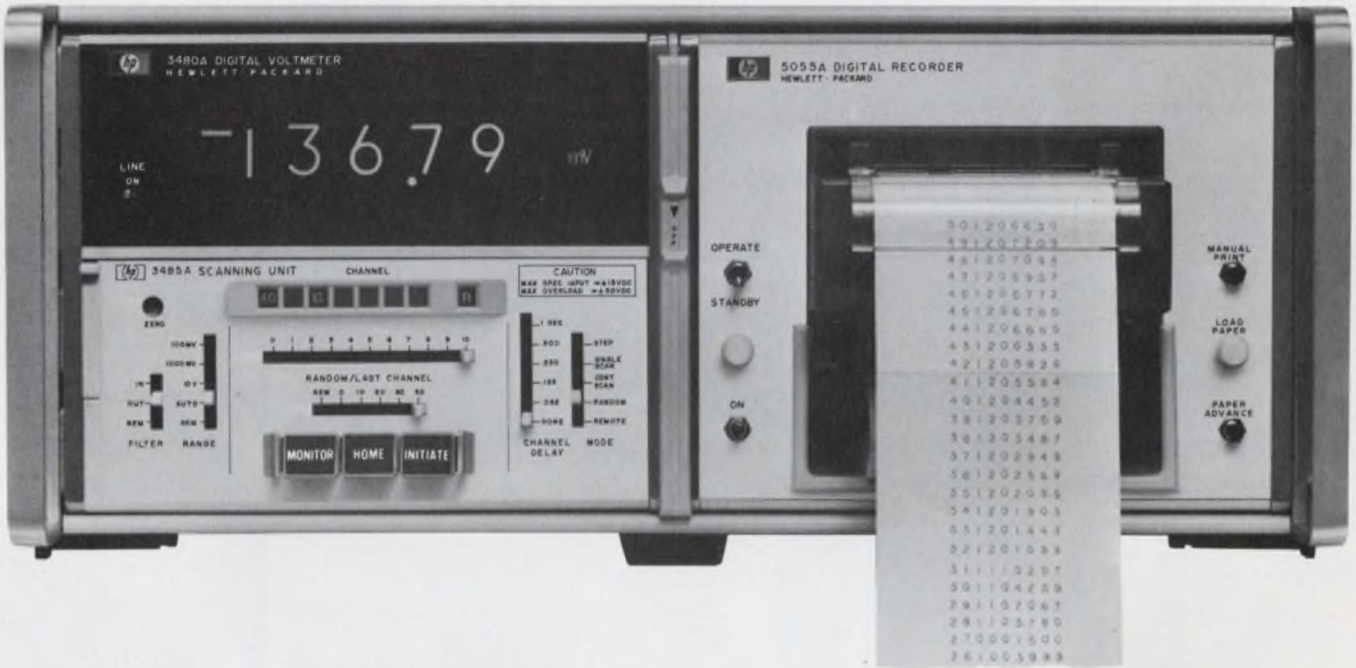
INFORMATION RETRIEVAL NUMBER 181

HP's new 50-channel data acquisition system.



It costs $4,475.

You're looking at HP's new 2070A Data Logger—the most exciting development in data acquisition systems in years.

Why do we say it's that exciting? Because the 2070A gives you **more data-acquisition capability per dollar** than any other system you can buy!

Specifically, it lets you monitor up to **50 two-wire channels,** at up to **1,000 channels/sec.** It lets you monitor inputs in three dc voltage ranges (100 mV, 1 V and 10 V)— with **built-in autoranging capability.** It lets you sample any of the 50 channels, on a random basis, or scan all 50—on either a single-scan or continuous-scan basis. And it gives you a **permanent, digitized record,** in the form of a print-out, in addition to an instantaneous, 4-digit display.

Other features include isolated BCD output, and remote-control capability. Yet the entire system—packaged as a compact, portable, self-contained unit—costs only $4,475. And for $1,000 extra, you can get a built-in data storage option that holds up to 50 readings—to let you scan at high speed, and then print out the results at a lower speed (10 readings/sec).

Applications for the 2070A include process control, production testing, environmental monitoring systems, drift measurements, vibration analysis, single-shot transient analysis, and many more. If you're involved in one of these things—or in anything that requires data-acquisition—contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

091/17

HEWLETT hp PACKARD

DIGITAL VOLTMETERS

INFORMATION RETRIEVAL NUMBER 2

Electronic Design 11

VOL. 19 NO.

FOR ENGINEERS AND ENGINEERING MANAGERS

MAY 27, 1971

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DISPLAY REGISTER
PRESET
INTERNAL
EXTERNAL
FETCH
IND
EXEC
PARITY ERROR
MEMORY DATA
RUN
HALT/CYCLE
INSTRUCTION STEP
INTERRUPT SYSTEM
EXTD
O/F
CLEAR DISPLAY
DECREMENT M
INCREMENT M

Meet the thoroughly modern mini: our new HP 2100 computer.

It's much more than a pretty new face.

It's a big step forward in small computers.

The HP 2100 combines all three of our earlier minicomputers in one. And its sub-microsecond memory makes it almost twice as fast as any of them. It's also much smaller. And you can expand from 4K to 32K in the same convenient mainframe.

This mainframe, incidentally, houses a thoroughly modern design—including the latest in MSI/LSI technology. Plus control Read Only Memory (ROM). Standard features usually found only in bigger systems include parity checking and hardware multiplication and division. And they won't put a big crimp in your budget. In fact, the HP 2100 is the most attractively priced mini we've ever offered.

Peripheral vision. The way we see it, a minicomputer just isn't modern if it can't communicate simply and easily with the outside world. So we designed the 2100 to go to work with more than a dozen peripherals. As well as 47 instruments. All you do is plug them in. Apart from saving your time, this also saves you a great deal of money. Because you don't have to design special interfaces. After all, why should a user have to do a computer designer's job?

All kinds of software. The 2100 uses FORTRAN, ALGOL, and BASIC. And we give you the widest choice of operating software packages available with any small computer. Time-share, real-time, and batch processing are the three main categories. And they're all compatible with our twenty-five hundred earlier systems.

Rugged testing. Our 2100 passes rigid environmental tests with flying colors. (Other small computers would simply fly apart at 3000 oscillations a minute, if they didn't freeze up at 32° F or melt at 131° F.) But our mini can really take it. It will hold its own in just about any situation—without missing a bit.

Add to these benefits our traditional worldwide support. Consider our reputation for quality. Evaluate our field engineering and analyst back-up. Check out our customer training programs. It all adds up to a thoroughly modern package.

That's why our new mini is much more than a pretty face. So how about getting better acquainted? Call your HP computer specialist. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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Publisher
Peter Coley

Editors
New York Office
850 Third Ave.
New York, N.Y. 10022
(212) 751-5530
TWX: 710-581-2874
Cable: Haydenpub

Editor: Frank Egan
Managing Editor: Ralph Dobriner
Managing Editor: Raymond D. Speer
Microelectronics, Steven A. Erenburg
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New Products, Roger Allan

Field Offices
Massachusetts
Jim McDermott
P.O. Box 272
Easthampton, Mass. 01027
(413) 527-3632

West Coast
David Kaye
2930 Imperial Highway
Inglewood, Calif. 90303
(213) 757-0183

Washington
Don Byrne
1111 S. Army Navy Drive
Arlington, Va. 22202
(202) 296-8982

Editorial Production
Dollie S. Viebig

Art
Art Director, William Kelly
Rita Jendrzejewski
Richard Luce

Production
Manager, Thomas V. Sedita
Helen De Polo
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Information Retrieval
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letters

A data bank suggested to evaluate companies

Sir:

I heartily agree with the statements made by "A Concerned Engineer" [see "Engineers Don't Starve—They Only Lose Prestige," a letter to the editor, ED 3, Feb. 4, 1971, p. 7]. He has stated again what has been stated and restated by thousands of engineers. However, he only alludes to the solution to the problem when he mentions "a tough-minded organization of responsible people concerned with the protection of the profession and its members."

About 99% of all engineers will agree that some sort of organization that represents engineers must be formed immediately. The only problem is that no one agrees on what the functions of the organization should be. I would like to put forth the suggestion that we engineers form an organization whose main function would be to accumulate and then distribute information on companies.

The organization would work as follows: Engineers (and not managers) would fill out questionnaires about the company or companies for which they work or had worked. The data on any company would be available to any member when he was seeking new employment. From this data, it would be obvious to the engineer which companies had the problem of Government-contract ups and downs (a minor problem) and which suffered from abuse of engineering manpower.

Without such an organization, many hundreds of engineering careers might be destroyed in a company before recruiting became a problem for that company—and then the company could merely recruit from another part of the country.

Thomas J. Golab
Senior Electronic Engineer
4811 Niagara Road
College Park, Md.

European management: Better than we think

Sir:

Born in Europe, I worked there as an engineer before immigrating to this country. I feel, therefore, that conclusions pertaining to the individual engineer in the article "U. S. Management: Better Than You Think" (ED 5, March 4, 1971, pp. 54-55) warrant comment.

First, I would like to reword the statement on part-time degrees. These are not really "frowned upon" per se in Europe. Earning a degree by bits and pieces and earning one by full-time enrollment are viewed as two different levels of education by European management. Indeed, it would take a host of evenings or weekends to match full-time, five-year attendance at an engineering school, as required in Europe to obtain an engineering diploma.

Secondly, although I don't deny that it would be a problem for a European engineer to meet mortgage payments after he had lost half of his year's salary or forfeited a bonus, what about if he were to lose his job completely by being laid off, as in this country? To my knowledge, the term "layoff" is still practically unknown in Europe.

Finally, the statement that "U. S. engineers are fortunate because their companies usually have a clear-cut goal—profit" needs amplification. So does the opinion that "firms here are more paternal." Just ask the "fortunate" engineers who, after many years of loyal services, are now driving taxicabs.

Charles A. Benet
Senior Engineer
2239 Medford Place
Escondido, Calif.

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 850 Third Ave., New York, N.Y. 10022. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

If you're reed-switching 5-10V, 5-10 ma loads

(as in keyboards and IC packages),

there's a good, small but growing company making good, small reed switches you should know about:

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In the last seven years, General Reed has designed and produced many millions of high-quality, miniature magnetic reed switches of Form A and Form C types. Expansion of our manufacturing, including the installation of over 1000 sq. ft. of Class 3-4 clean room facility, has now increased our capacity to deliver *highly reliable* snap-action reed switches *in quantity*, at competitive prices, to meet your requirements. Many standards can be shipped immediately from stock, specials in as little as three days depending on the characteristics you need. General Reed quality assurance techniques include on-line testing of electrical characteristics . . . production in controlled clean room areas . . . heat-treating in controlled atmospheres for precise control of magnetic and mechanical properties . . . mechanical run-in of at least 100,000 operations for all switches . . . microscopic inspection for all Form C switches.

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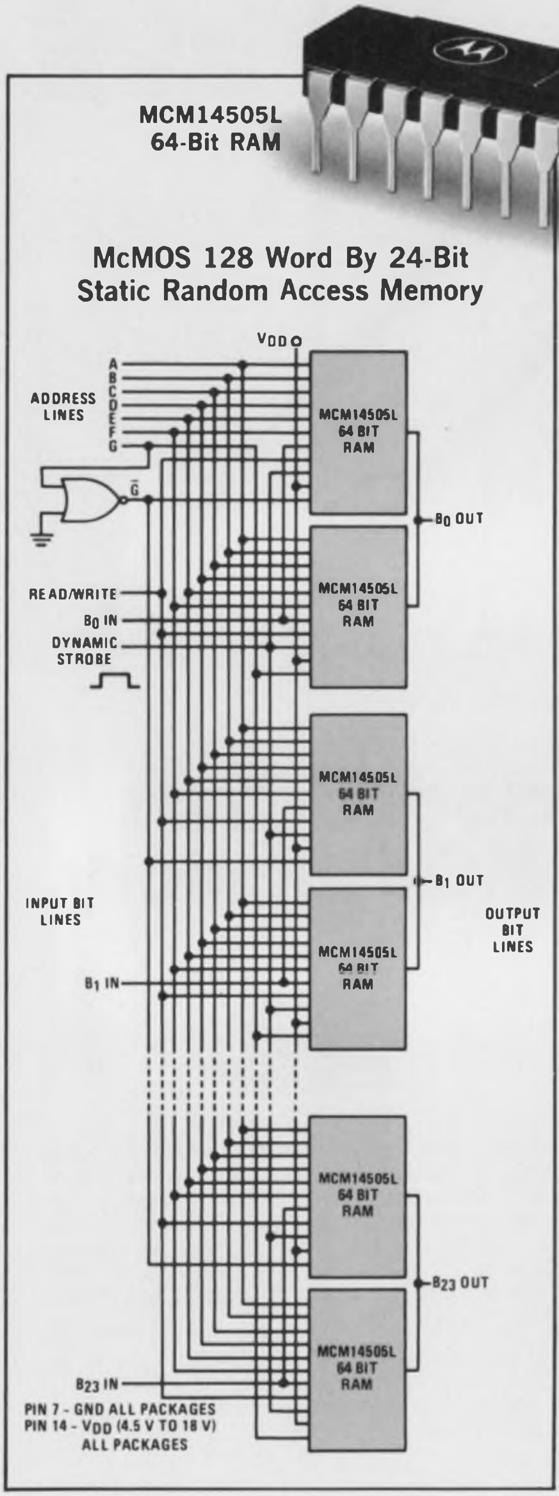
DIVISION OF SIGMA INSTRUMENTS INC.

INFORMATION RETRIEVAL NUMBER 7

A micropower, medium speed, system like this was impossible with bipolar ICs . . .

McMOS Can Do It.



It's simple and practical using Motorola's extremely low power McMOS. The 128-word by 24-bit Static Random Access Memory shown is just one of the many medium speed, micropower organizations possible with the flexible design of the latest addition to this rapidly expanding complementary MOS line, the MCM14505L 64-bit RAM.

Showing why McMOS is the answer for a wide variety of compact, portable, and battery operated designs for landlocked, airborne, and space applications, this 3 kilobit memory system provides the remarkably low quiescent power dissipation of 15 μW and dynamic system power dissipation (1 kH$_z$ cycle rate) of only 1 mW @ 10 V. Forty-eight MCM14505Ls and a gate for the chip select function are all this design requires, and the Wired-OR output capability (Tri-State Output) allows easy expansion.

Since it is designed with McMOS technology, this system may be operated with a single positive or negative power supply voltage ranging from 4.5* V to 18 V. (*The MCM14505L, like all McMOS products, is available to a 3 V spec. by prior arrangement.) It also achieves good medium speed operation as a result of the 200 ns access time and 250 ns read cycle time of the MCM14505L.

There are many other outstanding characteristics of the MCM14505L which translate into benefits in this and similar systems. And there are many desirable features about the whole McMOS family. Not only specs, but the way the line is growing, with systems-oriented new functions supplemented by second sourcing of the most useful existing functions. (See below)

Custom McMOS with manual and CAD design capability is another Motorola offering. Both metal and silicon gate technologies are available, with the latter used to develop such advanced products as our fully integrated electronic watch design for Girard Perregaux and a 25 MHz 4-bit shift register. For information on Custom McMOS write McMOS, Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, AZ 85036, Attn: Scotty

Or circle the bingo number to find out more about the following micropower McMOS units.

McMOS Features

- Quiescent power dissipation from 1.0 nW to 1.0 μW
- Low output impedance — 750 ohm (typ)
- Supply voltage range = *4.5 V to 18 V
- Basic gate delay — 25 ns (typ)
- Noise immunity = 45% of V_{DD} (typ)
- Diode protection on all inputs
- Operating temperature range −55°C to +125°C
- Single supply operation — positive or negative

Function	Type #	Price 100-up
64-bit read/write memory	MCM14505L	$25.00
Quad 2-Input NOR gate	MC14001L	3.30
Dual 4-input NOR gate	MC14002L	3.30
Dual type D flip-flop	MC14013L	4.75
Quad exclusive-OR gate	MC14507L	5.05
Quad 2-input NAND gate	MC14011L	3.30
Dual 4-input NAND gate	MC14012L	3.30
Dual 4-bit shift register serial in/parallel out	MC14015L	10.15

Available Soon
Dual J-K flip-flop
Triple Gate
Dual 4-bit latch
8-bit Serial or Parallel In/Serial Out shift register
4-bit AND/OR/Select/Exclusive-NOR Gate
12 stage Binary Counter
Programmable ÷ N Counter
Dual BCD Up Counter

*Available to 3 V spec on "special" basis

†McMOS is a trademark of Motorola Inc.

MOTOROLA MOS

—the broad line is our specialty!

INFORMATION RETRIEVAL NUMBER 9

designer's calendar

JUNE 1971						
S	M	T	W	T	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

June 14-16

International Conference on Communications (Montreal, Quebec, Canada). Sponsor: IEEE. W. C. Benger, Northern Elec. Co., Ltd., POB 3511, Station C, Ottawa 3, Ontario, Canada.

CIRCLE NO. 414

June 27-30

Consumer Electronics Show (Chicago). Sponsor: EIA. Alfred L. Perkins, Harshe-Rotman & Druck, Inc., 108 N. State St., Chicago, Ill. 60602.

CIRCLE NO. 415

JULY 1971						
S	M	T	W	T	F	S
				1	2	3
4	5	6	7	8	9	10
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25	26	27	28	29	30	31

July 13-15

International Symposium on Electromagnetic Compatibility (Philadelphia). Sponsor: IEEE. Ralph Showers, Moore School of EE, Univ. of Pennsylvania, Philadelphia, Pa. 19104.

CIRCLE NO. 416

July 20-23

Conference on Nuclear & Space Radiation Effects (Durham, N. H.). Sponsors: IEEE & Univ. of New Hampshire. T. M. Flanagan, Gulf Radiation Tech., P.O.B. 608, San Diego, Calif. 92112.

CIRCLE NO. 417

INFORMATION RETRIEVAL NUMBER 12

When you're already on top in linear IC's, you might as well rub it in.

Herewith, the LM216.

Designed for use in high impedance applications, the new LM216 series uses supergain bipolar transistors in a Darlington input stage instead of FETs, which results in exceptionally low offset voltage and input current errors.

Specifically, you'll get input offset currents of 0.000000000010A, typical. With bias currents as low as 50pA and maximum offset current down to 15pA.

The new LM216 also features internal frequency compensation and has provision for offset adjustment with a single 100k-Ohm potentiometer.

Morever, the LM216 will operate on supply voltages from ±3V to ±20V, drawing a quiescent current of only 300μA. (If you'd like, the LM216 can even be run from a single power supply like the 5V used for digital circuits.)

That pretty much covers the outstanding features of the new LM216 series op amps.

Which leaves only prices and where to get more information.

Prices (100 up) are as follows: LM216, $19.50; LM216A (high performance version), $40.00; LM316, $9.95; LM316A, $20.00.

Where to get more information is National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051. Phone (408) 732-5000.
TWX: (910) 339-9240. Cable: NATSEMICON.

National

INFORMATION RETRIEVAL NUMBER 13

INFORMATION RETRIEVAL NUMBER 14 ▶

With the Xerox MD40 you get a bit more.

0101
1101
0010
1

For starters, when you buy the MD40, you get 13-bit resolution for the price of 12. But that's not all.

You also get an instrument you can use as an A-to-D converter, as a high level multiplexer-digitizer with up to 256 channels, as a digitizer-controller for up to 1024 low-level channels, or as a combination high-and-low level digitizer. All without changing wiring or documentation, simply by plugging in different modules.

And you get the MD40 in standard 19" rack mounting, with your choice of two types of digital I/O connections, and any of six different output formats: 1's complement, serial or parallel; or BCD, parallel. Input can be single-ended or differential, gain programmable. And a list of other options.

And even though the MD40 is a 13-bit instrument, with double the resolution of comparably priced units, you can also get it with 8, 9, 10, 11, or 12-bit resolution, to get the perfect match for your application.

Finally, you get compatibility with our full line of 15-bit instruments.

To sum it up, with the MD40 you get not only one more bit, but quite a bit more.

To get more information call (213) 679-4511, ext. 1147 or 3392, or write to Xerox Data Systems, M1-63, 701 South Aviation Blvd., El Segundo, California 90245.

Xerox Data Systems

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INFORMATION RETRIEVAL NUMBER 15

LED displays are here! And Litronix is leading the way. If you're designing anything from a counter to a calculator, a digital clock or any other instrument requiring an economical, highly visible, reliable display, take a look at the Litronix line:

The MAN-1's identical twin, Data-Lit 10. It's a **true** second for the MAN-1. Same DIP package, .270 inch character height and high brightness, but we've added Litronix's guaranteed quality. The Data-Lit 10A, basically the same device as the Data-Lit 10, but with a low, low price tag. Their companions are the Data-Lit 101 and Data-Lit 101A, polarity and overflow displays.

Largest character size in a LED display, Data-Lit 6. Here's a wide angle, front plane, very visible .600 inch high character display. Great for distance viewing type displays. Mounts vertically into a standard 1/16 inch PC board connector.

Biggest bargain in LED displays, Data-Lit 8. Here's a money saver. Consumes half the power of DIP type display at the same brightness. Mounts on 0.3 inch centers which saves up to 40 percent on center to center spacing. Its companion, the Data-Lit 81, provides + and −1, decimal point left or right, colon and % sign.

The stand-up and be counted display, the Data-Lit 3. This .240 inch numeric plugs into a printed circuit board edge card connector for vertical display. Exhibits a high brightness and consumes very little power.

And now, introducing the low cost "skinny DIP," the Data-Lit 300. It has 1/8 inch character height and comes in a small dual inline package. Has a high brightness, low power and best of all, low cost. You can also buy it in any size array you want from 2 to 16.

So, if you're looking for a display, give us a whistle.

You can stop whistling nixie*

The bright guys

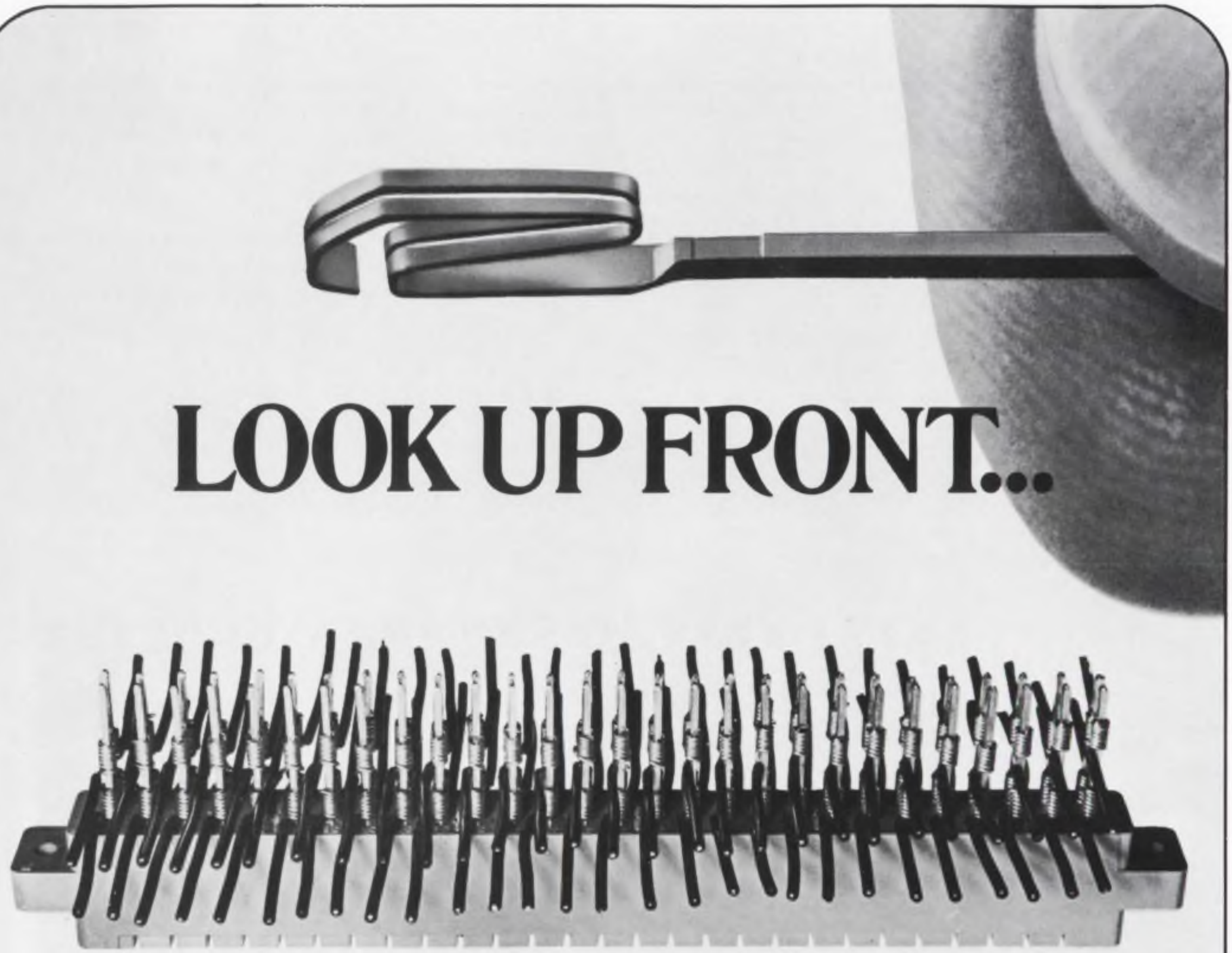
litronix

Prices given for 1000 piece quantities.

LITRONIX, INC., 19000 Homestead Road, Cupertino, California 95014 Telephone: (408) 257-7910 TWX: 910-338-0022

*NIXIE is the registered trade mark of the Burroughs Corp.

INFORMATION RETRIEVAL NUMBER 86



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You're looking at Continental's unique "Bellowform" contact. It hooks on the connector molding for a permanent grip that makes loose connections a thing of the past. So, before you solderless-wrap, check on what's up front! Select .025" square wire-wrapping terminations on .100" and .125" contact centers, or .045" square terminations on .156" and .200" contact centers. Call or write for our free Printed Circuit Connector Brochure. Once you hook up with Continental Connectors ... you'll never let go.

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CONTINENTAL CONNECTORS

Continental Connector Corporation / Woodside, New York 11377 / 212-899-4422

INFORMATION RETRIEVAL NUMBER 87

Signetics announces 19 silicon gate MOS circuits. In silicone packs.

8 Pin Silicone DIP—"V" Package

2503V	Dual 512 Dynamic Register	(10 MHz)
2504V	1024 Dynamic Register	(10 MHz)
2506V	Dual 100 Dynamic Register	(5 MHz)
2507V	Dual 100 Dynamic Register	(5 MHz)
2517V	Dual 100 Dynamic Register	(5 MHz)
2521V	Dual 128 Static Register w/Logic	(3 MHz)
2522V	Dual 132 Static Register w/Logic	(3 MHz)
2524V	512 Dynamic Register w/Logic	(5 MHz)
2525V	1024 Dynamic Register w/Logic	(5 MHz)

14 Pin Silicone DIP—"A" Package

2509A	Dual 50 Static Register w/Logic	(3 MHz)
2510A	Dual 100 Static Register w/Logic	(3 MHz)
2511A	Dual 200 Static Register w/Logic	(3 MHz)

16 Pin Silicone DIP—"B" Package

2501B	256 Static Random Access Memory	(750ns AT)
2502B	Quad 256 Dynamic Register	(10 MHz)
2518B	Hex 32 Static Register w/Logic	(2 MHz)
2519B	Hex 40 Static Register w/Logic	(2 MHz)

24 Pin Silicone DIP—"NX" Package

2513NX	64x8x5 Static Row Output Character Generator (ASCII, Katakana Fonts)	(450ns AT)
2514NX	512x5 Static Read-Only-Memory	(450ns AT)
2516NX	64x6x8 Static Column Output Character Generator (ASCII Font)	(450ns AT)

These new silicon gate circuits, added to those we recently introduced, represent a solid Signetics commitment to silicon gate as the most useful technology in MOS. We intend to stand by this commitment.

Note that all of these circuits fill existing system needs.

To summarize: we now have nineteen silicon gate MOS circuits available in silicone packs; we don't intend to be all things to all people; and we introduce new products because you need them, not because they turn us on.

Signetics—MOS 811 East Arques Avenue
Sunnyvale, California 94086 • (408) 739-7700
A subsidiary of Corning Glass Works.

INFORMATION RETRIEVAL NUMBER 16

Aerospace help sought In ground transportation

The Dept. of Transportation is seeking help from the aerospace industry to develop high-speed ground transportation.

"For a year or more we've been encouraging these people to get into transportation, because we think they have the basic technology that can be applied to any mode of transportation," a department spokesman told ELECTRONIC DESIGN.

In line with this, the department has named Jet Propulsion Laboratories of the California Institute of Technology as systems manager for development of all advanced urban mass-transit equipment. JPL's first contract award has gone to the Bendix Corp. of Ann Arbor, Mich., and Boeing in Seattle to develop and construct prototypes for a personal rapid-transit system. The initial contract is for $4-million, with an estimated total of $20-million for the whole job.

The Dept. of Transportation spokesman said that 15 engineers and systems men familiar with the aerospace industry had joined its systems development and technology office to try to encourage aerospace participation.

The department does not keep a list of aerospace concerns working on its projects, but a cursory check showed that, aside from Boeing and Bendix, these aerospace companies hold contracts for ground-transportation projects: United Aircraft is working on a turbotrain, Garrett Corp. and Grumman Aerospace, as a team, are building a tracked air-cushion vehicle, and a team consisting of the Budd Corp., Rohr and Westinghouse is developing train car bodies and a metroliner system.

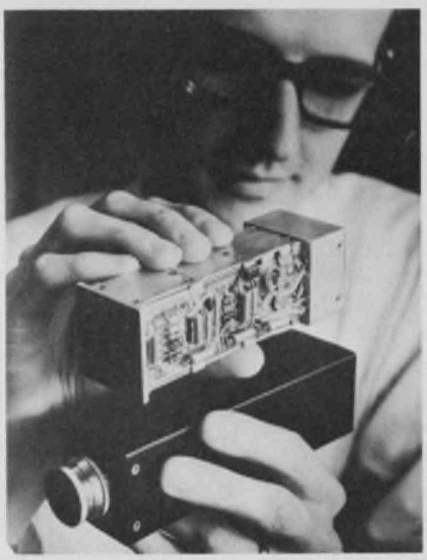
In the proposed budget for fiscal 1972, the department has earmarked $600-million for outside R&D contracts, most of which will be spent on ground transportation. In addition $700-million more is to go to the agency's transportation systems center in Cambridge, Mass.

'Smallest' TV camera weighs only 9 ounces

"The smallest television camera ever built" was described at the National Aerospace Electronics Conference in Dayton, Ohio. It weighs 9 ounces, is 1-1/2 inches square by 5 inches long and has a 1/2-inch-diameter vidicon image tube.

Developed for military and aerospace applications, such as gimbal-mounted TV tracking, TV-guided missiles, drone reconnaisance and space missions, the camera can also be useful, according to its designer, for a variety of scientific projects, perimeter defense monitoring and other surveillance jobs. For operation in the field, it can be powered by a battery.

The camera was described by James H. Meacham, chief designer of the Westinghouse Defense and Space Center in Baltimore.



Tiny TV camera has wide aerospace and industrial applications.

Because rugged hybrid integrated circuit units were used, Meacham reported, "the camera's circuitry is virtually immune to vibration."

Six major subsystems make up the camera: preamplifier, post-amplifier, sweep, sweep-failure protection, synchronization and input protection circuits. Each is handled by a separate hybrid integrated circuit that contains its own voltage regulator.

Although the camera has a 1/2-inch-diameter vidicon image tube, the other electronic parts could be used with a 1-inch electron gun, like those of standard low-light-level tubes—for example, secondary electron conduction or electronically bombarded silicon tubes.

The input voltage is 12 ±1 Vdc, and input power is 6 W at 12 V. The scan format is 525 lines, 30 frames-per-second switchable to 625 lines, 25 frames per second. The video bandwidth is 6 MHz.

U. S. urged to speed its air safety R & D

A mid-air collision between two jumbo jets would cost the airlines between $180-million and $190-million. The same sum could equip the entire domestic air-carrier fleet with the cooperative Time/Frequency collision-avoidance system.

So says Ted G. Linnert, director of the Engineering and Safety Dept. of the Air Line Pilots Association. At the recent 1971 National Aviation System Planning Review Conference in Washington, he was critical of the fact that it would be 1978 before the Time/Frequency collision-avoidance system could be operating.

He urged that high priority and funding by the Government be given to all types of collision-avoidance systems—a priority that the Dept. of Transportation is now giving to hijacking prevention, to cleaner engines for air-pollution reduction, and for quieter engines to lower the noise.

So far, development of the Time/Frequency collision-avoidance system has been privately funded by the manufacturers of the equipment and by the Air Lines through the Air Transport Association. There has also been research by others on simpler proximity-warning systems, such as infrared-seeker systems that home on high-intensity strobe lights on planes. But the Government has provided only limited funds.

Wescon moving show to downtown Frisco

Wescon is moving its San Francisco show from the Cow Palace to Brooks Hall and the Civic Auditorium in the downtown part of the city.

According to Ted Shields, assistant general manager of the show, "Since the show will be smaller this year than in the past, we are anxious to move it to smaller but more modern facilities."

The new facilities, offering air conditioning, will hold up to 750 booths and contain several comfortable rooms for the technical sessions. The show will be held Aug. 24-27.

Wescon had over 1000 booths the last time it ran in San Francisco, in 1969, and 986 last year in Los Angeles.

NASA pushes research on trillion-bit computer

The National Aeronautics and Space Administration is seeking a compact trillion-bit memory with read/write capabilities, and it believes an electro-optical memory will ultimately fill the bill.

Such a holographic system would be comprised of five elements: a laser, a beam deflector, a page composer, a storage medium and a detector.

Progress to date has been slow, mainly because of a lack of good holographic memory materials. But efforts to speed development are under way at the Harris Electro-Optics Center, Ann Arbor, Mich., with the recent award of a $290,000 contract for two items. The first is a test-bed experimental system, in which substitutions for any of the five principal elements of the system may readily be made. The second is generation of a computer program that will permit simulation of the performance of various thick and thin holographic recording materials in a typical system.

NASA plans to use a trillion-bit computer in space stations and lunar bases in the late 1970s and early 80s.

The test-bed system, scheduled for completion in January, 1972, is, according to Dr. Adam Kozma, general manager of the Harris program, a follow-on to previous NASA studies. It will have two holographic memories: a 250,000-bit read/write unit and a million-bit semipermanent, read-only memory.

The system, Kozma says, will be designed so that as new technology is developed, it can be updated by interchanging newer hardware for older. The read/write memory will be of thin holographic materials, while the read-only semipermanent memory will have volume storage. Also to be demonstrated is unambiguous, multiple readout of more than one holograph at any one site by the use of different wavelengths of light.

Further cuts foreseen in aerospace jobs

More bad news for the aerospace engineer: A study made under a grant by the National Bureau of Standards predicts that the number of unemployed scientists, engineers and technicians will double by the end of this year—from 100,000 now to 200,000 including many of the year's 27,000 graduating engineers and scientists.

"The second and third-order effects" of cuts in defense and space spending, the study reports, are just starting to be felt, and even with an upturn in the economy, there will be little relief for unemployed engineers and scientists, unless there is a much greater funding of civilian R&D.

Meanwhile the Aircraft Industries Association makes a less drastic prediction: There will be an 11.8 per cent drop in employment in the aerospace industry this year. A total of 151,000 scientists and engineers will be working by the end of the year, it says, as opposed to 167,000 in December, 1970. Four years ago the number was 235,000.

Although NASA did not fund this study, it was carried out at George Washington University where NASA finances science policy studies.

Need for new displays seen with cable TV

The enormous growth of cable television over the next decade will have an equally prodigious impact on the electronics display market, according to conferees at this month's Society for Information Display Symposium in Washington.

Norman Penwell, former director of engineering of the National Cable Television Association, predicts that by 1980 there could be as many as 47 million homes with cable-television services.

Add to this the introduction of two-way terminals, video recording and hard-copy readout—plus second and third TV sets in the home—and there exists a potential market for 100 million display devices by 1980, according to Penwell.

Joseph Markin, chief, research division of Zenith Radio Corp., Chicago, predicts that with more spectrum space available for cable TV, new modes of transmission will be considered, some not necessarily compatible with existing TV. One possibility, he observed, is stereo transmission. This would require two pickup devices at the camera end and probably two channels for transmission.

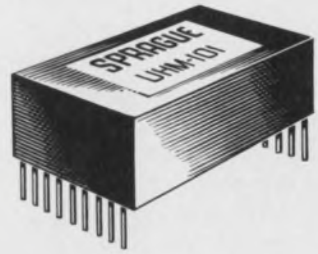
"A display would separate the two channels, using polarized light or synchronized shutters for each eye," Markin said.

Other techniques using holograms or multiple views and lenticular screens would require even more bandwidth but no special glasses for the viewer, according to the Zenith executive.

He also noted that there would be a need for larger panel displays, perhaps with diagonal lengths of 60 inches and areas of 1440 square inches compared with today's 300 square inches.

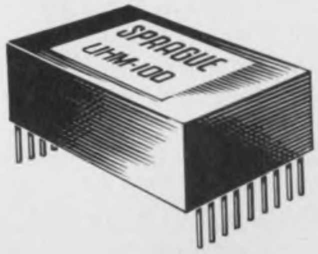
With this size, picture distortion and lack of resolution would become much more evident. Thus, Markin said, a "high-fi"-cable TV system would have to be developed with extended bandwidth.

NEW HYBRID MODULES



D-TO-A

DIGITAL-TO-PULSE WIDTH SYSTEMS



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Three new hybrid modules (UHM-100 4-bit timer, UHM-102 2-bit timer, UHM-101 set/reset) form D/A systems of 4, 6, 8, 10, 12, and 14 bits.

These systems convert a binary input into a pulse whose ratio of on time to period is proportioned to the input word. This pulse can then be averaged out to a d-c level.

Extremely versatile, these systems can be used in servo mechanisms, D/A testers, plotters, and other low to medium speed, high accuracy applications.

For the name of your nearest stocking distributor, call or write to Bill Campbell or Bill O'Connor, Functional Electronic Circuits Operations, Sprague Electric Co., 115 Northeast Cutoff, Worcester, Mass. 01606. Telephone 617-853-5000, Ext. 314, 270, or 313.

For Engineering Bulletins 29,040 and 29,041, write to Technical Literature Service, Sprague Electric Co., 347 Marshall Street, North Adams, Massachusetts 01247.

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INFORMATION RETRIEVAL NUMBER 18

LOW POWER TTL CRAM COURSE.

Low power TTL isn't exactly a household word yet among design engineers. So we'd like to offer a quick summary of low power TTL. What it is. Who uses it. Why. Why not. Plus, a list of our products.

After reading this page, you'll probably decide to specify low power for your next system. (If not, you'll at least have lots of cocktail party material.)

PART ONE: A DEFINITION

Low power TTL is an offshoot of the 54/74 family which is fully compatible with DTL and TTL. It is specifically designed for applications requiring very low power dissipation.

PART TWO: WHO USES IT

The military's been using low power TTL for four years, but it's also catching on in portable equipment, data terminals and other industrial applications as well.

PART THREE: ADVANTAGES

Low power TTL offers several nice advantages over standard TTL logic.

First, even at frequencies of 12MHz the devices dissipate very low power and generate less heat on the chip. As a result, low power TTL has proven to be much more reliable than standard TTL. (If you don't believe us, ask NASA.)

Then there's power savings. Typically, low power TTL gives you a *factor of 10* power savings over standard TTL. Which means you can use a 2.5A power supply, for example, instead of a 25A supply. Which means you save money.

Speaking of saving money, perhaps the biggest single advantage to using low power TTL is the money you save in your overall systems costs.

For example, low power TTL eliminates the need for a fan. Which eliminates the need for a thermostat. Which eliminates the need for a filter. And so on and so forth. (In fact, one of our customers says that the fan alone costs them enough money that even if they had to pay 200% more for low power devices in their systems, their overall systems costs would still be less expensive!)

PART FOUR: PRODUCTS

Right now, we have 21 off-the-shelf low power TTL devices (including four MSI functions):

DM54L00/DM74L00	Quad 2-Input NAND Gate
DM54L01/DM74L01	Quad 2-Input NAND Gate, Open Collector
DM54L02/DM74L02	Quad 2-Input NOR Gate
DM54L03/DM74L03	Quad 2-Input NAND Gate, Open Collector
DM54L04/DM74L04	Hex Inverter
DM54L10/DM74L10	Triple 3-Input NAND Gate
DM54L20/DM74L20	Dual 4-Input NAND Gate
DM54L30/DM74L30	Eight-Input NAND Gate
DM54L51/DM74L51	Dual 2-Wide AND-OR-INVERT Gate
DM54L54/DM74L54	Four-Wide 3-2-2-3-Input AND-OR-INVERT Gate
DM54L55/DM74L55	Two-Wide 4-Input AND-OR-INVERT Gate
DM54L71/DM74L71	R-S Flip Flop
DM54L72/DM74L72	J-K Flip Flop
DM54L73/DM74L73	Dual J-K Flip Flop
DM54L75/DM74L74	Dual D Flip Flop
DM54L78/DM74L78	Dual J-K Flip Flop
DM54L86/DM74L86	Quad EXCLUSIVE-OR Gate
DM54L90/DM74L90	Decade Counter
DM54L93/DM74L93	Binary Counter
DM54L95/DM74L95	Four-Bit Right Shift Left Shift Shift Register
DM76L70/DM86L70	Eight-Bit Serial-In Parallel-Out Shift Register

(NOTE: All devices are available in cavity-dip, molded-dip and flat-pack configurations.

We also plan to announce some Tri-State* MSI low power devices.

This ends our cram course. If you'd like to learn more, we'll be happy to send you a free copy of our full course — the liberally-diagrammed, specifications-packed, 36-page National Low Power TTL Brochure. Plus any of our Tri-State or 54/74 product data.

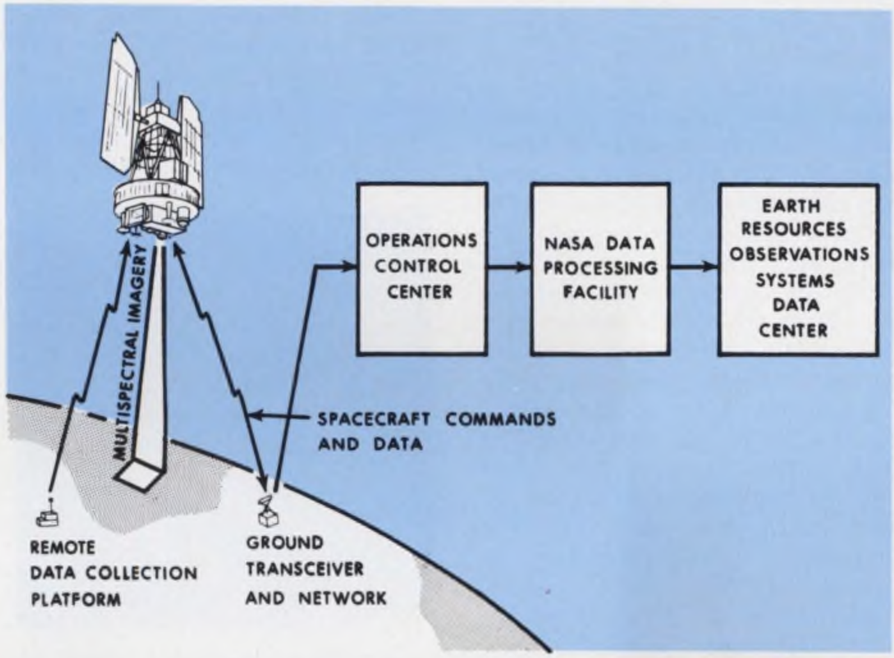
For yours, write, phone, TWX or cable us today. National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051. Phone (408) 732-5000. TWX (910) 339-9240. Cable: NATSEMICON.

*Tri-State is a Trademark of National Semiconductor Corporation

NATIONAL

INFORMATION RETRIEVAL NUMBER 19

We interrupt this magazine for a live preview of ERTS



The ERTS satellite will send data it collects plus that from ground-based platforms to Goddard's ground stations, then to a control facility, to data processing, and on to the data supply center in Sioux Falls, S. D.

Before the decade is out, television viewers may have a new feature—probably squeezed between the weather and sports: "Today's resources and environmental report—to help you manage your world a little better."

A composite photographic map in color, made up from several types of images, flashes on the screen in Des Moines, showing a 100-by-100-mile square of the particular area. "Here in the northern part of the state," an announcer says, "the corn blight has moved slightly to the east since the ERTS satellite [Earth Resources Technology Satellite] passed over us 18 days ago. . . ."

At the same time a television station in New Orleans is showing an annotated photograph of part of the Gulf of Mexico, pointing out light-colored plumes that have moved out into the Gulf from the Mississippi River. Since shrimp are more plentiful in these plumes, fishermen are told precisely where to go for the best catch. The information is essential because the plumes are often 30 miles long and five miles wide and can't be seen from the surface.

Other information that may be shown on TV includes areas of air and water pollution.

And for those who want their satellite information in printed form, pictures and newsletters are available for an annual subscriber's fee: rock formations on land and under the sea that could lead to oil and mineral deposits; crop concentrations throughout a big area that could show a fertilizer manufacturer where to stockpile his product for quick delivery to customers; and more.

All this will be accomplished by a fairly elaborate network consisting of satellite and ground sensors and a data-processing center. The Earth Resources Technology Satellite will fly in polar orbit at an altitude of 495 miles. The first satellite, ERTS-A, is scheduled to go up in the spring of 1972, and ERTS-B a year later. Besides the data that ERTS collects with its own sensors, it will accept data transmitted from the ground from remote, automatic sensing platforms. Information from high-flying aircraft carrying infrared and other sensors will also be used.

Data in the satellite will be stored on magnetic tape and telemetered, either on command or in real time, to earth stations in Alaska, California and at NASA's Goddard Space Flight Center, Greenbelt, Md.

Data from Alaska and California will be sent to Goddard by NASA's ground communications network, where it will be processed as photographs and digitized on magnetic tape. Goddard then will send the information to the Earth Resources Observation Systems (EROS) Data Center, to be built in the vicinity of Sioux Falls, S. D., and operated by the Dept. of the Interior. Eventually Sioux Falls will have a telemetry receiver and will take over Goddard's job. Sioux Falls was chosen because it is in the center of the United States and therefore in direct line of sight with the satellite as long or longer than anywhere else.

The Sioux Falls center will sell the data, at cost, to a variety of customers who need earth resources information. There may be other

John F. Mason
News Editor

agencies in the Dept. of Interior, foreign countries, universities, private industry or private agencies that will interpret the data for special-interest groups and provide newsletter services.

The big eye in the sky

The satellite, which is being built by General Electric's Space Div., Valley Forge, Pa., will carry two sensor systems: three return-beam vidicon television cameras covering the visible spectrum (blue-green, red and near infrared) and four multispectral scanners sensitive in three visible bands and one band in the near infrared, from 0.5 to 1.1 μ. A fifth channel in the thermal IR, from 10.4 to 12.6 μ, will be added to the scanner that goes into ERTS-B.

The TV camera system, designed and built by RCA's Astro Electronics Div., Princeton, N. J., will operate simultaneously the three independent cameras, each sensing in a different spectral band. The viewed ground scene will be stored on the photosensitive surface of the camera tube, which will then be scanned by an electron beam to produce a video signal output. Each camera will be read out sequentially, requiring about 3.5 seconds for the three spectral images. To produce overlapping images along the direction of the spacecraft motion, the cameras will be triggered each 25 seconds. The video bandwidth during the readout will be 3.5 MHz.

The line scanner, built by Hughes Aircraft, senses optical energy by an array of detectors, whose outputs will be sampled, encoded and formatted into a continuous 15 megabit-per-second PCM data stream.

While the TV images are received from separate cameras and inevitably have some registration error, the line scanned data will be inherently registered, as the bands will be scanned in parallel and will not be separated until sampled and digitized from the individual detectors.

On each frame, information regarding the frame will be annotated: picture identification, sensor identification, time and length of exposure, picture center and subsatellite point location, sun elevation and azimuth angles, spacecraft attitude, altitude and heading, gray scales, registration marks and location ticks. This annotation will be prepared from spacecraft telemetry processed on the ground.

While out of direct contact with one of the ERTS ground sites, two wideband video tape recorders will be used. Data will be transmitted to ground stations over two identical wideband (20 MHz) S-band data links centered at 2229.5 and 2265.5 MHz.

Video/FM and PCM/FSK modulation were selected for the TV cameras and line scanners to permit the same frequency modulator design to be used for both types of data. Electrical power (500 W) will be generated by two independently driven solar arrays, with battery storage for eclipse periods and launching.

The ERTS will sense the earth's resources with three TV cameras and a multispectral scanner.

The attitude will be controlled to within 0.7 degree by the same type of system used in the Nimbus weather satellites—a three-axis active system that uses horizon scanners for pitch-and-roll control and gyro-compass for yaw orientation. Orbit adjustment will be accomplished by a monopropellant hydrazine subsystem using one-pound force thrusters.

Collecting data from the ground

A large number of small data-collection sensors are already in place in the United States. To relay their measurements to the satellite, encoders and transmitters must be added. Ultimately, says the Dept. of Interior's EROS manager, William Fischer, there could be as many as 10 million platforms throughout the world. They would make measurements, such as volcanic temperatures, seismic readings, snow depths and pollution. The Radiation Div. of Harris Intertype, Melbourne, Fla., is building the remote data collection equipment for the program.

The platforms will transmit on a random time basis, sending messages of tens of milliseconds' duration. While the satellite is in mutual view of a transmitting platform and one of the ground receiving sites, the platform data will be relayed to the receiving site. From there it will be transmitted to the central Ground Data Handling System over NASA's existing land lines to Goddard.

In this way data from every remote platform will be obtained at least once every 12 hours. Each platform will transmit over eight FM analog channels at 401.55 MHz. The minimum power output will be 5 W. A crossed dipole antenna with a bifolium radiation pattern will be used. The unit is to weigh 15 pounds; the antenna, 21 pounds. The power source will be 24 ±3 Vdc, either available source or batteries. The unit is to provide reliable unattended operation for a minimum of six months and an operating lifetime, with repair, of five years.

The Ground Data Handling System at Goddard has facilities to control the satellite and to process the data. A central computer system, with interactive operations consoles, is the heart of the system. CRT displays, data entry keyboards, command keyboards, a communications panel, clock alarms and other status displays are included in the consoles.

Processed data in the form of color photographs and magnetic tapes will be sent to the Sioux Falls center. There, it will be cataloged and filed by a computer (the type has not been selected yet). Farmers and other groups can then subscribe to a service for information on their particular needs. The cost, for example, might be \$100 to \$120 for an entire growing season. For this, they would get color slides several times during the season and a weekly interpretative newsletter. ■■

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OUR OFFER: We'll send you your choice of any of our standard data conversion modules absolutely free — for a 30-day evaluation. Check your DAC's performance and compare competitive prices. In that way you'll learn some eye-opening facts about the new Philbrick and its ever-growing capabilities. Then, 30 days after you've plugged our D/A or A/D converter in your system we'll contact you. When we learn you like it, we'll apply the cost of your evaluation unit against your initial order — at the same discount price you earn through quantity purchases. If it doesn't perform to spec, return it. No questions asked . . . no hassle. One outstanding thing you'll discover when you plug in a Philbrick DAC is that it was "human engineered." Pins and bits are in sequential order. You get DIP pin compatibility. Features include $<\pm 0.002\%/\%\Delta V_S$ power supply rejection ratio, unequalled temperature stability and buffered input to reduce sink current. Eight standard models with 8 to 14 bit resolution. Custom D/A and A/D's? You bet! We can produce hundreds of customer specified DAC's usually within four weeks on OEM quantity orders. And Philbrick DAC's are low-priced, too. From our general purpose DAC's to the highly sophisticated deglitched models like a 14-bit binary ±1/2 LSB, deglitched output of <10 mV p-p and <200 nsec update rate. You get the best price/performance ratio. Philbrick power modules insure optimum performance and guarantee dependability. To help select your free trial evaluation module, send for our data packet containing all the details on Philbrick Data Conversion Modules. Contact your local field engineer or write Teledyne Philbrick, Allied Drive at Route 128, Dedham, Mass. 02026. TWX: (710) 348-6726. TELEX: 92-4438. Cable: TELEPHIL.

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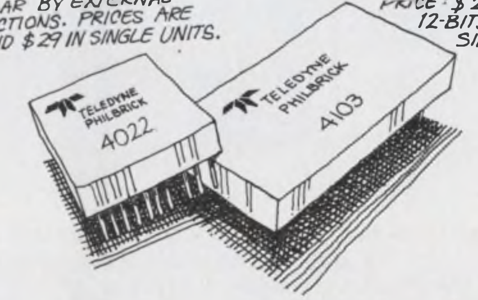

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Tear out this ad and show it to some of the boys in your lab. It's an offer you can't pass up.

INFORMATION RETRIEVAL NUMBER 20

Electronics helps advertisers keep track of their TV ads

You're a multimillion-dollar TV advertiser, say, and you want your ads to go on the air 10 times four days a week and 15 times on the remaining three days. You want each to run at a different time. How can you be sure the TV network is complying with your order?

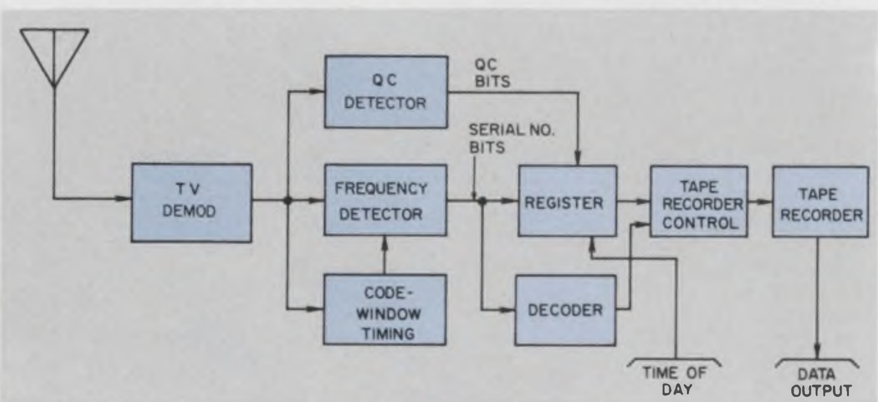
You can hire little old ladies to sit in front of television boxes all day long, tediously monitoring stations for your ads. You can employ the services of a monitoring company that makes full tape recordings of each day's offering by TV stations. Or you can arrange to have the monitoring done for you electronically—the fastest and easiest method of all.

One such electronic system is already available and a second is in the experimental stage. These systems put coded data, concealed from the viewers, on the transmitted ad picture or sound channel—data that identifies the advertiser and agency, indicates the exact time of day at the beginning and end of the transmitted commercial, and notes the presence or absence of video, audio or color signals. This data is recorded at local monitoring stations.

One system designed and being offered to subscribers by International Digisonics, Inc., of Chicago—the only system approved so far by the Federal Communications Commission—uses a nine-digit code, according to Digisonics' president, Glenn M. DeKraker. The code, which has 262,144 possible variations, is superimposed photographically on the picture when making filmed commercials, or is fed in electronically when making video tape recordings.

Jim McDermott
East Coast Editor

To identify TV ads, International Digisonics places a unique code pattern in the corners of film negatives or on video tape masters.



Binary code patterns that identify TV commercials are detected by unmanned monitors tuned to a TV station. The monitor output is recorded on tape. This includes an identification number, the time of day and the presence or absence of test, video, audio or color signals. This data is converted to digital format and stored on tape. Once a day the data is sent via phone to a central processing computer.

When the commercial is shown, this code appears as a series of black and white strips that are outside the normal viewing area (see photo) in the four corners of the raster.

The top-left and lower-right data bands contain the same information, while the top-right and lower-left duplicate their own unique bit pattern. As a result, one of the corner pairs is always detectable, even with horizontal or vertical misalignment.

A binary zero is created by a 10 μs sweep of the camera-tube beam across a code pattern that produces eight cycles of a 1-MHz signal, while a binary one appears as 12.5 cycles of a 1.25-MHz signal.

The coded data is sent twice: once for three-quarters of a second at the beginning of a commercial and again at the end. This data is picked up by local monitoring stations throughout the U. S. and the results are fed, during the station's off-the-air period, to a master computer-processor in Chicago.

Each monitoring site is remote (left) and has a master antenna system that receives signals from the stations being monitored. These signals are fed to a demodulator, the outputs of which are the composite video, sync, audio and carrier-detection signals.

The sync output from the demodulator is used to identify the

When space is at a premium turn to our stable 3/8" diameter cermet pots

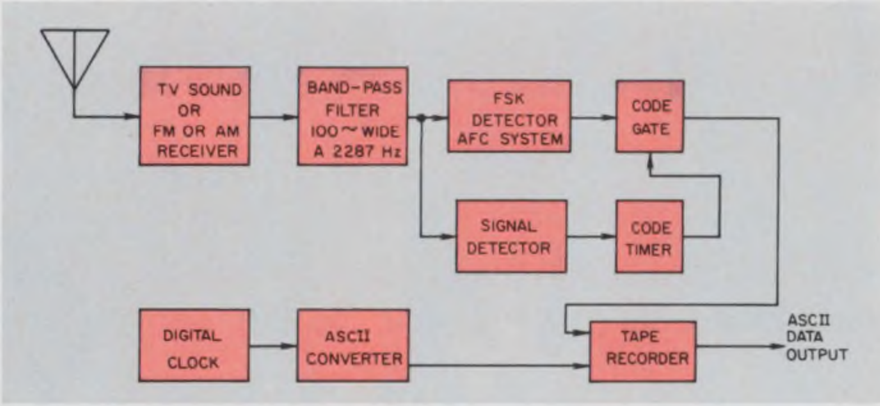
Allen-Bradley Type SP. Tiny panel-mount pots for solving your severe space problems. These cermet pots give you exceptional stability in high-temperature or high-humidity environments. A lot of performance, in a small pot. Rugged, too. Handles 1 watt loads to 70°C. Operational range −65° to +150°C. Rotational life 25,000 cycles with less than a 10% resistance change. Resistance range 50 ohms to 1 meg. For panel or PC board mounting. Leads fit standard 0.1 inch spacing. Immersion-proof, can be encapsulated. Plain or locking bushings, all watertight. Several shaft and bushing options.

Allen-Bradley SP. Available from your A-B electronics distributor, or write: Allen-Bradley, Electronics Division, Milwaukee, Wisconsin 53204. Export: Bloomfield, N. J. 07003. In Canada: Galt, Ontario.

Actual Size

NEW DIMENSION ELECTRONICS

ALLEN-BRADLEY



An aural system for identification of ads, by Audicom, uses frequency-shift-keyed audio signals that are buried in the ad by being sent with a ±35-Hz bandwidth and at a level of 50 dB below 100% modulation. A 100-Hz notch filter, with a 2877-Hz center frequency, is used to insert or to retrieve the signals. The monitored output is operative only when the presence of the frequency-shifted signal is noted by the signal detector.

corner locations in which the code appears, checking for the presence of the coded data in the composite video signal. When a code is detected, it is stored in the shift register until a complete word is received. At this point a tape recorder starts recording the following: an initial sync character, an identification word, the time, a quality-control character, a redundancy check character and a final sync character.

The output of the station monitor is sent to a command module that responds to requests received from a polling computer by sending data from the recorder.

A second electronic identification system, currently under test by the Audicom Corp., New York City, uses a technique called "submerged signaling," in which the identification signals are hidden in the sound channel of a TV station or of a regular FM or AM broadcast station.

This system operates by using a bandstop filter that cuts a channel 100 Hz wide in the frequency range between 2500 and 3000 Hz. Within this window, a 70-Hz, frequency-shift keyed (FSK) signal is sent at a level that is 50 dB below 100% modulation.

The identification data is sent for three seconds at the beginning and at the end of a commercial. The Audicom system uses an eight-character alphanumeric code adopted by the TV and broadcast industry. It is transmitted with the 11-bit-per-character American Standard Code for Information Interchange (ASCII) that is directly compatible as a computer input.

The present experimental work is being done using a 70-Hz FSK signal at a frequency of 2877 Hz, which was chosen to be between the notes of the musical scale to minimize interference.

At the monitor station (left), the signal selected by the bandpass filter is fed to an FSK detector and afc system that overcomes the freqency shifts of signals that may occur because of varying tape-recorder speeds. The signal detector checks for the presence of a data signal, actuating the code timer. The timer output controls the FSK detector system so that its output is fed to the tape recorder only when the data signal is present.

According to Murray G. Crosby, designer of the system, additional logic is provided at the monitor receiver to record such TV transmission defects as lack of video or audio signal. ■■

"Top-ten" prize winners announced

In case you've been wondering who the prize winners were in ELECTRONIC DESIGN's 1971 Top-Ten Contest, here they are:

W. A. Landers, Conductron-Missouri, St. Charles, Mo. (1st prize: Friden Model 1152 Programmable Printing Calculator.)

Raymond W. Sears, Jr., Bell Telephone Labs., Whippany, N. J. (2nd prize: Friden Model 1114 Electronic Display Calculator.)

Robert A. Boynton, Sikorsky Aircraft, Stratford, Conn. (3rd prize: Friden Model 213 Adding Machine (with automatic recall.)

Peter Donatsch, Haeni-Prolectron AG, Wil, Switzerland. (4th prize: EICO Model AX-5 "Light Fantastic" Audio Lighting System.)

Henry J. Scudder III, G.E.R. and D. Center, Schenectady, N. Y. (5th prize: EICO Model AX-5 "Light Fantastic" Audio Lighting System.)

J. H. McAdams, U. S. A. Metrology Center, Redstone Arsenal, Ala (Bulova Accutron).

Robert C. Peck, Los Alamos Scientific Lab., Los Alamos, N. M. (Bulova Accutron).

M. Zajac, IBM, New York, N. Y. (Bulova Accutron).

James L. Thomason, Hewlett Packard Co., Palo Alto, Calif. (Bulova Accutron).

Bill Gray, Syntex, Cupertino, Calif. (Bulova Accutron).

T. V. Rychlewski, GT&E Sylvania Electric, Seneca Falls, N. Y. (Bulova Accutron).

James York, Pacific Telephone, Los Angeles, Calif. (Bulova Accutron).

Kenneth W. Wadman, Mitre Corp., Bedford, Mass. (Bulova Accutron).

Prizes 14 through 75 were copies of the "Standard Dictionary of Computers and Information Processing," by Martin H. Weik.

new! Optoelectronic Devices from General Electric

In addition to the 16 brand new products briefly discussed below . . . and to help you with your design needs, General Electric offers you a full line of Solid State Optoelectronic products. Send for the free new GE Selection Guide covering this full line. (Circle Service No. 211 or write direct).

For the most complete manual on theory, characteristics, and applications available, send $1.00 for the GE 2-part SSL Manual – 106 pages in all. Write to:

General Electric Company
Miniature Lamp Department
Department # 382-MSP-ED
Nela Park, Cleveland, Ohio 44112

LAMPS

NEW SOLID STATE RED HEAD LAMPS
(gallium phosphide solid state lamps, sometimes called light emitting diodes)

SSL-212

Our tiniest SSL, only .08" diameter, .125" high. Light output, 1 mc. Both leads out of one end for easy mounting.

SSL-12

Same small diameter as the SSL-212 but with square base collar. .095 wide for modular application.

SSL-22L

The 1/8" longer barrel permits mounting in panels up to 1/8" thick with full 180° visibility. Easily seen across a lighted room. Rated at 10 mA and V_f = 2.15 volts.

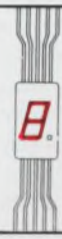
(Circle Service No. 212)

DISPLAYS

SSL-140
SSL-190

NEW RED NUMERIC DISPLAYS

Red, easy-to-read seven segment solid state readouts with character heights of .140" and .190". Wide segments for easy viewing. Flared leads for easy mounting.



(Circle Service No. 213)

DETECTORS

L14T

Programmable unijunction pellet in TO-92 package providing a low cost latching capability.

L14F

Hermetic "super-sensor", capable of operating at levels as low as one foot candle.

L15C, L15E

Darlington and transistor, respectively, designed for arrays requiring center to center spacing as close as 100 mils.

L15A

Phototransistor device, 60 mil dia. Pill package for discrete or array usage with both contacts on tabs at the end of the package. Pellet has high sensitivity and fast switching capability.

(Circle Service No. 214)

COUPLERS & ARRAYS

J300 ARRAY

Provides (9) L15E devices on 100 mil centers. Designed primarily for punched tape reader applications.

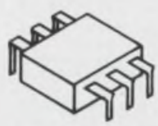
(Circle Service No. 215)

COUPLERS

H10A, B, C

Hermetic TO-5, utilizing a transistor, darlington, SCR chip, respectively.

H11A, B



(6) lead plastic package. Good transfer ratios without sacrificing isolation capability.

GENERAL ELECTRIC

Another electric car suggested, but this one has a heat engine

How can automobile manufacturers meet projected Federal standards for a 90% reduction in emitted engine pollutants by 1975? By building a propulsion system that combines the internal-combustion engine with an electric motor, according to a study completed by the Aerospace Corp., El Segundo, Calif.

Even better, the study found, would be a combination of a gas-turbine engine and electric motor.

The principle is summed up this way by Donald E. Lapedes, program manager for hybrid electric vehicles at Aerospace:

"A heat engine can be designed for lower pollutant emissions when the engine is restricted to operating at a constant speed. In the hybrid electric engine, the electric motor takes up the job of acceleration and deceleration, while the heat engine runs at a constant speed."

David N. Kaye
West Coast Editor

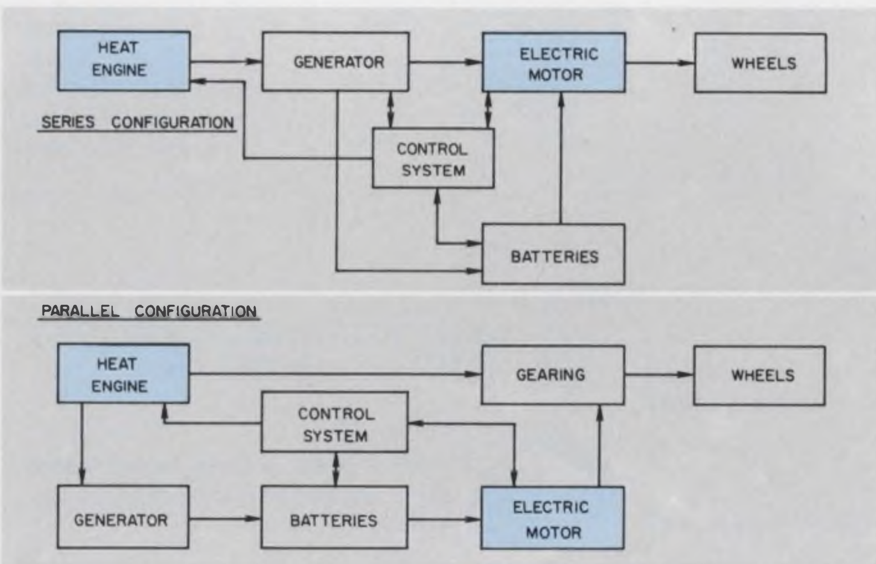
Lapedes notes that the heat engine and the electric motor can be hooked up in two basic configurations: series and parallel. In the series configuration, the electric motor drives the wheels directly. The heat engine drives the generator, which in turn drives the electric motor and recharges the batteries.

In the parallel configuration, the heat engine is connected to the wheels through a system of gears. The electric motor is also connected to the wheels through the same gears.

Both configurations require an electronic control system to sense speed and torque.

According to Lapedes: "The main advantages of the parallel configuration are more fuel economy and lower exhaust emissions, due to greater efficiency. This configuration is 10% to 20% more efficient than the series configuration. The main advantages of the series configuration are simplicity, flexibility and lower cost."

The program manager points out that although several types of electric motors could be used, he recommends a dc because of its simplicity and torque characteristics.



Hybrid electric motors can be designed in either series or parallel configurations. While the series configuration is more flexible and can be produced at a lower cost, the parallel configuration gives lower exhaust emissions by 10% to 20% and is therefore the choice of Aerospace Corp. designers.

Small motor and engine needed

Control could be accomplished by using SCRs to adjust the voltage to the field winding of the motor. The control circuitry would also keep the batteries charged. A consideration in the design of both the heat engine and the electric motor is light weight and small size. This is necessary so that as much room as possible can be left in the vehicle for the batteries; the more battery capacity that can be carried, the less stringent the design requirements on the rest of the system.

Daniel Berstein, a member of the technical staff at Aerospace and designer of the control system for the hybrid electric vehicle, says:

- The system must use low-power and high-reliability components.
- Low cost, noise immunity, simplicity and fail-safety must be designed in.
- Finned aluminum radiators, sealed parts, conformal coatings and the electronics should be separated from the heat engine.

Bernstein notes the importance of a fail-safe feature. "If something fails," he says, "the vehicle had better not lock into a full-on condition. The vehicle should come to a stop—but not too fast." ■■

Don't buy our AM12 circuit breakers anymore.

We have something better. The AM1.

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The AM1 (a series which embraces Models AM1, AM2, and AM3, depending on how many poles you want) enjoys UL recognition —as an Appliance-Control Component— throughout its entire current range to 50 amp at 240VAC or 65VDC.

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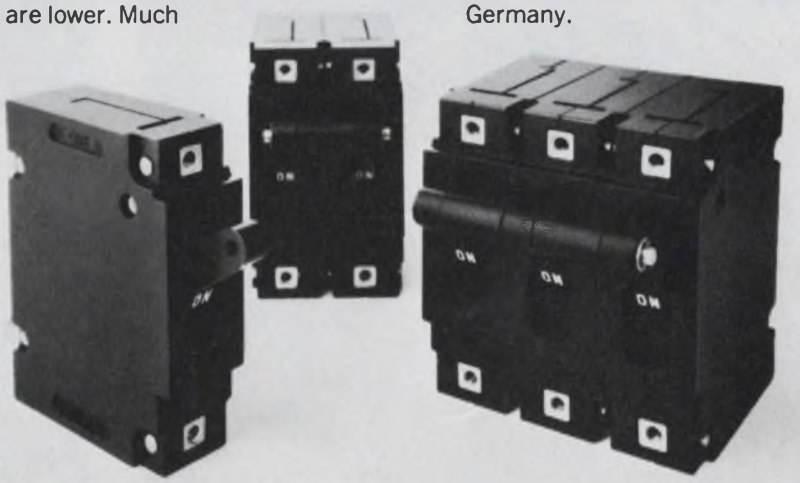
And the prices are lower. Much lower. Depending on the model you choose, you might save anywhere from 17% to 30% by choosing our new AM1 over your traditional AM12-type breaker.

Now about our venerable AM12 breakers. Be assured they're perfectly good, as good as ever. Better than their imitators. They still meet the Mil-Spec you may have in mind.

It's just that life is beginning to pass them by. We think you'd be wise to dust off your specs in favor of our new AM1. Write for Bulletin 3306. Heinemann Electric Company, 2616 Brunswick Pike, Trenton, N.J. 08602. Or Heinemann Electric (Europe) GmbH, 4 Düsseldorf, Jägerhofstrasse 29, Germany.



HEINEMANN

4957

INFORMATION RETRIEVAL NUMBER 23

A new use for MOS transistors: To detect accumulated radiation

A unique instrument for measuring radiation dose levels from a fraction of a rad to nearly 10^6 rads—and one that can be produced at 1/50th the cost of a conventional dosimeter—uses what is frequently considered a limitation of MOS transistor structures: a radiation-induced shift in the threshold voltage.

Called a Mosimeter and designed by two scientists at the RCA Astro-Electronics Div. in Princeton, N. J.—W. J. Poch and Dr. A. G. Holmes-Siedle—the new dosimeter has a p-channel, enhancement-mode MOS transistor as its radiation sensor.

In tests of such devices at RCA it became apparent that the change in threshold voltage during irradiation of certain MOS types was stable and repeatable enough to provide an accurate measure of the accumulated radiation dose. A circuit was designed (see figure) that translated this characteristic change into a meter reading.

The principal developmental work on the Mosimeter was done with discrete p-channel MOS devices. Use of these transistors produced a small, portable dosimeter (see photo), in contrast with the usual briefcase-sized thermoluminescent dosimeter. Dr. Holmes-Siedle says that in production the Mosimeter can be made to sell for well under \$50, compared with \$2500 for the thermoluminescent dosimeter.

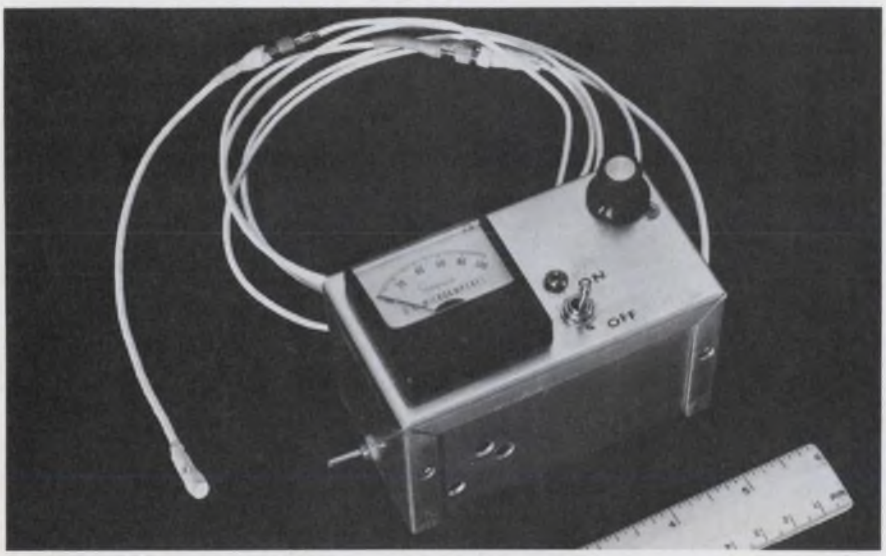
The Mosimeter works like this: Radiation ionizes the MOS transistor-gate insulating material, resulting in a trapped charge of positive ions. The net effect is that the transistor acts as a resistance that increases in value with the increasing dosage.

At dose levels up to 10^4 rads, the increase is linear, but above this value, saturation begins. (The circuit in the figure corrects for this saturation effect and provides a linear shift in effective resistance of up to about 1.5×10^6 rads.)

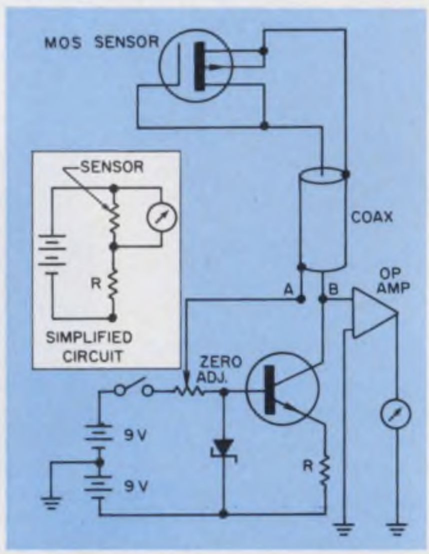
An important feature of the Mosimeter is that the dose-indicating meter circuit can be reset to zero after each exposure, thus providing a means of measuring the total accumulated dosage. For example, if the Mosimeter sensor is subjected to a series of 250 rad doses, 160 such exposures are required to reach an upper limit experimentally established as 4×10^4 rads.

The Mosimeter in the photo is calibrated for three dosage ranges: 20, 100 or 500 rads. The sensitivity could, in theory, be increased indefinitely by increasing the gain of the operational amplifier. But this increase is limited by instabilities inherent in the circuit, including temperature and voltage effects.

Mosimeter applications include the measurements of accumulated radiation dose for satellite components and the mapping of beams of X-ray, gamma-ray or particle accelerators. ■■



An MEM 520 p-channel MOS transistor is the radiation sensor in this model of the Mosimeter. Three ranges are available: 20, 100 and 500 rads. Up to 100 feet of coax can be used between the sensor and the meter box.



The potentiometer in this Mosimeter radiation-measuring circuit resets the meter to zero after each dose.

The *Thrust* in Optoelectronics

Plus news from Texas Instruments about

- MOS/LSI: Big choice in display system components
- TTL ICs: MSI decoder/drivers
- Hybrid ICs: Two new 1-amp voltage regulators
- S/C memories: New 2048-bit RAM array
- Linear ICs: New op amps, memory drivers
- Thyristors: More power for less cost – in plastic
- Transistors: First diode-protected MOSFETs

Optoelectronics:

TI has the capability—across the board.

From 1 mA silicon sensors which could sit neatly on the head of a pin to television image tubes which use 2.4 *million* photodiodes to set new standards for spectral sensitivity—that's the scope of TI optoelectronics.

And whether your work is at one of these extremes, or somewhere in between, you'll find TI easy and profitable to deal with. Easy because no one offers you more choices in standard products, or a broader custom capability, or more opto manufacturing know-how. Profitable because opto devices are 20 times more reliable than electromechanical parts and cost less over the life of your system...and when you need speed, they're 1000 times as fast.

Biggest sensor and emitter choice

One of your toughest design jobs is to match sensors and emitters for optimum cost-effective performance. You want standard parts if you can find them.

TI is the best place to look. We've got 22 types of emitters in 11 different packages and 47 types of sensors in 12 packages. Some manufacturers specialize in low-power devices, others in high.

TI has both—*and nearly everything in between.* In emitters, we go from the miniature TIL23 at 0.4 mW to the TIXL16 at 200 mW, nineteen types in all. Plus TI makes three types of laser diodes with up to 7 watts peak power. In sensors, TI offers 31 types of photodiodes and phototransistors, with sensitivity ranging from 40 μA to 7.0 mA, and 16 types of signal photodetectors and photodetector modules. It's the biggest standard line in the industry. Add to that a custom capability to produce infrared detectors for the electromagnetic spectrum from 1 to 30 microns and you see some of the potential TI has to help you optimize your designs.

Custom sensor and emitter arrays

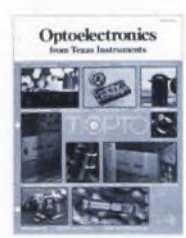
TI sensors and emitters are available mounted in printed circuit boards to your specifications for custom arrays or matrices. These complete units can be designed for tape readers, position indicators, pattern and character recognition, shaft encoders and many other special applications. Almost any configuration can be manufactured, and arrays are delivered tested and ready for installation. We can supply sensor arrays only, emitter arrays only, or sensor/emitter combinations. Components can be matched for improved performance when required.

If you're working in areas where devices must be accurately spaced on centers too close for discrete packages and too far apart for an economical monolithic approach, TI's beam-lead phototransistor arrays may be the answer. They're available in X-Y and linear matrices mounted on ceramic substrates.

Optically coupled isolators—now in low-cost plastic

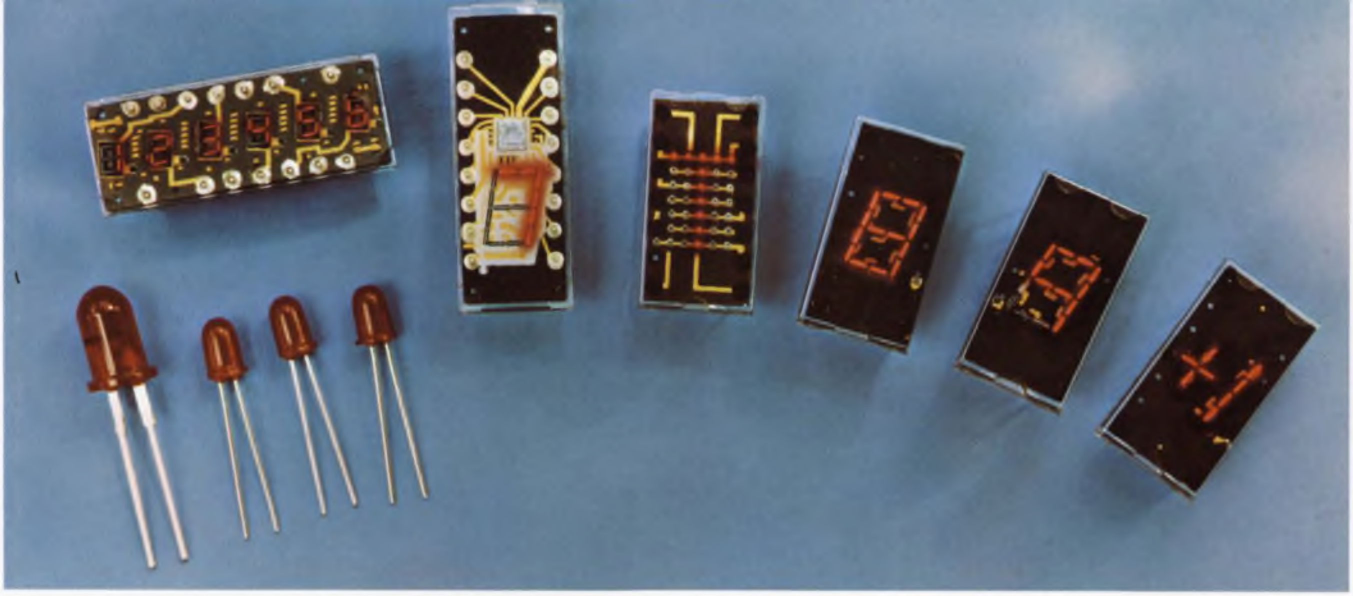
TI's optical couplers have long been electrically compatible with IC logic. Now, with the announcement of couplers in dual-in-line plastic packages, they are mechanically compatible as well...helping you cut costs from design to delivery. The new P-DIPs can be handled with the same automated assembly equipment and can use the same sockets and PC board design as the most popular IC packages. TI couplers—with response from DC to 100 kHz, high shock and vibration immunity, bounceless action, and speeds to 2 μsec—provide input/output isolation of up to 1500 V. Nine types are available, in four package types in addition to the P-DIP.

For more information on industry's biggest optoelectronic line, including an outstanding visible display capability (see special story opposite on fold-out), circle 260 on the Reader Service Card, or contact your TI sales engineer or local authorized TI distributor.



TI OPTO PRODUCT SPECTRUM

- Alphanumeric Displays
- Numeric Displays
- Visible Light Emitting Diodes
- Thermal Printing Devices
- Avalanche Photodetectors
- Beam-lead Phototransistor Arrays
- Custom Sensor/Emitter Arrays
- Industrial Phototransistors
- Infrared Detectors
- Silicon Photoamperic Detectors
- Silicon Sensors
- TIVICON™ Television Image Tubes
- Optoelectronic Materials
- Gallium Arsenide Laser Diodes
- Gallium Arsenide Light Sources
- Optically Coupled Isolators
- Optically Coupled Pulse Amplifiers



The thrust in data display is OPTO —low cost, low current, simple and small.

Optoelectronic displays are making it tough on tubes and tungsten. Costs are lower. Less power is needed—eliminating high-voltage power supplies in many applications. Drive electronics are simplified. Size and weight are reduced. And on the human engineering side, readability is better, too. The flat emitting plane of opto readouts greatly widens viewing angles... and there's less susceptibility to washout from high ambient light.

When all these good reasons make opto displays right for your application, TI is the logical place to buy them. TI produces all of its own Group III-V materials (gallium arsenide, gallium aluminum arsenide and gallium arsenide phosphide). TI has more high-volume semiconductor production experience than any other manufacturer. And when it comes to combining opto technology with digital logic, who's better equipped than the digital logic leader? It adds up to the best performance, delivery and price you can find anywhere. Plus a fast-growing, flexible standard line and top custom capability.

Six new DIP displays

Your opto display component choice has been greatly expanded by recent TI announcements. Among them is the new TIXL360 7-segment numeric device with a row of six digits in a single dual-in-line package. Intended for small calculators where the display is multiplexed, it has 0.1-inch characters with a pitch of 0.172 inch. Packages can be stacked end to end for an unlimited number of digits.

TI's new TIL302 and TIL303 are seven-segment numeric displays (also A, C, E, F, H, J, L, P, and U) with 0.25-inch characters. Both are in 14-pin DIPs. TIL303 has the decimal on the right.

TIL304 is a useful new overflow unit which shows plus or minus one when used with the TIL302 and 303.

A new alphanumeric display, TIL305, uses 35 diodes in a 5 x 7 matrix. All characters, digits and matrix-accommodated symbols are produced.

And coming soon is the next generation visible display. It's a new hybrid which includes a 0.25-inch 7-segment-with-decimal display, a decade counter, latch, decoder and current source driver—*all in the same 16-pin dual-in-line package.* Low power consumption, increased reliability (fewer external connections), and lower assembly costs will make it ideal for industrial controls, aircraft displays and portable instruments.

Breakthrough—the 35¢ VLED

TI has announced a breakthrough price on visible light emitting diodes—made possible by a new, highly-automated production line. TI's TIL209 now costs only 35¢ in 25,000 quantities (49¢ in 100-4,999 quantities). It comes in a molded red plastic package with an integral dome-shaped lens. An epoxy filler diffuses the emitted light, creating a uniform light source throughout the dome structure. Output is 15 microwatts at 20 milliamperes. The TIL209 is replacing tungsten lamps in home appliances, stereos, and cameras.

TI's new TIL210—a larger version of the 209—is ideal for panel-mounted indicator lights in computer systems, data-processing equipment and communications systems.

More new developments

TI's opto display innovations extend in many directions. Like a thermal printer, fully compatible with IC logic, which produces 30 characters per second... silently, without impact on heat-sensitive paper. And in the not-so-far future, liquid crystal displays. TI's liquid crystal R&D promises low power consumption, low-voltage (12 V) drive, simple color changes, MOS compatibility—and a low cost-per-digit that will open up more applications than any earlier technology.

For data sheets on the complete TIOPTO line of display components and VLEDs, circle 261 on the Reader Service Card.

oadest choice—by far—at TI.

Hybrid circuits

Two new voltage regulators offer 1-amp output, cover 80% of your needs.

You'll apply voltage regulators faster and with fewer external components using TI's pair of new hybrid devices.

Incorporating operational amplifier IC chips and Darlington transistor chips, the HIC106 and HIC107 produce output currents up to one ampere without an external pass transistor. Having this optimized current rating, they should fit about 80% of your requirements for such areas as logic card regulators in computers, as subsystem and system regulators, as instrument power supplies and as power supplies for linear and digital circuits.

No external compensation is necessary since the op amp IC in each is self-compensated. Either a precision potentiometer or a resistive divider is the only external component required.

Output voltage for the positive HIC106 is adjustable from 2 to 37.5 V, while that for the negative HIC107 ranges from −2 to −37 V.

For data sheets, circle 264 on the Reader Service Card.

Semiconductor memories

New, high-performance 2048-bit RAM array.

TI's new TTL-compatible SMA2001 is a one-package building block for organizing larger memory systems. Made up of beam leaded MOS storage chips and beam leaded bipolar decoding, sense, write and control chips, it offers 2048 bits of storage in a single 28-pin ceramic package. It's fast—125 ns typical read access time—with a typical low power dissipation of 0.65 mW per bit. **For details**, circle 265.

Linear

2 new memory drivers, 7 op amps reduce package counts, save space, cut costs.

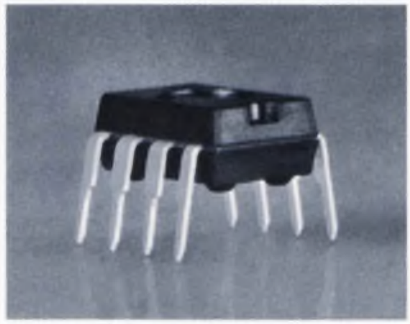
Two new TI memory driver integrated circuits—the 600-mA SN55/75325 and the 500-mA SN75308—can reduce PC board areas by 15 to 20% when used to replace discrete circuitry.

The SN55/75325 is an all monolithic memory driver that has two outputs committed as sources and two committed as sinks. Each output selection is facilitated through on-chip decoding which is compatible with TTL/DTL. The SN55/75325 is designed primarily for use with 2½ D and 3 D core memory systems but can also be used in plated wire systems.

The SN75308 is an array of eight high-current transistors designed for two-dimension memory systems using ferrite cores, plated wire, planar film, diodes, resistors or other memory elements. At 500 mA, collector-emitter saturation voltage is 0.45 V, resulting in low power requirements.

TI's IC memory driver line also includes the 400-mA SN75324 with on-chip decoding and the 150-mA SN75303 monolithic transistor array.

For data sheets on all four TI memory drivers, circle 266 on the Reader Service Card.



TI's 8-pin op amp package.

Op Amps—all the popular types in all packages

The price is right and delivery is fast on TI's op amp line—now with seven new functions to broaden your choice.

New TI devices include the SN72770 and SN72771 super beta op amps; the SN52/72747—a dual 741 in an 8-pin package; the SN52/72748 extended bandwidth, general purpose op amps; the SN52101A/72301A precision op amps (pin-for-pin replacements for the LM101A/LM301A); and the SN52107/72307 internally compensated op amps (pin-for-pin replacements for the LM107/LM307).

TI also offers the widest package selection of any op amp line: plastic (8- and 14-pin), ceramic dip and flat pack, and TO-99 metal can. Delivery on TI's economical line of 10 operational amplifier ICs (see chart) is 8 days ARO.

For data sheets, circle 267 on the Reader Service Card.

TI Op Amp Selection Guide

TYPE	DESCRIPTION	REPLACES
SN52/72702	Wide bandwidth, general purpose	μA 702
SN52/72709	General purpose	μA 709
SN52/72741	Internally compensated, general purpose	μA 741
SN52/72747	Dual SN72741	μA 747
SN52/72748	Extended bandwidth, general purpose	μA 748
SN52/72770	Super β	
SN52/72771	Super β, internally compensated	MC1556, 1456
SN52/72558	Dual 741 in 8-pin package	MC1558, 1458
SN52101A/72301A	Precision op amp	LM101A, 301A
SN52107/72307	General purpose, internally compensated	LM107, 307

Integrated Circuits: you'll find your br

MOS/LSI

For simple, economical display systems choose from TI's broad MOS/LSI line.

TI offers you the widest choice of MOS character generators and shift registers in the industry—designed for use with optoelectronic displays, CRTs or light panels. For dot matrix displays, TI has several families of MOS character generators covering all display modes (row, column and parallel outputs). Twelve types, programmed with the most common codes, are available off-the-shelf. Or we can program your code and your character font.

Typical of the new TI MOS character generators is the TMS 2500 JC/NC. It's a low-threshold, TTL-compatible, row-output device with an access time of under 350 ns. It's static—no clocks. It displays 64 characters on a 7 × 5 font and you can buy it in plastic for under $10 (250 units). The TMS 2501 is programmed with the USASCII code.

TI MOS character generators

TMS 2400	64x7x5	Row Output
TMS 2403	64x7x5	USASCII Row Output
TMS 2404	64x7x5	EBCDIC Row Output
TMS 2500	64x7x5 (32x7x10)	Row Output High Speed
TMS 2501	64x7x5	USASCII Row Output
TMS 4100	64x5x7 (32x5x14)	Column Output
TMS 4103	64x5x7	USASCII Column Output
TMS 4177	64x5x7	USASCII 10x7 Column Output
TMS 4178	64x5x7	Column Output
TMS 4179	64x5x7	EBCDIC Column Output
TMS 4880	76x35	Parallel Output
TMS 4886	64x35	USASCII Parallel Output

In more complex vector displays, large economical MOS ROMs are ideal for providing the character coordinates. Here, too, TI offers a broad choice.

Read-only memories

TMS 2300	2560-bit (256x10)
TMS 2500	2560-bit (256x1, 512x5)
TMS 2600	2048-bit (256x8, 512x4)
TMS 2800	1024-bit (256x4)
TMS 2900	1280-bit (256x5, 128x10)
TMS 4400	4096-bit (512x8, 1024x4)

If you're multiplexing an LED matrix or using a CRT, you'll be storing information in a refresh memory. Typical of the devices used for line refresh (see diagram) is the TMS3409 JC/NC quad 80-bit shift register—with recirculate logic on the chip. It can be driven by a single TTL clock. Available in both plastic and ceramic. The plastic 250-unit price is $6.60.

Shift registers for line refresh

TMS 3101	2x100 static	2.5 MHz
TMS 3102	2x80 static	2.5 MHz
TMS 3103	2x64 static	2.5 MHz
TMS 3112*	6x32 static	1.0 MHz
TMS 3113*	2x133 static	2.5 MHz
TMS 3114*	2x128 static	2.5 MHz
TMS 3409*	4x80 dynamic	2.5 MHz
TMS 3417*	4x64 dynamic	2.5 MHz

*recirculate, single clock

For cost-critical page refresh applications, TI has a family of large shift registers priced at well under a penny-a-bit.

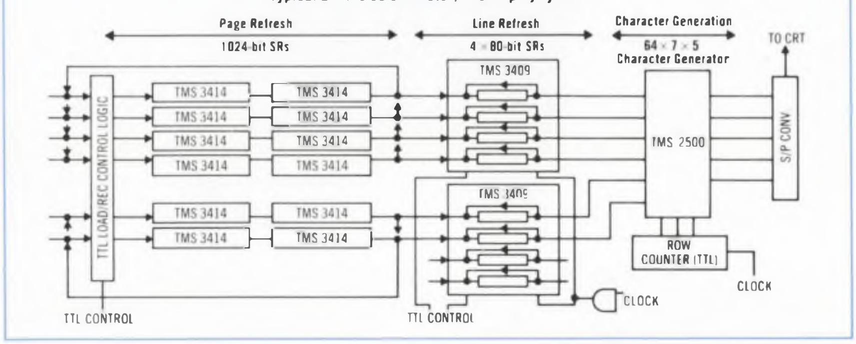
Shift registers for page refresh

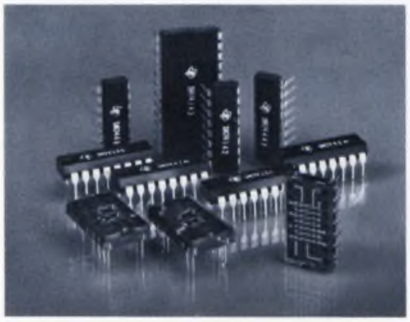
TMS 3309	2x512	10.0 MHz
TMS 3401	1x512	5.0 MHz
TMS 3402	1x500	5.0 MHz
TMS 3403	2x480	5.0 MHz
TMS 3404	2x512	5.0 MHz
TMS 3412	4x256	6.0 MHz
TMS 3413	2x512	6.0 MHz
TMS 3414	1x1024	6.0 MHz

For "smart" display terminals—which perform computations as well as produce the display—it is now possible to do both jobs with the same memory. TI's new dynamic RAMs (from 256 to 2048 bits) can do the jobs economically. The TMS 4023 NC, for example, is a low-power 1024-bit device priced at $8.80 (250 units).

For data sheets, circle 262.

Typical 24-line 80 character/line display system





TTL

New synchronous decoders/display drivers expand TI's line to nine.

TI's new SN74143/74144 are the first monolithic, 7-segment, LED display drivers consisting of a BCD counter, a four-bit latch and a decoder/LED driver in single, 24-pin package. The SN74143 has active low outputs for driving common cathode LEDs, and the 74144 has active high outputs to accommodate common anode displays. Both circuits have ripple blanking to suppress leading edge zeros and data available from the latch outputs.

To direct drive 7-segment LEDs, 7-segment incandescent indicators and Numetron* tube displays, choose from TI's SN54/-7446A, SN54/7447A, SN54/7448 and SN54/7449 BCD-to-seven-segment decoders/drivers. They may also be used to drive those 7-segment LED displays requiring high driving current. The SN7446A, and SN7447A will sink 40 mA of output current eliminating need for external components.

The SN54/74141 BCD-to-decimal decoder/driver direct drives gas-filled cold-cathode indicator tubes and NIXIE** tubes. Invalid inputs force all outputs off, thereby allowing the capability to suppress leading edge zeros.

High-output sink current (80 mA) makes the SN54/7445 and SN54/74145 4-line-to-10-line buffers/drivers ideal for driving LED matrices or incandescent light displays. The SN54/7445 outputs are capable of withstanding voltages up to 30 V, while the SN54/74145 provides an output voltage breakdown of 15 volts.

For data sheets, circle 263.

*Trademark of Radio Corporation of America
**Trademark of Burroughs Corporation

New economy semiconductors expand your broad choice at TI.

Thyristors

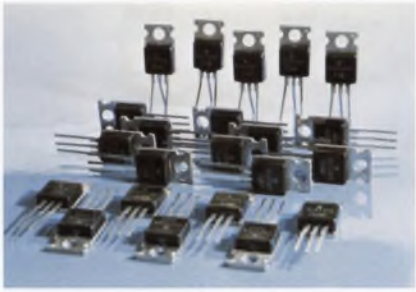
New high-performance SCRs, triacs in low-cost plastic.

With twenty new SCRs and two new triacs, TI now offers your widest choice of plastic-package thyristors.

Three SCR series are available (see chart). The 12-amp TIC126, the 8-amp TIC116 and the 5-amp TIC106.

In the TIC106 series a big 70-mil silicon wafer handles a 5-amp current at 80°C case temperature—*that's three times better than competition.* This larger chip also results in a peak gate power dissipation capability of 1.3 watts—*twice that of competition.*

TYPE	VOLTAGE (peak)	CURRENT (amps)
TIC106Y	30	5
TIC106F	50	5
TIC106A	100	5
TIC106B	200	5
TIC106C	300	5
TIC106D	400	5
TIC116F	50	8
TIC116A	100	8
TIC116B	200	8
TIC116C	300	8
TIC116D	400	8
TIC116E	500	8
TIC116M	600	8
TIC126F	50	12
TIC126A	100	12
TIC126B	200	12
TIC126C	300	12
TIC126D	400	12
TIC126E	500	12
TIC126M	600	12
TIC226B	±200	8
TIC226D	±400	8



And they're all in TI's new high-performance plastic package (TO-66). This new package design provides lower leakage, more moisture resistance, increased stability, and high resistance to thermal shock and vibration. They are direct replacements for competitive types and are plug-in substitutes for most TO-66 metal-can units—no adapters needed.

Prices are 20% less than metal can equivalents.

The two new triacs are also in low-cost high-performance plastic. The TIC226B has a repetitive peak off-state voltage of ± 200 V, and the TIC226D is rated at ± 400 V.

Fast, on-time delivery is assured by big volume production on TI-designed, automated assembly lines.

For data sheets on the 22 new thyristors, circle 268 on the Reader Service Card.

Transistors

First diode-protected MOSFETs offer high gain and high output impedance.

In FM tuners, top-line color TV sets and other such applications, you can now economically replace vacuum tubes with TI's three new dual-gate MOSFETs. The 3N201, 3N202 and 3N203 each have a 10-kilohm output impedance at 200 MHz, making circuit performance independent of transistor-to-transistor variations. Each is protected from excessive input voltages by integrated back-to-back diodes between gates and sources which eliminate precautionary handling procedures.

In addition, these new MOSFETs have a typical 12,000 micromhos gain, a low feedback capacitance of 0.03 pF max., and a typical low noise figure of 2.8 decibels. All together, these characteristics add up to the performance you want at considerably lower cost.

Use the 3N201 in VHF pre-amplifiers where linear, low-noise amplification is needed. Use the 3N202 as a VHF mixer and in TV tuners; the 3N203 in tuned high-frequency amplifiers. **For data sheets** on these low-cost, pacesetting MOSFETs, circle 269 on the Reader Service Card.

Simplified semiconductor selection

Here's quick relief from the confusions and risks involved in selecting from the tens of thousands of discrete semiconductors available today. It's TI's *Preferred Semiconductors and Components Catalog* — containing detailed specs and application data on 322 popular devices that will meet the big majority of your needs.

They've been pre-selected by computerized demand analysis from TI's 1,500 "standards" and 13,000 "specials." Included are small-signal and power transistors, diodes, thyristors, rectifiers, regulators, light sensors and resistors. All are known, proven and in wide use. All are in volume production, available from TI distributor and factory stocks. All are recommended for new or existing designs.

Result: you'll save time and money, reduce inventories and testing, and get faster delivery. For your copy of TI's *Preferred Semiconductors and Components* catalog, circle 270 on Service Card.

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BAFFLED

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INFORMATION RETRIEVAL NUMBER 24

technology abroad

A unique gas-sensing semiconductor has been developed by Figaro Engineering, Inc., Kobe, Japan. Composed of metals such as tin oxide, zinc oxide and ferric sesquioxide, the sensor decreases its electrical resistance when it encounters deoxidizing gases, such as hydrogen, carbon monoxide, methane, propane, alcohol, volatile oil and acetylene. In many cases this change is big enough to be used directly without amplification. Conductivity returns to the original value when gas is removed.

For its next generation of high-speed digital computers, the Caen laboratory of France's RTC Semiconductor Co. is developing a nanosecond emitter-coupled logic technology. The study is being carried out in collaboration with Compagnie Internationale pour l'Informatique, the French national computer company. RTC has developed a 36-gate MSI circuit on a single 12-mm² chip as an important step in its attempt to prove the technology. This corresponds to a circuit complexity of 1000 components. Power dissipation of the circuits is in the region of 500 mW. Advanced two-layer metallization techniques are used to interconnect the gates. This requires masks accurate to 1 μ and diffusions no more than 1/20th μ deep.

Using the high current carrier mobility of gallium arsenide, research workers at IBM's Zurich laboratories have developed a transistor with a 3-dB gain at 17 GHz, and with a cutoff frequency in the region of 30 GHz. According to IBM, this is two and a half times more than any known transistor. The transistor uses novel construction techniques, including Schottky diode junctions and a combination of contact and projection mask printing.

One of the highest density recording systems in Europe—a digital magnetic tape head with 36 separate tracks on a one-inch wide tape—has been produced by Gresham Lion of Hanworth, England. Operating at 10 inches per second, track centers are located within 500 micro-inches, and the track width is accurate to within 0.001 inch. Despite the close proximity of individual tracks, cross-talk is better than 26-dB down. Precision machining and careful assembly is involved in making connections to 216 closely packed terminals in the rear of the head.

A modified Braille alphabet that is computer-adaptable and can be read either by the blind or by sighted individuals has been devised by a Swedish electrical engineer, Leif Andersson. The alphabet is based on a six-dot system arranged in two vertical lines containing combinations of three dots per line to make up each letter. Individual letters can be read by the blind with the use of a pen, equipped with a photo cell, that produces vibrations when it encounters dark areas on the paper. The arrangement of the Braille-like dots is roughly similar to the outline of Roman letters, so that with practice, persons with normal sight can read them.

A low-cost, closed-circuit TV system with push-button control for each of three cameras has been introduced by Britain's Plessey Communications Systems, Surbiton, Surrey. The system's monitor and control unit measures only $5 \times 11 \times 9$ inches, giving a high-resolution picture of subjects illuminated with as little light as 20 lux. Plessey considers the system ideal for monitoring supermarkets, banks, or other areas for early detection of intrusion.

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OP AMPS AND LINEAR AMPS
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Up to 7 A peak current
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- HF amplifiers to 100 kHz

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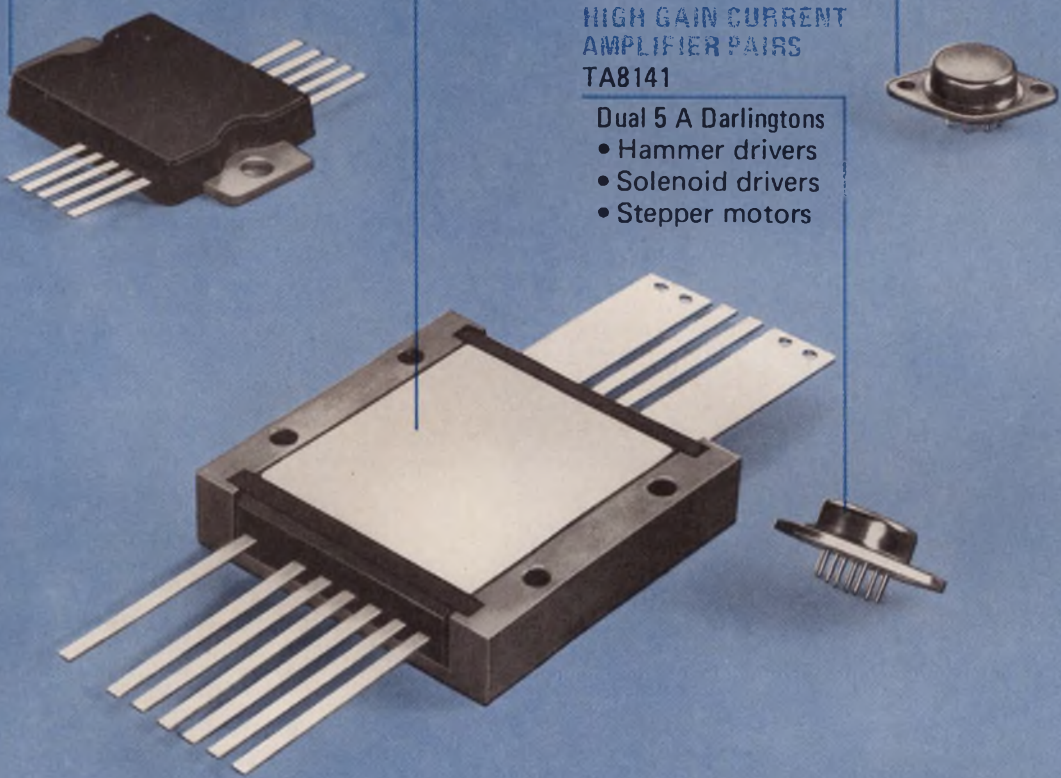
HIGH GAIN CURRENT AMPLIFIER PAIRS
TA8141

Dual 5 A Darlingtons
- Hammer drivers
- Solenoid drivers
- Stepper motors



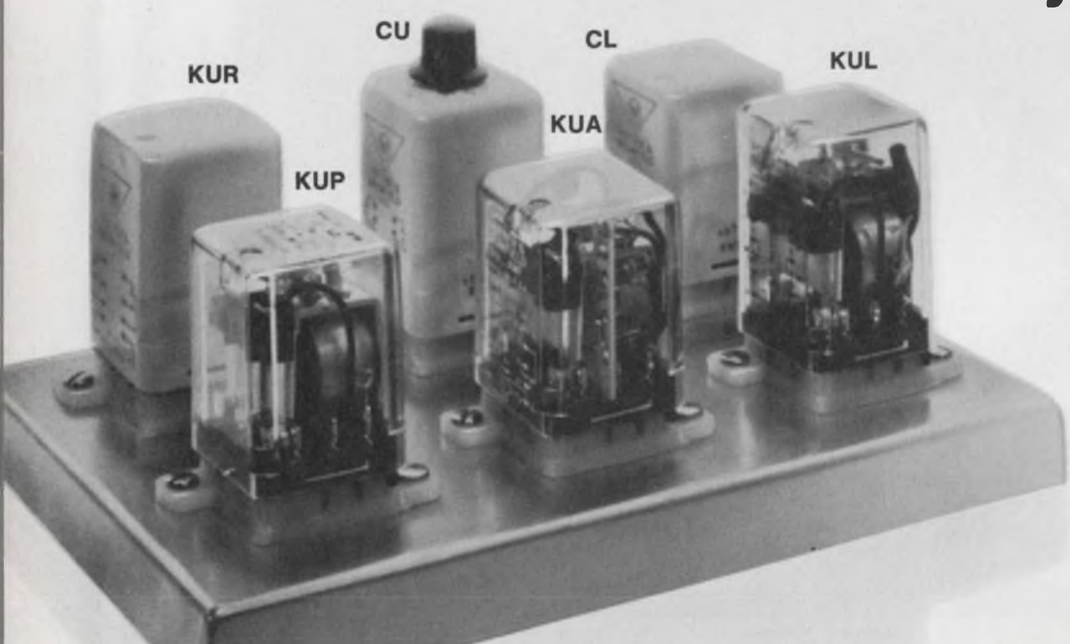
If your design requires power amplifiers, or power control circuits, or power supplies or something else you don't see here, call your local RCA Representative. For a copy of catalog 2L1149, along with product sheets detailing design concepts on various RCA power hybrid circuits, write: RCA, Commercial Engineering, Section 57E-27/UC3, Harrison, N.J. 07029. International: RCA, Sunbury-on-Thames, U.K., or P.O. Box 112, Hong Kong.

RCA
Solid State

INFORMATION RETRIEVAL NUMBER 26

Our KUP general purpose relays
switch up to 10 amperes...reliably

KUP-type relays
will sense 60 microwatts, latch, switch alternately or delay time. It's all in the family



First off, our KUP relays save you money. More than $2.00 each, compared with octal-type pin terminals. Then, to make your design job easier, the range of optional features includes a slotted case for direct-to-chassis mounting; sockets with solder, printed circuit, quick-connect or screw terminals; push-to-test button; indicating lamp; choice of .187″ or .205″ terminals. U/L recognized. Contact arrangements to 3 Form C. Rated 5 or 10 amperes. Coil voltages to 120 VDC, 240 VAC. List $4.50 to $6.40. The KUP spawned a remarkable family of switching devices. They are housed in the same case (some ¼″ higher), use the same sockets, cover a wide variety of control functions:

KUA Amplifier-Driven Relay. Standard sensitivity: 60 microwatts. DPDT contacts switch 5 amperes at 28 VDC or 120 V 60 Hz., 80% PF. Features continuous operation, built-in polarity protection. Recommended for interfacing low-level logic circuits and work-performing loads such as motors, contactors, solenoids. As low as $14.25 list.

KUL Magnetic Latching Relay. Takes half the space of mechanically-interlocking latchers. Provides permanent memory, continuous duty operation. DPDT contacts switch 5 to 10 amperes. Contacts remain in last position without power. $5.45 to $7.10 list.

KUR Alternate Action, Impulse Relay. Features unique combination of KUL single coil magnetic latching relay with solid state flip-flop circuit drive. Pulse width of 25 milliseconds will effect switching. Contacts switch 5 or 10 ampere loads. List price, $15.10 (DPDT).

CU Time Delay Relay. Low cost solid state relay for timing increments from 1 to 120 seconds. Switches 10 amperes and comes in 3 AC or DC versions: fixed time delay on operate; resistor-adjustable; knob adjustable. Priced as low as $14.20 each, list.

CL Time Delay Relay. Provides a delay on operate. Won't false operate. Times as low as 0.1 second. Otherwise similar to CU. $17.35 to $21.15 list.

Standard versions of these relays are available now from your electronic parts distributor. For complete information, call your local P&B representative or Potter & Brumfield Division of AMF Incorporated, Princeton, Indiana 47570. Telephone: (812) 385-5251.

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P&B performance. Nothing else comes close.

INFORMATION RETRIEVAL NUMBER 27

washington report

DON BYRNE, WASHINGTON BUREAU

Government goofing on ADP leasing, purchases GAO says

The General Accounting Office says the Government is not making maximum use of its automatic data processing funds because it is not buying the equipment for Government-wide use but rather for use by specific agencies on specific projects. The report also states that the Government could save well over a hundred million dollars by going to multi-year leasing of data processing equipment not available for purchase. GAO notes that because of the Government's budget process, multi-year leases are illegal in some cases. It indicated that legislation should be sought to erase this bar. It also said that the Government ADP equipment fund should be greatly expanded to cover a central purchasing operation. In FY 1969, the year under study, it noted that of the $169-million spent for ADP purchases, $166-million was spent by individual agencies. The Government now owns $1.9-billion worth of ADP equipment and rents equipment which would cost $1.2-billion to purchase. It operates 5277 ADP systems making it the biggest ADP user in the world, GAO said.

AF plans to 'unleash' its laboratories

The Air Force intends to give the directors of its laboratories more authority, so more innovative work can be performed. The move is in keeping with the desires of Deputy Defense Secretary David Packard, who wants the Air Force to begin "skunk works" development of aircraft. In this approach, an engineering team is given money and told to develop the best aircraft it can. The method was developed by a Lockheed designer, Kelly Johnson, who created among other things the U-2 and SR-71 spy planes. Grant L. Hansen, the Air Force's Assistant Secretary for R&D, has told Congress that each lab director will be able to devote funds immediately to a promising idea, rather than having to wait for formal budget processing for the program. He estimates it can save up to a year in development. The idea will be applied to all elements in the R&D program, including electronics, he said.

Automation of air traffic proves elusive

The Air Transport Association, representing the country's airlines, has told the Federal Aviation Administration that the data processing and storage required to automate the air-traffic-control system has required much more programming and computer capacity than anyone anticipated. It "may not be possible to achieve as much automation as had once been thought," the association said, adding that what has been done so far is but "foundation stones on which automation systems may be built."

The association also asked the FAA to make a basic decision now on the future role of primary and secondary radar. Primary radar is ground-based; it skin-tracks aircraft that do not carry beacon transponders to strengthen the return signal. Secondary radar is the airborne transponder; it strengthens the returning signal and also transmits flight information to the ground. The time has come, the airline group said, for FAA to say clearly that the use of primary radar alone is on the way out and that all aircraft operating in the national airspace system must, by a certain date, carry transponders. The association said, too, that it doubted the wisdom of putting digital communications on the air-traffic-control radar beacon system.

Navy developing new navigation system

The Navy is investigating a navigation system that employs an electrically suspended gyroscope. It would be used in future submarines for Poseidon and possibly for ULMS—the undersea long-range missile system. Sperry Rand is developing the new navigation system, to be known as the "improved shipboard inertial navigation system," and will deliver two units to the Navy under a $5-million contract.

Army seeks digital communications system

The "principal Army communications requirement for the future" is a digital transmission and switching system, says the new Army Chief of R&D, Lt. Gen. William C. Gribble Jr. He told the Senate Appropriations Committee that "the driving requirement for this system revolves around the fact that the digital approach is by far the best to provide the integrated and totally interfaced system required on the modern battlefield."

Capital Capsules:

Deputy Defense Secretary David Packard has notified Congress that **the Defense Dept. is scrubbing plans to build a third nuclear-powered carrier—the CVAN 70.** Sen. Allen J. Ellender (D-La.), new chairman of the Armed Services Committee, had opposed the transfer of funds to start construction on the ship, which reportedly would have cost over $1-billion. . . . **NASA has selected Boeing to build its Mariner spacecraft,** which will, in one mission, explore the areas around Venus and Mercury. The 900-pound spacecraft will cost around $47-million. Its launching is planned for 1973. . . . Dr. Frank Ryan has been named special consultant to the House Committee on Electrical and Mechanical Equipment. A former quarterback for the Cleveland Browns and Washington Redskins, **he will call the signals on the multi-million dollar computer program for Congress.** . . . There are persistent reports that **William McGruder, head of the Dept. of Transportation's SST office, will not return to Lockheed but will take up a position here as a super-lobbyist for the entire aerospace industry.** The industry is still smarting from its SST defeat, which it attributes, in part, to unprofessional lobbying. . . . The Army says that recent advances in terminal homing devices have prompted it to begin **development of the Hellfire missile, which promises greater protection from attacking helicopters.** Once launched, the missile navigates independently, allowing the gunship to turn away immediately from groundfire and seek new targets. . . . FCC Chairman Dean Burch, testifying before a House Committee, says **he expects a decision on specialized microwave carriers "within the next several months."** Earlier he had told Congress the decision would be forthcoming around the end of the year.

Get up to 240 low-cost control outputs from one I/O channel

Meet HP's new computer-stretcher, the Multiprogrammer . . . ready to help you solve the many problems encountered in designing automatic test and control systems — at minimal cost.

Minicomputers just don't have sufficient I/O channels and adding more is expensive. What's more important, many devices used in automatic test and control systems require control signals in forms other than the computer's binary output. This is why HP designed the Multiprogrammer System. It's a computer-controlled data distributor and converter that allows you to simultaneously or independently control up to 240 analog (or 2,880 digital) outputs . . . from a single computer I/O channel.

The Multiprogrammer houses a variety of plug-in cards that provide programmable resistance, voltage, contact closure, or TTL outputs. You "custom design" your own system by simply plugging in these cards, and you have the ability to change the system any time you want. There's an additional saving with reduced computer programming time. All outputs are automatically set to a safe state at power turn-on. Digital storage on each output card eliminates the need to refresh each output channel. Special circuits simplify event timing and sequencing. And, because you'll be operating the Multiprogrammer in rugged industrial environments, HP designed and built it to eliminate problems with noise transients, ground loops, and broken cables.

You need one master Multiprogrammer, Model 6936A ($1,300), which has 15 channels. You can expand this capability at any time by adding on up to 15 Multiprogrammer Extenders with no changes in computer hardware or operating software. Each Multiprogrammer Extender, Model 6937A ($800), has 15 channels. Programmable output cards now available are: Resistance Output ($345), Low Speed D/A ($385), High Speed D/A ($420), Relay Register ($370), and TTL Output ($200).

A detailed brochure on the **HP MULTIPROGRAMMER SYSTEM** including system description, specifications, and applications is yours for the asking. Just contact one of the 220 HP Sales/Service offices.

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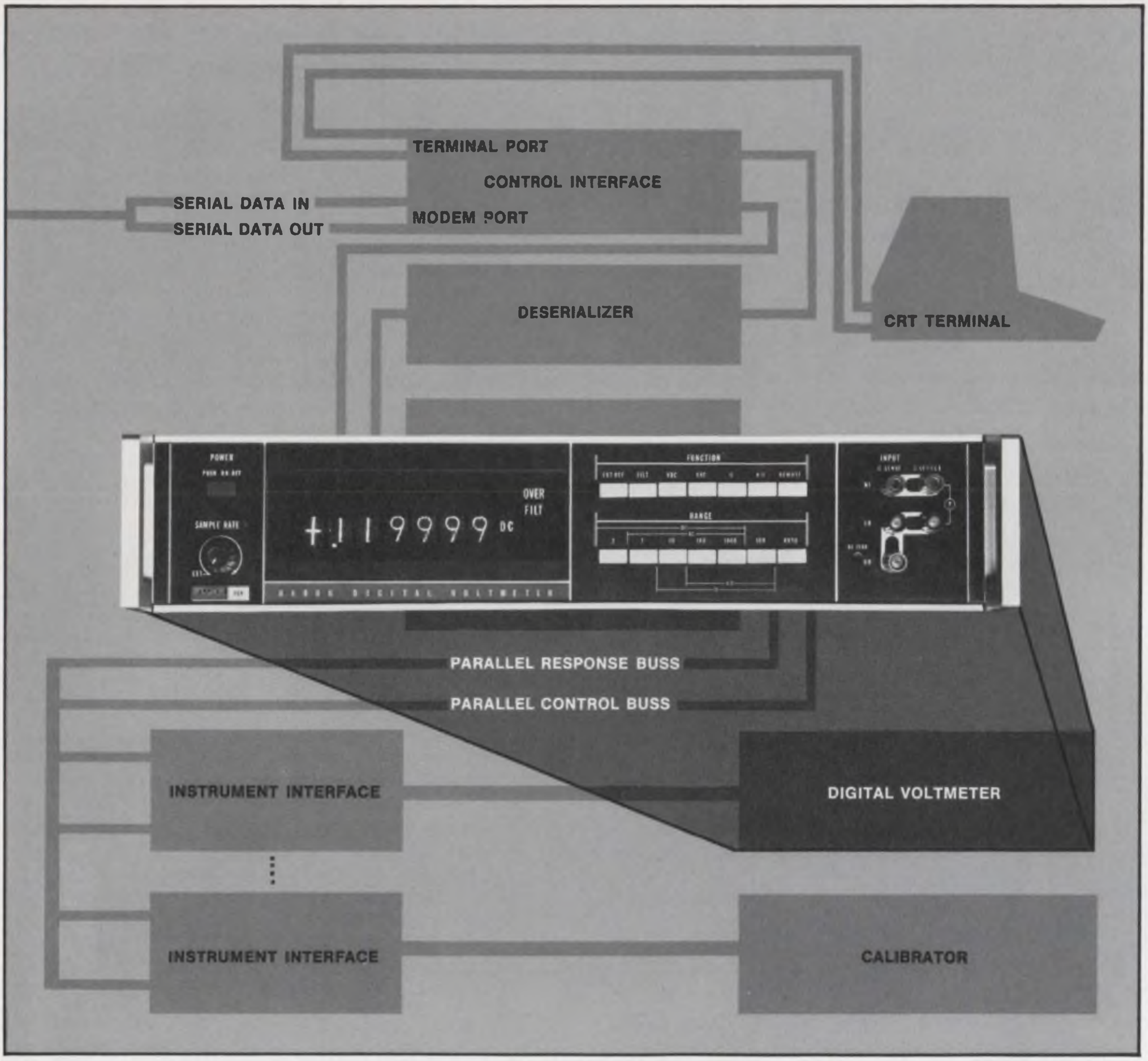

The new systems DVM with the big accuracy spec (0.004% for 90 days, 0.01% per year).

Here's the systems DVM with all time 24 hour, 30 day, and year long accuracies. It's the new Fluke 8400A with certified specs, autoranging on all parameters, options galore, and superior systems compatibility.

Five ranges of dc from 0.1v full scale to 1,000v with **0.004% accuracy** for 90 days and 0.01% for one year guaranteed. We give you five full digits plus "1" for 20% overrange. Featuring modular construction, the new DVM is only 3½" high by 19" wide. Resolution is **1 microvolt.** The Fluke 8400A will make 33 readings per second with a 3 millisecond aperture sample and hold. A switched filter on all ranges provides better than 65db noise rejection.

Any or all of the following options can be added at any time.

Seven ranges of 4 terminal resistance from 10 ohms to 10,000K ohms. Four ranges of ac from 1 to 1,000 volts with 0.05% accuracy to 10 KHz, ac/ac ratio and 4-wire dc/dc ratio, isolated data output. And **the 8400A will remember its remote control instructions** for convenient computer communication.

Base price is $2,450.

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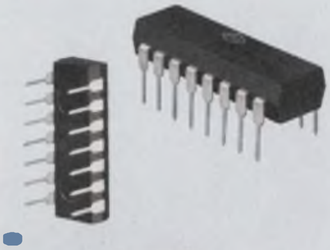
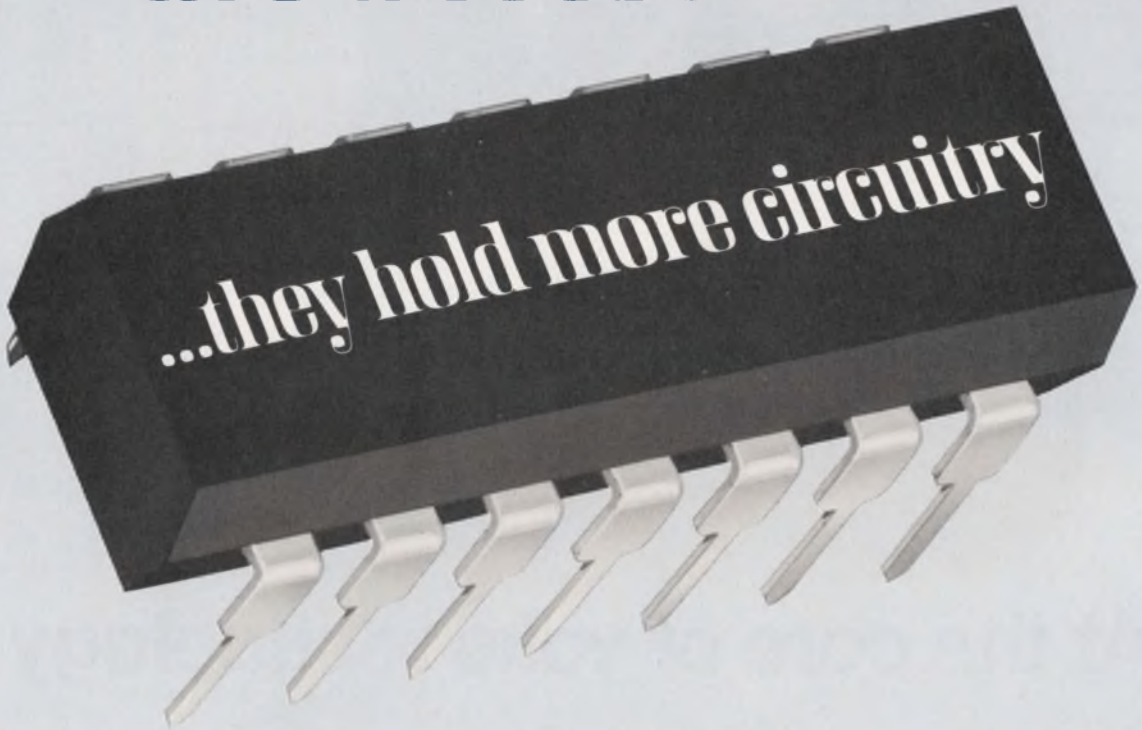
INFORMATION RETRIEVAL NUMBER 29

Centralab DIPs have a secret...





Every dual in-line package may look the same, but Centralab, through a unique manufacturing process, can now provide more circuitry per package. You can reduce the number of packages required for further miniaturization in design.

In resistor networks, including ladder networks, Centralab DIPs can accommodate a maximum of 24 resistors per package in 14 lead (TO-116) configurations. Our new 16 lead package provides up to 28 resistors.

A similar increase in elements is possible in two other general groups of networks:

- Resistor/Capacitor networks, including multi-layer ceramic chip capacitors.
- Active networks, including those with conventional semiconductor chips or beam-leaded devices.

The precision molded packages in either 14 or 16 lead configuration illustrated have a power rating of up to three watts and are designed to meet MIL Standards 883 and 202.

Centralab, the pioneer in thick-film technology, continues to lead with the introduction of these new packages. Laser adjusting techniques reduce resistor size, a special lead-frame material provides greater power handling capabilities, and automated final test equipment insures the reliability you demand. As producers of our own substrates, capacitors, resistor materials and semiconductors, we can provide customized circuity that meets your standards of performance and reliability . . . with delivery in four weeks.

For complete information and specifications, write Sales Manager, MEC, Centralab.

SPECIFICATIONS*

Ohmic values	10 to 10 Meg.
Tolerance	to 0.5%
Ratio match	to 0.5%
TCR (—55°C to +150°C)	<100 PPM/°C
TC Tracking	10-25 PPM
Operating temperature range	—55°C to +125°C
Power density	up to 3 watts
High temperature stability (2000 hrs. @ 125°C)	△ R <0.5%
Operating load life (1000 hrs. @ 70°C & 2 watts)	△ R <0.5%
Short time overload (2.5 times power rating	△ R <0.5%

*Typical

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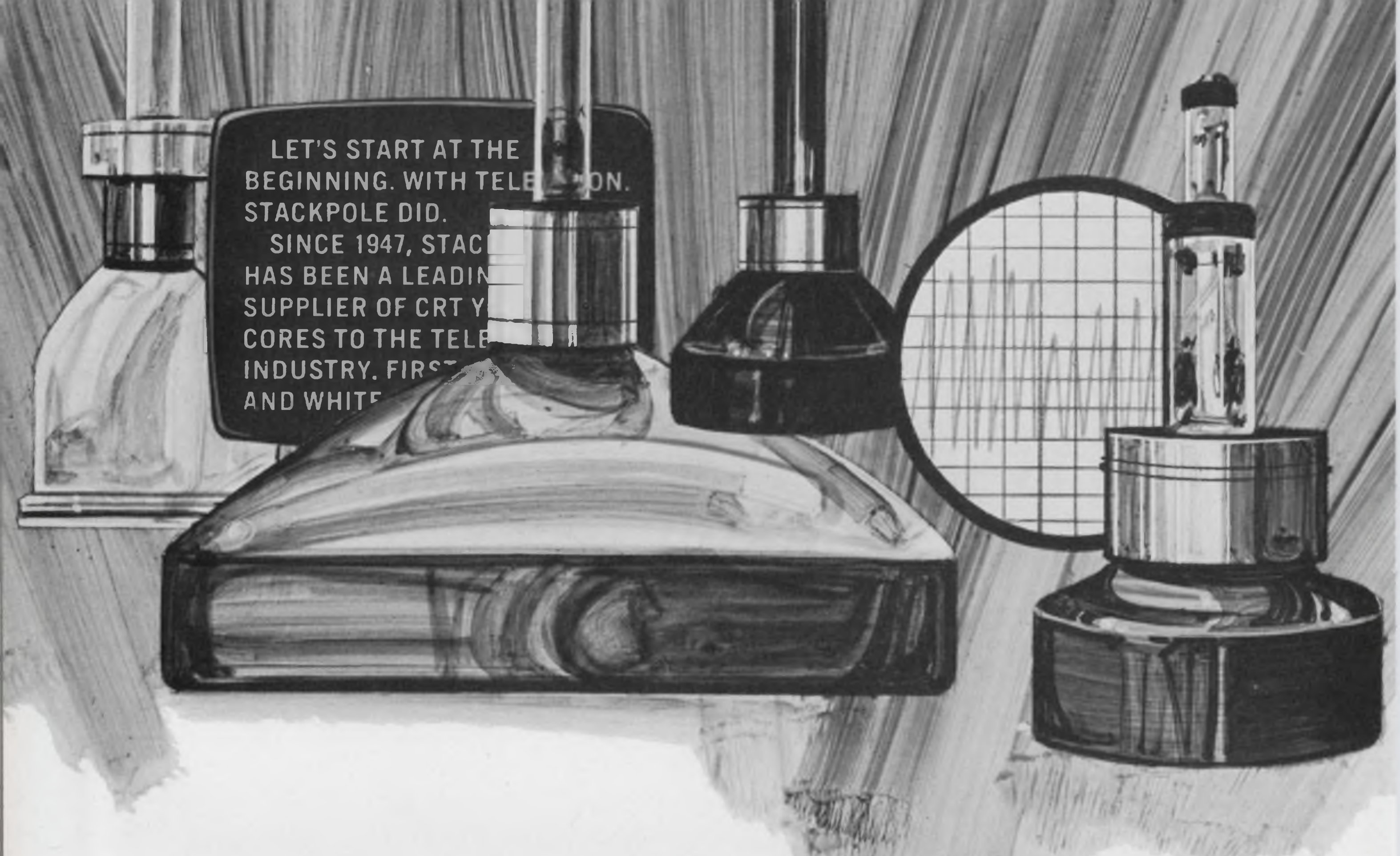

At the core of yoke technology

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Let's start at the beginning. With television. Stackpole did.

Since 1947, Stackpole has been a leading supplier of CRT yoke cores to the television industry. First, black and white. Now color. This makes us the oldest ferrite yoke core manufacturer in the U.S.

Now this knowledge and experience have been applied to the precision components necessary for CRT information displays. Whole rings. Quarter segments. Stator yokes.

What you get is a greater choice. First, tooling. Many configurations are already available. If not, Stackpole can develop precision tooling for you. Secondly, a family of ferrite materials permits greater flexibility in design, tighter control over results.

Stackpole also offers machining facilities for grinding to close tolerances.

TYPICAL CERAMAG® MATERIALS FOR INFORMATION DISPLAY YOKES

	7B	11	12	24
Initial Permeability	450	125	35	2500
Saturation Flux Density	2600	2550	2400	4500
Residual Flux Density	1650	1420	750	1700
Coercive Force	0.48	2.8	4.7	0.25
Curie Temperature	160	385	450	205

We've been around cathode ray tubes for a long time. Why not take advantage of the technology that can be yours at Stackpole. We may have the answer you've been looking for, or know how to get it. Simply contact: Stackpole Carbon Company, Electronic Components Division, St. Marys, Pa. 15857. Phone: 814-834-1521. TWX: 510-693-4511.

STACKPOLE®
ELECTRONIC COMPONENTS DIVISION

INFORMATION RETRIEVAL NUMBER 31

editorial

Europe's problems may prove to be ours

There are signs that the economic slump that gripped the United States for more than a year—and is only now starting to let up—is catching up with the rest of the world. Our buzz words of 1970—layoffs, cutbacks, profit squeeze—are being heard more and more in a raft of foreign tongues.

Before minimizing the significance of these signs, we should remember what overseas sales, particularly to Western Europe, have meant to American electronics companies. For many manufacturers, they have been the difference between red ink and black ink at the bottom of the balance sheet. In some cases, European sales represent more than 25% of an American company's total volume.

But these impressive figures have been the result of a robust economy in Europe. Any diminished productivity and consumption there will most certainly have a negative effect on a sizable segment of the American electronics industry.

To make matters worse, any decline in the European economy will almost certainly cause European electronics manufacturers to redouble their efforts to penetrate the U. S. market. This is what U. S. companies did in Europe when our recession began, and it would be foolish to consider the Europeans any less appreciative of worldwide marketing opportunities.

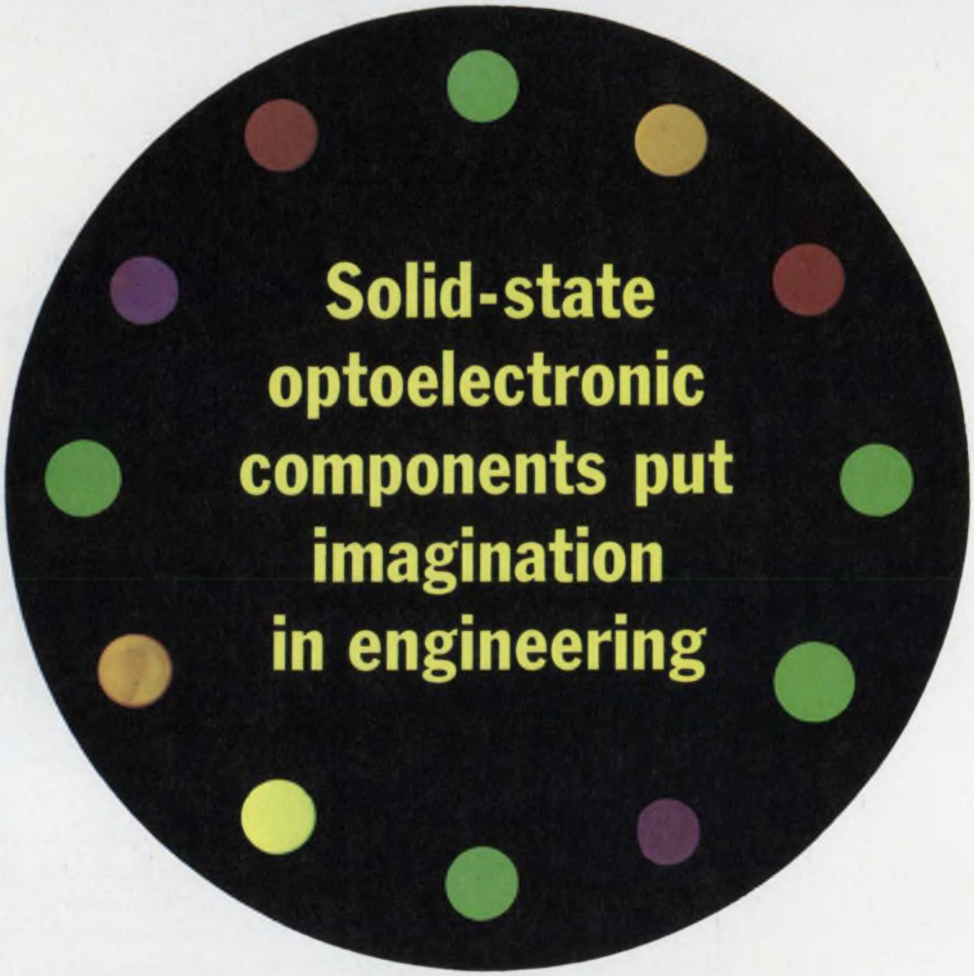
Western European companies have always looked longingly at the huge U. S. market. But except for a relative few, their efforts at penetrating have been something less than aggressive. With their own markets shrinking, though, many of these companies will have a lot going for them in this country, since European products and technology are of good quality, and their production costs are generally less than ours.

The net effect of this aggressive pursuit of the U. S. market, coupled with a softening of the European market, could cancel much of the expected upswing in our own economy. So those who may be tempted to gloat over the fact that Europe's turn for rough times may be coming had better think twice.

Electronics is a worldwide market, in which national or regional problems have international implications. Those who think differently aren't ready for the 70s. Those who recognize the fact will plan their marketing and product-development strategies accordingly.

Frank Egan

FRANK EGAN



Solid-state optoelectronic components put imagination in engineering

Multicolor LED devices, from Phillips Laboratories, Briarcliff Manor, N.Y.

Here is the first of two articles offering a handbook view of an emerging technology that should find wide use soon

Five years from now, many design engineers are going to ask themselves how they ever got along without optoelectronics. Those who are smart are investigating the prospects right now. For the era of optoelectronics, ushered in by solid-state radiation sensors and emitters, is just beginning.

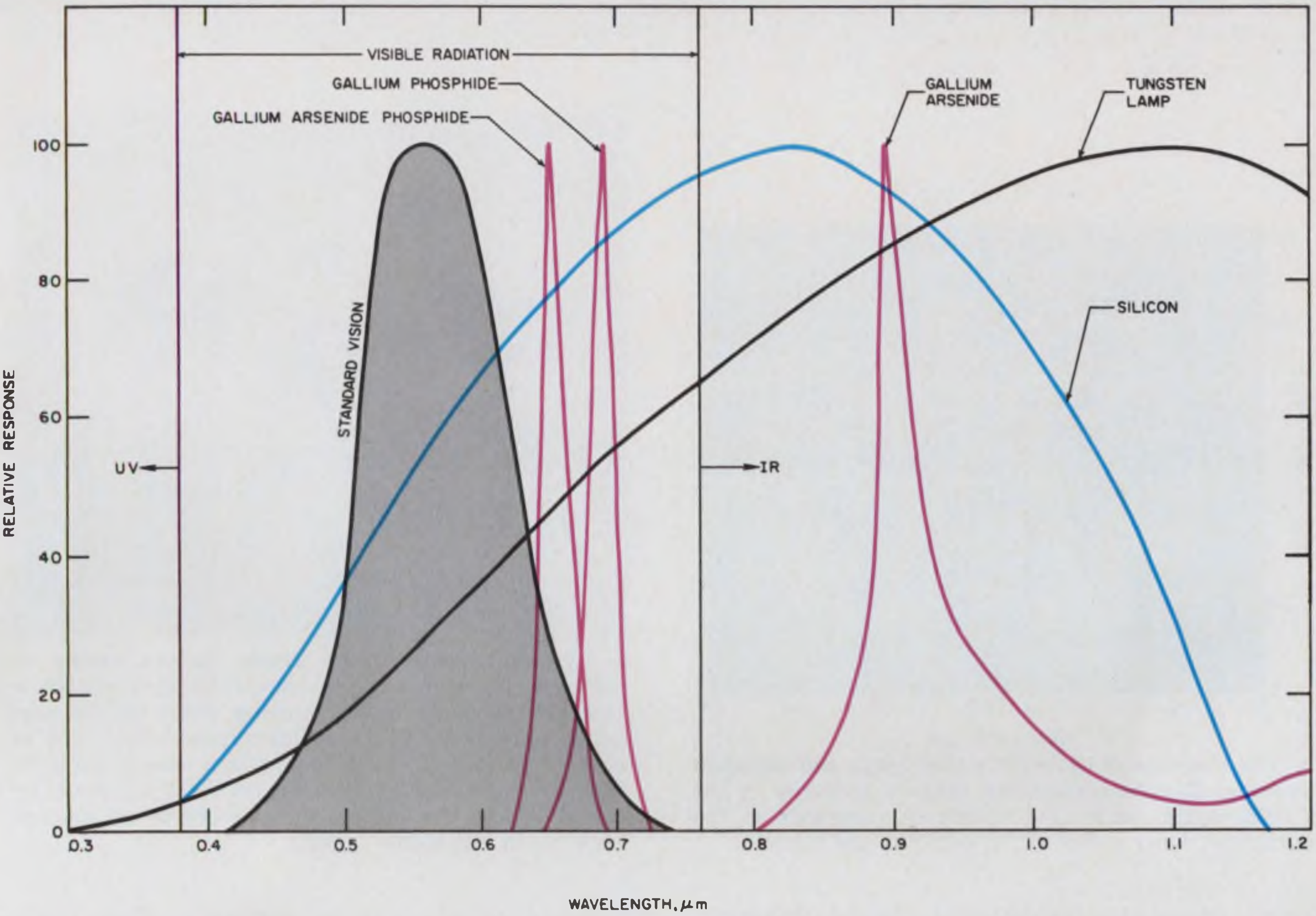
The latest phase in solid-state evolution that has already produced at breakneck speed the transistor, the hybrid circuit and the integrated circuit, optoelectronics gives the designer a host of low-cost components that operate in the near-infrared, the visible and the ultraviolet portions of the radiation spectrum. And with these operating potentials come new ways to solve old and new design problems. Already optoelectronic devices are found in applications ranging from intrusion detectors to laser measuring systems, from optical computer-tape and card readers to optical computer keyboards, and from simple panel indicator lamps to complex alphanumeric displays.

Solid-state optoelectronics components are appearing in a wide variety of shapes, sizes and packages. But devices with common features are emerging throughout the industry. Let's examine these features and how they affect application in systems.

Jim McDermott
East Coast Editor

Silicon photosensors are leaders

There are two primary effects governing the operation of solid-state photosensitive devices: photoconduction and photogeneration (photovoltaic effect). The phenomenon of photoconduction depends on the fact that whenever a con-



1. **The spectral response curves** of the average human eye, silicon photosensitive devices, and solid-state and tungsten filaments normalized here to a 100% value. In practice, the absolute magnitudes of response vary.

ductor is exposed to radiation of the proper wavelength, the absorbed energy releases electrons at the surface, and electron-hole pairs are produced. In semiconductors, these electrons and holes remain separated long enough to provide current flow that increases the conductivity when voltage is applied.

The increase in conductivity depends upon the number of electrons available for conduction at any instant. As a result, the conductivity depends upon the intensity of the radiation as well as the area of the surface exposed to it.

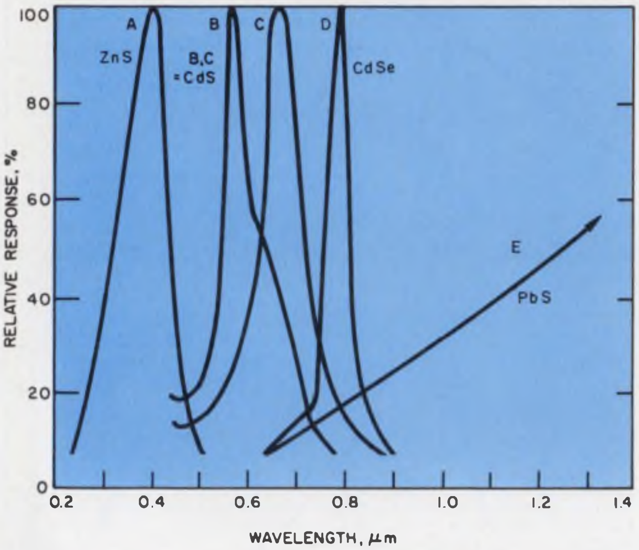
The use of photoconduction in junction silicon devices dominates the present technology. The devices include photodiodes, phototransistors and multijunction photosensitive units, such as light-activated SCRs.

The inherent spectral response of silicon is in the near infrared (Fig. 1), peaking slightly above 0.8 μm. As a result, these silicon radiation sensors are well-suited to operate with the new generations of light-emitting devices, which are a product of the gallium arsenide, gallium phosphide and gallium arsenide phosphide technology. The output of tungsten lamps also falls in the region of maximum silicon-device sensitivity.

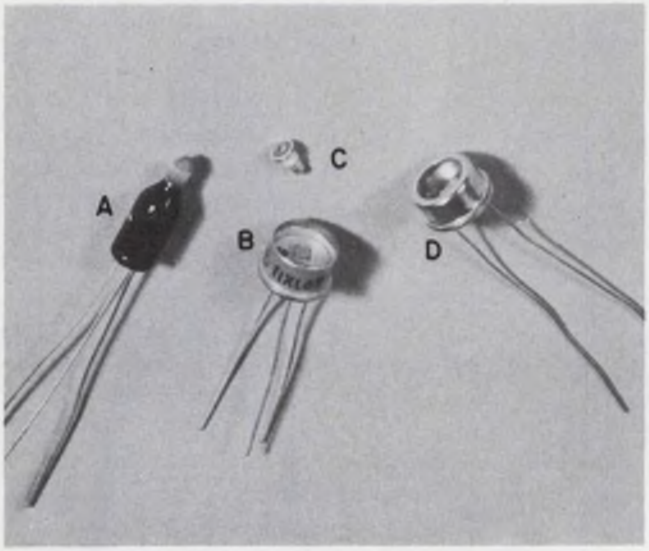
The second principle class of low-cost photoconductive devices are comprised of bulk compounds, such as cadmium sulfide, cadmium selenide and lead sulfide. These items are fabricated by pressing a powder onto a ceramic substrate and sintering it. Contacts are provided at each end of the sensitive area. These photoconductive cells are essentially a uniform semiconducting mass with megohms of resistance in the dark—resistance that drops to a few thousand ohms or less in light.

The photoconductive cells have a fairly low frequency response—on the order of a few hundred or thousand cycles, while the response range of the silicon junction devices is in the megacycle region. Operating currents of the junction devices are on the order of microamperes or a few milliamperes, whereas those of the photoconductive cells can range up to 0.5 A. Unlike silicon, the response of the cadmium sulfide and selenide in the photoconductive cells lies in the visible region (Fig. 2), so the cells are suitable for applications that use visible light, like camera-exposure controls or street-light controls.

The second basic effect that provides useful radiation-sensing devices is that of photogeneration. In this case, a photojunction device is operated in the photovoltaic mode (see Fig. 12)—



2. The **response of cadimum sulfide (B,C) and cadimum selenide (D) photoconductive cells** is primarily in the visible region, while zinc sulfide (A) responds in the ultraviolet. Lead sulfide (E) is useful in the infrared.



3. **High-performance silicon diodes** have a variety of packages. The p-i-n diode by Hewlett-Packard (A) has a fiberoptic coupling to the sensitive area. Of the avalanche photodiodes by Texas Instruments (B,C), one is in a pill package (C) for mounting in a coax or stripline microwave structure. A Schottky-barrier p-i-n diode by United Detector Technology (D) has a broadened spectral response in the visible region.

that is, if radiation is applied to the junction, a voltage is produced across it. These photovoltaic cells are usually produced as large-area silicon or selenium devices (Fig. 10). But in certain applications, like tape readers and shaft encoders, they are made in a variety of small silicon-cell arrays (Fig. 17).

Silicon—and, to some extent, selenium—are the most widely used low-cost photovoltaic cells for industrial and control applications. The spectral response of selenium peaks in the visible region, so that these cells, like the cadmium sulfide and selenide units, are used in photometric devices and camera-shutter controls, as well as other applications depending on visible light.

3 classes of photojunction radiation sensors

Useful photojunction devices include the photodiode, phototransistor and photoswitch (light-activated SCR).

The photodiode, the simplest of the three classes, is usually a small-area device constructed with a glass or plastic lens that focuses radiation on the pn junction. It is operated in the back-biased mode, and consequently the operating currents are small—usually from tens of microamperes to a few hundred.

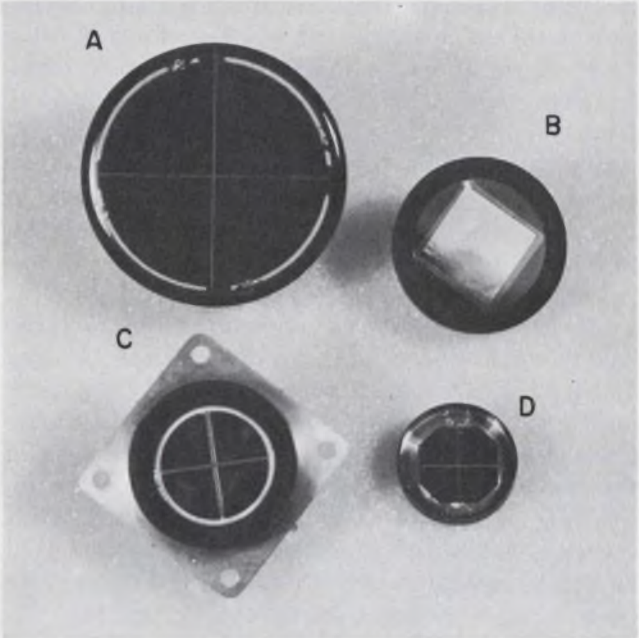
To obtain maximum sensitivity, some means of concentrating the available illumination on the device is frequently required, such as fiber-optic light pipes or an auxiliary optical system.

Photodiodes, like their standard junction counterparts, are subject to temperature and other environmental effects well-described in the literature. The normal diode back-bias leakage current is, for radiation sensitive devices, called the dark current, since it is measured with no radiation on the junction.

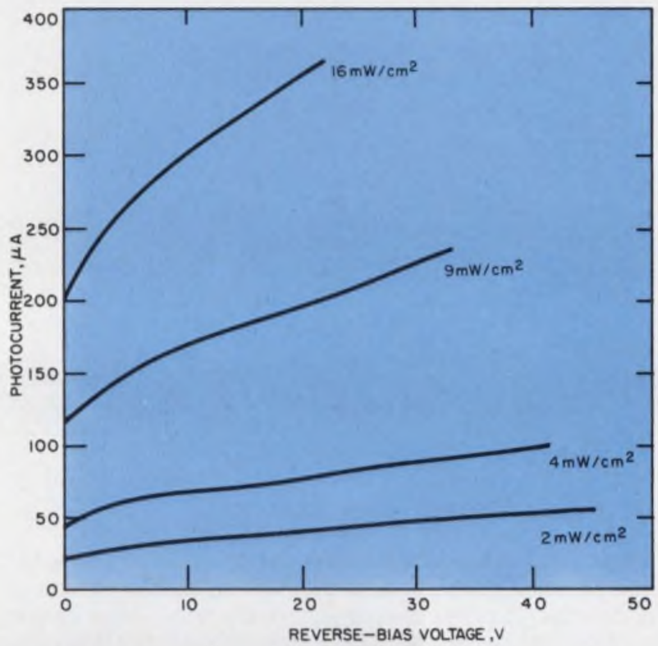
The earliest photodiodes were germanium, but today silicon diodes have taken over (Fig. 3) because their dark currents are three or four orders of magnitude less than germanium. However, the dark current of silicon diodes increases exponentially with temperature, doubling for each 10° C. The forward current caused by radiation follows the same rule.

More than one type of silicon photodiode is available. The lowest cost are those produced with diffused or epitaxial planar techniques. Typical rise times in response to square-wave pulses of radiation are 2 μs with diffused techniques and slightly more with epitaxial planar; it depends on the radiation level.

Silicon planar p-i-n photodiodes are available with very low dark currents, and they provide very fast response to pulsed radiation—from less than one to a few nanoseconds. Because of the low p-i-n-diode dark currents—generally a few



4. **Cells are available** for spot-positioning location and control, for use with visible light or with laser systems. A basic type is the four-quadrant cell: a selenium photovoltaic by Vactec (A), an RCA p-i-n device (C) and a p-i-n silicon cell by Electro Nuclear Labs (D). A five-terminal, single-surface silicon p-i-n cell by United Detector Technology (B) gives the X and Y coordinates for the spot position.



5. **Increases in both illumination and back-bias voltage of a silicon photodiode** raise the output current levels. In the example here, the illumination on the junction of a Texas Instruments 1N275 lies in a band between 0.7 and 1.1 μm, at a cell temperature of 25°C.

hundred picoamperes or less—these devices can be used for the detection and demodulation of very low radiation signal levels, such as in star trackers. In some cases they can replace photomultipliers.

While the noise-equivalent power of the p-i-n photodiode is lower than that of other types of photodetectors, for low-level applications they require high-gain, high-input resistance amplifiers. This, however, degrades the over-all response time.

The p-i-n diodes can be fabricated with the Schottky barrier technique as well as with planar diffusion. The Schottky barrier is formed by evaporating a transparent, conducting gold layer on one side of a silicon wafer and a thick aluminum layer on the opposite side. Surface doping is shallow, and the Schottky type has substantially increased spectral response over the diffused silicon for light in the visible region. Certain types of ultraviolet-enhanced cells are sensitive in the near-ultraviolet region.

The sizes of p-i-n photodiodes range from small area devices packaged in TO-18 cans to devices with an area about the size of a quarter or larger. A particularly interesting application of the larger sizes is in position-sensing systems.

In this case, the sensitive area may be either round or square employing a single front barrier (Fig. 4), or it may be constructed with four quadrants. In any case, when the input light spot is exactly at the device's center, no electrical signals are generated. If the spot moves off center, it produces a signal that is a function of its location along, or between, the X and Y optical axes of the device.

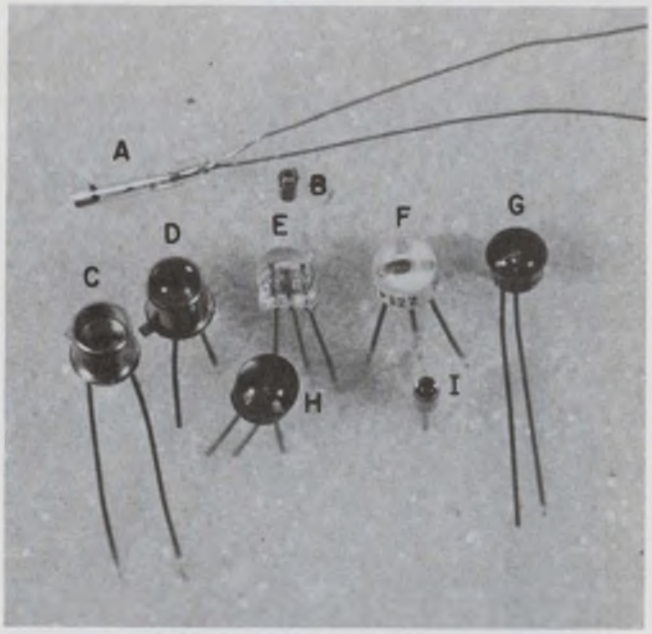
Single-axis detectors, with active areas between three and 9 inches long, provide an indication of the beam-spot location along the length of the device.

Other applications for the p-i-n photodiodes, and also for avalanche photodiodes, are as laser pulse detectors.

Maximum back-bias voltages for standard photodiodes range from 30 to 50 V. At low illumination, the photocurrent output tends to increase linearly with the bias voltage (Fig. 5). At higher light levels, the increase in output for a given increase in voltage is substantially higher.

More sensitivity with phototransistors

Phototransistors are more sensitive than photodiodes. If light is applied to the reverse-biased base-collector junction of a transistor, the absorbed energy creates electron-hole pairs that produce current flow. The current is proportional to the radiation intensity, and it is multiplied by the beta gain of the transistor. Thus the phototransistor is many times more sensitive than



6. **Silicon phototransistors are produced with and without base leads,** as shown in this representative group of low-cost devices. Displayed are an npn planar device by General Sensor (A) and a pill-package by Texas Instruments (B) for mounting directly on printed-circuit boards. Transistors by Motorola (C) and Clairex (D) are in TO-11 cans, while one by General Electric (E) is molded in clear plastic. The FET by Siliconix (F) is mounted on a ceramic base, while a Fairchild high-sensitivity device (H) is mounted on a plastic header. Other devices include one by General Sensor (I) and a new version by Texas Intruments (G).

the simple diodes. However, the collector-to-base leakage current—the dark current—is amplified by the same beta factor and must be considered in phototransistor applications.

Phototransistors today are almost universally npn silicon planar devices (Fig. 6). And because of the low dark currents encountered with silicon, the base leads on many phototransistors, are not brought out—only the collector and emitter leads are. For these types, only light or other radiation can be used as an input.

Other silicon phototransistors have a base lead. But use of the base connection to adjust the device for optimum gain usually decreases the device's sensitivity. This occurs because the base-to-emitter resistor shunts some current around the base-emitter junction that is not amplified by the transistor beta factor. The open-base transistor consequently has greater optical gain.

Phototransistors, like their in-the-dark counterparts, are limited by temperature and other environmental factors. To stabilize the device for operation over a wide range of temperatures, the base lead is useful. It is also necessary if an electrical control signal must be combined with the optical signal.

The response of all phototransistor types to radiation inputs produces operating characteristics that are representative of transistor operation with an electrical input (Fig. 7). Collector dark currents are on the order of a few nanoamperes, while light currents range typically from about 1 to 8 or 10 mA. Since most phototransistors are today designed for digital or switching applications, the response is given in terms of turn-on and turn-off times, typically in terms of a few microseconds.

Phototransistors are packaged in a variety of configurations (Fig. 6) depending, to a large extent, upon where they are designed to be used and how much they're to be sold for. The clear plastic package is the lowest cost device. Some transistors are packaged with a spherical lens in the top, while others have flat lens. In general, the flat types have a wider angle of light-beam coverage, while the spherical-lens types are used to minimize light-beam crosstalk in arrays. The clear plastic packages have unique optical patterns that are in manufacturers' specifications.

Sensitivity can be improved

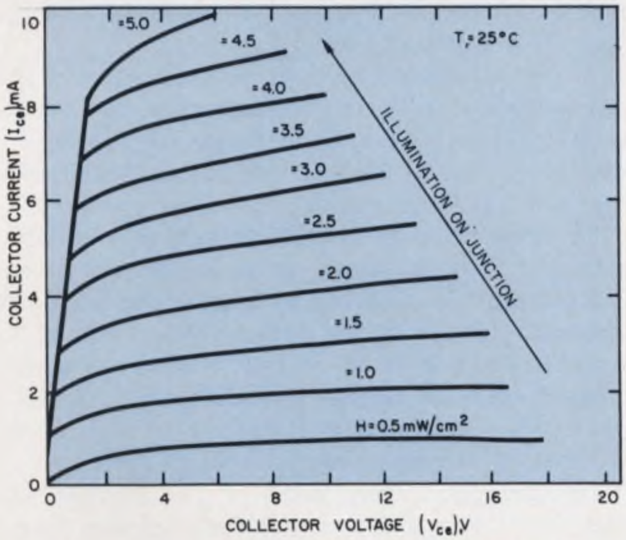
To improve the photosensitivity of phototransistors, device designers have developed Darlington phototransistors and other combination circuits (Fig. 8). These devices have a chip that contains a silicon planar phototransistor plus a direct-coupled amplifier stage. The increase in sensitivities obtained with these Darlingtons ranges from three to as high as 10 times that of conventional phototransistors. For many applications, the base lead of the Darlington is not used, just as with regular phototransistors.

Although maximum collector currents for the Darlingtons range from 150 to 200 mA, typical operation draws only a few milliamperes.

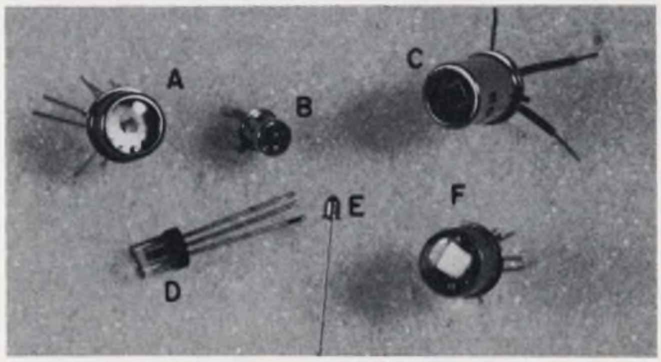
RCA has gone the single Darlington one better and produced a twin Darlington photodetector and amplifier, with enough output to drive a relay or thyristor directly from a 5-to-15-V supply (Fig. 8A). The photosensitive section consists of Darlington pairs driving a power amplifier section that is connected in a differential configuration.

Separate terminals are brought out for the photosensitive section, as well as for the amplifier and high-current switch, which has a 100-mA capability.

The dynamic response of the Darlingtons leaves something to be desired when compared with the single phototransistor. It is much slower in that the delay time—the time required for the output to increase from zero to one-tenth the maximum value—is about one-fifth of the total rise time. The rise time is on the order of, typically, 75 to 100 μs. Also, the fall-time—the period required for the output to decrease from a maximum to 90% of its value—is somewhat



7. **The operating curves of a phototransistor** are identical to those of a conventional device, except that the input is illumination of either visible or infrared energy. The curves above, for a Fairchild FPT120, are for a tungsten lamp at a color temperature of 2870°K.



8. **For increased sensitivity, higher power output and other reasons,** photodevices are fabricated with Darlington amplifiers or other circuits in the same package. The conventional photo Darlingtons here are by Clairex (B) and General Electric (D, E). The RCA unit (A), for switching operation, has twin Darlington circuits plus a power amplifier output. In a unit by Electro Nuclear Labs (F), the package contains a photodetector and an operational amplifier. For sensing in the 4-to-6 μm region, an Optoelectronics unit (C) contains a lead-sulfide photoconductive cell mounted on a thermoelectric cooler that supercools the sensor.

greater than the delay time.

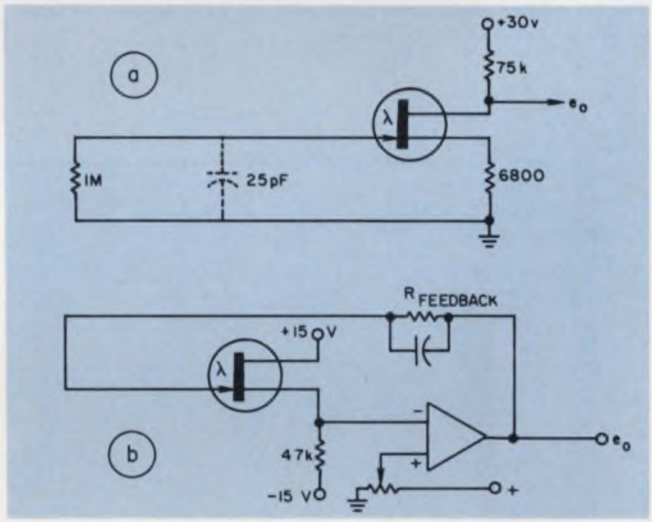
The most sensitive single transistor is the silicon field-effect device. Because the input impedance is high, relatively high gate or control voltages can be developed from small photocurrents. The input sensitivity for the gate photocurrent is about 1.0 μA/mW/cm². Additional amplification occurs in the FET circuit, and current gains can reach 10^4 or greater, depending upon the circuit constants and other factors. This can result in an over-all sensitivity of about 10 mA/mW/cm², which is higher than the other single-junction devices.

For high amplification, particularly with a constant-light input, large values of gate resistance are required. As a result, temperature-drift problems occur with the large resistor values. However, it is possible to adjust the bias to minimize such drifts.

A basic FET photodevice is shown in the circuit of Fig. 9A. Here the frequency response is limited by the combination of the 1-megohm gate resistor and the 25-pf internal gate-to-sink capacitance. This may be reduced to about 5 pf by use of a source-follower connection. But the most effective way is to use an operational amplifier, as shown in Fig. 9B.

Here the feedback holds the gate at virtual ground, so that the effect of C_{in} is negligible. In this case the pulse response is limited largely by the characteristics of the operational amplifier. Typical rise and fall times for such a circuit are 0.9 and 0.8 μs, respectively, when triggered by a 20-mA pulse through a light-emitting device held up to the FET transistor lens.

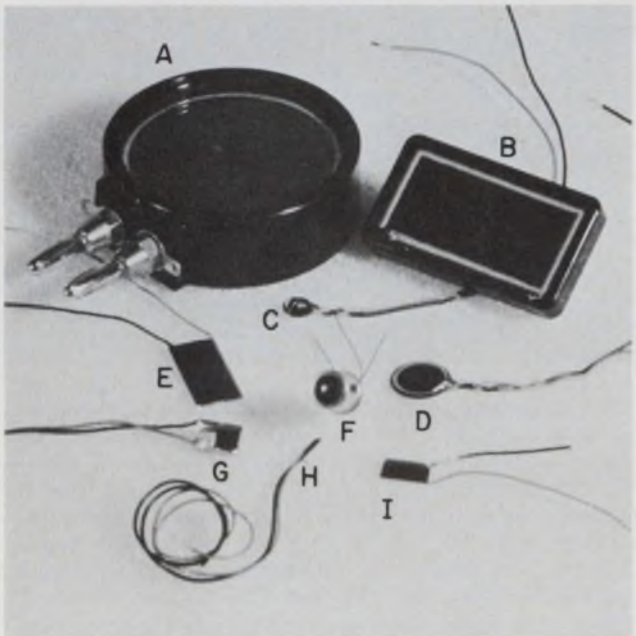
The highest current-carrying capacity of any



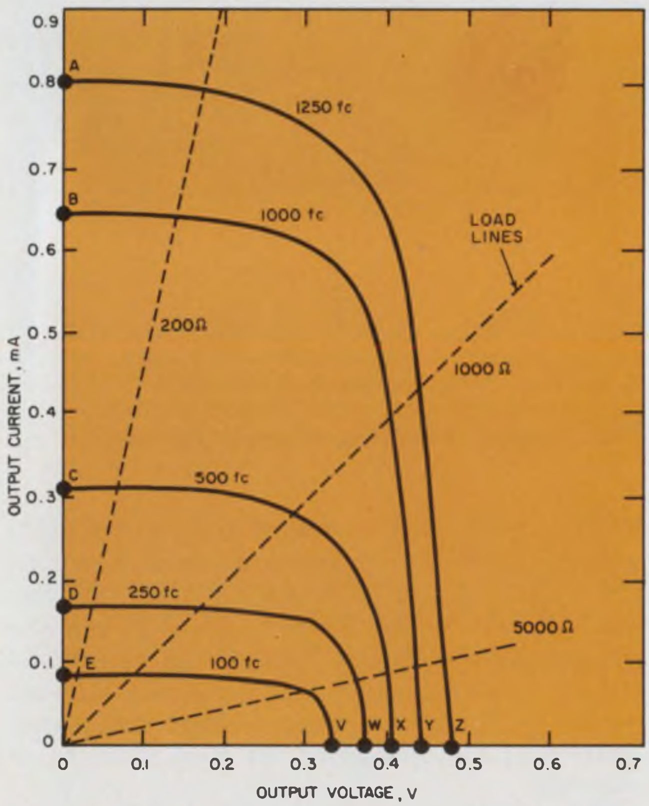
9. **The basic circuit of a photo FET** (a) shows the gate-to-drain capacitance, which limits frequency response. The effect is overcome by using an operational amplifier (b).

of the junction photodevices is found in the light-activated SCR. For example, General Electric's L9B light-activated SCR can carry an rms forward current of up to 1.6 A. Because it has a triggering lead available, both an electrical signal and a light signal can trigger the device. Like the regular SCR, once the device is triggered, it conducts until the voltage across it is removed or reversed.

When an impulse of light triggers the device ON, its internal resistance drops to the fraction of an ohm during turn-on time, and then it rises to a few ohms. The intensity of light or IR radiation needed to trigger the SCR ON decreases with an increase in temperature or device volt-



10. **Silicon and selenium photovoltaic cells** are produced in a wide range of sizes. Selenium cells by Vactec vary from large-area devices (A,B) to small wire-terminal units (C,D). Silicon cells by Solar Systems include one packaged in a transistor can (F) and others of thin, wafer construction (E,G,H,I).



11. **Small silicon photovoltaic cells** are widely used in punched-card and tape readers. The output voltage and current of a typical readout cell by Sensor Technology are shown here, with varying load values. Short-circuit currents lie at A through E along the Y axis, while open-circuit voltages are at V through Z along the X axis.

age. The addition of a current bias will also reduce the triggering level.

The required level of light necessary to fire the light-activated SCR is greatest when the device is first turned ON and decreases as the device warms up. This is because the lead current raises the junction temperature.

For conventional ON-OFF switching, the light-activated SCR can carry up to an ampere or so. But should it be required to trigger the device at a specific light level, the device voltage should be regulated and the load current reduced to a few milliamperes. Maximum power control capabilities of light-activated SCRs go up as high as 50 W, with efficiencies close to 100%.

The principal advantages of the devices are high current capabilities plus fast turn-on times, ranging from 30 μs to less than 1 μs for very high illumination levels. The device's turn-off time is fixed by its inherent recovery time to about 30 μs.

Light-activated SCRs can be used to replace relays, to drive other, more powerful SCRs, to provide switching logic functions, and for many other industrial and control applications.

Sensors that generate their voltage

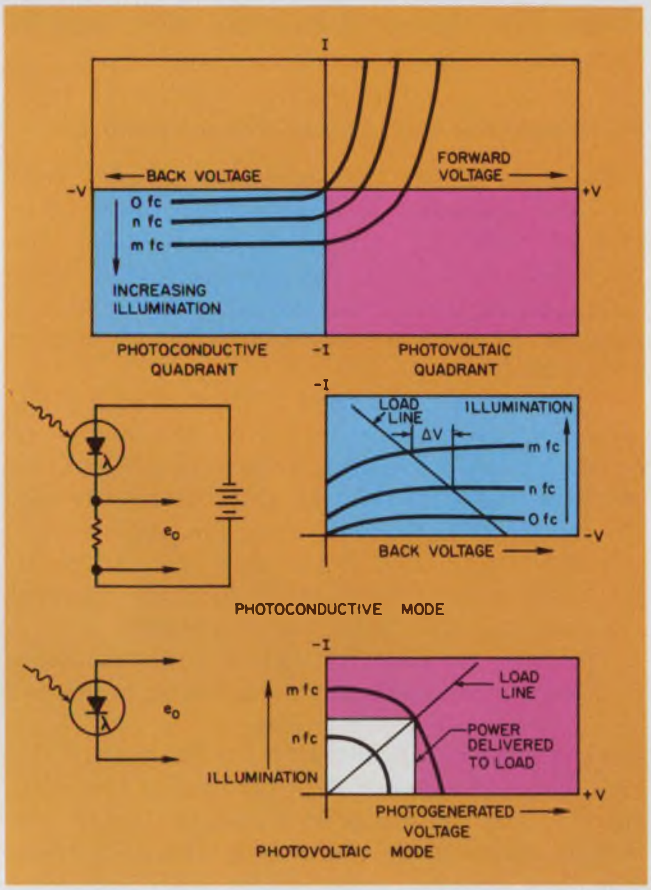
Photojunction devices may be operated in either the back-biased photoconductive mode or in the photovoltaic mode, in which case no bias voltage is applied. However, if the junction is illuminated, a voltage appears across it (Fig. 12).

In general, both silicon and selenium photovoltaic cells are manufactured as relatively large-area devices, compared with phototransistors (Fig. 10). However, for applications like punched-card and punched-tape readers, the cells are made and assembled in small arrays (Fig. 17).

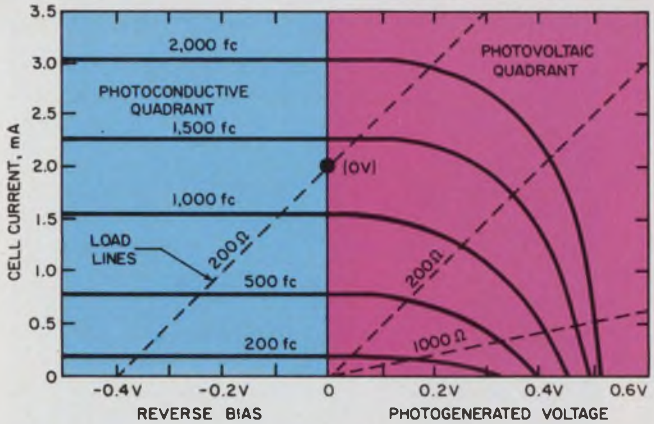
Selenium cells were the first to be used in the photovoltaic mode to provide the power for automatic control of the operation of a still-camera shutter. However, the requirements for increased sensitivity could be met only by oversized cells, and the camera manufacturers turned to systems using cadmium-sulfide photoconductive cells, which are much smaller and have higher sensitivity and power output, in their circuits.

For both selenium and silicon, open-circuit voltage of the photovoltaic cell is approximately the same; it is a logarithmic function of the illumination level. The relationship of voltage to light is linear for low light levels. Except for very small cells, the open-circuit voltage is independent of cell area. However, it increases with illumination.

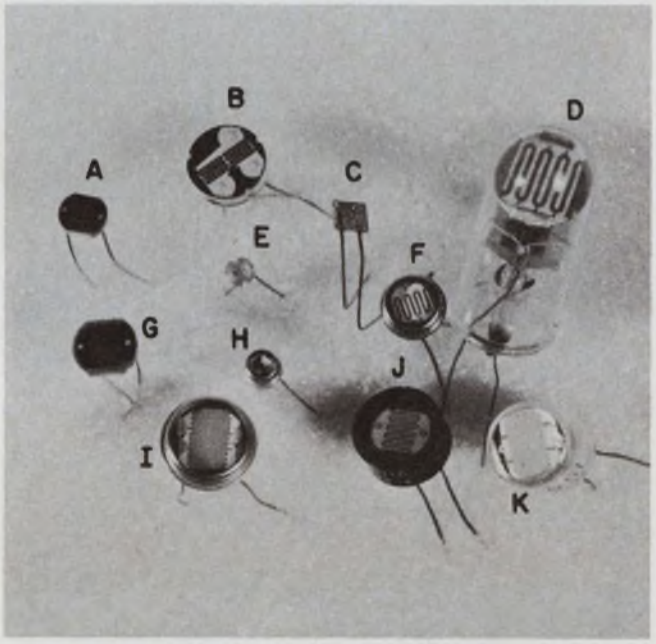
Photovoltaic cells produce an output current that is independent of the load under two conditions: low illumination and low load resistance.



12. **Photovoltaic cells, as well as any pn junction device,** can be operated either in the photoconductive mode or the photovoltaic mode. The top curves (A) are shown with quadrants as normally drawn. In B and C the quadrants have been reoriented, for simplicity.



13. **The operating characteristics of a photovoltaic cell,** by Solar Systems, fabricated for two-quadrant application. With low values of reverse bias and load resistance, it is possible to change the polarity of the output voltage by increasing the illumination from low to high levels.



14. **The spectral response of cadmium sulfide and selenide cells** is in the visible region, so they are used for visible light controls. Cells by Vactec (A,G) are for exposure-control systems in popular American cameras, while one by Clairex (E) is used in the tiny Minox "spy" camera. Clairex also makes a dual-element cell (B) for control of a projector auto-focusing system, and another (I) for turning street lights on and off. For moist ambient atmospheres, cells by Amperex (D) and Clairex (K) are sealed in glass envelopes. There are also general-purpose cells (C,F,H,J).

In this respect they act like constant-current generators. As both illumination and load resistance are increased, the variation of cell current with generated cell voltage becomes more linear.

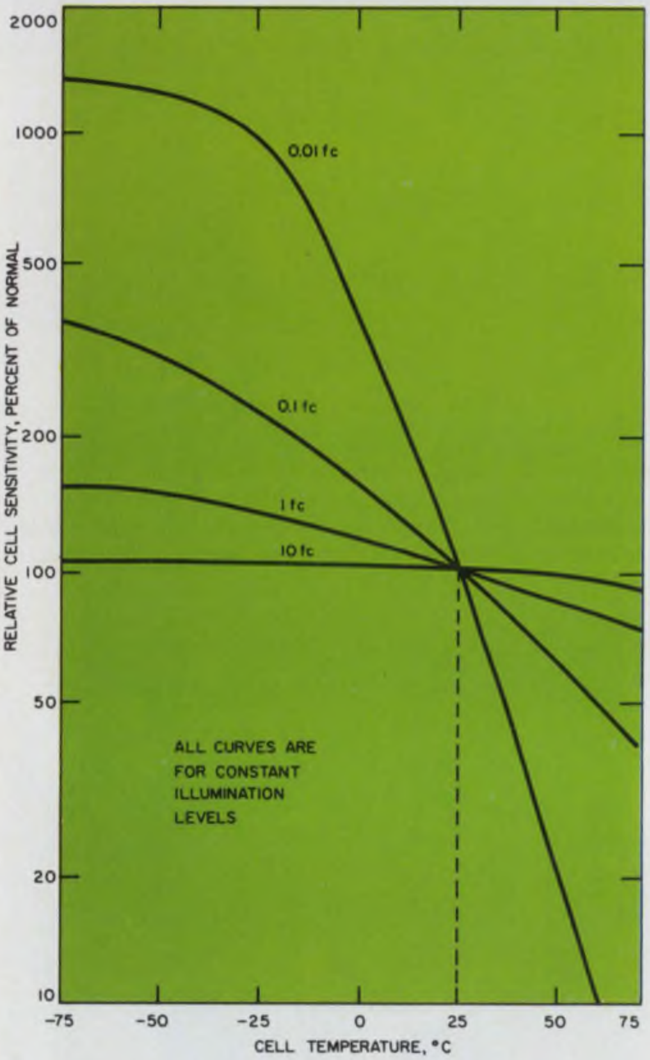
As with any junction device, photovoltaic cells are affected by changes in cell temperature. As the temperature varies from the nominal 25°C, the short-circuit current increases and the open-circuit voltage is reduced (Fig. 11). However, the magnitude of these changes varies with both the load value and the cell area, and it increases with increasing illumination.

Photovoltaic cells can be used in the photoconductive mode (Fig. 12). But for effective operation in both photoconductive and photovoltaic quadrants, the cells must be specially fabricated. Figure 13 shows the characteristics of a cell that is designed to operate in both modes.

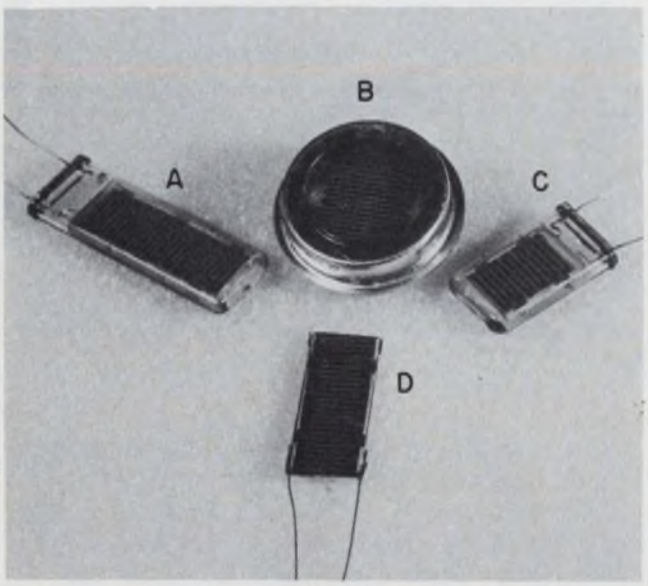
The frequency response of photovoltaic cells is limited by the cell size, because of capacitance effects. However, as the diameter of the cell is reduced, the response time is faster, approaching the theoretical limit of 2 μs for silicon and 20 μs for selenium. Response for the typical smaller silicon cells can exceed 15 kHz.

The response can be increased, but it requires proper load matching and the neutralization of cell capacitance by a peaking inductance. For example, one typical small-area cell so treated is adequate for pulse counting at a 1-MHz rate.

While photovoltaic cells can be generally used in the same kinds of circuits as other photodiodes, one factor must be considered: the internal resistance of the cell is high with low



15. **Temperature changes affect photoconductive cell current and sensitivity.** These curves show typical variations for a cell under differing levels of illumination.



16. **Power photoconductive cells** by Amperex can control up to 500 mA of continuous current, with maximum cell voltages of 400 V. Maximum ratings for (A) 3 W, 500 mA; (B) 1 W, 250 mA; (D) 0.75 W, 500 mA; and (C) 2 W, 250 mA.

illumination; it declines as the light level is increased.

Photoconductive light sensors change resistance

Cadmium sulfide and cadmium selenide cells are very-low-cost photoconductive cells that change resistance from megohms to a few thousand ohms with the application of light (Fig. 14). By design, this light-to-dark resistance ratio can be made to vary from 100 to 1 to over 10,000 to 1.

Cell currents range from a fraction of a milliampere to several hundred mA. The change in cell resistance from dark to light conditions depends on the material used to fabricate the cell, the cell's doping, its geometry, the applied voltage, the illumination levels used, the cells's "illumination history" and its temperature. Spectral response is in the visible region (Fig. 2).

The basic conductivity (g) of a photoconductive cell is dependent on the following relations:

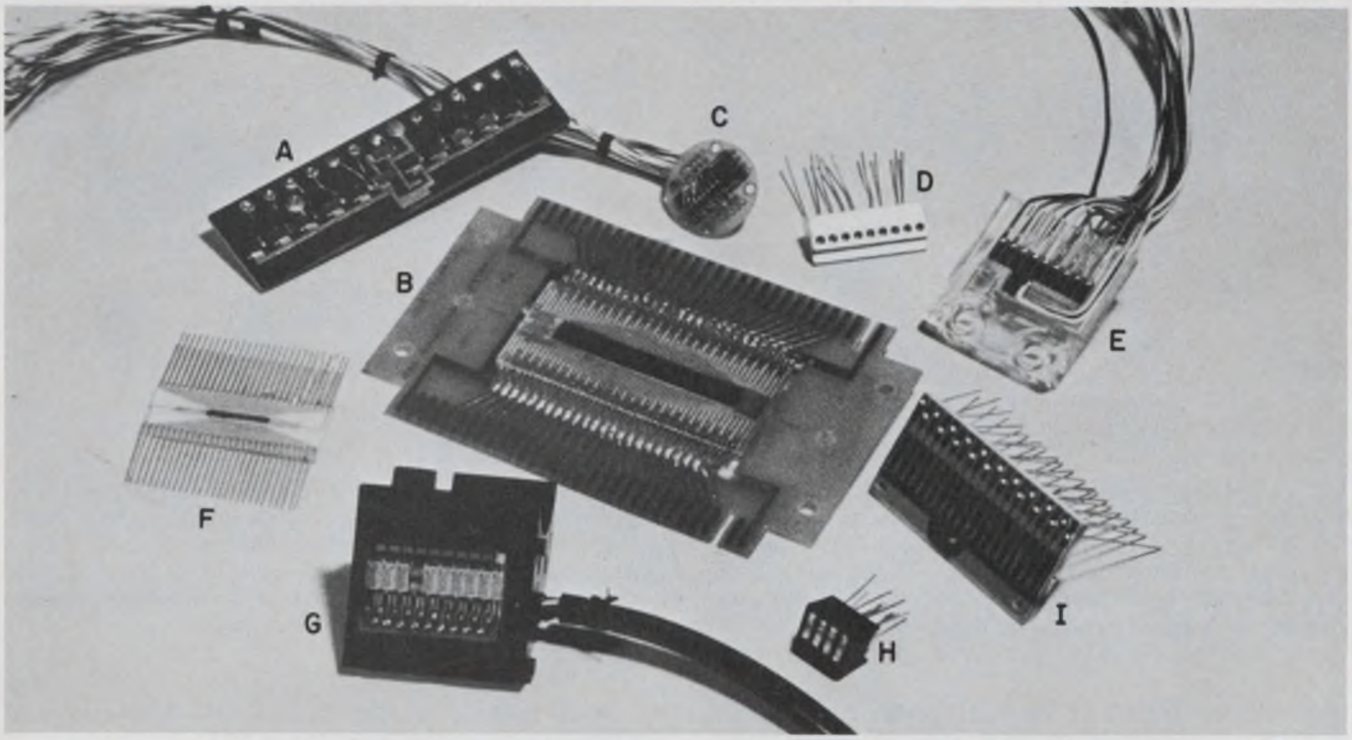
$$g = \sigma t (l/w)$$

Here σ is the bulk conductivity of the basic material. This conductivity depends on the following factors: the cell material (CdS or CdSe), the doping agents used, the method of cell fabrication, and the cell aging under both light and voltage. The thickness of the photoconductive layer (t) is important, in that an increase in it can raise the conductivity (lower the resistance). But this is limited by the depth to which the light can penetrate. As a result, effective cell thickness varies with illumination intensity.

The cell form factor, (l/w), can drastically affect the cell conductivity. This factor is the ratio of the length (l) to the width (w) of the sensitive area. In manufacturing, this ratio is deliberately increased by the use of different kinds of comb-like, wavy and interdigitated patterns (Fig. 14), to increase the ratio between dark and light resistance.

In practice, variations in the cell illumination level, the cell voltage and the illumination history have marked effects on cell operation. Cell sensitivity for any voltage is greatest at the lower light levels, decreasing somewhat with an increase in light intensity. If the illumination level is held constant, the cell presents a constant resistance, and in this case, an increase in cell voltage increases cell current linearly.

The response of a photoconductive cell to a square pulse of light is similar to the response of an RC network to a square wave of voltage, in that both have delays in the rise time and also in the fall (decay) time. These delays increase in a photoconductive cell as the cell illumination level is lowered. It is characteristic of photoconductive cells that turn-on delay is substantially longer than the turn-off.



17. **Photodiodes, phototransistors and photoconductive cells** are used in optoelectronic arrays. Examples of silicon photovoltaic arrays are found in a card reader (A), optical decoder (C) and punched-tape reader (G) by Sensor Technology, and a tape reader (E) by Solar Systems. The Sensor Technology reader has hybrid amplifiers to mate the cell outputs directly with TTL logic. A nine-transistor array by General Electric (D) is designed for tape reading. Photoconductive cells are used in a four-element Clairex array (H) for reading credit cards, while the multi-element Vactec array (I) reads punched cards. Diode arrays for optical character reading include a 54-element array by Optron (F) and a 96-element assembly by Electro Nuclear Laboratories (B).

The rise time is also raised by an increase in the cell voltage. However, here the decay time decreases, particularly for reduced levels of illumination. For best response cell illumination should be high and cell voltage low.

The frequency response of photoconductive cells is, because of the cell characteristics, low. In general, it ranges from a few hundred cycles for most cadmium sulfide cells to somewhat higher for selenides. Special photochopper cells are produced, and these are tailored to have faster response. Typical values are: 0.4-ms rise time and 3-ms decay time. Cells that control camera shutters have been developed with a response of 2 ms or better.

The illumination history of a cell affects its response to light. If the cell is exposed to light over a long period of time, its sensitivity to change decreases and its resistance becomes higher. Even for shorter periods, a hysteresis, or memory effect that depends upon the cell's previous exposure to light is evident—that is, cell conductance at a specific light level is a function of the duration of a cell's previous exposure to light and the intensity of that light. This effect is larger for cadmium sulfide. But the selenides tend to reach equilibrium more rapidly.

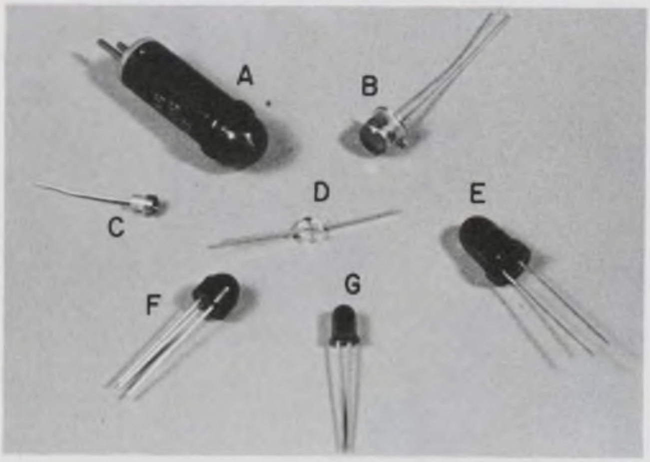
For continuous measurement of random light levels, the hysteresis effect limits the precision of the measurement. But for intermittent measurements, the effect of previous light history may be minimized by keeping the cell in a constant light environment between measurements.

Like other semiconductors, photoconductive cells are affected by temperature variations. Cell dark current increases with temperature, and cell sensitivity decreases (Fig. 15). Conversely, with a decrease in temperature, both cell dark current and sensitivity improve. The temperature-sensitivity variation is most marked at low light levels, but it is substantially decreased with high illumination.

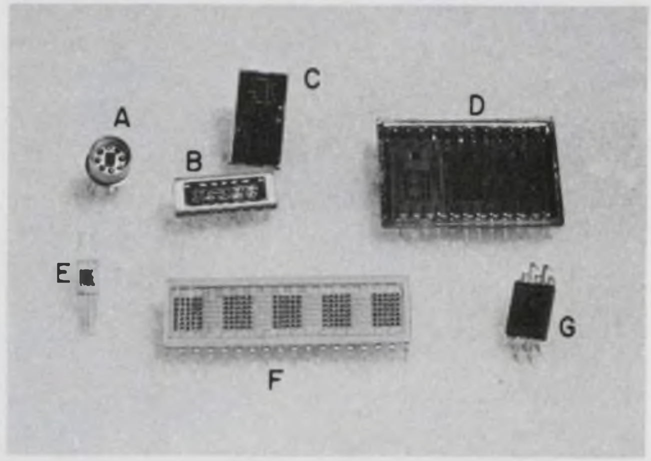
The smallest photoconductive cells require amplifiers for useful applications, but for the intermediate sizes, sensitive relays can be operated directly.

Power cells have been developed that can dissipate 1 W in open air and 3 W with a heat sink (Fig. 16). Cell current is limited to 500 mA. These devices are suited for switching and control applications involving lamp or inductive loads, because they can withstand short-term current and voltage surges, provided cell temperature is kept within allowable limits.

Light-sensitive patterns of photoconductive-cell material can be laid down in any configuration



18. **Visible light-emitting diodes** are being produced in a variety of packages. The sizes range from small emitters for arrays by Opcoa (C) and Litronix (D) to plastic-encapsulated lamps by Fairchild (F), TI (G) and GE (E) to a transistor-cased unit by HP (B). A LED ready for insertion in a panel is made by Dialite (A).



19. **There are many types of LED alpha and numeric displays:** (A) a seven-segment numeric display by Texas Instruments; (B) a monolithic five-digit display, (D) a three-digit display and (F) a five-character alphanumeric display, all by Hewlett-Packard; and single-digit displays (C, E) by Monsanto and (G) by Litronix.

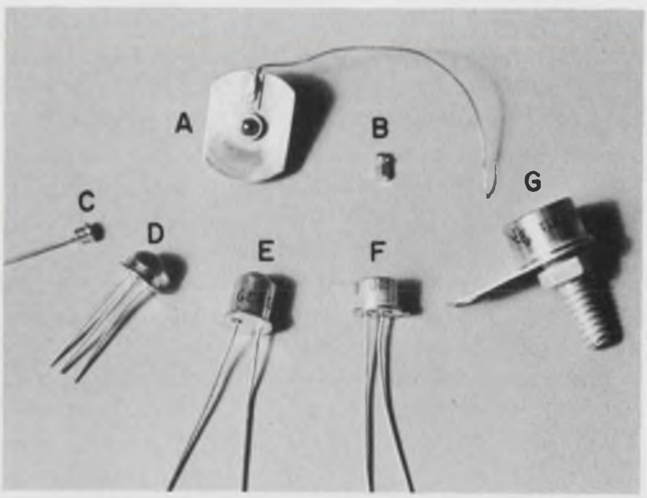
that can be drawn or photographed. As a result, various low-cost card and tape-reader arrays have been produced (Fig. 17).

Mass-produced LEDS: a breakthrough

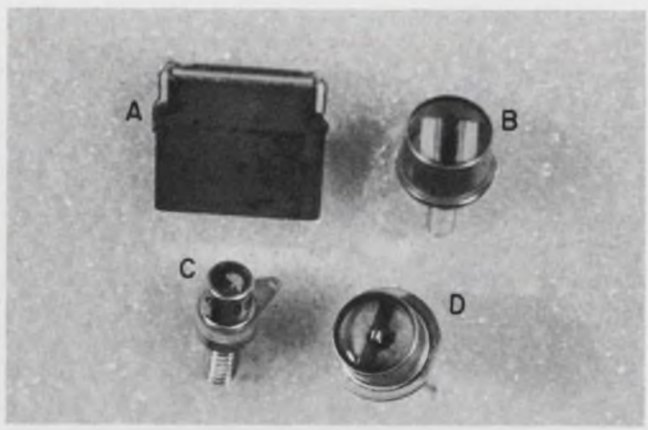
A recent breakthrough in the optoelectronics component field has been the widespread development of technology for the mass production of light-emitting diodes (LEDs) that radiate in the visible as well as the invisible near-infrared portions of the spectrum (Fig. 1). The devices currently being produced fall into these categories:

- Single-diode visible light emitters for panel lamps and indicators (Fig. 18).
- Arrays of diodes for digital numeric and alphanumeric displays (Fig. 19).
- Infrared-emitting diodes that are non-lasing mode, for industrial controls (Fig. 20).
- Single infrared-emitting laser diodes and arrays for high-power radiation, laser ranging and gated viewing systems (Fig. 21).

The LED is pn-junction diode that emits visible or invisible radiation when biased in the forward direction. The precise wavelength is determined by the doping in the three principal materials that are used to make the LED devices: gallium arsenide phosphide, gallium phosphide, and gallium arsenide. Gallium arsenide is also used to make laser diodes radiating at 0.9 μm.



20. **Invisible, infrared-emitting diodes for industrial and control applications** have outputs ranging from 0.2 mW by Hewlett-Packard (B) to 200 mW by Texas Instruments (A). Radiated power between these values is produced by the others, made by General Electric (C, E), Fairchild (D), Hewlett-Packard (F) and Texas Instruments (G). All operate at room temperature.



21. **Laser diodes for high infrared power output** are available as single-junction devices and in arrays. A cryogenic module by RCA (A) has an average output of 1 W using a linear array of 30 diodes. A 25°C array package by RCA (B) has a peak output of 50 to 300 W, depending on the number of diodes (10 to 60). Single-diode, 25°C devices range from a Texas Instruments unit (C) with a peak output of 7 W to an RCA device (D) with 65-W peak.

Both gallium arsenide and gallium arsenide phospide diodes emit light from the junction only. Consequently the light appears as a thin, flat beam and the packages in which it appears are designed to produce a radiation pattern suitable for visual observation. For visible indicator diodes, the light is generally spread out, while for use in card readers, the package is small and the beam is generally concentrated in a spot.

Gallium phosphide diodes are transparent by nature, and they emit visible red light in the vicinity of 0.7 μm (Fig. 1). The light is emitted in all directions. In the packages for these devices reflectors are tailored to divert the light in the proper forward beam pattern.

Red transparent dye is frequently used in plastic or glass lenses to spread the visible radiation and produce a bigger light.

A prime advantage of visible LEDs that observers feel will eventually lead them to replace all small tungsten indicator lamps is the low power and low voltage required. Typical forward voltages are about 2.1 V for 10-to-20-mA drive currents for these lamps.

A major consideration in the use of the various solid-state lamps is their life. Half-lives of tens of thousands of hours appear realistic—enough to outlive engineers who put them in designs.

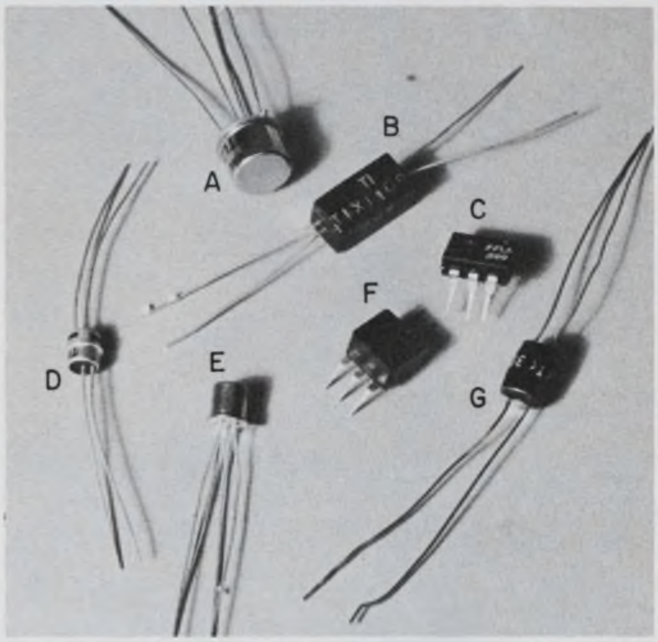
The invisible IR emitting diodes are used for industrial applications, such as intrusion detectors and production-line counters. The power output of these devices ranges from about 0.2 to 200 mW. In devices with higher outputs, the package is designed for heat removal.

Because the IR radiation of these LEDs matches the response curve of silicon transistors and diodes, tiny LEDs are assembled in linear arrays for punched card-reader applications. It should be noted that there is a spread in the output levels of diodes manufactured at the same time, as well as a spread in the sensitivities of phototransistors or diodes assembled in arrays (Fig. 19). For this reason, industry spokesmen recommend that card-reader arrays be obtained in matched sets from the device manufacturer.

For laser systems, gallium-arsenide lasers are available as single diodes or in packages with laser arrays (Fig. 21). The power output of single laser diodes ranges from about 7 to 65 W peak, while the output of the diode stacks ranges from 50 to 300 W peak. For the higher outputs, cryogenic modules, with the laser arrays mounted on them, are useful.

Optical couplers begin to appear

There are many situations in which data must be transmitted between two circuits that must be electrically isolated from each other. While such isolation has in the past been provided by relays, isolation transformers and other arrangements, a host of new components called optically coupled isolators have appeared (Fig. 22). These devices are a combination of an IR light-emitting diode and a photosensitive transistor, diode or photoconductive cell. The input is applied to the LED terminals. The LED output turns the photosensor ON, producing an isolated output.

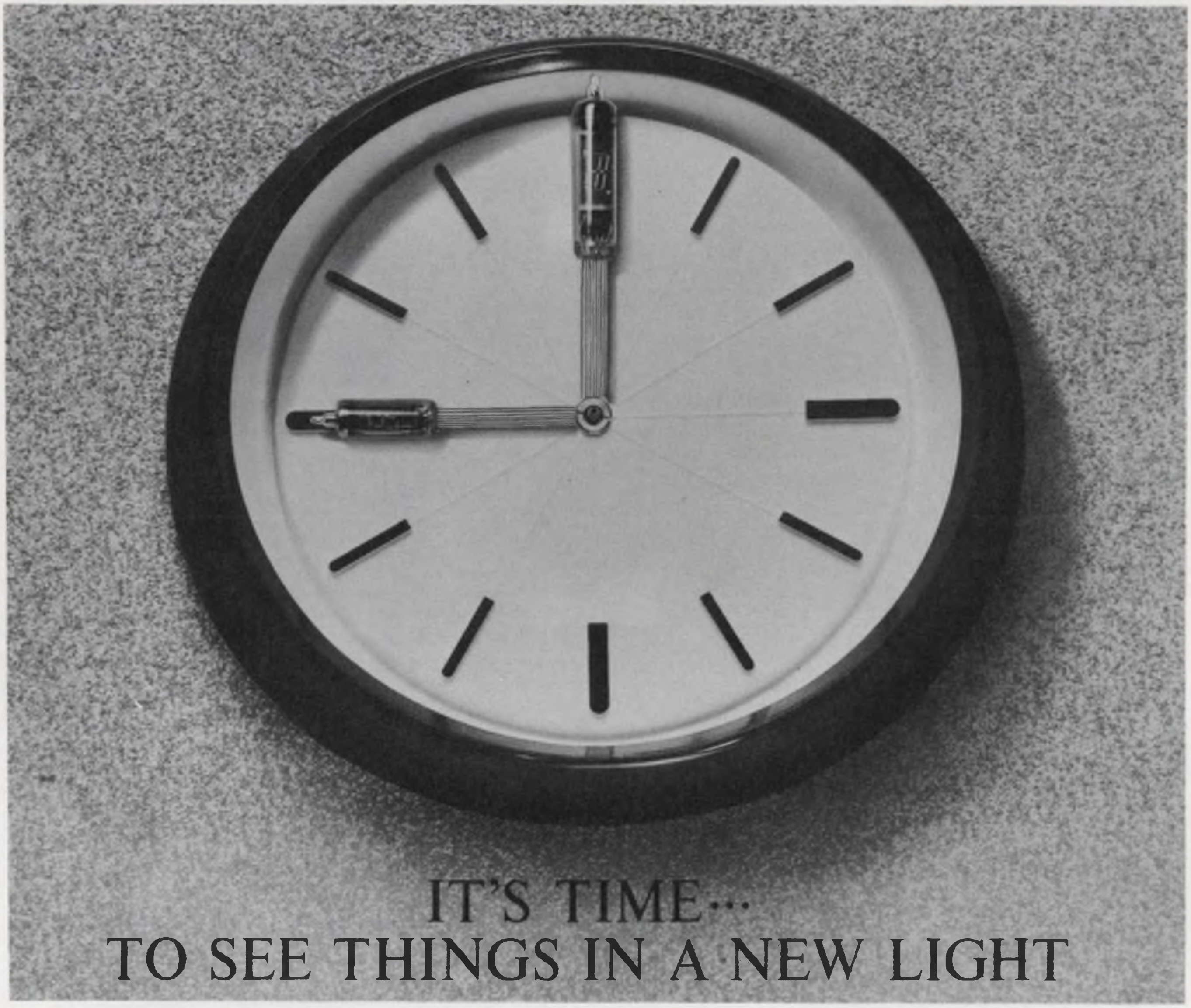


22. **Optical couplers use light-emitting diodes driving a photosensitive device** to provide megohms of isolation at up to several kilovolts between input and output terminals. In units by Vactec (A, G) a light-emitting diode output is applied to photoconductive cells. The photosensor in devices by Texas Instrument (B, D), Fairchild (C) and Clairex (F) is a transistor. The output in a Hewlett-Packard unit (E) is produced by a p-i-n diode.

The coupling between the LED and the photosensor may be fiber optics or just a small glass lens. The insulation resistance between the input and output terminals is typically 10^{11} ohms.

Inputs to these devices are in the neighborhood of 1.3 to 1.5 V at currents ranging from 10 to 100 mA. The type of output and the frequency response obtainable depends upon the individual optical coupler design. For example, there are modules in which the LED radiation is applied to a photoconductive cell. Dark resistance ranges from 400K to 10^8 ohms, with ON values dropping to 50- and 2K-ohms, respectively.

The majority of these devices use silicon planar phototransistors as the light-sensitive element. Transient response and other considerations apply to the phototransistors previously discussed. There are also couplers with a p-i-n diode as the sensor. The cutoff frequency for current transfer in these devices ranges from 3.5 to 7 MHz. Normal input currents range from about 10 to 30 mA, but output currents are 10 or 12 microamperes. ■■



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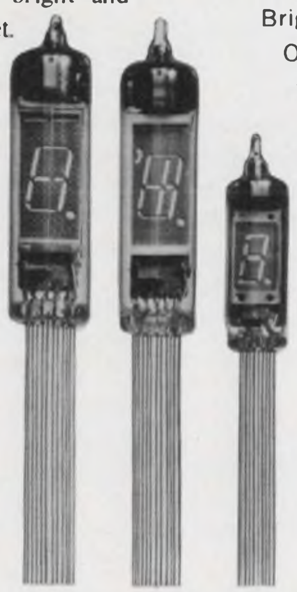

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The minicomputer and the engineer—Part 4

Interfacing: A balancing act of hardware and software

The processing power and usefulness of a computer depend largely upon the range of peripherals that can be connected to it. But peripherals can't just be plugged into the computer. Interfaces are needed—combinations of hardware and software design. Interfacing can be simple or difficult, depending on the characteristics of a computer's Input/Output (I/O) facilities.

The I/O system of any computer can be defined as the means by which that computer and its memory communicate with peripheral device interfaces, which in turn communicate with the peripherals themselves. Figure 1 illustrates the path of communication. The figure is not meant to portray any physical system in particular. The variation in I/O systems from different manufacturers, and often between different computer models from the same manufacturer, is great.

The purpose of almost any piece of peripheral equipment is to perform services that the central processor cannot do by itself: to sense stimuli from signal sources (analog-to-digital converters), to provide stimuli to external equipment (digital-to-analog converters), to receive data (keyboards, card readers) to provide hard copy of results (printers, plotters), or to store large amounts of information (discs, magnetic tape). In most cases, these devices are usually standard items; they are not designed for any one computer in particular. The interface connects the device to the computer using the I/O system.

With systems employing small computers, the cost of the peripheral equipment and its interfacing to the computer almost always outweighs the cost of the basic computer. The I/O facilities may help to minimize this cost by:

- Allowing the designer to choose between a hardware-oriented or software-oriented solution to an interfacing problem.
- Allowing the designer to use only those parts of the facilities necessary for operation of the interface.
- Being able to handle a variety of data rates.
- Allowing standard, readily available electronic components to be used.
- Permitting connection of the interfaces to the computer without processor modifications.

Programmed transfer or DMA?

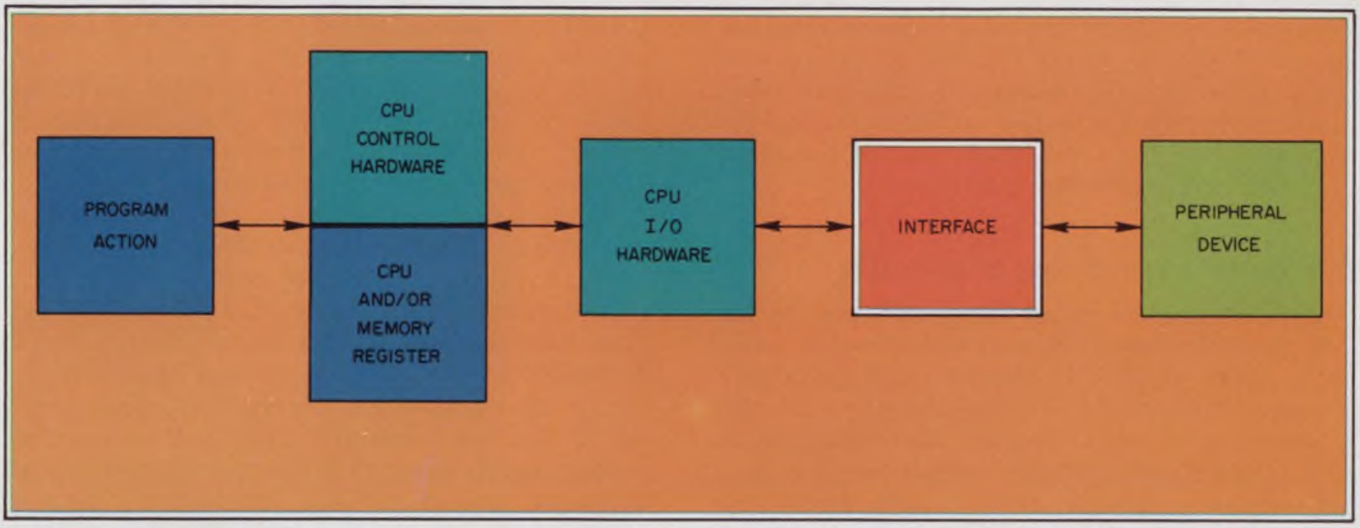
Most small computers provide two methods for transferring between the computer mainframe (processor and memory) and a peripheral device: programmed transfers and direct memory access (DMA).

In a programmed transfer, the computer program must execute one or more instructions to complete the transfer of one unit of information between a processor internal register and a peripheral device register.

In a direct-memory-access transfer, the device interface transfers the unit of information directly between core memory and the peripheral (or interface register) in an operation that is completely transparent to the basic central processor. In most computers, processor operation is temporarily suspended for approximately one memory cycle while the transfer is taking place. When the transfer is finished, normal program execution resumes, with all processor registers intact. Direct memory access is usually used to transfer large blocks of data between memory and the peripheral device at high rates.

The programmed transfer is the simplest method of transferring information. Basically all that is provided by the computer is a set of signal

Bradstreet Vachon, Manager, Computer Special Systems and **William Weiske Jr.,** Project Engineer, Digital Equipment Corp., Maynard, Mass., 01754.



1. **Computer-to-peripheral communication is a combination** of both hardware and software. The characteristics of a computer's input/output (I/O) facilities determines the design of the interface.

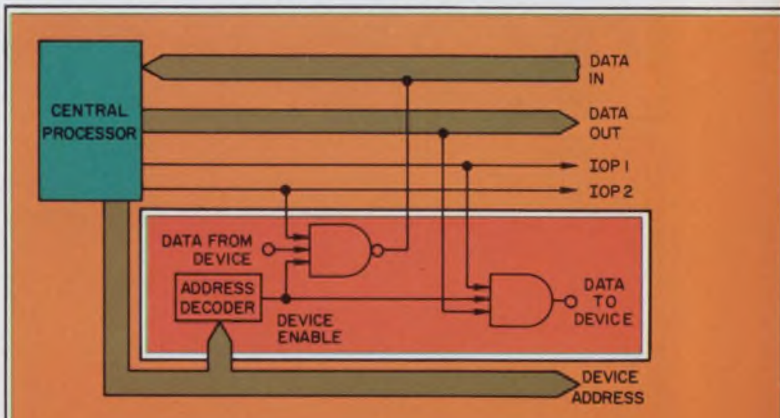
wires between the processor and the interface to carry the information to be transferred, plus several control signals that affect the strobing of data into or out of the interface register. Accompanying the data and control signals is usually a set of device address signals identifying the interface that is to participate in the transfer. To make the transfer, the program needs only to execute the appropriate I/O Transfer (IOT) instruction. This instruction specifies the device address and the control signals that are to be generated.

The elements necessary for a typical programmed transfer operation are illustrated in Fig. 2. The device address is decoded in each interface. When a device recognizes its address, it provides an enabling signal, which then allows the control pulses to perform an action, such as gating data onto the DATA IN lines. Each interface uses high-impedance receivers to sample the outgoing data and control lines, so that the lines are not overloaded. To drive the ingoing lines, each device uses open-collector drivers; all input signals are therefore wire-OR'd together. The CPU controls the I/O timing, so that the transients have settled before they are read. The signals on the I/O bus lines are typically TTL levels.

The direct-memory-access transfer is a more complex method of information transfer. When a transfer is to be made, the interface must request use of the DMA I/O facilities. When the request is met, the interface must first provide the core memory address to or from which the transfer is to take place. Then, if the transfer is into memory, the interface must provide the actual data to be transferred. If the transfer is out of memory, the interface must accept the data sent from memory. The interface must then perform a housekeeping operation by updating its internal registers. The DMA interface also makes use of the programmed transfer facilities, since inputs to the current-address, word-count and control registers are usually processed under program control. The interface must also be able to provide the program with an indication that the block of data has been transferred.

Table 1 lists some of the advantages and disadvantages of the programmed transfer and direct-memory-access methods.

Some computer I/O facilities allow a variation of the DMA transfer. Instead of the interface containing word-count and current-address registers, core memory locations are used for these functions. The interface needs only to specify where in memory these locations are. The I/O system takes on the additional housekeeping functions. This facility could be termed a multi-cycle direct memory access, since memory must be accessed three times: once to examine and update the current address, once to update the word



2. **Programmed data transfer uses the minimum** number of interface components. These are an address decoder, a bus driver and a receiver.

count and detect the end of a block of information, and once to access the unit of information itself. This type of transfer is attractive when moderately high data rates are expected and the user wants to avoid the higher cost of hardware registers in the interface itself.

Interrupts: a reordering of priorities

Physically, most small computers include the I/O system hardware as part of the central processor. Part of this hardware implements programmed transfer I/O transactions, and part (usually an option) handles direct-memory-access transactions. Another part—one that does not actually transfer data—is responsible for interrupting the processor in response to conditions arising in one or more of the interfaces. For example, the program needs to know when a previously initiated operation in an interface is complete, so it can initiate a new operation in that interface. The interface notifies the program by "asserting," or raising, a "flag" that is sensed by the I/O system. This in turn interrupts the current program and directs the processor to a special section of the program (service routine) designed to respond to the interrupt. This process is called a program interrupt, or an I/O trap. It eliminates the need for continuous monitoring of devices by program routines.

Interrupt facilities range from simple to complex. The simplest method is to inclusively OR all interface flags together. If any one flag is asserted, the program interrupt is initiated when no other higher-priority operations are pending in the processor. Once the processor acknowledges the interrupt, program execution must be directed to check all interface flags, to determine which interface or interfaces caused the interrupt. This software checking is termed polling.

A more efficient method of handling interrupts is to have the interrupting device identify itself to the I/O system. Identification is usually made by having the interface transmit a unique number to the I/O hardware. This method has the advantage of decreasing the time between the interrupt request and the start of the service routine, since flag identification is automatic.

When several interfaces request interrupt service simultaneously, there is the problem of priority. Some systems define priority by the order in which the interfaces are connected to the I/O bus—the closer the interface to the CPU, the higher the priority. This is very easily implemented. When the I/O hardware recognizes that some, yet undetermined, devices want to interrupt, it sends a signal down the bus. This signal, usually called a "grant," is passed on from interface to interface along the bus. Interfaces with their flags raised stop this signal from passing to the next device.

A still more sophisticated method of establish-

Table 1. Data Transfer

	Advantages	Disadvantages
Programmed Transfer	Economical — relatively little hardware required Opportunity to examine each data unit transferred — allows software choice of future action Device under direct program control — allows software to assume more active interfacing role	Usually restricted to relatively low data rate devices since software attention required for each transfer Software overhead may reduce available data processing power
Direct Memory Access	Able to accommodate high data rates (This advantage may outweigh all disadvantages.) Very little software overhead	Higher cost — more complex hardware Transfers practical only in blocks of data Little opportunity to examine each unit of data as it is transferred Some computers require special multiplexors when more than one DMA device is connected

ing priority is to have several request and grant lines, each pair having a specific priority. Then priority is not as dependent upon physical position on the bus.

If the operating program is able also to assign a priority to the processor, then the I/O system will permit interrupts only on lines with priority greater than processor priority. This has much application in real-time systems, where it is necessary to hold pending lower priority tasks until more critical tasks are completed.

Figure 3 illustrates a simple program interrupt structure. Each device drives the interrupt line with an open-collector driver. Therefore the signal on this line is the inclusive OR of all device flags. (There may be more than one flag per device.) The skip line, when asserted by the coincidence of a device select signal and an IOP pulse, causes the program to skip its next instruction, thereby providing a way to identify the interrupting device.

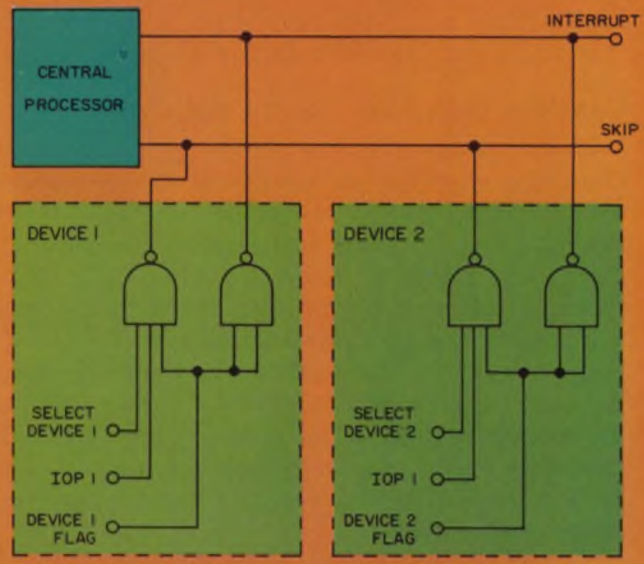
Computer manufacturers use an extremely wide variety of methods in organizing their I/O facilities. In some computers the programmed transfer, DMA, and memory busses are physically separate (Fig. 4). In others the programmed transfer and DMA facilities are combined, with the result that certain signal lines, such as the data and address lines, are combined and may be used by both types of transfers.

One configuration that is extremely efficient is the common bus arrangement, where the memory and all I/O devices share the same bus (Fig. 5). Interface registers act exactly the same as core memory registers. Therefore there is no need for special I/O instructions. The full power of the entire instruction set can be used in manipulating the interface registers.

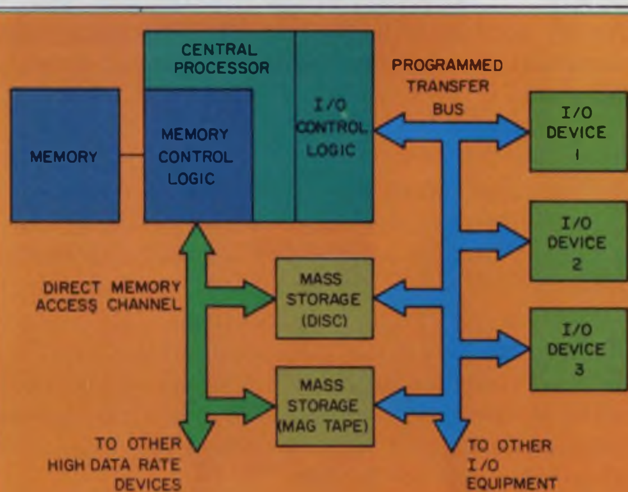
Basic to such an arrangement is a master-slave relationship among devices connected to the bus. Only one device (either CPU or an interface) may be bus master at any one time. Only this device may use the bus to perform data transfers. Normally the processor is bus master.

An interface may become bus master for one of two reasons: to perform a DMA transfer or to perform a program interrupt. It gains bus control by asserting the appropriate request line. The processor samples all request lines periodically. When one or more lines are asserted, the priority arbitration logic in the processor determines which grant line to assert. After sending the grant and receiving an acknowledgment, the processor relinquishes control and the device becomes bus master.

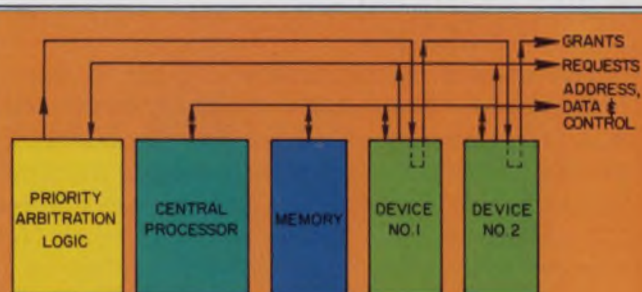
Inherent in the common bus structure is a closed-loop method of communication. This has several advantages: Bus timing is simplified, since there is a positive acknowlegment of a response; transfers to device registers take place



3. **This simple program interrupt structure** ties all peripheral devices to the same interrupt line. The skip line provides a means for device identification.



4. **A common practice in minicomputers** is to use separate buses for programmed transfer and direct memory access (DMA). DMA requires more complex hardware but handles higher data rates.



5. **A bus-organized computer is more efficient** than the multiple bus structure shown in Fig. 4. Peripheral devices must compete with the CPU for use of the bus.

at memory speeds rather than at slower IOT speeds; and a master can detect a device error if a slave sync signal is not received.

Consider data rates before deciding

Many factors influence the design of the interface: the electrical properties of the peripheral device, the electrical properties of the I/O bus, the data rate, cost and software requirements, to name only a few.

Should information be transferred under program control or by direct memory access? To help answer this, we must look at the data rate—the number of words or bytes of information to be transferred per second. If the rate is high, the DMA would probably be chosen, even though it is more costly. However, as data rates drop, other possibilities open.

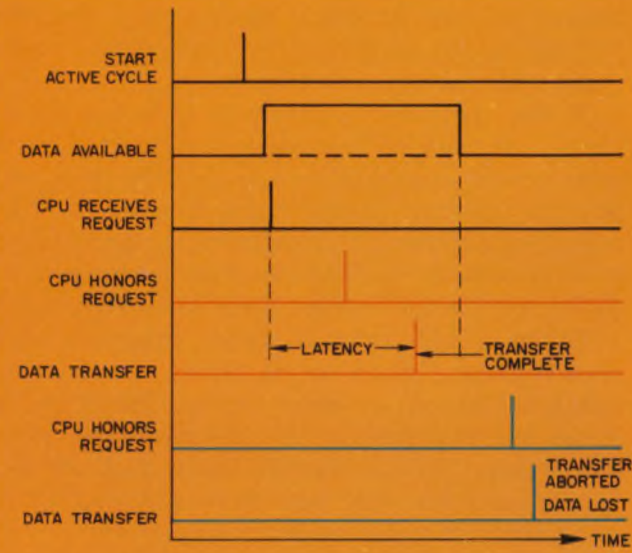
To understand the speed requirements, let's investigate the property called "latency." This is the time a device must wait from the moment it requests I/O service until that service (a data transfer) is completed. For example, when an analog-to-digital converter has completed a conversion, it will request service by asserting a "done" status indicator. If the interface uses programmed transfer, the program must be notified, usually by interrupt, and then it must take action by reading the voltage value. If the interface uses DMA, it must request the DMA facilities and then make a transfer into core storage.

In either case the data will be available until the next A-to-D conversion cycle is initiated, after which time the data will be lost. Such initiations are frequently controlled by a clock of a certain frequency. Knowing this frequency tells the designer how much time he has to work with. If the latency induced by the I/O system and operating software is always less than this time, data will not be lost.

The designer must therefore ask two questions: How long is the data available? And what is the worst-case latency? The design will be sound, at least from the timing point of view, if the data is available for at least as long as the maximum possible latency. Figure 6 is a timing diagram showing data, service and latency relationships.

The answer to the question "What is worst-case latency?" is not always evident. If no other interfaces are requesting service, the latency is predictable on the basis of the computer's characteristics. For example, the latency encountered for a DMA device is usually within three or four memory cycle times, and on some computers it may be within one cycle time. This time period is based on the fact that the I/O hardware must first synchronize to the request and then sync this to the next memory cycle.

The latency encountered in servicing a program interrupt arises first from the fact that the processor must finish the instruction currently being executed before recognizing the request. Then it must perform the housekeeping operations necessary for the interruption of program flow. This requires saving the address of the next instruction of the normal flow, so that it can return after the interruption has been serviced. Added to this minimum time is the time it takes for the device-polling or other housekeeping before the data transfer takes place. The whole situation is complicated if two or more devices are requesting service simultaneously.



6. **The choice between programmed transfer and direct memory access** often depends upon how long data is available. Data may be lost if the peripheral must wait too long for service.

Set priorities to remove latency problems

Usually there are ways to minimize the latency problem. They are used when devices may interfere with one another or when software overhead must be reduced. One of these methods is to arrange devices in a priority structure: the device having data available for the shortest period of time receives service first. Built-in priority interrupt structures are available on some computers. If problems arise, such a structure is invaluable, since it is usually found with the more sophisticated interrupt schemes that save time by providing hardware-identification of interrupting devices.

Double buffering is another method of minimizing latency problems. It consists of providing back-up storage in the interface hardware. Several units of information are stored there before a request for service is made. Then all units are read in rapid succession. In DMA transfers, this

Table 2. Design Factors

	Advantages	Disadvantages
Programmed Transfer	Simplicity of Design Software may examine the data for the out-of-limits condition Limits may be changed by the software	High software overhead, reduces other available processing time Double buffering required
Direct Memory Access	Can be handled without double buffering Little software attention required	DMA is basically more complicated Special comparison circuitry necessary to detect limits Limits not as easily changed Programmed transfer necessary for interrupts and status information

is termed burst mode. No other devices are allowed to use the channel until the several transfers are complete.

As an example, let's say that a system requires a digital sensor to be interfaced with a minicomputer. This sensor samples, say, the power being generated by a gas turbine, and it converts this power to a digital number. Further, it is desired that the power be sampled periodically in response to a timing clock. The properties of the sensor are such that, once given a read command, it will initiate a conversion cycle, and after 20 μs the data will be ready. The sensor will hold this data for 30 μs, after which the data will be destroyed. Let's say that samples are to be taken at 10 kHz, or every 100 μs, and that for every sample period an error indication will be given for any reading outside of a specified range.

Since the data rate is fairly high, but not extremely high, either DMA or programmed transfer might work. Table 2 lists some of the positive and negative factors for the programmed-transfer and DMA approaches, respectively.

From the table, it appears that the programmed-transfer design would be less costly in this case and also much more flexible, since limit detection is done by the program. Double buffering is, however, necessary, since the 30 μs data availability is really not enough time to guarantee freedom from latency problems. With a double buffer, the data will be available for a full 100 μs (until the next clock pulse).

In the great majority of cases, the user will not have the stringent speed and latency requirements previously emphasized. Therefore interfacing consists simply of following the rules laid down by the manufacturer of the computer and peripheral device. Certain guidelines should be heeded, however. These are:

- A particular interface should be designed so as not to monopolize the I/O facilities beyond its needs. It should not request the facilities before it really needs them.
- System expansion should be considered. Don't assign device identifying codes indiscriminately. There are usually only a limited number of these.
- Make sure a diagnostic or maintenance program can be written to exercise the interface. If a malfunction should occur, this is the easiest, and sometimes the only, way of finding the fault.
- Design with preventative and corrective maintenance procedures in mind.
- Become familiar with the software that will be required to operate the interface. A good hardware/software tradeoff results in efficient operation.
- If an interface is designed with expanded capability but is to be used only in its limited configuration at first, make sure all the extended features operate. This will guard against deficiencies in the future that only a design change will be able to remedy.
- Prepare complete documentation for the interface and keep it up-to-date.
- Talk with a programmer. He may provide a nonengineering viewpoint, which may help pinpoint future problems. ■■

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We don't have a crystal ball. And rarely resort to mystic means in recommending what terminal should be used for a particular data communications application.

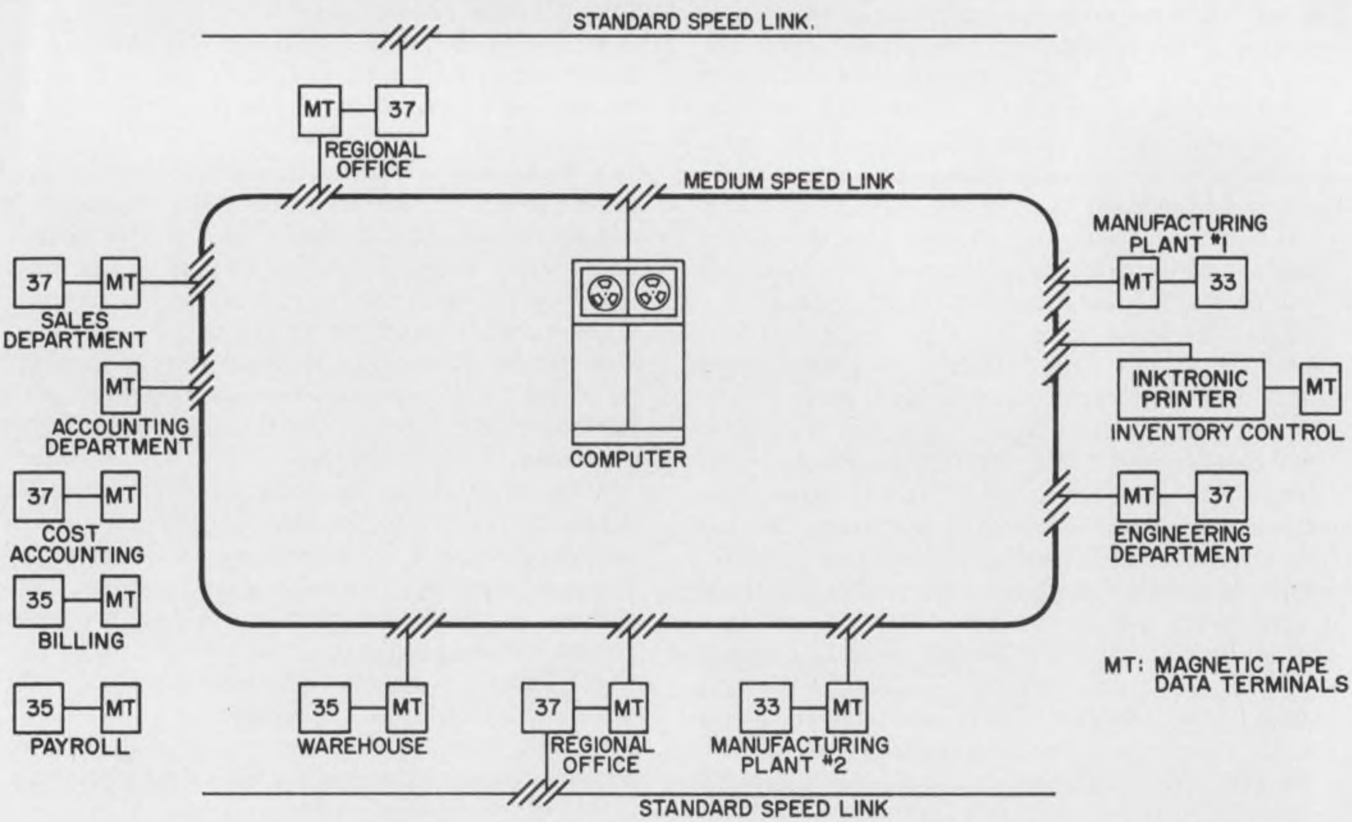
Some of the things, we at Teletype look at, that make the job a little easier are these:

Distribution	Volume
Urgency of message	Language
Frequency of use	Accuracy

The diagram below demonstrates how you can fit a number of Teletype terminals into a system based on function and usage requirements. Magnetic tape makes the speed and language of various terminals compatible. In this hypothetical case we use one computer program, one major line control procedure, one computer port, one type of data set per link. And deliver greater data through-put per on-line dollar. Using terminals that offer the best capabilities within each station's communication situation.

Using Teletype magnetic tape data terminals, combined with various Teletype keyboard send-receive sets, you obtain some unique system flexibility. And the on-line time saving aspects of operation are really dramatic. Magnetic tape data terminals can keep data flowing on-line at up to 2400 wpm.

In the example shown, the manufacturer has linked sales, engineering, accounting and inventory control departments to a central office computer. As well as manufacturing plants, warehouse and regional offices. He's covered all critical data points with a common medium speed link, using a variety of terminals. Magnetic tape data terminals make it possible.



DATA COMMUNICATIONS

equipment for on-line, real-time processing

Routine aspects of the system are maintained in standard speed links. Branch offices are tied into the regional office terminals on standard speed networks. Regional offices batch routine branch office data on one magnetic tape. Transmit the data to the central office processor at one time. Saving a number of additional computer port requirements.

Since data generated at manufacturing plants is urgently needed, but volume is low, low-cost model 33 terminals are used here. The warehouse data volume is higher, but not complex, so a heavy-duty model 35 is working here.

Volume requirements are heaviest in the accounting department. Cost accounting, payroll, billing and invoice payment functions generate data all day long. Here magnetic tape is prepared off-line at various terminals. And an on-line stand-alone magnetic tape terminal is used to transmit data to and receive data from the central processor.

Sales and engineering departments are equipped with Teletype 37 terminals. But for different reasons.

This terminal offers engineering people some unique format flexibility. Half-line and full-line forward and reverse line feed can be used to communicate complex equations and engineering formulae to the processor. It is possible to add special graphic engineering symbols to the normal compliment of letters, numbers and punctuation marks found in the typebox (up to 32).

The sales department uses the model 37 for order processing. It has on-line vertical and horizontal tab set control, and form feed platen (optional) which makes data transmission and reception on multiple copy business forms easy and economical.

At the inventory control point, this manufacturer has an urgent need to obtain printed page copy of large volumes of inventory items. Magnetic tape is used to feed data to the processor and a Teletype Inktronic® KSR set receives data and prints page copy on-line up to 1200 words per minute.

As you can see, Teletype's modular terminal design allows you to use various units as building blocks to meet the most demanding system needs. Teletype also has the station and error control accessories necessary for more efficient and economical data communications operations. Since cost is a very important part of the mix, Teletype offers greater terminal capabilities on a price/performance basis than any other manufacturer.

If you're involved in designing a teleprocessing, time-sharing, remote batch or computer switched system; looking into a multi-point private line, point-to-point private line or switched data communications network; talk to Teletype about terminals. For ideas, equipment and understanding, you'll find no better source. Anywhere.

Teletype data communications equipment is available in send-receive capabilities of up to 2400 words per minute. If you would like specific information about any of the equipment described here, write: Teletype Corporation, Dept. 89-16, 5555 Touhy Ave., Skokie, Ill. 60076.

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model 35 series: *A rugged, heavy-duty line of 100 wpm terminals. Uses ASCII.*

model 37 series: *One of the most versatile heavy-duty terminal lines going. Generates all 128 characters of ASCII. Operates at 150 wpm. Prints in upper and lower case.*

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Need square waves in the MHz range?

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The generation of high-frequency, good-fidelity square waves has become a problem of increasing importance in the last few years. The tendency towards higher digital clock rates in both computers and processors has forced design engineers to find new ways to generate square waves ranging from approximately 1 MHz in small general-purpose equipment to in excess of 50 MHz in sophisticated equipment under development. By rule-of-thumb, rise and fall times of these square waves should be less than one-tenth of the clock period. At the lower clock rates, this requirement is not much of a problem. However, at clock rates in excess of 50 MHz, the rise and fall times must be less than two nanoseconds.

A multitude of circuits have been designed to provide high-frequency square waves, but the large majority of these are highly complex and do not adequately perform the desired function. The problem of high-frequency square-wave generation, in the range of 10 MHz to greater than 200 MHz can easily be solved by using a balanced pulse snap diode circuit (see box) to efficiently convert a sinusoid to a square wave. Not only does this circuit perform well over a wide range of clock rates, but it can also produce rise and fall times in the subnanosecond range without complex circuitry. The only active devices in the circuit are two pulse snap diodes. These are coupled with an inductor, a resistor and several capacitors to make-up the whole converter.

For analysis, consider symmetrical case first

Analysis of the pulse snap diode converter circuit is best explained by first considering the simple case of a symmetrical square-wave output. The circuit schematic for this simple case is shown in Fig. 1, where diodes D_1 and D_2 are pulse snap diodes. Capacitors C_1 and C_2 are very large, low-inductance bypass capacitors that have a very low impedance at the drive frequency and remain capacitive at the high frequencies associated with the very fast rise and fall times of the output.

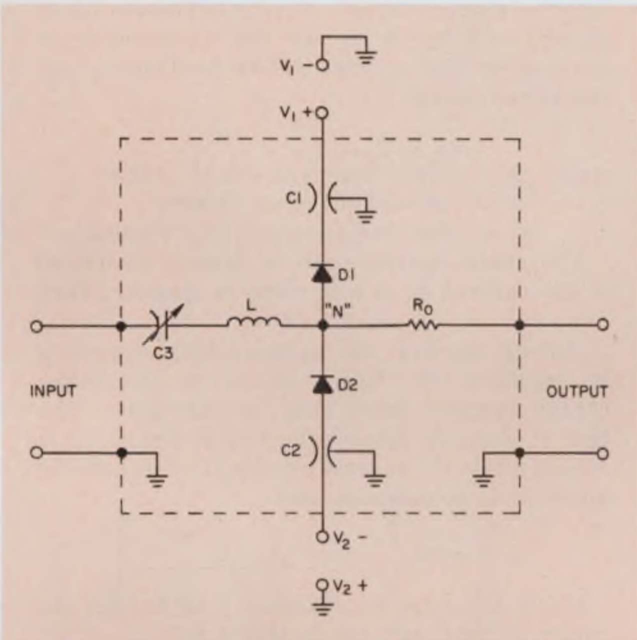
The combination of capacitor C_3 and inductor L serves two functions. First, C_3 and L match the input source impedance to the converter's input load impedance. At the lower end of the converter's operating frequency range, capacitor C_3 may not be necessary. Second, a large value of L ensures effective isolation of the sinusoid source from the switching transients that occur at node "N." The output impedance of the converter is determined by the value of R_o, since the impedance at "N" is very nearly zero. It differs from zero only by the parasitic impedances of the diodes.

Two assumptions about the diodes are necessary to simplify the circuit analysis: the first is that diodes D_1 and D_2 have zero voltage drop during both forward conduction and charge storage. The second assumption is that the diodes have infinite minority-carrier lifetimes. These assumptions ensure that all the charge stored during forward conduction must be removed by a reverse current before the diode makes the transition to the OFF state. In other words, there are no minority charge recombination effects to be concerned with in the analysis.

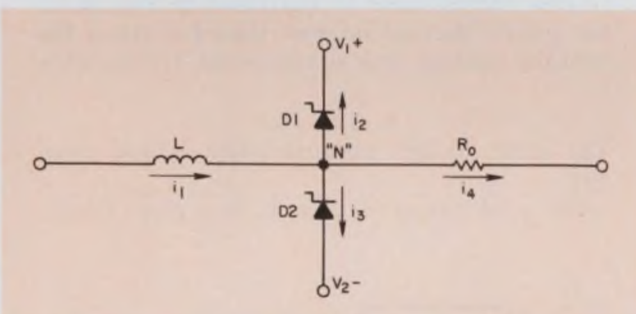
When the sinusoidal input voltage, $e_s(t)$, has a large peak-to-peak value and the reactance of indicator L is very large, the current, i_1, into node "N" must be nearly sinusoidal. This current must also equal the current leaving the node, thus giving rise to the four possible currents shown in Fig. 2.

Assuming that i_4 is equal to zero (the output is open circuited) then, because of the directional nature of the diodes, i_1 must equal i_2 or i_3 but not both. Since the diodes are assumed to have no voltage drop, the instantaneous voltage at "N" must be either V_{1+} or V_{2-}. And when the magnitudes of the bias voltages (V_1 and V_2) are equal, the output voltage must have a zero average, because there is no dc voltage applied directly to "N." The charge storage properties of D_1 and D_2 will then give rise to the waveforms shown in Fig. 3. Each diode will appear to have zero voltage drop until all the charge stored in the junc-

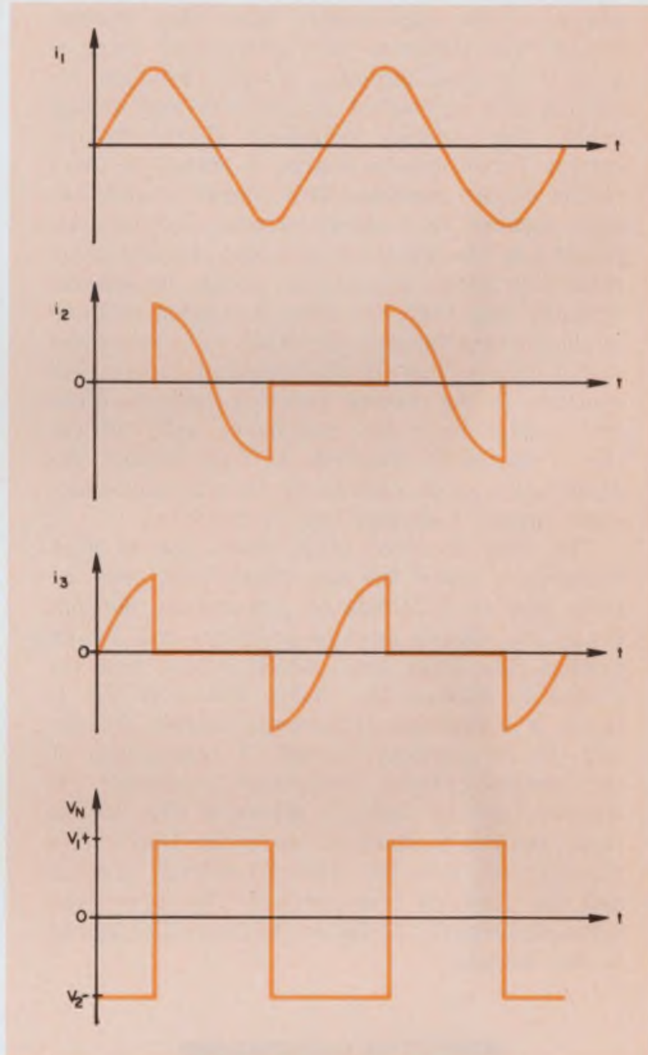
Bernard S. Siegal, Applications Mgr., Discrete Devices, and **Michael K. Turner,** Applications Engineer, Siliconix, Inc., 2201 Laurelwood Rd., Santa Clara, Calif. 95054



1. **Sine-wave to square-wave converter** uses two pulse snap diodes as the only active components. Charge bias points for the diodes are set by bias supplies V_1 and V_2.



2. **Current summation** at node N is the basis of converter operation. With the output open-circuited, the instantaneous voltage at "N" is either V_{1+} or V_{2-}.



3. **Waveforms for converter of Fig. 1** show that the area under the forward-current curve for the diodes is the same as the area under the reverse-current curve.

tion during forward conduction is removed during reverse conduction. So the area under the forward-current curve for each diode equals the area under the reverse-current curve. The top portion of the i_2 curve of Fig. 3 shows forward conduction and the bottom portion shows reverse conduction. The situation is reversed for the i_3 curve.

The phase relationship between the source voltage, e_s, and voltage V_N at node "N" can be broken into two parts. First, there is a 90° phase shift between e_s and i_1 due to inductor L. Second, node voltage V_N and current i_1 are 90° out of phase due to the capacitive nature of the charge storage diodes. If the initial assumption of infinite minority-carrier lifetime is dropped, then the forward conduction area of Fig. 3 must be larger than the reverse conduction area to account for

What's a pulse snap diode

The pulse snap diode is a silicon rectifying-junction device, similar in construction to high-speed pn junction diodes, but characterized by long minority-carrier lifetime and the controlled release of stored charge during reverse biased conditions. These properties make the dynamic or switching characteristics of the pn junction and pulse snap diode markedly different.

The pn junction will store charge during the forward bias condition but will release the charge at an uncontrolled rate when reverse biased. The structure of a pulse snap diode is a p-i-n (p-type, intrinsic, n-type) junction requiring precise control of geometry and doping profile for desired switching characteristics. During forward bias, charge is stored in the I region of the junction. This charge storage occurs because the minority-charge carriers injected into the I-layer have a low recombination rate. The diode appears as a low impedance, typically less than one ohm. A sudden reversal of the current through the diode will remove the stored charge. The circuit-dependent current will continue in the reverse direction, and the diode will appear as a low impedance until all the stored charge is removed. At that instant, the diode will switch rapidly to its high-impedance state, typically greater than a megohm.

The time required to go from low to high impedance, called the transition time, may be from tens to hundreds of picoseconds, depending on the diode's junction geometry and doping profiles. The delay time, which is that time required to exhaust the charge stored in the I-layer, is a function of minority-carrier lifetime and the reverse-bias current. A comparison of the reverse-current switching properties of the two types of diodes is shown in Fig. A. The time required to store charge in the I-layer is a function of both the minority-carrier lifetime and the forward bias current. The larger the forward current, the faster charge can be stored in the device.

The design of pulse snap diode circuits is based on a few simple equations. The amount of charge stored during forward bias can be derived from the charge continuity equation.

$$i(t) = \frac{dQ}{dt} + \frac{Q}{\tau}$$

where i = total instantaneous diode current
τ = effective minority carrier lifetime of diode
Q = total charge stored in diode junction $(Q > 0)$

Depending on the mode of operation, either dc or ac charge storage, the instantaneous diode current will be dc or ac. For convenience, a constant dc bias current will be considered, and the stored charge is:

$$Q_F = I_F \tau (1 - e^{-t_F/\tau})$$

where Q_F = forward-current stored charge
I_F = forward charging current
t_F = time during which I_F is applied

The above equation can be greatly simplified if the ratio of t_F to τ is three or greater; then

$$Q_F = I_F \tau (1 - e$$

Having derived the relationships necessary to calculate the charge stored in the diode, charge removal must next be calculated. The time required to remove the stored charge, t_d, is dependent on the reverse current, I_R, through the diode. If I_R is constant, then

$$t_d = \tau \log_e \left[1 + \frac{I_F (1 - e^{-t_F/\tau})}{I_R} \right]$$

Using the same approximation as before, the equation for t_d can be simplified to

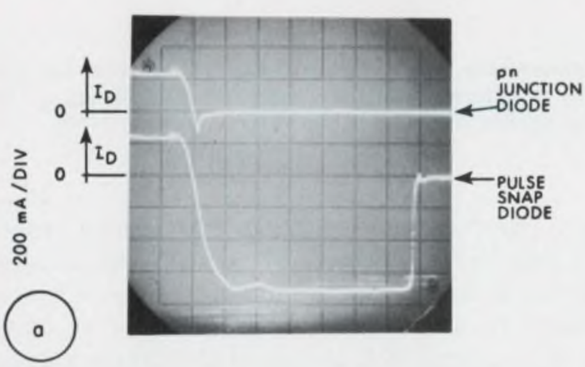
$$t_d \simeq \tau \log_e [1 + (I_F/I_R)]$$

The relationship between the various terms for the constant forward current and constant reverse current case is illustrated in Fig. B. If the reverse current is more than five times the forward current, the equation for t_d simplifies to

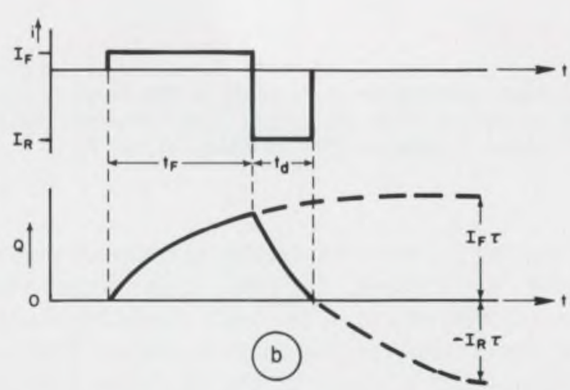
$$t_d \simeq (I_F/I_R)$$

The error in this approximation is less than 10%.

The total transition time, t_T, in a given circuit



A. **Difference in switching characteristics** of pulse snap diodes and pn junction diodes are obvious from these traces of the reverse-current turn-off characteristic of each.



B. **Constant current (top) and charge waveforms** show that the time, t_d, to remove the stored charge from a pulse snap diode is dependent on the reverse current, I_R, through the diode.

is dependent on diode design, circuit configuration and the level of charge stored in the diode junction. The diode basic transition time, t_t, is inversely proportional to the breakdown voltage and directly proportional to the charge storage level. Typically, a 100-volt pulse snap diode will exhibit a t_t of approximately 350 ps; for a 25-volt device, t_t is approximately 70 ps. The transition-time/charge-storage characteristic is illustrated in Fig. C for a typical diode. Low-voltage pulse snap diodes cannot store as much charge as higher-voltage devices. So a tradeoff must be made between voltage-handling capability and very rapid switching times.

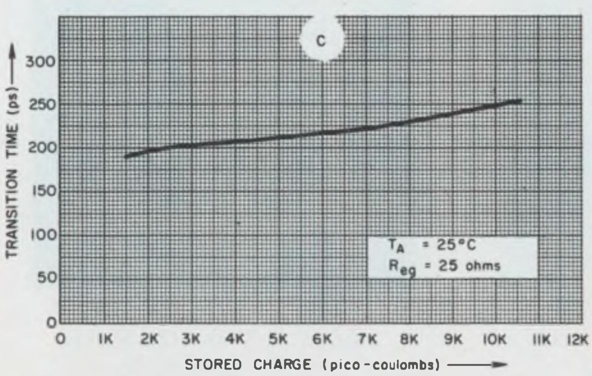
The circuits described in this article make use of ac charge storage. The incoming signal must supply the charge to the diodes. The dc voltages are used for setting the charge bias points, but supply minimal amounts of current. Under most conditions, it is possible to use the slight rectifying nature of the diodes to generate self-bias voltage across a fixed external resistor.

You may know it by other names

The pulse snap diode is basically the same as the snap varactor, a device long familiar to the microwave circuit designer. Other commonly used names for the snap varactor are: snap-off diode, step-recovery diode, and punch-through varactor. The major difference between the pulse snap diode and the snap varactor is in parameter emphasis. In pulse-circuit applications, the critical points are:

- the manner in which the diode changes impedance states,
- the control of storage and delay times,
- the dependance of these characteristics on stored charge and/or temperature.

In comparison, rf applications require concentration on the diode's capacitance, transition time, and power handling. Therefore, the name pulse snap diode denotes a device for which transient characteristics are properly specified to assure repeatable pulse circuit performance.

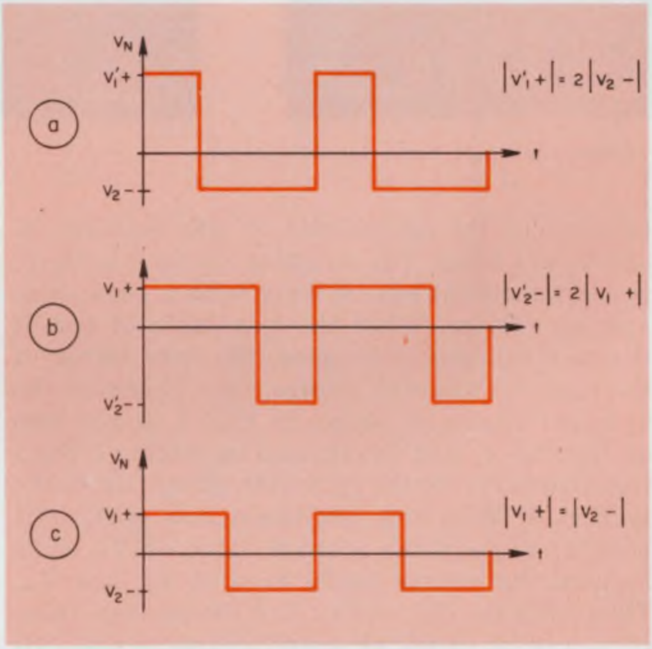


C. **Transition time vs stored charge curve** for an SV110 pulse snap diode shows the increase in transition time for additional amounts of stored charge. Stored charge is a function of time and I_F.

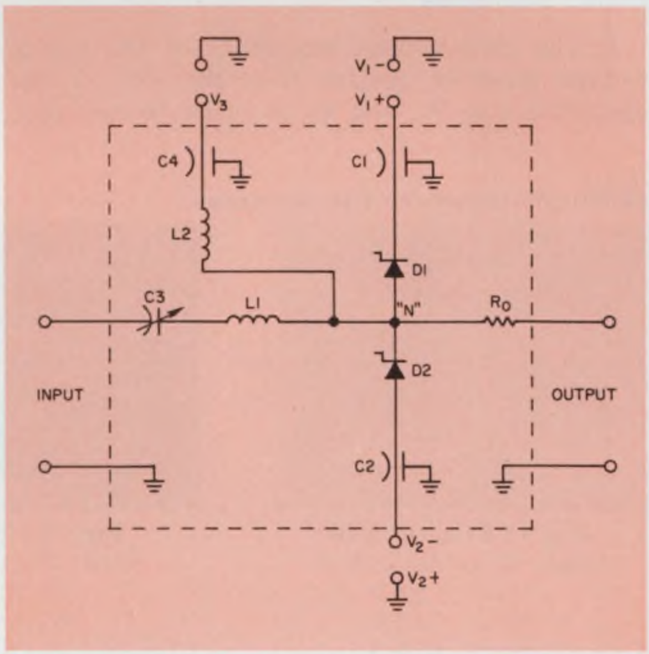
charge recombination. The net effect of finite lifetime is a reduction in phase lag between i_1 and V_N and a slight loss of efficiency due to recombination currents.

A further phase lag reduction will occur when current i_4 drives a resistive load. If the circuit drives a complex impedance load, the phase of the output becomes dependent on the load. Regardless of the nature of the load, though, i_4 should not be more than half of i_1.

Thus far, this analysis has considered only the



4. **Bias voltages V_1 and V_2** determine the duty factor of the square wave, and thus the average voltage.



5. **Adding a third bias port,** V_3, makes it possible to vary the average value of the voltage at node N while keeping the V_1 and V_2 voltages fixed.

Fig. 6 Freq. 10 MHz
Scope: 1 V/div. 20 ns/div.
$V_1 = 5$ V
$V_2 = -5$ V
Input power: 300 mW
Output power 135 mW
Rise time: 1 ns
Fall time: 2 ns

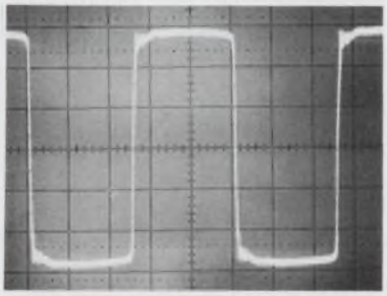


Fig. 7 Freq. 10 MHz
Scope: 1 V/div. 20 ns/div.
$V_1 = 5$ V
$V_2 = -5$ V
Input power: 388 mW
Output power: 140 mW
Rise time: 0.5 ns
Fall time: 0.6 ns

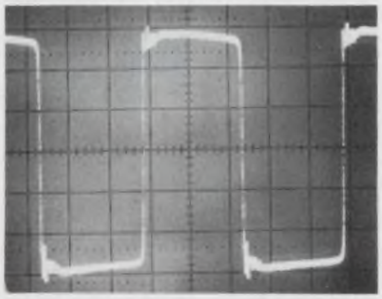
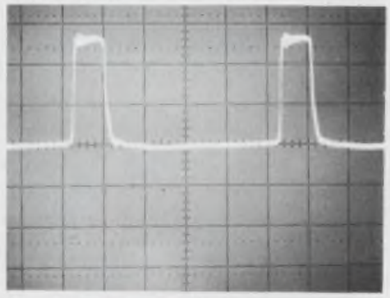


Fig. 8 Freq. 10 MHz
Scope: 2 V/div. 20 ns/div.
$V_1 = 10$ V
$V_2 = 0$
Input power: 340 mW
Output power: 65 mW
Rise time: 0.5 ns



10-MHz, two-port converter waveforms

case where the magnitudes of bias voltages V_1 and V_2 are equal. The resultant output waveform is a symmetrical square wave with a zero value average voltage. When the magnitude of one of the bias voltages is changed, the duty factor of the square wave will change, thus changing the average voltage, as shown in Fig. 4. A non-zero average of V_N can be obtained by adding a third bias connection to the converter circuit, as shown in Fig. 5. With this additional bias port, it is possible to vary the average value of V_N while keeping the voltage peaks fixed at V_{1+} and V_{2-}. Thus, both the duty factor and the average value of V_N can be varied by simply changing the voltage, V_3, applied to the third bias port.

The actual design of the converter is very simple, and essentially involves satisfying the following conditions:

1. The peak-to-peak magnitude of the source voltage must be greater than the sum of the magnitudes of V_{1+} and V_{2-} in order to overcome circuit losses and to insure proper switching action.

$$|e_{s(p-p)}| > |V_{1+}| + |V_{2-}| + |V_{diodes}|$$

2. To minimize recombination losses, the diode minority-carrier lifetime must be greater than the period of the input frequency. In actual practice, the following equation appears to hold:

$$\tau \geqq 2\pi/\omega, \text{ or simply } 1/f.$$

3. The output impedance of the converter is determined by the value of resistor R_o. The diodes will definitely contribute to output impedance for cases where $R_o \leqq 10$ ohms. However, when $R_o > 10$ ohms the diode effects can be neglected.

4. The peak value of the input current, i_1, should be greater than twice the peak value of the output current, i_4.

$$i_1 > 2i_4$$
$$i_4 = V_N/(R_o + R_L)$$
$R_o = \text{Re}\,[Z_L] = R_L$, where Z_L is the load

10-MHz, three-port converter waveforms

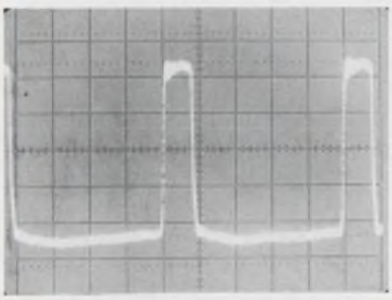


Fig. 12 Freq. 10 MHz
Scope: 20 ns/div. 2 V/div.
$V_1 = 10$ V
$V_2 = -10$ V
$V_3 = +7.5$ V
Input power: 1.068 W
Rise time: 1 ns

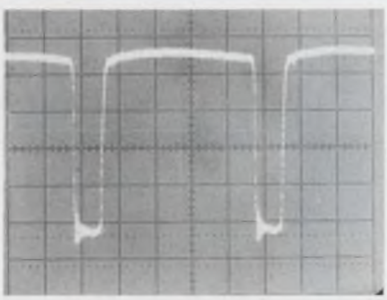


Fig. 13 Freq. 10 MHz
Scope: 20 ns/div. 2 V/div.
$V_1 = 10$ V
$V_2 = -10$ V
$V_3 = -7.5$ V
Input power: 1.068 W
Rise time: 1 ns

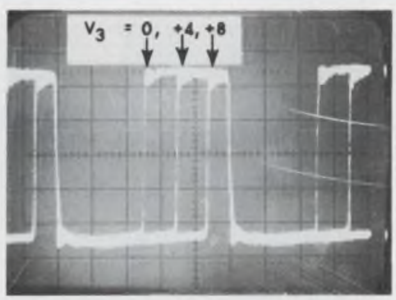


Fig. 14 Freq. 10 MHz
Scope: 2 V/div. 20 ns/div.
$V_1 = 10$ V
$V_2 = -10$ V
$V_3 = 0, +4, +8$ V
Positive pulse width variations with change in V_3 bias.

Fig. 9 Freq. 10 MHz
Scope: 2 V/div. 20 ns/div.
$V_1 = +10$ V
$V_2 = -5$ V
Input power: 350 mW
Rise time: 2 ns

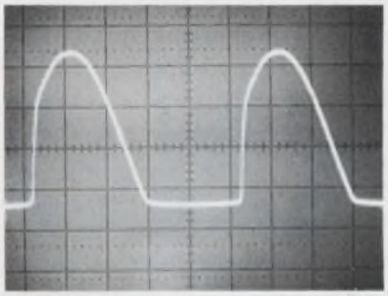


Fig. 10 Freq. 10 MHz
Scope: 2 V/div. 20 ns/div.
$V_1 = +10$ V
$V_2 = -5$ V
Input power: 500 mW
Rise time: 2 ns

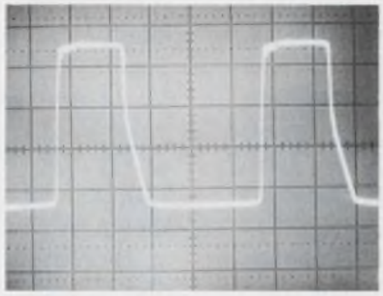
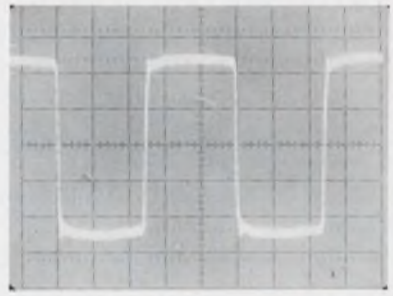


Fig. 11 Freq. 10 MHz
Scope: 20 ns/div. 2 V/div.
$V_1 = 10$ V
$V_2 = -10$ V
Input power: 1.068 W
Output power: 460 mW
Rise time: 1 ns
Fall time: 1 ns



impedance

$$i_1 = V_N/2R_L$$
$$i_1 > V_N/R_L$$

Since V_N nearly equals either V_{1+} or V_{2-},

$$i_1 > V_{1+}/R_L \text{ or } V_{2-}/R_L$$
$$i_1 = e_s/Z$$

At low frequencies, where C_3 may not be needed, impedance Z is merely the reactance of L. When C_3 is used at high frequencies, then Z becomes

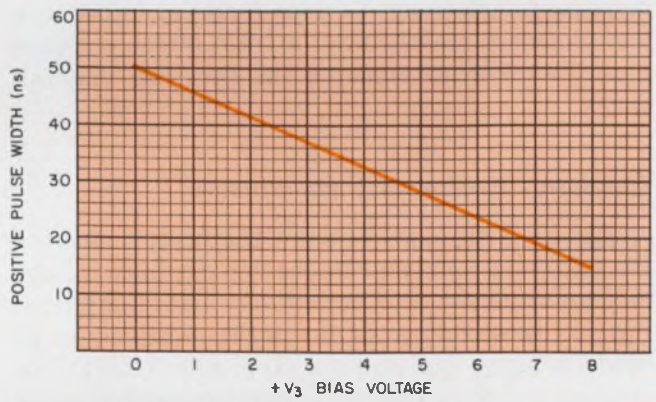
$$Z = R + j(\omega L - 1/\omega C)$$

where R is the real part of the input impedance; typically the value of R is less than one ohm.

5. When the third bias port is used, the following voltage relationship must hold.

$$V_{2-} < V_3 < V_{1+}$$

The average value, or dc component, of the output voltage must equal V_3. The reactance of L_2 in Fig. 5 must be large enough so as not to affect the circuit. The same type of capacitor can be used for C_4 as for C_1 and C_2. With no extra bias



16. **Linear relationship exists** between bias voltage V_3 and the output pulse width for the converter of Figs. 12 through 15.

Fig. 15 Freq. 10 MHz
Scope: 20 ns/div. 2 V/div.
$V_1 = 10$ V
$V_2 = -10$ V
$V_3 = +9.5$ V
Input power: 1.068 W
Rise time: 1 ns
Fall time: 5 ns

100-MHz, two-port converter waveforms

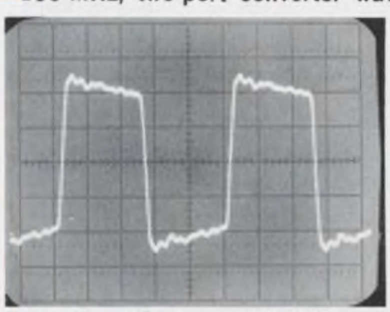


Fig. 17 Freq. 100 MHz
Scope: 2 ns/div. 1 V/div.
$V_1 = 5$ V
$V_2 = -5$ V
Input power: 517 mW
Output power: 85 mW
Rise time: 400 ps
Fall time: 400 ps

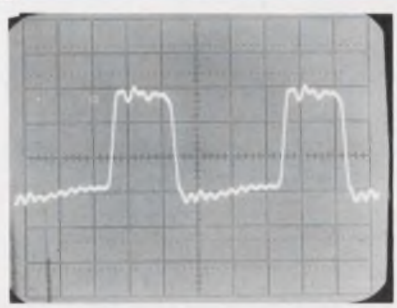


Fig. 18 Freq. 100 MHz
Scope: 2 V/div. 2 ns/div.
$V_1 = 10$ V
$V_2 = -5$ V
Input power: 1.1 W
Output power: 150 mW

port, the output voltage will have a dc component that is dependent on the relationship of V_{2-} to V_{1+}.

To demonstrate the performance of the pulse snap diode sine-to-square wave converter, three different circuits were constructed. The first two were intended for 10 MHz operation and differed only in that one had a third bias port (Figs. 1 and 5). In each case, L_1 and C_3 were chosen to be series resonant at the input frequency of 10 MHz. The value of L_2 in the three-port circuit was chosen equal to L_1 for convenince. Capacitors C_1, C_2 and C_4 were 0.1-μF ceramic bypass types, and inexpensive Siliconix SV110 pulse snap diodes in small axial lead packages were used in both units.

In the circuits, the value of R_o is load dependent:

$$R_o = \text{Re}\,[Z_L] = R_L;\ \text{when } R_L > 10 \text{ ohms}$$
$$= R_L - R_N;\ \text{when } R_L \leq 10 \text{ ohms.}$$

The node resistance, R_N, is approximately 0.5 ohm for the SV110 diodes. When Z_L is a real impedance it may be possible to delete R_o with an increase in efficiency. Various forms of impedance transformers may be used instead of R_o, but care must be taken to preserve the fast rise and fall times.

Waveforms illustrate the performance

Figures 6 through 11 show the performance of the two-port converter under various bias-voltage and input-power-level conditions. The slight ringing on the waveform is due to the relatively large diode package inductances (typically 3 nH). The ringing problem can be further exaggerated by overdriving the input, as shown in Fig. 7. The power input can vary by ±7% from optimum without changing the ringing on the output.

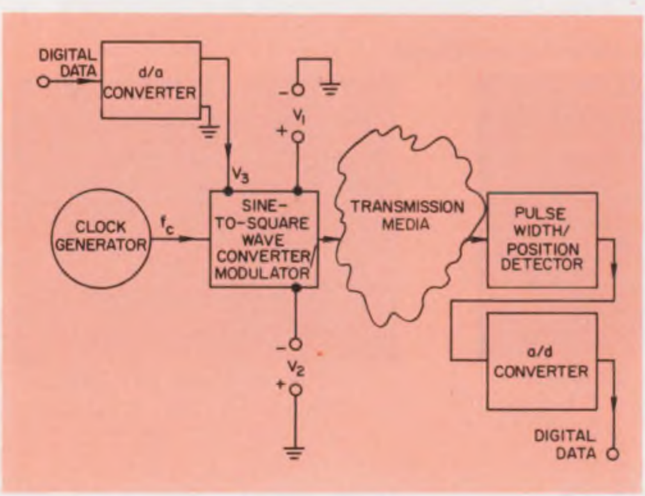
Figure 8 shows how a positive pulse can be generated by setting $V_2 = 0$. The input power for a given set of values of V_1 and V_2 must be sufficient to ensure adequate charge storage in the diodes. Otherwise, the output will be distorted sine waves, as shown in Figs. 9 and 10. Increasing V_1 and V_2 to 10 volts requires a corresponding increase in input power (Fig. 11).

When bias voltage V_3 of the three-port converter is set equal to zero, this circuit performs like the two-port version. Varying the value of V_3 results in the different wave forms shown in Figs. 12, 13 and 14. As V_3 is brought closer to either V_1 or V_2, a triangular spike is produced, as shown in Fig. 15. The relationship between V_3 and the output pulse-width is linear and yields the graph shown in Fig. 16. Variations in V_3 have no effect on the output pulse amplitudes as long as condition 5, stated previously, is satisfied.

A 100-MHz, two-port converter was built to demonstrate higher frequency performance. The values of L_1 and C_3 were chosen for series resonance at the operating frequency. Pulse ringing was kept to a minimum by using low-inductance pulse snap diodes, in this case Siliconix SV114s. These are ceramic stripline packaged devices with approximately 0.4 nH of inductance. Values of C_1, C_2 and R were the same as for the other units. Circuit performance is shown in Figs. 17 and 18.

Careful attention to high-frequency construction techniques was found to be a must for optimum converter performance. Point-to-point wiring leads to degradation of the square wave in two ways: first, excess lead and/or device inductance can lead to unacceptable ringing. Particularly important is the loop inductance from V_1 to V_2. Second, stray and parasitic capacitances can cause unsatisfactory pulse drop. This effect is very evident in Fig. 17. Construction techniques which tend to minimize these strays, thick or thin film hybrids for example, will result in a marked improvement in the output waveform.

The three-port, sine-to-square wave converter has a very interesting potential application that is yet to be explored. Consider the converter operating at fixed bias levels (V_1 and V_2) and input frequency. Variations in V_3 would provide either pulse-width or pulse-position modulation of the output. The V_3 modulation frequency might easily approach half the value of the input frequency; that is, if $f_{in} = 100$ MHz, then $f_{V3} \leq 50$ MHz. Enormous amounts of digital data could then be transmitted from one point to another by the system shown in Fig. 19. ■■



19. **Large quantities of digital data** can be transmitted with a system that uses a pulse snap diode sine-to-square-wave converter for modulation purposes.

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INFORMATION RETRIEVAL NUMBER 39

Vary gain electronically

with differential amplifiers. You can get linear operation as well as large signal-handling capabilities.

There are many ways to electronically vary the gain of an amplifier,[1,2,3] but most of them suffer from problems such as nonlinear gain change, temperature drift or poor signal-handling capability (see Table 1). However, a linear, temperature-stable, variable-gain amplifier can be obtained by using the unique current-division property of the basic differential amplifier. This technique, which uses standard ICs, can be applied to amplifiers operating from the audio to video frequencies.

The design of the variable-gain amplifier requires a knowledge of the properties of the differential amplifier. This basic analysis is also a must in the operation of many modern ICs.

The basic differential amplifier

The equations for the collector currents of the basic differential amplifier (Fig. 1), assuming $Q_1 = Q_2$ and $\alpha = 1$, are

$$I_{c1} = I_t/[1 + \exp(m\Delta V)], \tag{1}$$

and

$$I_{c2} = I_t/[1 + \exp(-m\Delta V)], \tag{2}$$

where

$\Delta V = (V_2 - V_1)$, $m = q/KT$, K is Boltzmann's Constant, q is the electron charge, and T is the temperature in degrees Kelvin.

Since I_t is a constant, and $(I_{c1} + I_{c2}) = I_t$, (3) any decrease in I_{c1} corresponds to a like increase in I_{c2}.

Dividing I_{c1} by I_t, the Current Division Ratio (CDR) is obtained:

$$I_{c1}/I_t = 1/[1 + \exp(m\Delta V)] = \text{CDR} \tag{4}$$

Expanding Eq. 2,

$$I_{c2} = I_t \exp(m\Delta V)/1 + \exp(m\Delta V). \tag{5}$$

Rearranging Eq. 4,

$$\exp(m\Delta V) = [1 - \text{CDR}]/\text{CDR} \tag{6}$$

Substituting Eq. 6 into Eq. 5,

$$I_{c2}/I_t = 1 - \text{CDR} \tag{7}$$

The current source may be obtained with a common emitter transistor as shown in Fig. 2. If the input signal drives the common emitter transistor Q_3, then

$$I_t = E_{in}/R_e, \tag{8}$$

where I_t is the current through Q_3 due to the input signal. The current I_t will divide between Q_1 and Q_2.

The circuit gain for Fig. 2 (assuming $\alpha_1 = \alpha_2 = \alpha_3 = 1$) may be expressed as

$$E_{o1} = -I_{c1} R_{c1}. \tag{9}$$

From Eq. 4 and the relationship

$$E_{in} = I_t R_e, \tag{10}$$

and

$$E_{o1} = -\text{CDR}(R_{c1}/R_e) E_{in}. \tag{11}$$

The gain, A_{v1}, is given by

$$A_{v1} = -\text{CDR}(R_{c1}/R_e). \tag{12}$$

Using the same procedure, the gain for E_{o2} may be found as

$$A_{v2} = -R_{c1}/R_e (1 - \text{CDR}). \tag{13}$$

Thus the gain for the amplifier of Fig. 2 is dependent on R_{c1}, R_e, CDR and not upon the input signal being amplified.

Linearize the gain change

A linear gain change characteristic can be obtained by making I_{c1} or I_{c2} a linear function of ΔV. This, and inherent temperature stability, can be obtained with the circuit illustrated in Fig. 3. Transistors Q_1, Q_2, Q_3 and Q_4 are matched integrated differential amplifiers (RCA CA 3026). The op amp drives the base of Q_{3A} so that the collector voltage of Q_{3B} equals V_C.

$$\text{Thus } I_4 = ((V_{cc} - V_C)/R_7) = \Delta V_c/R_7, \tag{14}$$

and the collector current is a linear function of the control voltage. Since the current division ratio is dependent only on ΔV (Eq. 4),

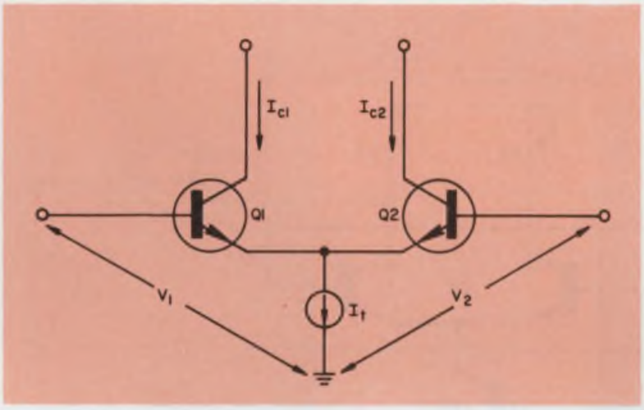
$$\text{CDR} = I_4/I_6. \tag{15}$$

Now substituting $I_6 = V_{EE}/R_{10}$ and Eq. 14 into Eq. 15, we get

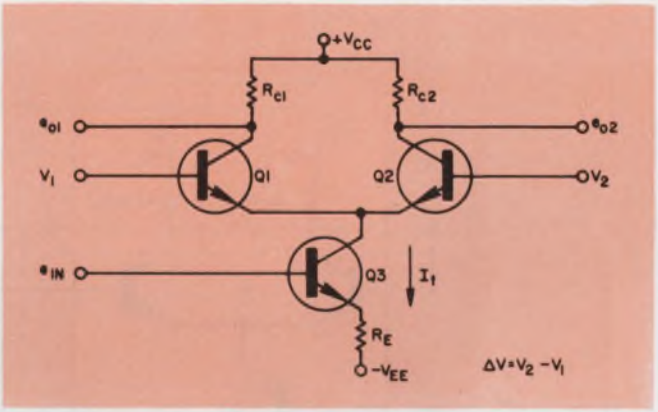
$$\text{CDR} = \Delta V_c R_{10}/R_7 V_{EE}. \tag{16}$$

Since the CDR of Q_1, Q_2 and Q_3, Q_4 are equal, the current division of the gain stage (Q_{1A}, Q_{1B} and Q_2) is a linear function of the control voltage V_C. Substituting Eq. 16 into the gain equations 12 and 13, we find that the gain is a linear func-

Richard S. Hughes, Senior Electrical Engineer, Code 3527, U. S. Naval Weapons Center, China Lake, Calif. 93555.



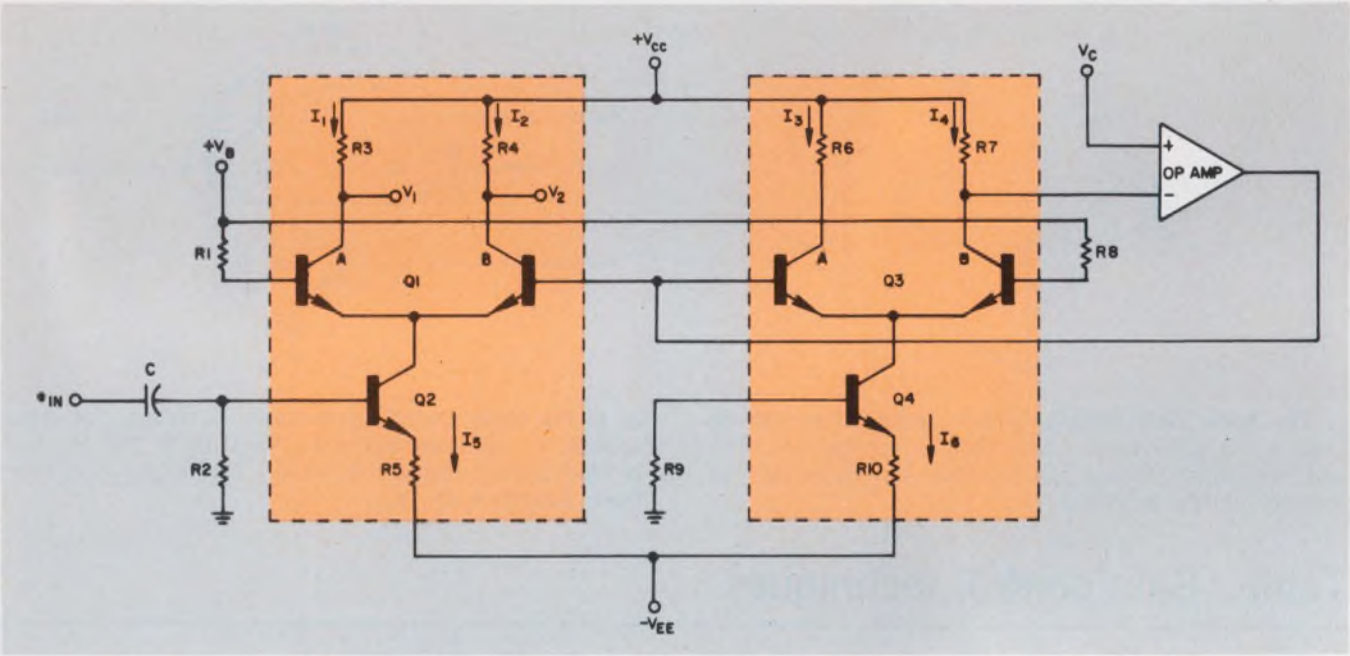
1. **The basic differential-amplifier configuration** can be used for a wide variety of amplifier applications. The constant-current source can be either a common-base or common-emitter amplifier.



2. **In the basic variable-gain amplifier circuit,** the input voltage, e_{in}, is converted to a current by Q_3 and R_E, and is then divided through Q_1 or Q_2. The outputs are non-linear functions of ΔV.

Table. Gain control techniques

Element	Mechanism	Control range	Control/ output isolation	Large signal handling	Comments
P-n junction	Forward resistance	Good	Poor	Poor	Simple, predictable
Bipolar transistor	Saturation resistance	Fair	Poor	Fair	Beta dependent
FET	Channel resistance	Good	Poor	Fair	Unpredictable gate-control voltage requirements for driving fairly high impedance loads
Photocell-lamp	Photocell resistance	Good	Good	Good	Requires power to drive lamp; cell must be shielded from ambient light
FET	Transconductance	Fair	Poor	Poor	Unpredictable gate-control voltage requirements for driving fairly high impedance loads
Bipolar transistor	Transconductance	Fair	Poor	Poor	Commonly used in AM-i-f applications
Tetrode vacuum tube	Transconductance	Fair	Poor	Good	Filament power
Differential amplifier	Current division ratio	Good	Good	Good	Op amp provides linear, temperature stable operation



3. **Linearization and temperature stabilization** of the variable-gain amplifier of Fig. 2 is accomplished by the op amp and a second differential stage. The polarity of the gain slope depends on the output of Q_1 selected.

tion of the control voltage, ΔV_c:

$$A_{v1} = -(R_3/R_5)\ (R_{10}\Delta V_c/R_7V_{EE}), \tag{17}$$

$$A_{v2} = -(R_4/R_5)\ (1 - R_{10}\Delta V_c/R_7V_{EE}). \tag{18}$$

If we let R_3 equal R_4 and add Eq. 17 and Eq. 18, we find that

$$A_{v1} - A_{v2} = R_3/R_5. \tag{19}$$

Equation 19 indicates that, as A_{v1} increases, A_{v2} decreases by the same amount. Excellent temperature stability is obtained since the operational amplifier will make sure that the collector voltage of Q_{3B} equals the control voltage.

The gain-controlling amplifier section (Q_3, Q_4 and the op amp) is ac-isolated from the gain-controlled amplifier section (Q_1 and Q_2). Thus the CDR (and the gain) is not affected by the input signal, which can be dc.

The dc collector voltages are dependent on the Current Division Ratio. If the control voltage is modulated, this modulation also appears at the collectors of Q_{1A} and Q_{1B}. Since Q_{3A} and Q_{3B} are ac-isolated from the gain-controlled amplifier, $V_{c1A} = V_{c3A}$. If the outputs of Q_{1B} and Q_{3A} are used to drive a differential amplifier with gain A_{cm}, the common-mode dc voltage may be subtracted out.

Two steps to a practical design

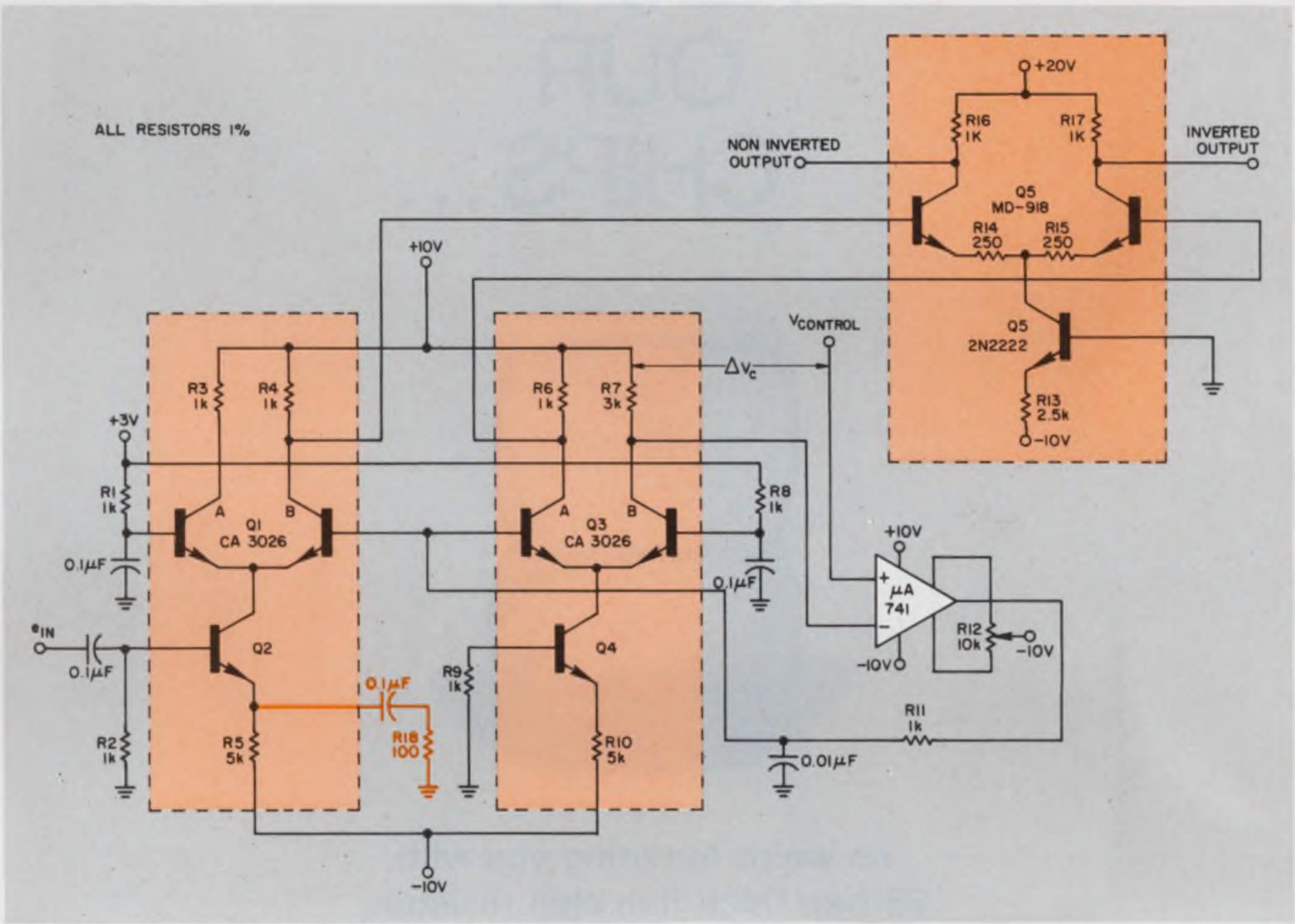
The design of a complete amplifier becomes a relatively straightforward matter. Only two steps are required: first, determine the maximum gain ($\Delta V_c = 0$) and then determine the gain slope ($dA_v/d\Delta V_c$). Both can be determined theoretically from the gain equation (Eq. 18).

$$A_{v(max)} = R_4/R_5 \tag{20}$$

$$dA_v/d\Delta V_c = R_4/R_5\ (R_{10}/R_7V_{EE}) \tag{21}$$

If a common-mode rejection amplifier is used on the output, its gain A_{cm}, multiplies Eq. 20 and Eq. 21.

A complete amplifier designed and built using the current division rate techniques is shown in Fig. 4, with Q_5 and Q_6 used as the common mode amplifier. V_{cm} has a calculated gain of 2. The gain is equal to $R_{16}/2R_{11}$. The output dc level is



4. **This complete variable-gain amplifier** was built with standard ICs. A dc amplifier (Q_5 and Q_6) was added to remove the common-mode voltage from the output of the gain-controlled amplifier (Q_1 and Q_2).

constant (to within 10 mV) over the complete variable gain range. Resistor R_{18} is added to increase the ac gain. The gain equation may be given as

$$|A_v| = R_4/R_{18}\,(1 - R_{10}\Delta V_c/R_7 V_{EE})\,V_{cm}$$
$$= 20\,(1 - \Delta V_c/6). \qquad (22)$$

The maximum theoretical gain is 20 (for $V_c = 0$) and decreases to 0 for $V_c = 6$. The theoretical gain slope is 3.3.

The actual maximum gain of the amplifier built was 14. Some of the reasons were: the nonzero output impedance at the emitter of the input transistor Q_2; the gain of the common-mode amplifier was reduced due to the dynamic emitter resistance of Q_5; 5% resistors were used in place of the 1% values assumed in the calculations. ■■

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Be a welcomed speaker at technical sessions and design meetings. Capture the interest of your audience with a good start.

"And now let's welcome our speaker, a man who has done so much to further the science of electronics . . . Dr. Thaddeus Savant."

The audience applauds politely as the speaker approaches the podium. Will this be another ho-hum speech filled with generalities? Some think so and have already adjusted their bodies for a snooze.

The speaker removes a pill box from a coat pocket. Necks are craned. What's he up to? Now he extracts a tweezer, inserts it into the box, removes a tiny object that is barely visible from the front row. "Gentlemen," he says, "this is not a flea. This is a chip only one-tenth of an inch square. It can contain as many as 5000 transistors."

Those who had contemplated sleeping this one out come to attention. The speaker picks up a model of a human brain and continues: "It is possible that some day these tiny chips can be built into a three-pound package with 12 billion circuits that will vie with the human brain."

The audience maintains its attentive pose. This speech is going to be all right. This fellow has something to say, and he's saying it in an interesting way.

The speaker did nothing that is not already known among professional speakers. He made a good start. He knew how fleeting audience interest can be—how an audience tests a speaker during the first few minutes, drops him when the start presages a dull speech.

Openers that capture audience interest

You will probably be called upon to give a talk at technical sessions, design meetings, and even as a technical authority at community meetings in your neighborhood. Equal in importance with what you say is how you say it. A good opener for your talk is required, especially when you're the fifth speaker at a technical session where audience attention is beginning to lag.

Fred E. Ebel, Cutler-Hammer, Milwaukee, Wis. 53216

You'll find, too, that when you capture the attention of your audience at the start, you'll capture its respect as well.

What, then, can be done to ensure a start-up that will grab audience interest?

We have already seen one effective method—the prop or visual exhibit. Even though the flea-sized chip was difficult to discern (ordinarily a taboo in visual technique), it did arouse curiosity. And, of course, the model of the brain took the onus off the chip's small size.

Other effective start-ups or openers include these:

- A startling or provocative statement.
- An anecdote.
- A joke.
- A good quotation.
- A challenging question.
- A statement of purpose.
- An ad-lib remark.

Here's an example of a startling or provocative statement that could be used for a speech on how electronics can help prevent pollution. "One of these days you'll be able to drink water from (name of polluted water source), and enjoy it!"

A prop could heighten the drama of the statement. For example, the speaker could drink from a bottle, with the accompanying statement: "I have just quenched my thirst with the effluent of treated sewage."

Another example of a startling statement is: "Imagine a nation of human robots programmed by a dictator. It may not be likely, but it's possible." This could be a speech on the implantation of solid-state logic devices in the human body.

Starting with a story or anecdote is a good practice. The story need not be original, but so much the better if it is. For example: "The other day I dropped into our microelectronics lab and found one of the engineers on his knees looking at the floor through a magnifying glass. I asked him what he was looking for, and he said he was searching for a chip that he'd dropped. It hit me clearly then that we are now miniaturizing to the degree where we can't see what we're making. And that's what I want to talk to you about tonight."

Lester Hogan, president of Fairchild Camera & Instrument Corp., often uses a statement of purpose liberally laced with a historical parallel to open his remarks. He employs mild humor and occasionally gestures spontaneously to illustrate a point.

Jack Morton, (R) vice president, Bell Telephone Laboratories, sometimes opens his talks with a story or anecdote suitable for the occasion. He also draws heavily on example experiences in business to capture the attention of his audience.

Donald Marquis, director of the Project on Research and Technology, Sloan School of Management, MIT, is urbane, witty and low keyed as a speaker. He will employ an ad lib opener that he has culled from events immediately preceding his talk.

A personal story generated on the spot is surefire. Suppose, for example, that during the dinner the program chairman complains to the speaker about the tarnishing of silverware by the egg salad.

The speaker smiles because fate has dropped a story into his lap that fits the very subject of the speech. He, therefore, starts like this, "That egg salad we had tonight was delicious. But your program chairman was unhappy. As you know, sulfur tarnishes silverware and eggs are quite high in sulfur. Naturally, his fork, as well as mine and yours, was black. Well, the new plastic we developed may well be the answer to silverware that stays bright even though exposed to gobs of delicious egg salad."

Laugh producers are consistent winners

The humorous beginning is always effective. A joke or a humorous story that ties in with the theme is an excellent way to start a speech.

Let's say the theme is materials, with emphasis on economy. The speaker could begin in this way: "An engineer was asked to design a 100-foot mast that would support a 40-pound load, resist 80-mile-an-hour winds and cost no more than $50. For three months, he tried to design such a mast, then gave up. His note to the individual making the request read: *Cannot design a mast at this low figure. But I am enclosing a package that contains a solution.* The package contained an acorn."

The current controversy on metric system vs English system of units is a natural for humorous introductions. "No doubt you've heard of the possibility of our adopting the metric system. But wouldn't such a change play hob with our wise sayings and aphorisms? How awkward, for instance, to say: '28.35 grams of prevention are worth 453.59 grams of cure.' Or, 'A miss is as good as 1.61 kilometers.' And how would a young lady feel if she were told her dimensions were 918 mm, 612 mm, 920 mm."

Jokes make excellent beginnings. A good laugh at the start puts the listeners in a receptive mood. Naturally, the joke must fit the subject.

Quotations make good starts, too. For example, Samuel Johnson's aphorism, "Few things are impossible to diligence and skill" could be the start of a speech showing how painstaking effort and technical knowledge resulted in a major engineering breakthrough.

Asking a rhetorical question can also be an effective speech opener. A speech outlining the advantages of speedy X-ray diffraction and spectrometry analytical methods could start with this question: "Are you still using classical methods of analysis in your chemical laboratory?" Incidentally, a pause after the question heightens effectiveness. In the foregoing example, a pause would prod the listener to mentally review his company's analytical methods.

Brevity—soul of a silver tongue

The beauty of the question-opener is its terseness. The speaker does not tire the audience with pap that so frequently includes the word "important." Here's a typical dull beginning: "It is important that an alloy of high heat resistance be used when the product is to be subjected to high temperatures."

Perhaps the least dramatic of speech openings is the statement of purpose. Utterly devoid of flamboyancy, this no-nonsense opening is the familiar, "Tell 'em what you want to tell 'em."

Here are some examples: "Tonight I'm going to tell you how you can get 25% more circuitry on a silicon chip." Or, "The purpose of my speech tonight is quite simple: I intend to show you the effect of radiation on some common insulating materials." Or, "Tonight I'm going to tell you how to protect an electric motor from burnout."

When to throw away your opener

There is still another opening that is difficult to beat because of its spontaneity. It is the clever ad lib. This opening makes itself available when, as if on cue, an event occurs that fits in ideally with the speaker's theme. The speaker can then throw away his carefully planned introduction.

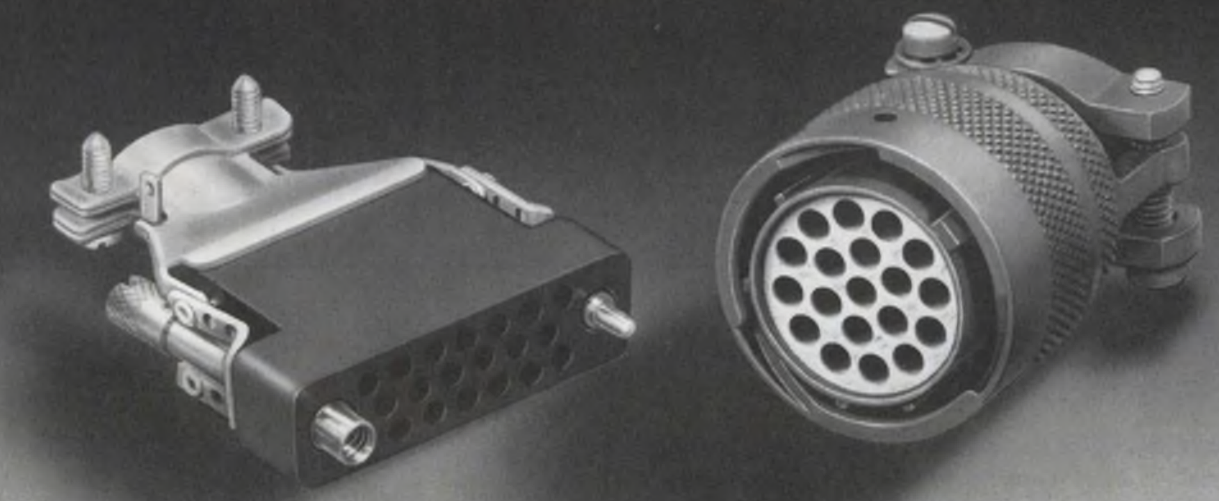
True, the impromptu remark that is clever does not always come easy. But it still can be effective, even when it is not a brilliant witticism. Consider the success of some current comedy shows on TV that depend heavily on fast, short cuts from one actor to another. The sudden surprise factor alone creates laughter.

The unrehearsed events that can occur as the speaker reaches the podium are limitless. Suppose, for example, the subject is noise pollution. The speaker peruses his notes, looks up, and at that moment the *rat-tat-tat* of an air hammer fills the room.

The speaker can ignore the distraction—and some do. But the listeners are looking at him—expectantly. They *want* him to say something. Anything. He racks his brain, asks himself what he can say that is clever, that will make the group laugh, at least smile. He nods toward the source of noise, and says, "Since I'm talking about noise pollution you didn't think I'd come here without my sound-effects man, did you?"

A speech has been likened to a verbal dinner, with the start the cocktail that whets the listeners' appetite. The next time you speak, remember to serve a "cocktail" before "dinner." ■■

Identical twins.



One contact system serves both.

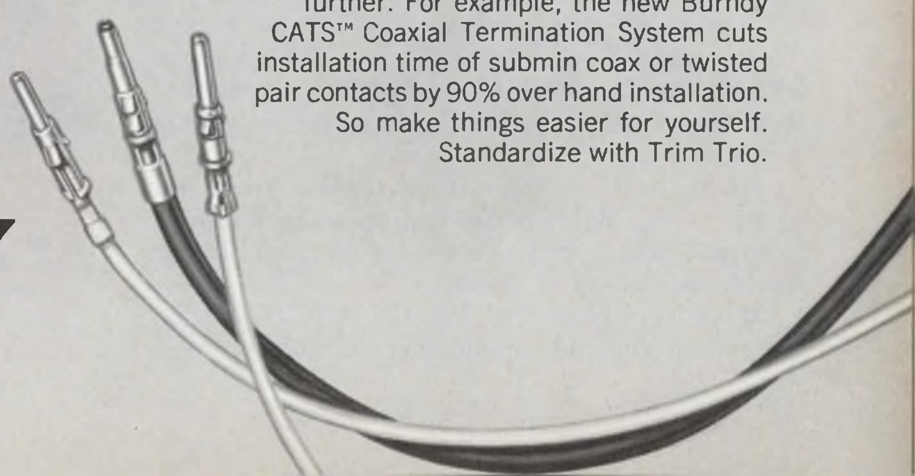
In spite of different designs and different applications, rectangular connectors and miniature round connectors can now use identical Trim Trio contacts. Installed with identical tooling.

You get advantages of standardization where it counts. Think of the reduction in inventory of both parts and tooling. Of the hours saved on operator training. Yet design variations are unlimited and applications cover the spectrum from computers to communications to avionics.

And the variations increase because—in the same connector block or shell—you can intermix submin coax, machined or strip formed contacts. Which is what the Trim Trio system is all about.

Burndy installation tooling cuts costs further. For example, the new Burndy CATS™ Coaxial Termination System cuts installation time of submin coax or twisted pair contacts by 90% over hand installation.

So make things easier for yourself. Standardize with Trim Trio.



BURNDY
Norwalk, Connecticut 06856

Squelch noise pick-up by complementary emitter driver

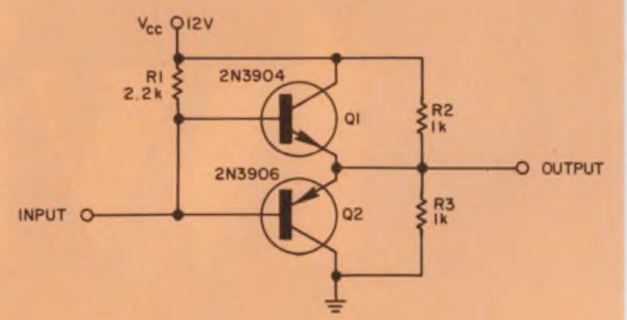
Provide your complementary emitter driver with high noise immunity by placing two equal low-value resistors across its output. The conventional configuration's output is subject to noise pickup and waveform distortion (due to capacitive loading) when its load is remotely placed or has high impedance or capacitance.

When one transistor is ON, the other represents a high collector-emitter impedance. The addition of equal resistors, R_2 and R_3, lowers this impedance symmetrically. This "source loading" also provides a positive biasing of the ON transistor. The resistors' value should be chosen as low as possible to keep within the capabilities of the driving stage.

As a result of this minor modification, the driver's output waveform will conform more closely to its input and be less sensitive to cross-talk, signal-line, power-line or ground-line noise.

Jan C. Sabol Jr., Parametrics, Inc., Measurement and Control Systems, 284 Racebrook Rd., Orange, Conn.

VOTE FOR 311



Low-value equal resistors across the output of this complementary emitter driver improve its noise immunity by making it less sensitive to load conditions. Crosstalk is also reduced.

Program the pulse width of a hybrid monostable

A hybrid one-shot formed with a series 7400 logic gate and a discrete pnp switching transistor allows you to exercise direct digital control over pulse width. Pulse timing changes are made by selecting discrete timing resistances sequentially or in weighted combination to give the desired RC product. These changes are effected by transistor switches that are returned to ground, such as through type 7400 open-collector logic.

The basic elements of the monostable are one-quarter of a 7400 quad gate (G_1) and a type 2N3906 common-emitter switch (Q_1). In the static state, G_1 is held low by a high input, and Q_1 is saturated through the timing resistance.

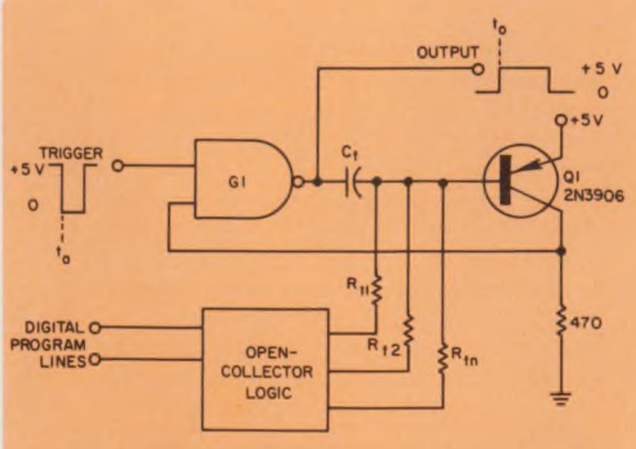
A negative step input to G_1 drives its output to the logic ONE state, turning Q_1 OFF via the charge on C_t. This capacitor then discharges towards ground through R_t, forming the timing interval.

When the V_{be} of Q_1 is reached, the circuit returns to the stable state. Output pulse width is 0.55 RC, and Q_1 drive requirements allow timing resistances of up to 40 kΩ.

Many variations are possible with this basic circuit to suit the application. A pair of one-shots cross-coupled and programmed in dual fashion, for example, will give a digitally variable frequency. By programming in complementary fashion, one can achieve duty-cycle variation with constant frequency.

Walter G. Jung, 1946 Pleasantville Rd., Forest Hill, Md.

VOTE FOR 312



You can digitally control the output pulse width of this hybrid monostable multivibrator. Pulse width, which equals 0.55 RC, is varied through the selection of timing resistance.

Versatile ramp generator varies start and stop levels

Most ramp generators provide an output that is variable in amplitude, width and slope. In addition to these characteristics, the ramp generator diagrammed here offers a variable start-and-stop level and a variable duration hold-point anywhere along the ramp slope.

When power is applied to the circuit, Q_1 is biased ON by the current flow through R_1. The application of a positive pulse to the base of Q_1 turns it OFF, and its collector voltage falls to a value determined by the divider, consisting of R_2, R_3, R_4, R_5 and R_6. The amplitude of this negative pulse, which drives Q_2, is established by the position of switch S_1.

The values shown for R_3, R_4, R_5 and R_6 provide pulse amplitudes of approximately −35, −30, −20 and −10 V, respectively. The resistor values may be changed to provide other pulse amplitudes, so long as the total resistance is about 7.5 kΩ.

Q_2 is forced into conduction by the negative pulse applied to its base from the wiper of S_1 and produces a negative pulse at the junction of D_2 and D_3. With no pulse present at this junction, current flows from the −50-V supply through R_8, D_4, D_5, D_3 and R_7 to ground. Current flow (about 1 mA) from this supply is held constant by the current-regulator diode, D_4.

Under these conditions, C_1 charges to a dc level of approximately −1.5 V, due to the voltage drop across D_3 and R_7. When the input pulse at J_1 causes a negative pulse to be developed across R_7, D_3 is back-biased and C_1 charges through R_8, D_4 and D_5. The capacitor's voltage is a linear ramp with an intercept of −1.5 V and is the waveform generated at the base of Q_5 with no input at J_2.

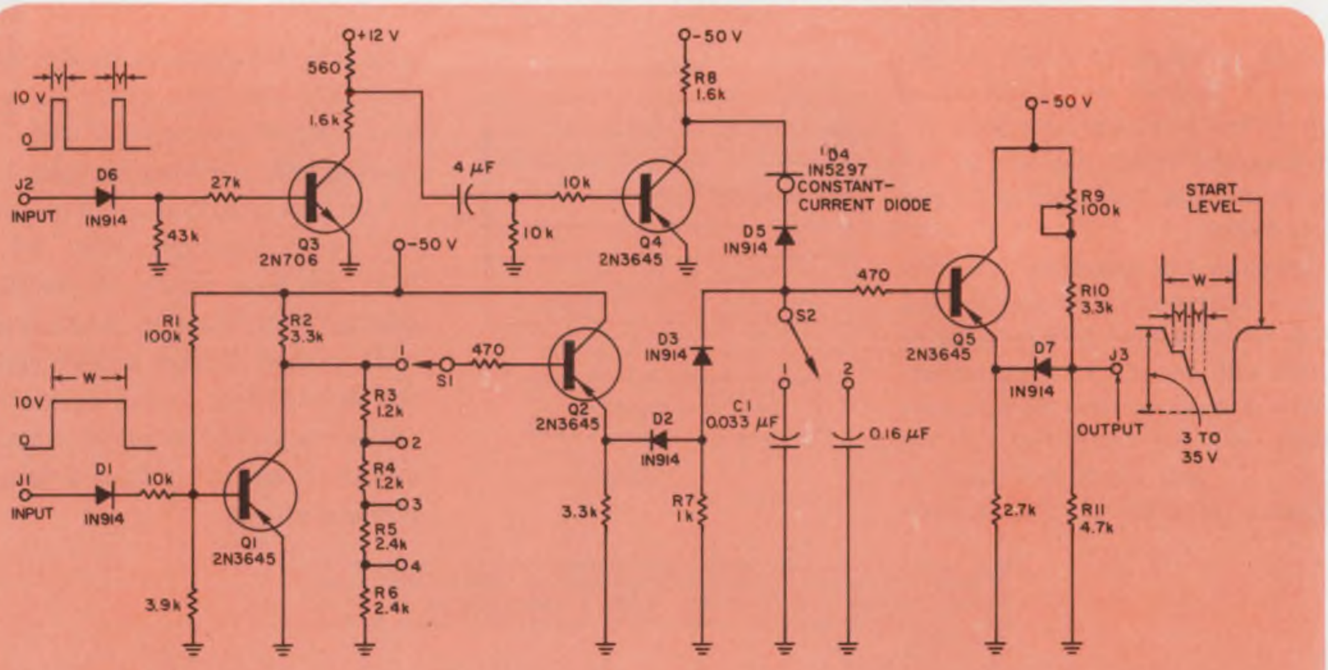
Constant-current diode D_4 provides about 1 mA over a range of 1 to 100 V. Resistor R_8 was added to limit the current flow when Q_1 is saturated. Because of the presence of R_8, the pinch-off voltage of D_4 is increased from 1 to approximately 7 V. This increase, however, does not affect ramp linearity, since the voltage across D_4 never drops below 20 V. The slope of the ramp is determined by the charging capacitor selected by switch S_2.

A positive pulse applied at J_2 is coupled through D_6 to the base of Q_3, causing the transistor to conduct. The resultant negative-going pulse is applied to the base of Q_4, making it saturate for the duration of the pulse. When Q_4 is saturated, no current flows through D_4, and C_1 does not charge or discharge.

As a result, a step is produced in the ramp output at J_3. The width of the step is determined by the width of the pulse at J_2, and it may be positioned at any point along the ramp by delaying the pulse at J_2 with respect to the pulse at J_1. The dc start level of the ramp output may be varied from −2 to −25 V by the voltage divider action of resistors R_9, R_{10} and R_{11}.

The slope of the output ramp is determined by the value of charging capacitance selected by S_2.

R. L. Starliper and J. J. Bill, Engineers, Western Electric, Burlington, N. C. VOTE FOR 313



Use different input pulse waveforms to change the start-and-stop level of this variable-parameter ramp generator. One input sets over-all ramp length, while the other determines step size.

Model 844 is all you need for your low cost/high performance requirements in virtually unlimited applications. Think of it as a standard building block that's cost-effective, compatible, efficient, versatile — all in a hermetically sealed 12-pin TO-8 can.

These performance specifications are the best in the market for a dual regulator (to MIL-STD-883):

Regulation: ±0.005%
Current: ±300 mA, isolated
Output: preset ±12 v or ±15 v, ±0.5% initial tolerance

And the price? $20 (1-9 quantity). Contact your local Helipot Sales Engineering Representative for additional information.

Beckman® INSTRUMENTS, INC.

HELIPOT DIVISION FULLERTON, CALIFORNIA 92634

Helipot's new dual voltage regulator has many facets!

HELPING SCIENCE AND INDUSTRY IMPROVE THE QUALITY OF LIFE

Versatile timing circuit is based on pulse coincidence

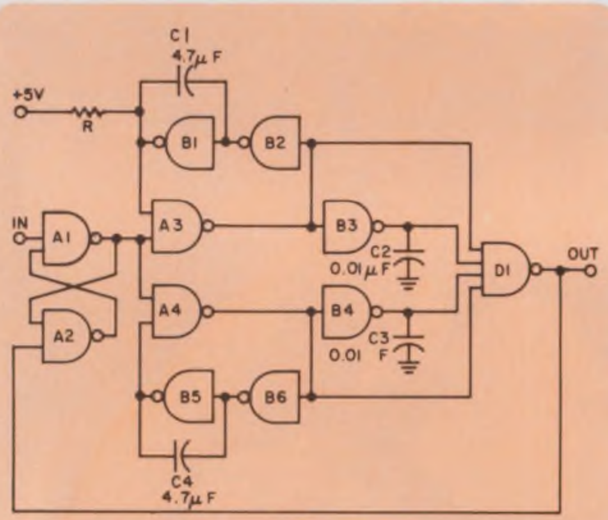
Time delays of long duration with small capacitors can be obtained by having a pulse set a flip-flop and turn on two pulse generators of slightly different frequencies. The first coincidence of the nth pulse of one generator and the nth + 1 pulse of the other occurs when the desired time interval has elapsed. This coincidence is detected by an AND gate, whose output is used to reset the flip-flop that first started the pulse generators.

The circuit of Fig. 1 has the enabling flip-flop composed of dual NANDs A_1 and A_2. The NANDs, inverters and capacitors—A_3, B_1, B_2, C_1 and A_4, B_5, B_6, C_4—make two astable circuits. Narrow pulses are derived from the astables by forming the AND of each output with its slightly delayed complement (Fig. 2). The complements and delays are created by the inverters and capacitors B_3, C_2 and B_4, C_3. A final coincidence NAND uses a single 4-input gate D1. With the component values indicated, delays of 15±2 seconds can be obtained.

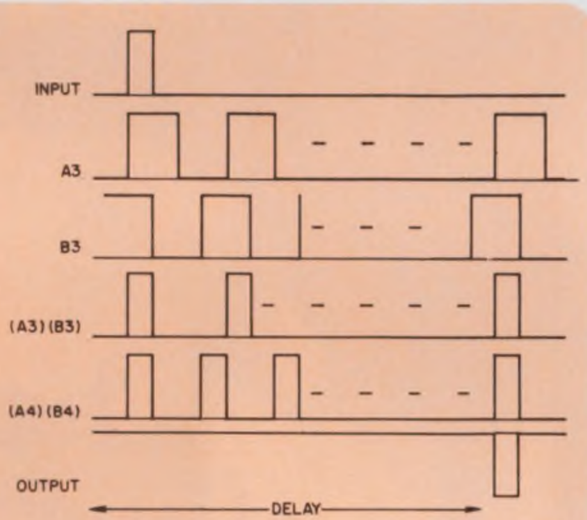
The pulse-width-to-period ratio t/T should be adjusted so that pulse coincidence, if narrowly missed at the proper time, will occur between the next pulses. The delay is then roughly T^2/t.

Gunnar Richwell, Potter Instrument Co., Inc., E. Bethpage Rd., Plainview, N. Y. 11803.

VOTE FOR 314



1. **Only NAND gates and capacitors are used** to build this variable-delay circuit. Capacitors C_1 and C_4 control timing. Resistor R is optional if additional fine control is needed.



2. **A delay between the output of A_3 and its complement, B_3,** is used to create narrow pulses, $(A_3) \cdot (B_3)$. Coincidence between $(A_3) \cdot (B_3)$ and $(A_4) \cdot B_4)$ determines circuit timing.

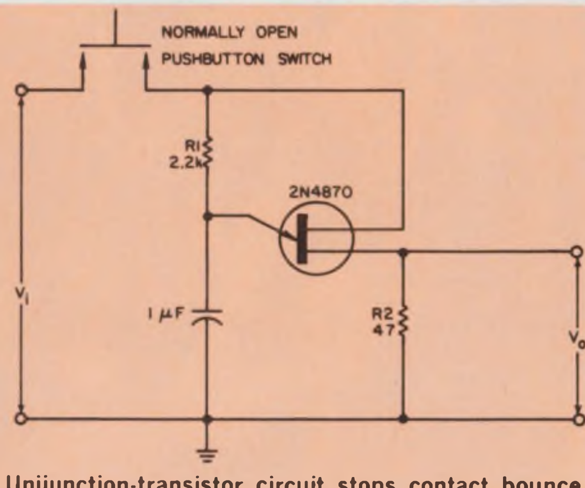
Clean up switch closures with a fast UJT pulse

Eliminate switch-closure contact bounce with a circuit that provides one clean pulse with a 200-ns risetime and a 2-μs falltime. Standby power is not required after the switch is released.

Because resistor R_1 provides a current greater than the valley current of the unijunction transistor, the UJT can fire only once. With proper selection of R_2 and the supply voltage, the circuit can be made to interface directly with digital logic circuitry. Supply voltage can range from 3.5 to 20 V.

Peter Stasz, Electronics Engineer, Medtronic, Inc., 3055 Old Highway 8, Minneapolis, Minn. 55418.

VOTE FOR 315



Unijunction-transistor circuit stops contact bounce by supplying a pulse with a 200-ns rise-time. Resistor R_1 permits the UJT to fire only once by overriding the device's valley current.

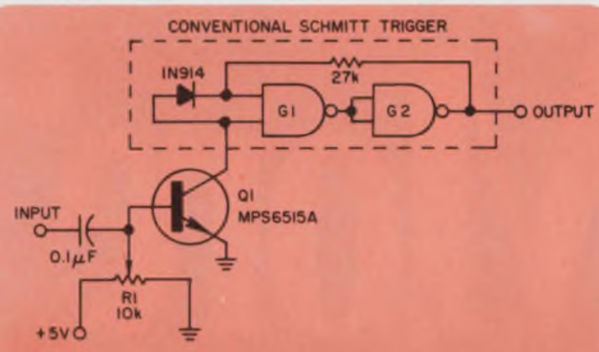
Variable Schmitt trigger responds to 50-mV inputs

Adding a transistor amplifier to the input of a conventional Schmitt trigger results in a variable triggering threshold and greater sensitivity for the circuit. Triggering levels can be as low as 50 mV and operating frequencies as high as 20 MHz.

Without the input transistor, the triggering level is entirely dependent on the switching point of G_1, which is generally on the order of 2.1 V for a TTL NAND gate. In addition the trigger point varies from IC to IC, an undesirable condition for some applications.

Potentiometer R_1 forward-biases Q_1 and sets G_1's steady-state input voltage at the verge of the gate's switching point. When an input signal is applied, G_1 changes state and regular Schmitt-trigger action occurs.

The NAND gates are one-half of a Texas Instruments SN7400N or a Motorola MC7400P. R_1 can be any 20-turn trimmer potentiometer.



Vary the threshold of your Schmitt trigger with the addition of just a single transistor. The "modified" circuit is sensitive to 50-mV triggering levels at frequencies of up to 20 MHz.

E. I. Levy, Project Engineer, Pan American World Airways, Pan Am Building (M/U #25), Miami, Fla.

VOTE FOR 316

$1000 prize goes to Idea-for-design author

ELECTRONIC DESIGN's Idea-of-the-year award for 1970 goes to George Oshiro of Los Angeles for his idea, "Exclusive-OR gates replace choppers in phase-lock loop." George is the recipient of a $1000 check and a commemorative plaque to document the occasion.

The winning idea, which was published in ED 3, Feb. 1, 1970, has led to several potentially significant applications involving digital phase-lock loops in the area of communications.

George is self-employed as a consulting engineer, and is also in the process of developing a high-speed modem, which he plans to market late this summer. One of the key circuits in the modem uses his winning idea.

Although George has filed to patent his circuit, he will allow unrestricted use of it for laboratory development purposes. Information regarding its commercial use can be obtained by writing to: PO Box 90876, Los Angeles, Calif. 90009.

$1000 winner George Oshiro was born in Maui, Hawaii. He attended the University of Hawaii, UCLA, and Pacific States University, from which he received his BSEE in 1964. A veteran of the U. S. Army, George enjoys swimming, bowling and music of all kinds.

IFD Winner for February 4, 1971

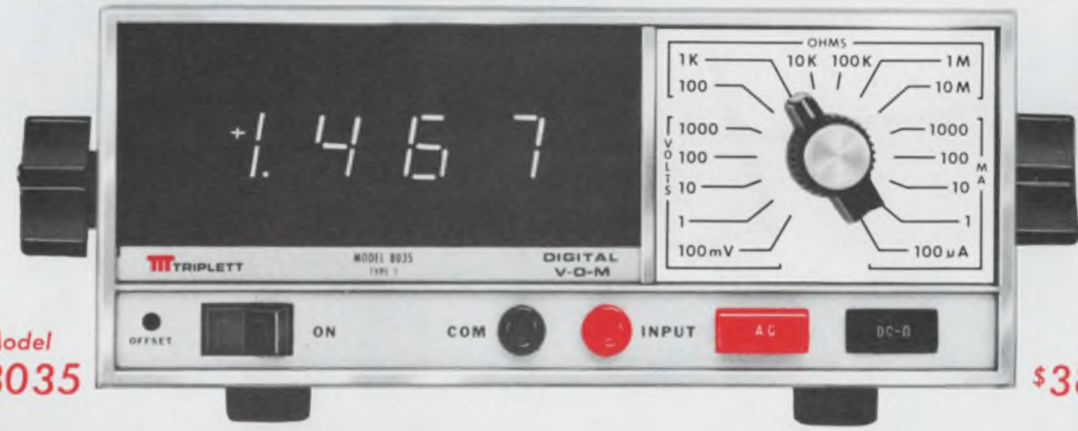
G. Pranzo Zaccaria, Engineer of European Space Research and Technology Centre, 40 Estec, Noordwijk, Holland. His idea "Voltage-to-Frequency Converter Provides Linearity of 0.4%" has been voted the Most Valuable of Issue award.

Vote for the Best Idea in this Issue.

VOTE! Go through all Idea-for-Design entries, select the best, and circle the appropriate number on the Reader-Service-Card.

SEND US YOUR IDEAS FOR DESIGN. You may win a grand total of $1050 (cash)! Here's how. Submit your IFD describing a new or important circuit or design technique, the clever use of a new component or test equipment, packaging tips, cost-saving ideas to our Ideas-for-Design editor. You will receive $20 for each accepted idea, $30 more if it is voted best-of-issue by our readers. The best-of-issue winners become eligible for the Idea Of the Year award of $1000.

If you need a high quality 3½-digit V-O-M at your price . . . buy Triplett's new 8035



Model 8035

$385

1. **EASY OPERATION** — Single polarized plug for test leads eliminates switching leads when changing functions.
2. **LOW POWER CONSUMPTION** — Less internal heating for greater stability and reliability.
3. **LOW CIRCUIT LOADING** — Greater measurement accuracy with 10 megohm input resistance for all AC and DC voltage ranges.

Designed for R&D, production, quality control, maintenance and classroom use, Triplett's new Model 8035 Digital V-O-M features an automatic polarity display, 100% overrange capability, out-of-range display blanking and high input resistance to make it nearly foolproof.

With 26 ranges, the Model 8035 boasts accuracies from ± 0.1% to ± 0.5% of reading ± 1 digit . . . ranking it among the best on the market. Its green, polarized window and its single-plane, seven-bar, fluorescent display combine to insure bright, reflection-free readability from virtually any viewing angle.

Hardware for rack mounting is available.

See the Model 8035, priced at $385, at your local distributor. For more information, or for a free demonstration of the convenience and accuracy of the 8035, call him or your Triplett representative. Triplett Corporation, Bluffton, Ohio 45817.

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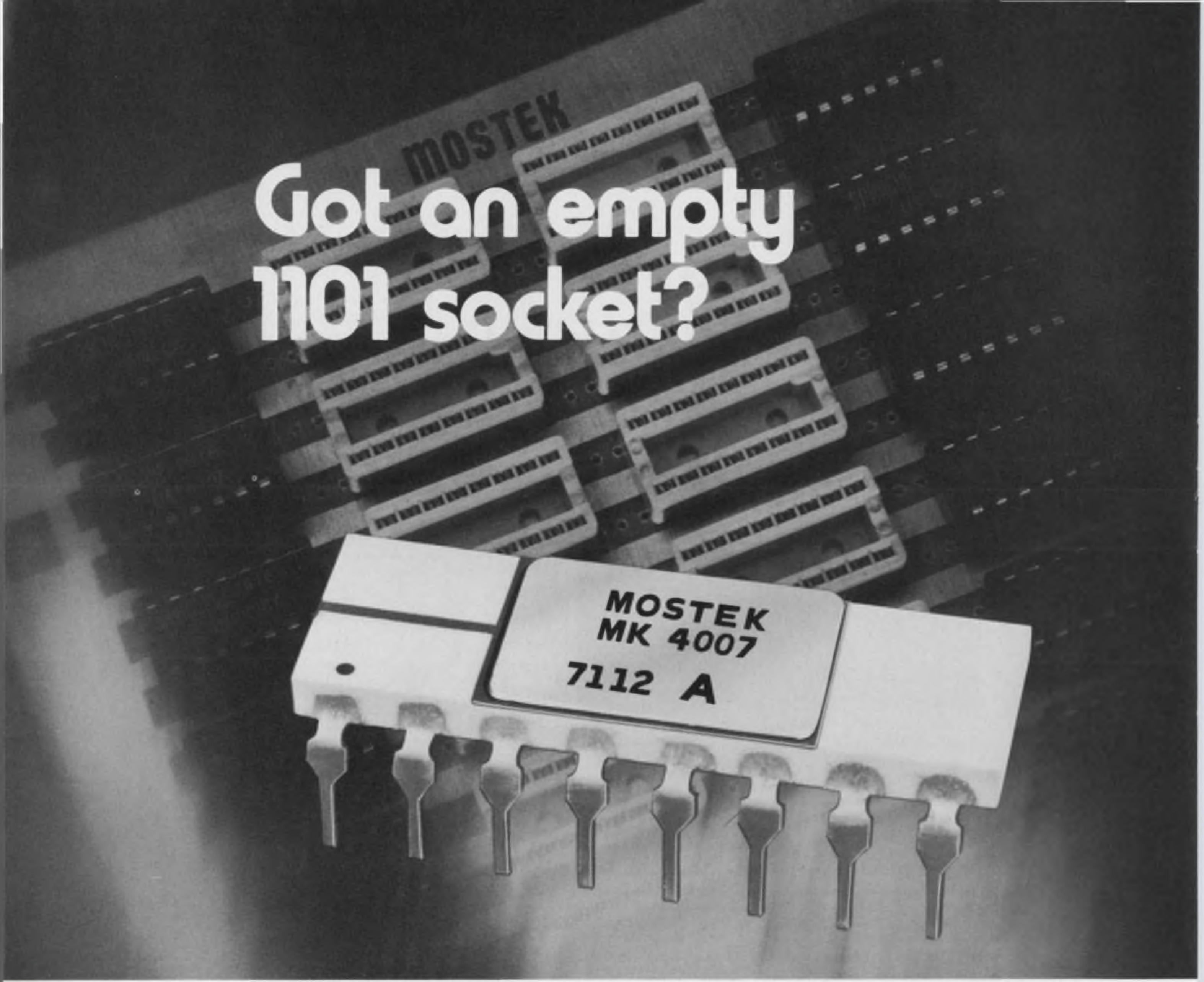
The World's most complete line of V-O-M's choose the one that's just right for you

INFORMATION RETRIEVAL NUMBER 47



Fill it with the coolest 256-bit RAM around... from MOSTEK

Whether you've already got an empty 1101 socket—or just considering a replacement—you'll find MOSTEK's new MK 4007 P your ideal choice in 256 x 1-bit RAMs. Here's why:

Low power: 250 mW!

Wide voltage range: +5V; −7 to −15V, fully covers the range of any other existing part.

Full DTL/TTL compatibility including the outputs which have a fan-out of 2 with tightly controlled sink currents.

High performance: This exceptional combination of low power/high performance is made possible for the first time by ion-implanted constant current (depletion) devices.

Speed: All 4007s operate at less than 1μ sec access time up to +75° C...ambient.

16-pin ceramic package: You get ceramic hermeticity at plastic prices!

Now, add-up these key benefits and compare them with what you get in any other 1101 replacement. Wouldn't it be smart to switch **now** rather than try to fix? Find out for yourself how MOSTEK makes it easy to use MOS by calling Gordon Hoffman or Dave West at (214) 242-1494. Or contact your nearest Sprague Electric Company representative or distributor.

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The Calculator-on-a-Chip Company

INFORMATION RETRIEVAL NUMBER 48

CMOS 64-bit self-decoding RAM dissipates 0.3μ W

Motorola Semiconductor Products, Inc., 5005 E. McDowell Rd., Phoenix, Ariz. Phone: (602) 273-6900. P&A: $25 (100-up quantities); stock.

A 64-bit complementary MOS random-access memory, the first of its kind with complete address decoding on the same chip with the memory cells, features total memory power dissipation of a mere 0.3 μW. This makes it suitable for battery operation.

The new memory features low output capacitance and a tri-state output that allow multiple memory outputs to be tied together without adversely affecting their performance characteristics.

The output capacitance is typically 5 pF, which results in only a moderate reduction in speed when a large number of outputs are OR'd together. And the tri-state output, similar to some TTL designs, results in an essentially open output circuit unless the individual memory chip is addressed and strobed.

This, coupled with an extremely low output leakage current (typically 10 nA), keeps the output voltage levels from changing significantly as more outputs are tied together. And with output levels virtually independent of fanout, nearly all of the power-supply voltage is available as logic swing, regardless of the number of units wired together.

As a result, a typical noise immunity of 45% of the power-supply voltage is maintained under all load conditions.

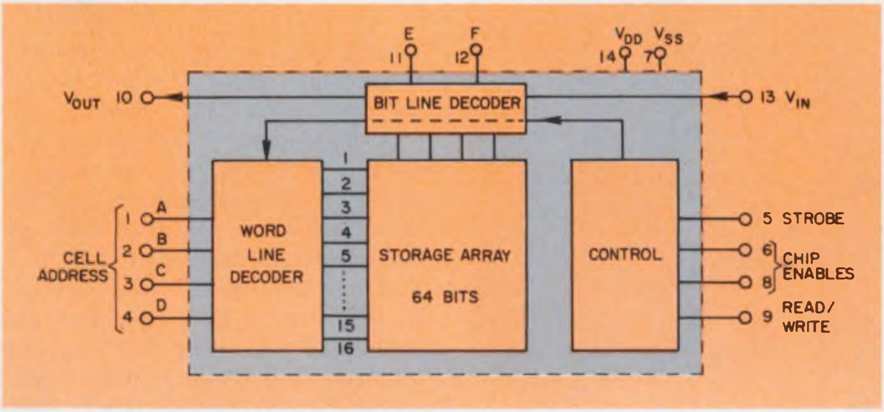
Because the new memory has all its control circuitry on one chip, it operates without externally added circuits in small scratch-pad and buffer-memory applications.

And for larger memory requirements, its wired-OR capability and two built-in chip-enable circuits allow storage capacity expansion to 256 bits, without any external parts, simply by interconnecting up to four individual memories.

Even greater memory capacity can be achieved by adding additional input decoding capability. In fact, over 50 outputs can be tied together for a capacity of more than 3000 bits, without seriously degrading performance.

Marketed under the type number MCM14505L, the new 64-bit memory comes in a 14-pin hermetically sealed ceramic package, and has an operating temperature range from −55 to +125°C.

CIRCLE NO. 250



Ultra-low-power dissipation CMOS RAM has decoding and control circuits on one chip. The memory is organized as 64 words by 1 bit.

Dual 100-bit registers clock at a 5-MHz rate

Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. Phone: (408) 739-7700. Price: $3.70 (100 to 999-lot quantities).

Two 5-MHz dual 100-bit MOS dynamic shift register ICs are now available in quantity for use in low-cost buffer and sequential-access memories. The 2506 and 2507 devices use two clock phases. Power dissipation at 1 MHz is 400 μW/bit and the clock capacitance is 40 pF. The former drives bipolar ICs and the latter MOS ICs.

CIRCLE NO. 251

P-channel IC generates dot-matrix characters

Solitron Devices, Inc., 8808 Balboa Ave., San Diego, Calif. Phone: (714) 278-8780.

The UC7541 is a monolithic p-channel device designed specifically for dot-matrix character generation where column-by-column data output is desired. Its chip enable access time is 350 ns max and column select access time is typically 200 ns. Typical character access time is 400 ns. Power dissipation is 200 mW. The device is available in 24 and 28-pin DIPs and in flatpacks to operate over −25 to +85°C.

CIRCLE NO. 252

Four-binary-code ROM generates int'l message

Texas Instruments, Inc., 13500 N. Central Expressway, Dallas, Tex. Phone: (214) 238-2011. P&A: $9.90 (250 to 999 quantities); 3 wks.

A new MOS/LSI message generator implemented on a 2048-bit ROM designated TMS2605, generates the international "Quick Brown Fox" message in four binary codes: USACII, EBCDIC, Baudot, and Selectric. The complete message produced is the familiar "The Quick Brown Fox Jumped Over The Lazy Dog" and the numerals "1234567890."

CIRCLE NO. 253

Monolithic power op amp provides 1-A output at 15 V

Fairchild Semiconductor, 464 Ellis St., Mountain View, Calif. Phone: (415) 962-5011. P&A: under $5; June, 1971.

A new single-chip op amp from Fairchild Semiconductor provides a 1-ampere output current at ±15 V.

Designated the μA791, this high-performance op amp is designed specifically for such power applications as audio amplifiers, servo and ultrasonic drivers, voltage regulators and heater circuits.

Fail-safe operation is provided in two ways. A high-temperature power shutdown circuit senses the chip's temperature and clamps the bases of the op amp's output transistors, whenever power limitations are exceeded. Output power and power dissipation are so limited so as to keep the chip's temperature below a preset value of 140°C.

And the output current is symmetrically short-circuit limited to 1 A, for a limiting resistance of 0.5 Ω.

System accuracy is improved by a large-signal voltage gain of 50,000 and the use of balanced offset null circuitry.

Input specifications include 2 mW of offset voltage, 20 nA offset current, only 50 nA of bias current and 2 MΩ of impedance.

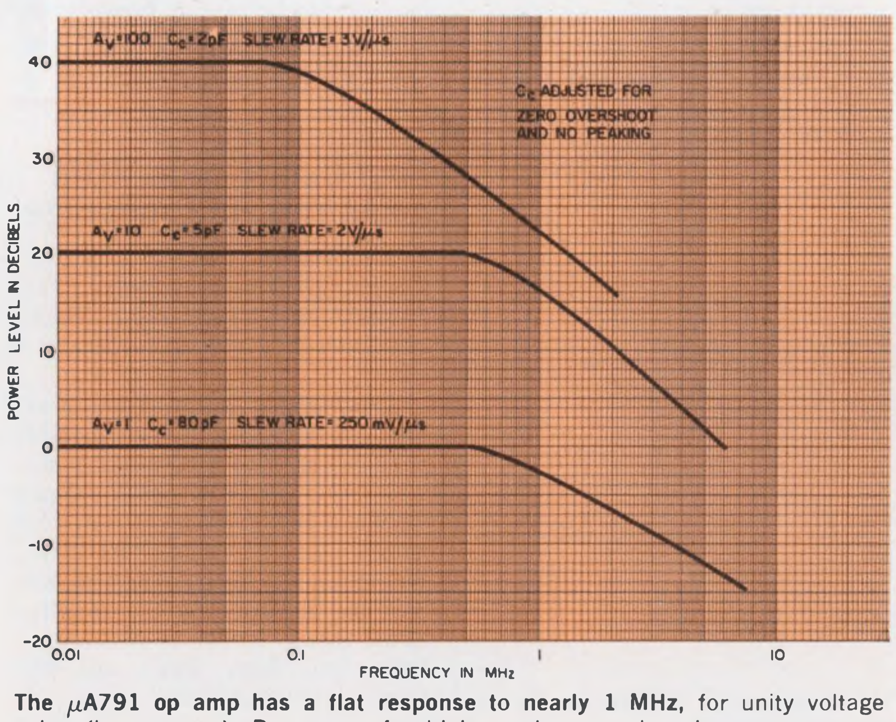
The μA791 features a wide input voltage range of ±15 V and a differential input voltage range of ±30 V.

It is operated from ±18-V supply lines at 12 mA. The power supply rejection ratio is specified as 30 μV/V.

Additional specifications include a common-mode rejection ratio of 90 dB and an operating temperature range of −55 to +125°C.

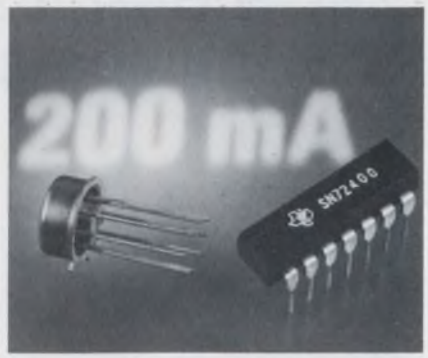
Packaging is in a TO-3 hermetically sealed 10-pin case, which has a good thermal resistance of less than 6°C per W and adequate heat sinking for a 5-W rms audio amplifier at 70° C ambients.

CIRCLE NO. 254



The μA791 op amp has a flat response to nearly 1 MHz, for unity voltage gains (lower curve). Responses for higher gains are also shown.

IC voltage regulator operates at 200 mA

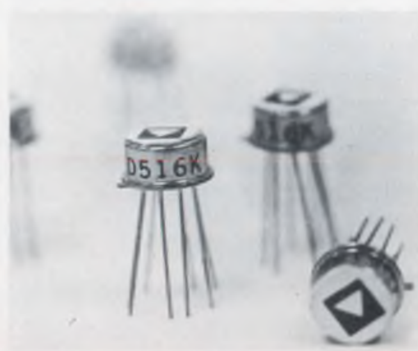


Texas Instruments, Inc., 13500 N. Central Expressway, Dallas, Tex. Phone: (214) 238-2011. P&A: $2.50 (100-piece quantities); 3 wks.

A new linear IC voltage regulator operates over a 2 to 37.5-V output range at 200-mA levels without an external power transistor. Output current for the SN72400 can be increased by adding an external power transistor. The regulator consists of a zero-TC reference and error amps, an output transistor, and a remote shutdown circuit which allows the regulator to be turned on or off by a logic pulse.

CIRCLE NO. 255

High-speed IC op amp has 5 pA bias current



Analog Devices, Inc., 221 Fifth St., Cambridge, Mass. Phone: (617) 492-6000. P&A: $32; stock.

A high-speed IC op amp packaged in a TO-99 can and employing FET-input circuitry for 10^{11}-Ω input resistance features 5 pA of maximum bias current. The AD516 also has low initial offset voltage of less than 1 mV. Specifications include 30-V/μs slew rate, 3 μs to 0.1% settling time, 30-MHz small-signal bandwidth at 100:1 gain and 90 dB common-mode rejection.

CIRCLE NO. 256

Need another reason to buy Raytheon Miniverters™?

If performance weren't reason enough to buy our multiplexing A-to-D converters, Raytheon Data Systems offers quantity discounts up to 40%. And we now have a 15-bit Miniverter.

The basic 15-bit ADC (18 microseconds conversion time) costs an industry low $1550. When your application requires analog multiplexing and a sample-and-hold amplifier, just add those modules to the pre-wired connector block. Your system now converts up to 16 analog channels at a throughput rate of 40 kHz while maintaining an accuracy of 0.02% ±½ LSB. If your application requires a greater throughput rate, the MADC15M offers a variable conversion rate and can be short cycled for less resolution. You can get the complete 16 channel multiplexed ADC for only $2450. In OEM quantities of 100, you pay only $1470 each.

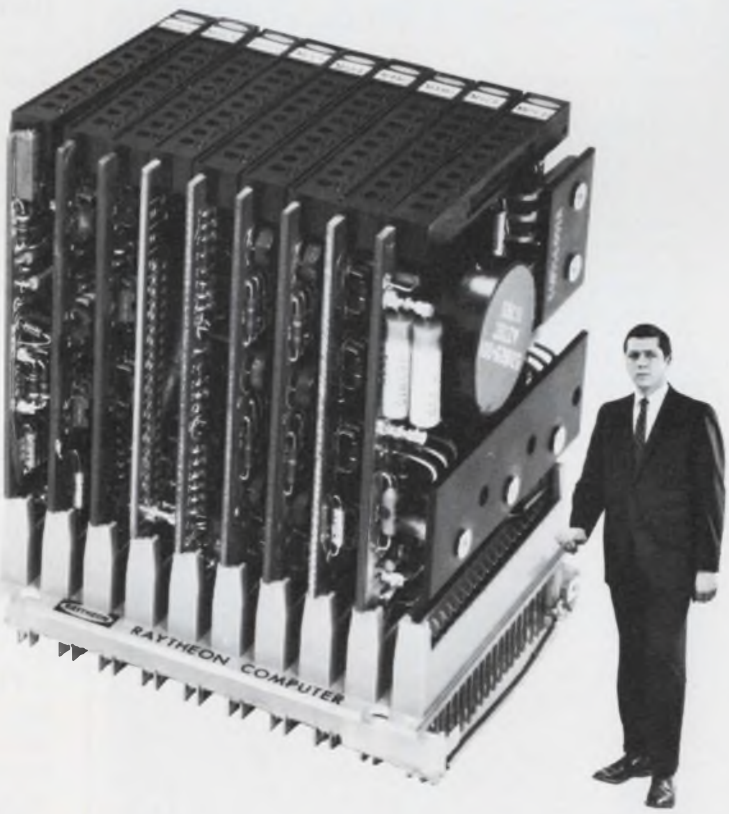
And if your system needs a computer, consider one of our 16-bit CPU's with cycle times from 900 ns to 1.75 μs. Prices start below $10,000. And Raytheon Data Systems has the only complete software library in the minicomputer class — with over 600 programs and subroutines to choose from.

Write today for Data File E-210. We'll send you all the facts and figures on our price/performance-proven conversion equipment.

Raytheon Data Systems Company, 2700 S. Fairview St., Santa Ana, California 92704. Phone: 714/546-7160.

RAYTHEON

Discount.



Raytheon Data Systems Company. We offer all there is.

INFORMATION RETRIEVAL NUMBER 49

N-channel JFETS have 0.5-pF capacitance

Siliconix, Inc., 2201 Laurelwood Rd., Santa Clara, Calif. Phone: (408) 246-8000. P&A: $2.10 or $2.25; stock.

A new series of n-channel silicon junction FETs exhibit C_{rss} of less than 0.5 pF and C_{iss} of less than 2 pF. The U273/A through U275/A family of FETs have a noise figure of 30 nV/$\sqrt{\text{Hz}}$ at 1 kHz and 10 nV $\sqrt{\text{Hz}}$ at 100 kHz.

CIRCLE NO. 257

MOS 1024-bit RAM accesses in 150 ns

Advanced Memory Systems, Inc., 1276 Hammerwood, Sunnyvale, Calif. Phone: (408) 734-4330. P&A: $55 (100-unit lots); stock.

A breakthrough in monolithic MOS RAM performance is the 6002 1024-bit RAM which features an access time of 150 ns and a cycle time of 200 ns. It is packaged in a 22-pin ceramic DIP.

CIRCLE NO. 258

High-resistance FETs have 10^{15} Ω inputs

General Instrument Corp., 600 W. John St., Hicksville, N. Y. Phone: (516) 733-3333. Price: $5, $7 (100 piece lots).

Two new MOSFETS, 2N4066/2N4067, feature 10^{15} Ω input resistance, a normally-off state with zero gate voltage, and square-law transfer characterictics. They are designed for high impedance amplifiers, op amps and logic circuits.

CIRCLE NO. 259

600-A SCR rates 2600 V

General Electric Semiconductor Products, Electronics Park, Syracuse, N. Y. Phone: (315) 456-2298. P&A: $600 (2200-V model); 30 days.

The new C602 SCR utilizing an alloy diffused process is rated at 2600 V and 600 A average. It is housed in a pressure-mounted Press Pak. In the C600 series are a 900-A 1200-V and a 750-A 1800-V version.

CIRCLE NO. 271

HOW LOW CAN WE GET?

We looked at the competition, then built a better potentiometer, the Model 3006, a low cost cermet unit for PC board use.

Here's how we did it:

Model 3006

actual size

GAVE IT MORE POWER

¾ watt at 70°C

MADE IT SURER

superior setability: longer element, 15 turns and 16 independent wiper contacts to make sure

SEALED IT TIGHTER

to Mil-R-22097

BUILT IT LOWER

only ¼″ off the board

PRICED IT LOWER

only 81¢ in 25,000 piece quantity, much lower for more

Send for full data on the 3006, and we'll send along dramatic proof of how tough a little unit it really is.

BOURNS

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

INFORMATION RETRIEVAL NUMBER 51

Two-MHz a/d is a memory, transient recorder and d/a

Computer Labs, 1109 S. Chapman St., Greensboro, N. C. Phone: (919) 292-6427. P&A: $4900 for basic unit; 4 to 6 wks.

A new and unique measuring instrument—the LAB210 Transiverter—is an a/d converter that functions as a memory, a transient detector and a d/a converter with the addition of the proper options.

As an a/d converter, it is capable of dc through 2-MHz word rates, with 10-bit resolution when driven by external sources. Internal clock rates of 100 Hz or 2 MHz can be selected by front-panel pushbuttons.

Accuracy is specified as 0.1% ±1/2 LSB for analog input frequencies from dc through 1 MHz. Aperture time is 0.35 ns.

Aperture time is the uncertainty time that exists between the moment a command signal is given for a/d conversion, and the time the analog input signal actually enters the a/d.

Three pushbutton-selectable analog input voltage ranges are available—1, 10 and 100 V. Unipolar positive, unipolar negative and bipolar input analog signals can all be digitized.

The output is TTL compatible and consists of 10 parallel binary bits, either offset or straight, depending on the input range used.

A $310 option allows the LAB-210 Transiverter to also function as a 100 10-bit-word memory. Words can be written into the memory, upon enable commands, at 2 MHz, when operating on the LAB-210's internal clock; words can be written into the memory at any frequency from 2 kHz through 2 MHz when operating on external encoding signals.

Rear-panel BNC connectors are available for memory output.

A second option costing $200 allows the LAB210 Transiverter to also read maximum or minimum values of a transient pulse and become a transient detector, beside being an a/d.

On full-scale step-function input signals, it achieves 10-bit accuracy within 150 ns.

The input transient is sampled internally at 2 MHz. Output register and display hold the maximum (or minimum) value of the analog input until a higher maximum (or lower minimum) is received at the input. The display is also resettable from the front panel.

Both maximum and minimum digital values are available through rear-panel BNC connectors.

The transient detector and memory options cannot be used at the same time. Either may be used independently with still a third option—a $510 d/a converter—that can also be used by itself.

With the d/a option, the LAB-210 Transiverter becomes a combination a/d and d/a converter. The d/a accuracy is ±1 LSB (output signal vs d/a input).

CIRCLE NO. 272

Scope in 4 versions ranges up to 60 MHz

Tektronix, Inc., Box 500, Beaverton, Ore. Phone: (403) 644-0161. P&A: $1850, $1875, $1900, $1700; May, 1971.

Four new versions of the 453A portable scope are the 453A-1, 453A-2, 453A-3 and 453A-4. Deflection factors and bandwidths are 5 mV/div at 40 MHz, increasing to 50 MHz at 10 mV/div, and 60 MHz at 20 mV/div to 10 V/div. Calibrated sweeps extend from 0.1 μs/div to 0.5 s/div (normal) and 0.1 μs/div to 50 ms/div (delayed).

CIRCLE NO. 273

Dc/rms 3-1/2-digit DVM ranges up to 0.1 GHz

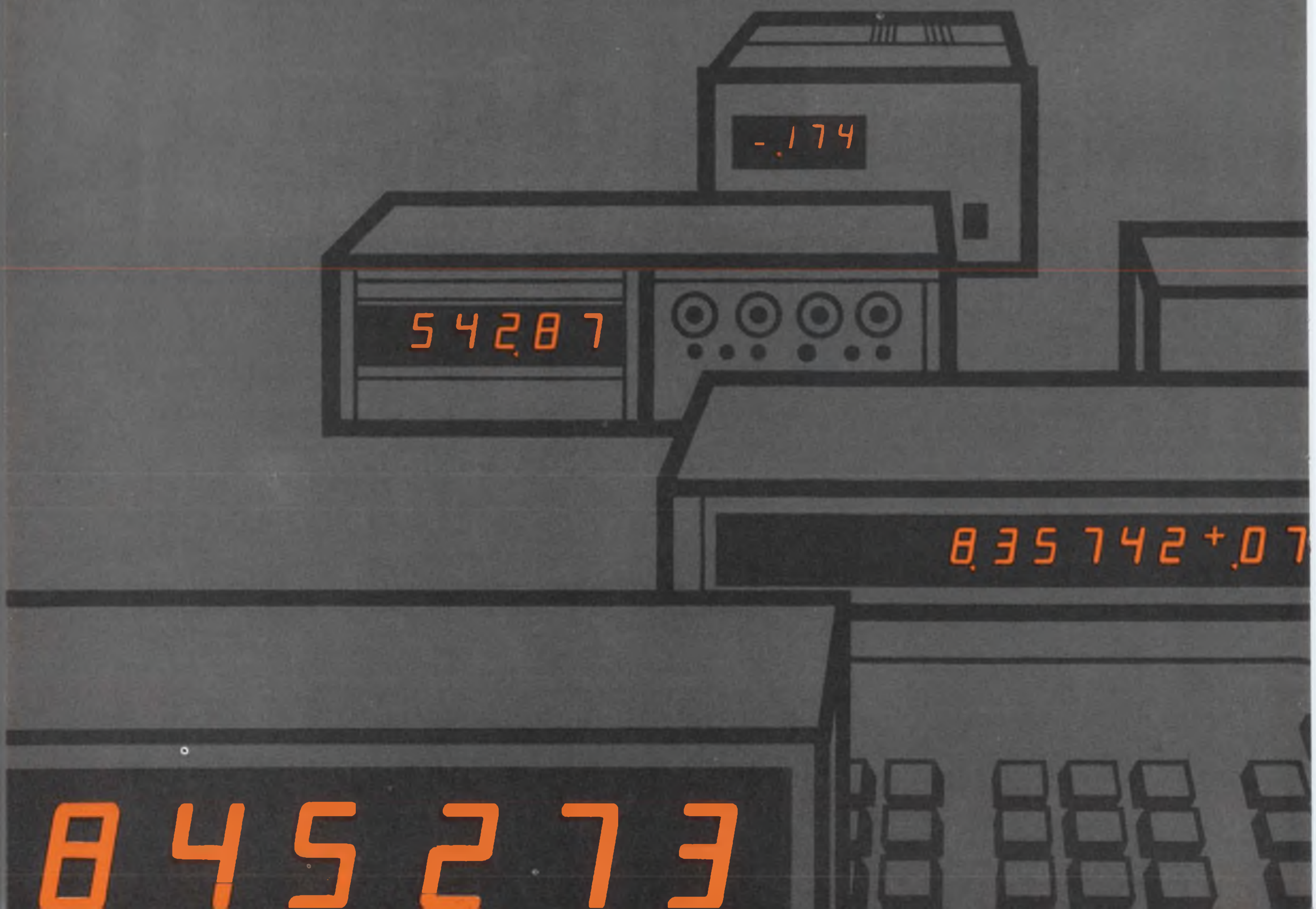
Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 493-1501. P&A: $1400; June, 1971.

A new dc and true-rms digital voltmeter that covers the ac measurement range from 1 Hz to 0.1 GHz is the model 3403A. Using a three-digit LED display and a fourth-digit overrange, the DVM also reads decibels as an option. It measures 10 mV to 1000 V ac full-scale at ±0.2% accuracy. It also reads −60 to +60 dBV with 0.1-dB accuracy, and is 4-1/2 by 7-3/4 by 9-1/2-in.

CIRCLE NO. 274

Announcing new Sperry display devices! At $2.30* per digit--

it's a whole new ball game



For starters, you pay less to get much more value — the result of design and fabrication breakthroughs. New Sperry seven-segment display devices† offer significant advantages over others on the market. High visibility and outstanding performance at a remarkably low cost make them especially suitable for use in calculators and other business machines, test and measurement instruments, process control equipment and many consumer products. Take a look at these major Sperry advantages.

Greater clarity and brightness —
Sperry displays are bright, crisp, and very easy to read. The pleasing orange glow provides excellent character definition and gives the segmented figures the appearance of continuous script. They're highly readable under all lighting conditions — not overpowering in soft light, yet clearly legible in direct sunlight.

Preferred character size and spacing —
Offering a character height of 0.33" with 0.375" centerline spacing, Sperry displays have the appearance of printed figures. Even when they are stacked end-to-end, the uniform spacing is retained. The reduced size permits engineers to save critical housing space without loss of readability.

Wider viewing angle —
Advanced planar design permits Sperry displays to be read accurately within a 150° viewing angle. Characters are housed on a flat plane so all figures are displayed equally bright and clear regardless of combination.

Reduced current requirements —
Sperry devices rank among the lowest. Typical current drain is only 200 μA per segment or 1.4 mA for a figure 8. Power dissipation is just 200 mW. Displays operate on 170 volts DC so they can be used in existing equipment without redesigning the power supply.

Multiplex capability —
A single decoder/driver may be used to multiplex several decades without impairing the appearance of the display. In standard applications, a decoder/driver can be used for each digit.

Proven reliability —
The cold cathode, gas discharge principle utilized in the new Sperry display devices has proven reliable in thousands of applications including a number of cockpit instruments aboard the Boeing 747. Sperry displays have a useful life expectancy in excess of 100,000 hours.

A full line of accessories is available, including connectors, decoder/drivers, and multiplex boards for horizontally stacking and multiplexing.

For complete technical information on the new Sperry display devices, use this publication's reader service card or phone or write:

Sperry Information Displays Division
P.O. Box 3579, Scottsdale, Arizona 85257
Telephone (602) 947-8371

SPERRY
INFORMATION DISPLAYS

in display devices!

The Sperry SP-733 (3-digit model), actual size. Also available are 2 and 1½ (a ± device with a figure 1 and a full 7-segment character) digit models.

*Price is based on 5,000 quantity.
†Patents Pending

SPERRY RAND

26-range compact DVOM has analog readout too

Simpson Electric Co., 5200 W. Kinzie St., Chicago, Ill. Phone: (312) 379-1121. P&A: $395; stock.

The 460 is a DVOM with 26 measurement ranges that combines the advantages of ±0.1% accuracy, multiple-range testing, non-blinking display and front-panel analog-meter readout—all in one instrument. Ranges include 5 for ac and dc volts, 5 for ac and dc currents and 6 for resistance.

CIRCLE NO. 275

Easy-to-use lock-in works 100 dB below noise

Keithley Instruments, Inc., 2877 Aurora Rd., Cleveland, Ohio. Phone: (216) 248-0400. Price: $1895.

A new and easy-to-use lock-in amplifier, called the model 850 Autoloc, features recovery of signals up to 100 dB below noise level. It operates from 1 Hz to 50 kHz without any frequency adjustment. Three controls—phase, sensitivity, and output time constant are all that are used.

CIRCLE NO. 276

50-MHz counter resolves to 9 digits

Wayne Kerr Co., Ltd., Roebuck Rd., Chessington, Surrey, England.

A new six-digit 50-MHz counter provides nine-digit measurement resolution. Known as the FC50, it can directly measure frequency, period, time or counts, and automatically locate the decimal point. Period and elapsed-time measurements are from 1 μs to 10^5 s. Counting covers pulses of any duration and of any rate up to 50 million/s. The instrument accepts 20 mV to 100 V rms.

CIRCLE NO. 277

Portable IC tester checks most DIPs

Kurz-Kasch, Inc., 1421 S. Broadway, Dayton, Ohio. Phone: (513) 223-8161. P&A: $169.50; stock.

Model IC-590 is a portable battery-operated IC tester for static and dynamic testing of all 14 and 16-pin DTL/TTL ICs of the 5 and 15-V families. Flatpack and TO-5 modules may also be tested by adapters. A built-in clock provides 2-Hz and 15-kHz test ratings. All input and output conditions are displayed by two lamp indicators for logic levels 0 and 1.

CIRCLE NO. 278

Voltmeter/calibrator is 0.002% stable

Electronic Development Corp., 11 Hamlin St., Boston, Mass. Phone: (617) 268-9696. P&A: $1350; stock.

A new diff voltmeter/calibrator, model 2901, features voltage accuracy and stability of 0.002% for calibrator and voltmeter modes. Calibrator output is selectable from ±100 nV to ±100 V at up to 100 mA. The voltmeter has 8 ranges from 100 μV to 1000 V.

CIRCLE NO. 279

160-MHz synthesizer resolves down to 1 Hz

General Radio, 300 Baker Ave., Concord, Mass. Phone: (617) 369-4400. Price: $5800 (slave), $6400 (master).

The new 1168 frequency synthesizer offers 1×10^{-9}/day stability and 1-Hz-incremented resolution from 10 kHz to 160 MHz. The output can be externally phase modulated at ±3 radians to 300 kHz or ±1 radian at 1 MHz.

CIRCLE NO. 280

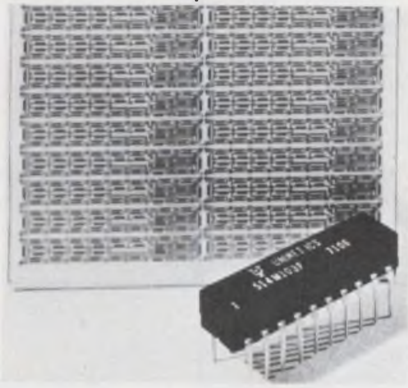
Computer-grade switch has dual legends

Compu-Lite Corp., 17795 Sky Park Circle, Irvine, Calif. Phone: (714) 546-9045. P&A: $2.70 to $4.48; stock to 2 wks.

A new computer-grade illuminated pushbutton switch with a 5/8-in. square lens cap features a functional split legend. Designated the model 28, the snap-lock-installation switch offers momentary or alternate actions with hard gold contacts rated from low level to 10 A resistive at 117 V ac. The switch uses two T-1-3/4 lamps.

CIRCLE NO. 281

Thin-film DIP ladders start from $4.50

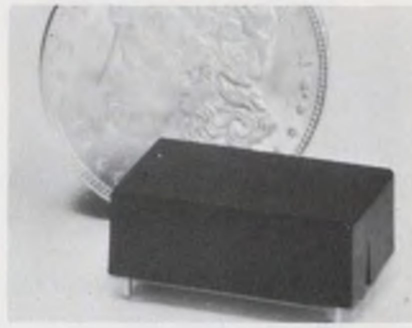


Uninetics, Inc., 3150 Pullman St., Costa Mesa, Calif. Phone: (714) 540-5935. P&A: see text.

DIP 8, 10, 12 and 14-bit R-2R thin-film resistor ladder networks are available, off-the-shelf, at the following low costs (100 to 249-lot prices): 8-bit $4.50; 10-bit, $10.15; 12-bit, $14.65; and 14-bit, $33.80. All four networks track under 1 ppm/°C. Transfer linearities range from 0.5% to 0.005%. Characteristic resistance of all networks is 1% standard at −55 to 125°C.

CIRCLE NO. 282

Low-profile relays switch 5 A at 26 V



American Zettler, 697 Randolph Ave., Costa Mesa, Calif. Phone: (714) 540-4190. P&A: $1.81 (1000-unit lots); stock.

The Thinpak series of miniature relays measures only 0.435-in. high and is capable of switching 5 A at 26 V dc. The Thinpak model 535 is designed for 0.6-in. center-to-center PC card mounting. High-pressure spdt contacts enable the unit to switch capacitance or lamp loads with high current spikes. The relay is available in coil voltages from 6 to 115 V dc with an operate and release time of 4 ms.

CIRCLE NO. 283

Resistors for hybrids come in rod form

Mepco, Inc., Columbia, Rd., Morristown, N. J. Phone: (201) 534-2000.

Thick and thin-film rod resistors are available for use in place of chip resistors on hybrid substrates. They offer advantages of reliability due to no chip and wire attachments, small size and simple handling. Values are presently available up to 20 MΩ.

CIRCLE NO. 284

Optic-coupled isolator operates from 115 V ac

Solar Systems, Inc., 8124 Central Park, Skokie, Ill. Phone: (312) 676-2040. Price: $4 (100-lot quantities).

A new optically coupled isolator, the SSC-600, includes a neon bulb, dropping resistor and silicon photocell to operate directly from 115 V ac. Output current is 200 μA and input-to-output isolation is 1000 V min.

CIRCLE NO. 285

5 to 20-MHz thermistors cut capacitance to 1 pF

Cal-R, Inc., Thermonetics Div., 1601 Olympic Blvd., Santa Monica, Calif. Phone: (213) 451-9761. P&A: 10¢ to $2; 1 to 3 wks.

Thermistors having capacitance values less than 1 pF from 5 to 20 MHz are available. Lo Cap chip thermistors are available from 100 Ω to 150 kΩ at 25°C at a standard tolerance of ±10%.

CIRCLE NO. 286

One-piece indicators use 0.375-in. lenses

The Ucinite Co., United-Carr Div. of TRW, Inc., 459 Watertown St., Newtonville, Mass. Phone: (617) 524-8400.

A new line of space-saving one-piece indicator lights feature a lens dia of 0.375 in. and snap-in mounting for use in narrow areas. New Dotlites may be mounted without clips or tools in 0.312-in. holes in panels with thicknesses from 0.03 to 0.062 in.

CIRCLE NO. 287

Multi-component DIPs increase flexibility

Corning Glass Works, Electronic Products Div., Corning, N. Y. Phone: (607) 962-4444. P&A: see text.

A new line of resistor, capacitor and diode network combinations in dual in-line packages, known as Cordips, offer economy and flexibility over discrete components.

Complex interconnections within Cordip packages enable the design of smaller, less complex circuit boards with greater component densities.

Depending on the circuit complexity, Cordip networks provide up to 16 components in molded 14-pin packages and up to 20 components in 16-pin cases.

Combinations of components with different tolerances, temperature coefficients and ratings are possible in one package.

Resistance ratios of greater than 15,000 to 1, in values of 10 Ω to 150,000 Ω, are available.

Tolerances available are 1, 2, 5 and 10% and temperature coefficients can be 50, 100 and 150 ppm/°C over the temperature range of −55 to +165°C.

The capacitance range is 10 to 10,000 pF, with 50-V ratings at temperature stabilities better than ±15% over an operating temperature range of −55 to +125°C.

By connecting resistors in series and capacitors in parallel these ranges and ratios can be increased.

Typical prices of Cordip units are 83¢ for a 14-pin DIP containing thirteen 5% resistors. A 14-pin DIP with nine 5% resistors and two 10% capacitors costs $1.80.

All prices are for 1000-piece quantities. Availability ranges from 8 to 12 weeks.

CIRCLE NO. 288

12-A silicon diodes cost down to 40¢

Sarkes Tarzian, Inc., 415 North College Ave., Bloomington, Ind. Phone: (812) 332-1435. P&A: see text, 10 to 14 days.

A new family of 12-A encapsulated silicon diodes range in price from 40¢ each (50 PIV) to 60¢ each (1000 PIV) for 10,000-unit quantities. Designated the 6QD series, the rectifiers are available in seven PIV ratings from 50 to 1000 V.

CIRCLE NO. 289

Dipped mica capacitors feature small sizes

Electro Motive Mfg. Co., Inc., Willimantic, Conn. Phone: (203) 423-9231.

A new line of El-Menco transmitting dipped mica capacitors ranging from 47 pF to 0.1 μF feature small sizes from 2.01 by 0.85 by 0.22 in. up to 2.07 by 0.91 by 0.44 in. Type TDM43 capacitors include peak working-volt ratings from 1500 down to 250 V.

CIRCLE NO. 290

PC board fixture simplifies assemblies

Zeva Electric Corp., 3 Great Meadow, Hanover, N. J. Phone: (201) 887-1399. P&A: $296; stock.

A low-cost manual PC board assembly fixture saves up to 30% assembly time and makes cutting, bending or crimping of component leads easier. Called the BG 1, the unit is basically a PC board holding frame with adjustable crossbars and a lid with rubber cushion to hold down components. It holds up to a 20-1/2 by 12-1/2-in. board or a multitude of smaller boards.

CIRCLE NO. 291

Rack/panel connector has stable contacts

Malco Manufacturing Co., Inc., 5150 W. Roosevelt Rd., Chicago, Ill. Phone: (312) 287-6700.

A new miniature rack-and-panel cable connector and housing assembly, Mini-Rack, features a spring-clip male-blade crimp contact for good stability. This hand or automatically crimped male blade uses precision spring clips that lock contacts into place.

CIRCLE NO. 292

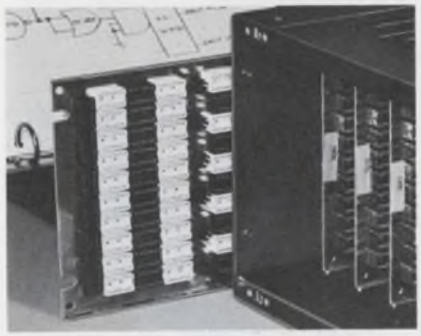
Connectors use blade/spring contacts

Amphenol Industrial Div., 1830 S. 54 Ave., Chicago, Ill. Phone: (312) 242-1000.

A complete line of single and multi-row connectors — featuring blade and spring contacts for firm, positive and low electrical resistance connections — are available. The 115 series rack-and-panel connectors use a flat blade male contact that enters multiple rows of C-shaped female spring gripping fingers.

CIRCLE NO. 293

Computerized system speeds packaging



Interdyne, 2217 Purdue Ave., Los Angeles, Calif. Phone: (213) 477-6051.

A new "automated direct-entry packaging technique" known as the ADEPT program provides computerized circuit mechanization and packaging of steel or fiberglass wire-wrapped chassis. Supplied with basic equations or logic diagrams, the program computerizes the design, producing system reports, loading analysis, logic allocations, component placement, and wire lists.

CIRCLE NO. 294

Tool for coax cable strips cables handily

The Deutsch Co., Electronic Components Div., Municipal Airport, Banning, Calif. Phone: (714) 849-6701. Availability: stock.

A new stripping tool for single and double-braid coaxial cables makes clean square shouldered cuts. The tool accommodates cables with outside dia from 0.175 to 0.216 in., and when fitted with special bushings will accept cables as small as 0.075 in.

CIRCLE NO. 295

Point-to-point control works closed loops

Tektronix, Inc., Box 500, Beaverton, Ore. Phone: (503) 644-0161.

The 1711 is a point-to-point numerical positioning control featuring closed-loop operation and automatic backlash take-up. Resolution is 0.0001 in. and maximum slide departure is 99.9999 in. in each axis. Positioning rate is 400 in./min standard (1000 optional).

CIRCLE NO. 296

3-1/2-digit readout costs only $149

Digilin, Inc., 1007 Air Way, Glendale, Calif. Phone: (213) 240-1200. Price: see text.

A new 3-1/2-digit readout is priced at $149. Where the readout is separated from the process being measured, the new 2320 remote display combined with a 2330 DPM can reportedly replace a current transmitter and analog display on a price competitive basis.

CIRCLE NO. 297

One-in.^{3} power control handles 360-W loads

Vesta Corp., 13 La Rocca Center, Horsham, Pa. Phone: (215) 343-3434.

Nicknamed the "ice cube" by its designers, a new solid-state power control can handle inductive and resistive loads up to 360 W, yet is housed in tiny 1-in.^{3} plastic case. It operates at 120 and 240 V in 60 and 400-Hz versions.

CIRCLE NO. 298

Display-tube supply has 5 and 200-V outputs

Instrument Displays, Inc., 223 Crescent St., Waltham, Mass. Phone: (617) 894-1577. Price: $60.

New model PS2B dual-voltage power supply, designed exclusively for cold-cathode display tubes, provides both 200 V at 50 mA and 5 V at 1 A in a compact package warranted for 1 year. The 200 V are unregulated while the 5 V are regulated.

CIRCLE NO. 299

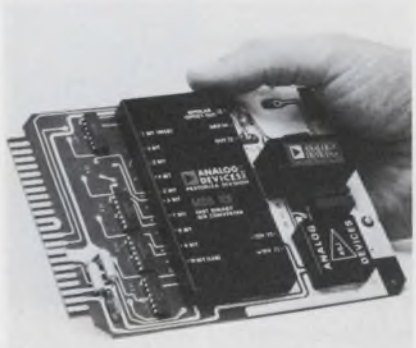
Frequency converter gives dc output volts

Techniques Electroniques & Nucleaires, 142 Ave. de la Republiques, 91 Montgeron, France.

The CM-FT is a frequency-to-voltage converter which provides a positive dc output voltage proportional to sinusoidal, trapezoidal or rectangular input signals. Its frequency range covers 1 Hz to 100 kHz. The output voltage goes from 0 to 10 V.

CIRCLE NO. 300

Fast-settling 10-bit d/a reduces glitch to 50 mV

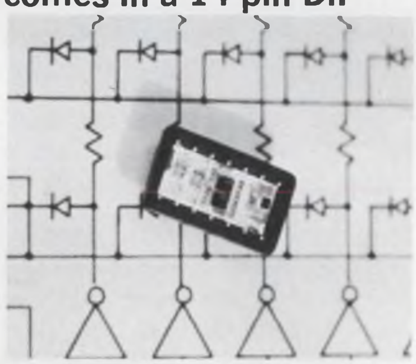


Analog Devices, Inc., Route 1 Industrial Park, Norwood, Mass. Phone: (617) 429-4700. P&A: $700; 2 wks.

A new d/a 10-bit converter system designed specifically for CRT graphics displays, features 500-ns full-scale settling to ±1/2 LSB, 50-mV max glitch and ±1/2 LSB linearity. Model DAC-10D operates over 0 to 70°C. Its input register handles binary or 2's complement TTL or DTL commands. Output is ±2.5 or ±5 V at 20 mA. Size is 4-1/2 by 6 by 0.75 in.

CIRCLE NO. 301

6-bit d/a converter comes in a 14-pin DIP



Micro Networks Corp., 5 Barbara Lane, Worcester, Mass. Phone: (617) 756-4635. P&A: $29; stock.

Model MN301 current-summing 6-bit d/a converter comes in a 14-pin DIP complete with monolithic switches, thin-film ladder network, internal reference and op amp output. It has output voltages of either 0 to −9.884 V or +5 to −4.884 V. Accuracy is 1/2 bit over operating temperature range of 0 to +70°C, slew rate is 0.5 V/μs, settling time is 3 μs and power consumption is 300 mW.

CIRCLE NO. 302

Wideband tiny VCOs work up to 400 kHz

Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. Phone: (213) 894-2271. P&A: $295; 2 wks.

The series V-512 voltage-controlled oscillators (VCOs) convert varying analog voltages and predetection signals, over dc to 400 kHz, to linearly proportional sine waves. Standard units are available with center frequencies from 1.688 to 900 kHz.

CIRCLE NO. 303

Low-cost FET op amp drops bias to 10 pA

GPS Corp., 14 Burr St., Framingham, Mass. Phone: (617) 875-0607. P&A: $25; stock.

The 8501 is a new low-cost low-profile (0.275-in. high) FET-input hybrid op amp with low bias current of ±10 pA. Its input impedance is $10^{11}\Omega$ and its slew rate is 7 V/μs.

CIRCLE NO. 304

2 to 15-kV supplies start from $45

Chicago Condensor Corp., 3255 W. Armitage Ave., Chicago, Ill. Phone: (312) CA7-7070. P&A: from $45; stock.

HVN high-voltage power supplies feature four models at 2, 5, 10 and 15 kV and 5 mA dc starting from $45. Line and load regulation are 5 and 20%, respectively. Ripple is 2%. Units are oil impregnated and outputs are floated.

CIRCLE NO. 305

Three-phase controllers handle 10-hp motors

Hamlin Electronics, Inc., 3066 W. Clarendon Ave., Phoenix, Ariz. Phone: (602) 277-4834. Price: $41.70, $62.70, $71.70.

Three new solid-state controllers, models 623, 645 and 646, handle 3-phase power for 2, 5 and 10-hp motors. Voltage ratings for all three controllers are 208/240 and 480 V. Current ratings are 7, 17.5 and 30 A, respectively.

CIRCLE NO. 306

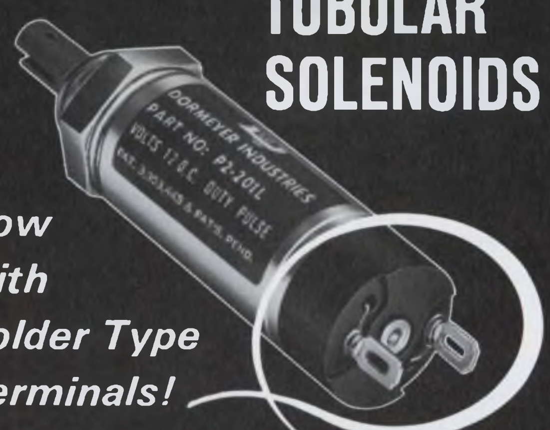
The gaussmeter comes to the production line.

If any of the products you make include permanent magnets, you could use a Bell gaussmeter. It's the best quality control check you can use. And in addition to testing, we can even help with production. We have a complete line of magnetizers, sorters, stabilizers, and demagnetizers.
Write for our detailed brochure to:
4949 Freeway Drive East,
Columbus, Ohio 43229.
F.W. Bell Inc. A member company of Allegheny Ludlum Industries.

INFORMATION RETRIEVAL NUMBER 62

Easier To Hook Up!

DORMEYER *PULL TYPE* TUBULAR SOLENOIDS



Now with Solder Type Terminals!

They're still available with leads, too!

Write for complete specs!

DORMEYER INDUSTRIES, Inc.
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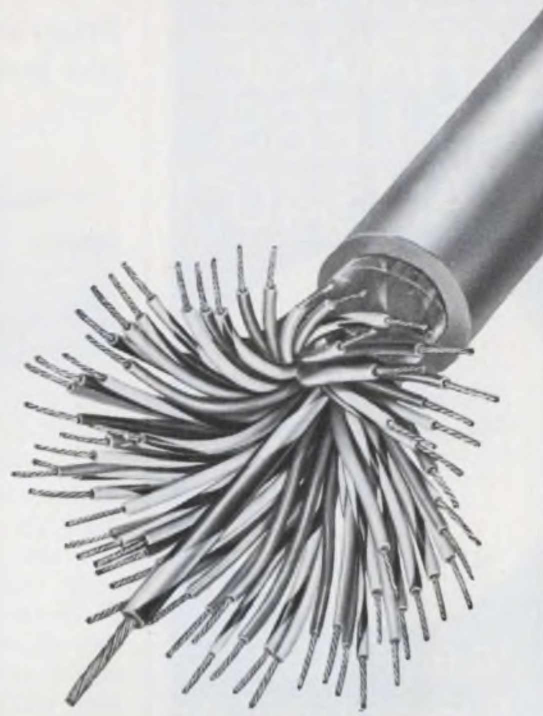
DORMEYER Dependability

INFORMATION RETRIEVAL NUMBER 63



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will make it.

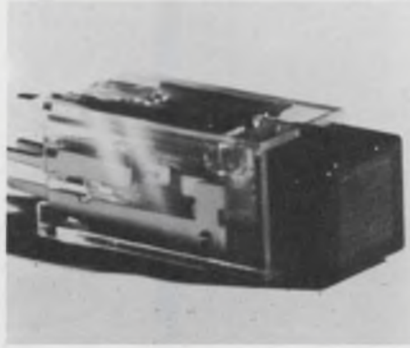
Get exactly what you need in multi-conductor cable. We'll design and produce multi-conductor cable to meet just about any individual requirement.

We have the plant, the equipment, the personnel and the know-how to solve your particular problem.

Victor
Electric Wire & Cable Corp.
WEST WARWICK, RHODE ISLAND

INFORMATION RETRIEVAL NUMBER 64

Programming modules use pushbutton switches



Interswitch, 770 Airport Blvd., Burlingame, Calif. Phone: (415) 347-8217.

A new series of data-programming modules feature integral pushbutton switches. Four models are offered as standard arrangements: spdt, dpdt, 4pst, and a 4pdt unit with four series diodes and a common input line. All are available in momentary-contact and alternating-ON-OFF versions, and can be provided with lamps that light in the ON position.

CIRCLE NO. 307

Modular power supplies mount in many styles

Mid-Eastern Industries, 660 Jerusalem Rd., Scotch Plains, N. J. Phone: (201) 233-5900. P&A: from $129; stock.

The new MIC series of modular power supplies are available with outputs from 3 to 200 V at 10 to 1 A and with panels of three styles: quarter, half and full-rack sizes without panels. The racks hold up to eight modules. Each supply is line and load regulated to 0.02%. Remote sensing, parallel or series operation and overload protection are standard.

CIRCLE NO. 308

SCR static inverter belts out 200 W 60 Hz

Knud Lindberg A/S, 200 Islevdalvej, DK-2610 Roedovre, Denmark.

Type MP6 SCR static inverter supplies 200 W of rfi-silent 60-Hz power for use in mobile and maritime electronics. It includes a clock generator producing a clock frequency with high accuracy, and a transformer that combines step-up transformation, output-voltage stabilization and filtering for sine-wave outputs.

CIRCLE NO. 309

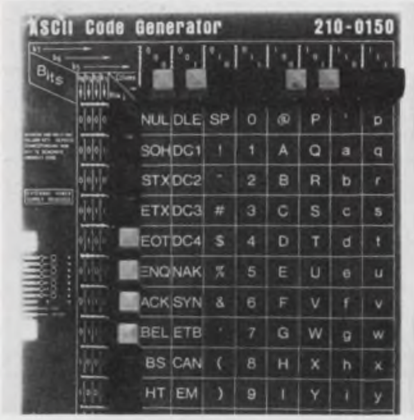
Digital counters complement encoders

Baldwin Electronics, Inc., 1101 McAlmont St., Little Rock, Ark. Phone: (501) 375-7351. P&A: from $520; 45 days.

The BC60 series bidirectional digital counters are general-purpose accumulators designed for usage with Baldwin 5V series incremental encoders. They have accumulations of six digits, either in positive or negative direction.

CIRCLE NO. 310

$98 code board generates ASCII

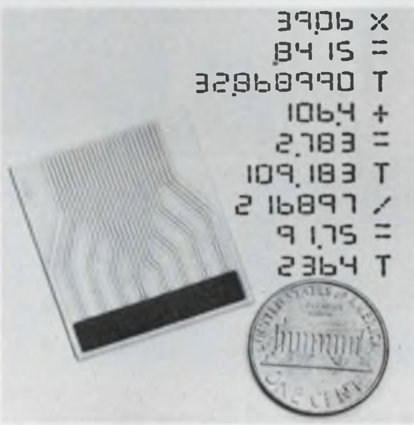


Mechanical Enterprises, Inc., 5249 Duke St., Alexandria, Va. Phone: (703) 751-3030. P&A: $98; stock.

The new low-priced Mercutronic ASCII code generator board costing only $98 generates all 128 characters of the 7-bit ASCII code. It is wired for positive logic with a bounce-free TTL-compatible output and displays bit levels by LEDs.

CIRLLE NO. 321

Thermal print head interfaces MOS ICs

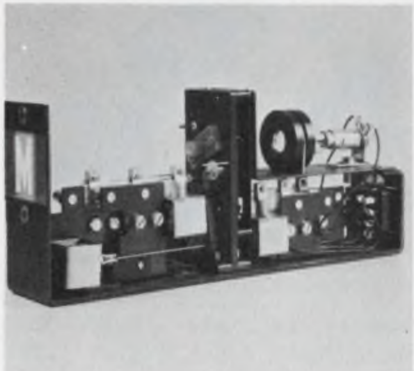


Displaytek Corp., 4241 Sigma Rd., Dallas, Tex. Phone: (214) 239-9193. P&A: $3 to $5 per character; midyear, 1971.

A new stationary thermal print head is capable of directly interfacing with MOS circuitry. The DC 4180 features a multi-character print head with a seven-bar floating decimal point. The seven-bar segment can recreate all digits 0 through 9 on thermally sensitive paper. Models include 8, 12 and 16-character readouts.

CIRCLE NO. 322

Visual readout is self-decoding



Major Data Corp., 891 W. 18th St., Costa Mesa, Calif. Phone: (714) 548-7898. Price: $100.

The Major-64 is a self-decoding visual readout device for computer peripherals and digital displays. It directly accepts any four, five or six-line binary codes and selects and projects any one of 64 1-in.-high images on an integral screen. All images are on one high-stability film. Each area may contain any alphanumeric symbol, reducible line drawing, screened photograph, text material or combinations of these images.

CIRCLE NO. 323

Electronic keyboard is a teletypewriter

Controls Research Corp., 2100 S. Fairview, Santa Ana, Calif. Phone: (714) 557-7161. Price: $245.

A new electronic keyboard for the communications market is available. The model TTY37 is designed for teletypewriter replacement in interactive computer printing and display terminals. Features include n-key rollover and a multiple interlock system that duplicates an electric typewriter and produces coded key outputs sequentially in the same order as key depressions.

CIRCLE NO. 324

30-MHz ssb transistor delivers 75 W PEP

RCA Solid State Div., Route 202, Somerville, N. J. Phone: (201) 485-3900. P&A: $55 (100-unit lots); stock.

A new linear power transistor for hf ssb equipment is available to deliver 75 W PEP at 30 MHz with IMD below −30 dB, 13 dB gain and 40% efficiency. The 2N6093 operates from 28 V.

CIRCLE NO. 340

Rugged 15-mW laser tubes cost from $65

C. W. Radiation, Inc., 111 Ortega, Mountain View, Calif. Phone: (415) 969-9482. P&A: see text; 10 days.

Unique one-piece construction of the cold aluminum cathode assembly makes a new family of He-Ne laser tubes with 15-mW outputs reliable and inexpensive (from $65). They have 5000 h. life.

CIRCLE NO. 341

2.2 to 2.3-GHz amps gain from 15 to 38 dB

Avantek, Inc., 2981 Copper Rd., Santa Clara, Calif. Phone: (408) 739-6170. P&A: from $800; 30 days.

The new AMT-2300M series thin-film transistor amplifiers offer four gain options ranging from 15 to 38 dB over the 2200 to 2300-MHz frequency band. Gain flatness is 0.5 dB, noise figure is 5.5 dB and VSWR is 2.0. Power output for 1-dB gain compression is a minimum +6 to +10 dBm. The thin-film circuitry is deposited on sapphire substrates.

CIRCLE NO. 342

P-i-n photodetectors size up to 10-in. long

Solid State Radiation, Inc., 2261 S. Carmelina Ave., Los Angeles, Calif. Phone: (213) 478-0557.

Ten-in.-long photodetectors are available, using double-diffused silicon p-i-n structures. They include continuous sensing surfaces of 2, 4, 6, 8 and 10 in. Spectral response is from 0.3 to 1.1 microns.

CIRCLE NO. 343

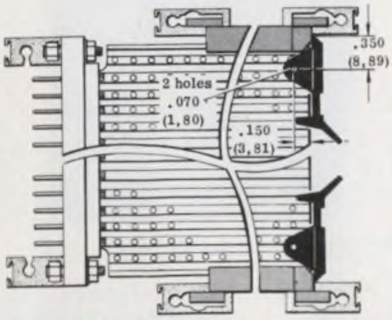
Low-distortion 0.4-GHz mixer costs $50

Mini-Circuits Laboratory, 2913 Quentin Rd., Brooklyn, N. Y. Phone: (212) 252-5252. Price: see text.

A new ultra-low-distortion (−70 dB) double-balanced mixer, the RLK-7, is available for dc to 400-MHz operation at a cost of only $50. With only 1 dB of compression at +15 dBm levels, its typical noise figure is 7.0 dB. Local-oscillator isolation is 50 dB.

CIRCLE NO. 344

evaluation samples



PC card ejectors

Simple new PC card ejector devices known as Card Ejectors provide a mechanical means of extracting PC cards when using card frames incorporating modular type connectors with a large number of contacts. These Card Ejectors are assembled onto drilled corner holes on circuit boards with spring pins that are supplied. To remove a circuit card, simply pull the Card Ejectors forward. Two prongs on the back of each Card Ejector clip either side of the circuit board, preventing any kind of unwanted free movement. Card Ejectors are molded in black Noryl and suit 1/16-in.-thick boards. Samples are available. Vero Electronics, Inc.

CIRCLE NO. 345

Keyboard buttons

Free samples are available of doubleshot molded keyboard buttons. They come in stock and custom versions. Stock units are of accent-gray color and use white inscriptions for alphabets and numerals. The inscriptions are in Gothic type. Custom buttons are available with special sizes and shapes. Some stock buttons are also available in white, blue, charcoal and red colors, for the bodies or inscriptions. Mechanical Enterprises, Inc.

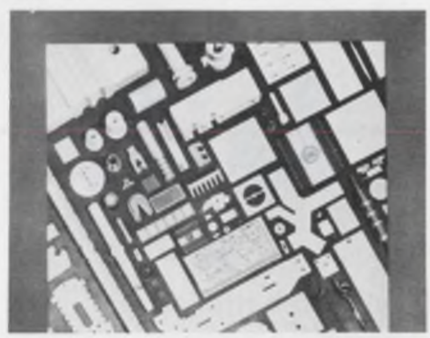
CIRCLE NO. 346

design aids

Printed circuit design

"Printed Circuit Design and Drafting" is a self-teaching book which leads the reader from "What is a printed circuit board?" to a 23rd chapter entitled "Preparation, Dimensioning, Hole Identification and Notes." In between, in carefully sequenced form, is information for properly designing and drafting printed circuit boards. Excellent illustrations, figures, tables and charts are carried on left-hand pages to supplement information on right-hand pages. Every step is covered from idea conception through artwork, photography, etching and plating. The book is a valuable reference costing $15. TAD Products Corp.

CIRCLE NO. 347



Technical ceramics chart

A most comprehensive data chart on technical ceramics that can be helpful to any design engineer is available. The chart lists in detail the mechanical and electrical properties of several ceramic materials. These include steatite, fosterite, cordierite, alumina, beryllia, titania, titanate, zircon and machinable, crushable and leachable ceramics. American Lava Corp.

CIRCLE NO. 348

application notes

Programming techniques

Twelve classes of programming applications designed to optimize the man/machine interface are described in a new 16-page applications bulletin. "Programming Techniques and Circuits for Electronic Controls, Instruments and Systems" begins with brief definitions and discussions of programming fundamentals. Five basic kinds of programming—function selection, value setting, mode determination, formatting and distribution, plus six basic types of hardware—switches, matrices, data modules, tapes, cards, and electronic memories are described. Interswitch.

CIRCLE NO. 349

LEDs and photometry

A four-page application note is available on light-emitting diodes and photometry. The paper discusses fundamentals of photometry measurement criteria and the factors which must be considered in the application of LEDs. It is intended for the electronic engineer who is starting to apply LEDs and other optoelectronic devices, but finds the subject of photometry to be a confused mass of strange units, confusing names for photometric quantities and general disagreement as to what the important requirements are for his application. Litronix, Inc.

CIRCLE NO. 350

Transistor thermal rating

A four-page application note describes a new rating system that enables circuit designers to avoid thermal-fatigue failures in silicon power transistors during equipment operating life. It describes a rating chart that indicates the expected life of a silicon power transistor, in number of thermal cycles, as a function of power dissipation and case-temperature change. RCA Solid State Div.

CIRCLE NO. 351

Bias distortion

Measurement of bias distortion in asynchronous modems and communication systems is the subject of a two-page technical bulletin that provides an introduction to bias distortion terminology and measurement. Causes of bias distortion are discussed and typical signals and measurement circuitry are illustrated. International Data Sciences, Inc.

CIRCLE NO. 352

Digitizing shaft data

An eight-page technical article entitled "Acquisition of Shaft Angle Data" reviews the advantages and disadvantages of the three main transducer types. These are used for reading out mechanical position in terms of electrical signals, with the ultimate purpose of providing digital position data for computers and other digital systems. The three transducer families discussed are digital shaft angle encoders, resolvers and synchros and precision-type potentiometers. North Atlantic Industries, Inc.

CIRCLE NO. 353

Process and control systems

A 58-page book of basic information on control loops, primary measuring elements, pneumatic and electronic controllers and recorders and control valves is available. Divided into three sections, the booklet contains basic definitions and describes the closed-control loop. It also describes the function of basic controller parts and outlines the principle of internal feedback in a controller. A short illustrated analysis of common mechanical and pneumatic instruments, in addition to representative types of control valves, are also given. The Foxboro Co.

CIRCLE NO. 354

new literature

Thick-film technology

"The Fundamentals of Thick Film Hybrid Technology," a basic text used in State of the Art, Inc.'s thick-film seminars, is now available to those unable to attend the seminars. The text consists of approximately 300 looseleaf pages detailing thick-film hybrid technology from its historical developments to the final circuit design. Two purchase options are available: one is a flat fee of $90 and the other is a totally refundable fee of $180, creditable against the firm's tuition charges for the five-day thick-film seminar. The purchase price includes quarterly updating supplements for a period of one year after purchase. State of the Art, Inc.

CIRCLE NO. 355

Se photovoltaic cells

Selenium photovoltaic cells—broad-area detectors of light in the near-ultra-violet and visible range—are described in a brochure. In addition to cell outlines and output current diagrams, a general discussion follows for selenium cell construction, terminal characteristics and amplifier considerations. Vactec, Inc.

CIRCLE NO. 356

Circular connectors

An extensive offering of standard circular connectors for both military and commercial applications is detailed in a new 56-page catalog. The publication contains a glossary of terms, photographs, line drawings, electrical characteristics and mechanical specifications for all circular connectors. Amphenol Connector Division.

CIRCLE NO. 357

Keyboard price list

To help the designers of terminals, calculators and other key-entry devices, an illustrated keyboard price list with 22 stock keyboard configurations is available. Mechanical Enterprises, Inc.

CIRCLE NO. 358

Instrument rental

A folder is available with descriptions of the new Tektronix rental program and lease and purchase plans. Products shown for rental are maintained in Tektronix service centers throughout the U. S. Tektronix, Inc.

CIRCLE NO. 359

Switches

Everything you need to know for specifying and ordering precision electrical switches is included in a new catalog. Included is a switch selector-locator that simplifies selection of any of 24 different snap-action switch types listed in order of electrical rating. The catalog also covers new leverwheel/thumbwheel switches and matrix selector switches. Cherry Electrical Products Corp.

CIRCLE NO. 360

Pomona catalog

The 20th anniversary edition of Pomona Electronics general catalog has just been released. This 1971 catalog of electronic test accessories has been expanded to 60 pages, and now contains more than 450 individual products, including 47 new items. Pomona Electronics.

CIRCLE NO. 361

GaAsp LEDs

Details for GaAsP LEDs are available in a new bulletin. Dialight Corp.

CIRCLE NO. 362

Photoelectric controls

A new 36-page catalog includes photoelectric controls and application sketches. Autotron Inc.

CIRCLE NO. 363

Optoelectronic devices

A new six-page bulletin describes a complete line of optoelectronic devices. These include sources, sensors and optically coupled devices. Texas Instruments, Inc.

CIRCLE NO. 364

Electric counters

Technical literature is available for high-speed electric resettable mechanical predetermining counters. Counters shown have speeds to 6000 counts/min and torques of 4 oz-in. Veeder-Root.

CIRCLE NO. 365

Analog gate chart

An analog gate selection chart, which serves as a design aid for determining an appropriate gate for analog application, is available. Teledyne Semiconductor.

CIRCLE NO. 366

Op amp reference file

For an easy look at a state-of-the-art line of fast-settling and general-purpose op amps, a handy four-page condensed reference file is available. Dynamic Measurements Corp.

CIRCLE NO. 367

Diode chips

A seven-page brochure lists semiconductor diode chips for hybrid circuits such as hot-carrier, p-i-n, and step-recovery diodes. Hewlett-Packard.

CIRCLE NO. 368

Wire and cable

A comprehensive compilation of wire and cable information is contained in a 110-page catalog. Standard Wire and Cable Co.

CIRCLE NO. 369

Optical shaft encoders

A new four-page general catalog contains data on optical shaft angle encoders. Sequential Information Systems, Inc.

CIRCLE NO. 370

Optical encoders

Optical encoders, linear measuring systems, counters and displays are all shown in a colorful comprehensive eight-page general catalog and specifier's guide. Itek Corp., Wayne-George Div.

CIRCLE NO. 371

Cermet potentiometers

A series of 2-W industrial and military cermet potentiometers are described in a new catalog. CTS of Berne, Inc.

CIRCLE NO. 372

Stepping switches

A new 32-page catalog contains data on remote stepping switches. It is divided into three sections: engineering considerations, detailed product specifications and a building-block guide for specifying. Ledex, Inc.

CIRCLE NO. 373

Drafting equipment

A new catalog describes a complete line of precision drafting equipment for industrial, professional and educational drafting rooms. Vemco.

CIRCLE NO. 374

16-bit d/a

A six-page foldout data sheet describes a 16-bit d/a converter. Analog Devices, Inc.

CIRCLE NO. 375

Data coupler

A new data coupler is spotlighted in a four-page bulletin. The instrument directly converts a digital BCD input of up to 16 bits to a tabulated data output, or a punched paper-tape output, or both. Beckman Instruments, Inc.

CIRCLE NO. 376

SCRs/rectifiers

A new design engineering-oriented catalog and cross reference provides comprehensive information on SCR and rectifier assemblies for power rectification and control applications. Westinghouse.

CIRCLE NO. 377

Lasers

A brochure on pulsed solid-state lasers explains design and specifications for 44 laser models. Holobeam, Inc.

CIRCLE NO. 378

Aluminum extrusions

One-stop aluminum extrusion service, from rough sketches to simple shapes or complex finished parts, is described in a new publication entitled "Total Extrusion Capability." The 29-page four-color booklet recommends the proper extrusion process by describing its versatility and economy. Alcoa.

CIRCLE NO. 379

Line-voltage regulators

A new four-page brochure describes a series of line-voltage regulators for computers. Sola Electric.

CIRCLE NO. 380

Temperature controls

A new 20-page catalog shows a complete and expanded line of temperature controls. Briscoe Mfg. Co.

CIRCLE NO. 381

Programming devices

A 12-page quick-reference catalog describes five lines of programming devices. Electromechanical in design, the devices provide low-cost dependable programming and direct control of processes without intermediate circuitry. Sealectro Corp.

CIRCLE NO. 382

Indicator/switches

Panel switches and panel indicator lights are described in a new eight-page catalog. Raytheon Co.

CIRCLE NO. 383

Chip capacitors

An expanded line of monolithic ceramic chip capacitors is covered in an eight-page brochure. It lists all critical parameters on the most commonly used commercial sizes, as well as six new styles listed under MIL-C-55681. San Fernando Electric.

CIRCLE NO. 384

bulletin board

of product news and development

Motorola Semiconductor is slated to immediately introduce 8 **new CMOS ICs with another 17 to be introduced during the remainder of 1971.** The 8 ICs are: MC14001 quad 2 NOR gate, MC14002 dual 4 NOR gate, MC14011 quad 2 NAND gate, MC14012 dual 4 NAND gate, MC14013 dual D flip-flop. MC14015 dual 4-bit shift register, MC14507 quad exclusive OR gate and MCM14505 fully decoded 64-bit read/write memory.

CIRCLE NO. 385

Twenty-six low-power and 12 medium-power **MOS p-channel static logic cell designs** have been added to Motorola Semiconductor's library of Polycells—computer-stored building blocks for designing MOS LSI circuitry

CIRCLE NO. 386

Teledyne Semiconductor has announced it is **second-sourcing 76 FETs** in the following families: low-R_{ON} devices, general-purpose amps, high-speed switches, high-breakdown-voltage devices, low-noise voltage devices and low input-impedance dual units.

CIRCLE NO. 387

National Semiconductor has announced its entry into the **analog switch market** with 80 second-source DTL/TTL-compatible ICs.

CIRCLE NO. 388

Hewlett-Packard has **cut prices on two of its solid-state display lines.** The 5082-7000 series indicators were reduced in price from $70 to $55 per digit for 1 to 9 quantities. Series 5082-7100 indicators were slashed down to $40 per digit from $70 per digit, for quantities of 1 to 9.

CIRCLE NO. 389

Data Technology has announced a 20% **cut in the price of its model 120 frequency synthesizer.** The $500 reduction for the fully programmable 2-MHz model 120 with 1 pmm/°C stability brings its price down to $1995.

CIRCLE NO. 390

Design Data from Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card.
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Time History of Low Frequency Real-Time Spectra Now Displayable on Your Scope

Now you can see the changing character of the frequency content of a signal **in time,** with Federal Scientific's Option 66-2 3-Dimensional Automatic Display Generator. It accepts inputs from any of Federal Ubiquitous® family of Spectrum Analyzers or Averagers and displays spectrum data on a CRT storage-display unit such as Tektronix 611. A three-dimensional display of spectrum amplitude vs frequency vs time is obtained — achieved by displacing successive spectrum traces vertically (in adjustable steps) and horizontally, to simulate a 3-D display through an isometric presentation.

CIRCLE NO. 171

Federal Scientific Corporation
a subsidiary of Elgin National Industries, Inc.
615 West 131st Street, New York, N. Y. 10027

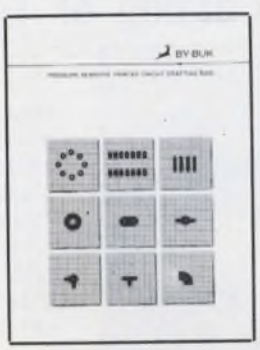
New Ferroresonant "FPS" Power Supplies

Power/Mate Corp. has introduced its new expanded line of 129 models of its ferroresonant "FPS" Series DC regulated power supplies now described in this four page catalog. The new "FPS" models collectively cover from 5.0 to 60 VDC and currents up to 125 amperes. The "FPS" Series feature high performance, 70-90% efficiency and low, low cost. Plus, they are backed by Power/Mate's full Five Year Warranty. The catalog covers complete specifications, model numbers, mechanical dimensions and prices. Write, call or TWX for your free copy.

CIRCLE NO. 172

Power/Mate Corp.
514 South River Street
Hackensack, New Jersey 07601
(201) 343-6294 TWX: (710) 990-5023

PC Drafting Aids Catalog



Thousands of time saving, cost saving artwork ideas are found in the By-Buk P-50 catalog of pressure sensitive printed circuit drafting aids. With the most practical artwork patterns for: TO cans, multi-pads, dual-inlines and flat packs featured. Donuts, connector strips, teardrops, ovals, tapes, tees, elbows, etc., by the hundreds are included in the most comprehensive list of sizes. Opaque black, transparent red and transparent blue materials for one and two-sided board designs. For a free copy and samples, write today.

CIRCLE NO. 173

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Hayden Book Company's 1971 Catalog describes a wide range of guidebooks, texts, and references of interest to engineers Among areas covered are electrical and electronics engineering, professional engineering examinations, and computer technology and programming. Also included are texts, references, and guides for training and updating technical personnel. **Circle the reader service number for a free copy.**

CIRCLE NO. 176

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Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-ServiceCard
(Advertisement)

Centron Precision Drafting Aids Catalog

The latest catalog in pressure-sensitive precision component matched artwork symbols and drafting aids. Completely opaque pre-cut symbols are printed on pressure sensitive .0015" matte acetate film accurate to ± .001". Featured are choices in packaging to the user which affords greater convenience and cost savings. Donut pads are offered in both roll and strip form and precision tape is packaged in air-tight zipper bags to preserve freshness even after use. SEND FOR YOUR FREE CATALOG AND SAMPLES.

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Centron Engineering, Inc.
1518 W. 132nd Street
Gardena, California 90249

Instant Circuit Boards!™

Engineers at CIRCUIT-STIK, INC., have developed a complete family of circuit sub-elements and circuit materials designed to work together producing "INSTANT PROTOTYPE CIRCUIT BOARDS." Individual circuit boards can be assembled and tested from engineering sketches the same day. CIRCUIT-STIK's sixteen page catalog describes circuit sub-elements and materials that are pre-drilled, pre-plated, fluxcoated, and have pressure sensitive adhesive substrates ready for mounting and soldering of electronic components. (U. S. Patent #3,538,389 and other patents pending)

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Circuit-Stik, Inc.®

CIRCLE NO. 178

1518 West 132nd Street, Gardena, California 90249
Telephone (213) 532-1450

Power Conditioning Modules

Tecnetics, Inc., introduces its new catalog featuring its following lines of components and systems:

- DC-DC regulated power supplies
- Hybrid voltage regulators
- Hybrid DC-DC converters
- Hybrid DC-AC inverters
- Modular AC-DC regulated power supplies
- AC-DC unregulated power supplies
- Custom transformers

Write, call or TWX for your free copy.

CIRCLE NO. 179

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Advertising Sales Staff
Keith Aldrich
Sales Manager

New York 10022
Robert W. Gascoigne
Samuel M. Deitch
Daniel J. Rowland
850 Third Avenue
(212) Plaza 1-5530
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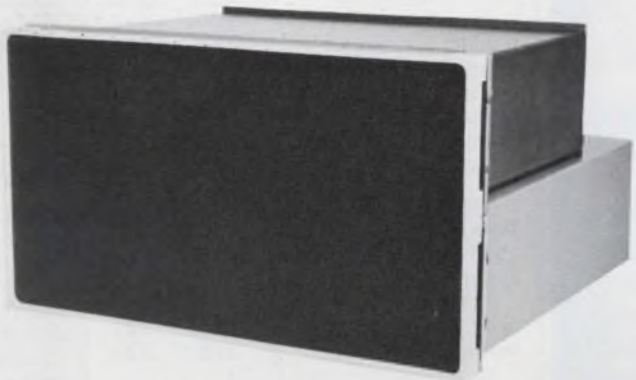

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