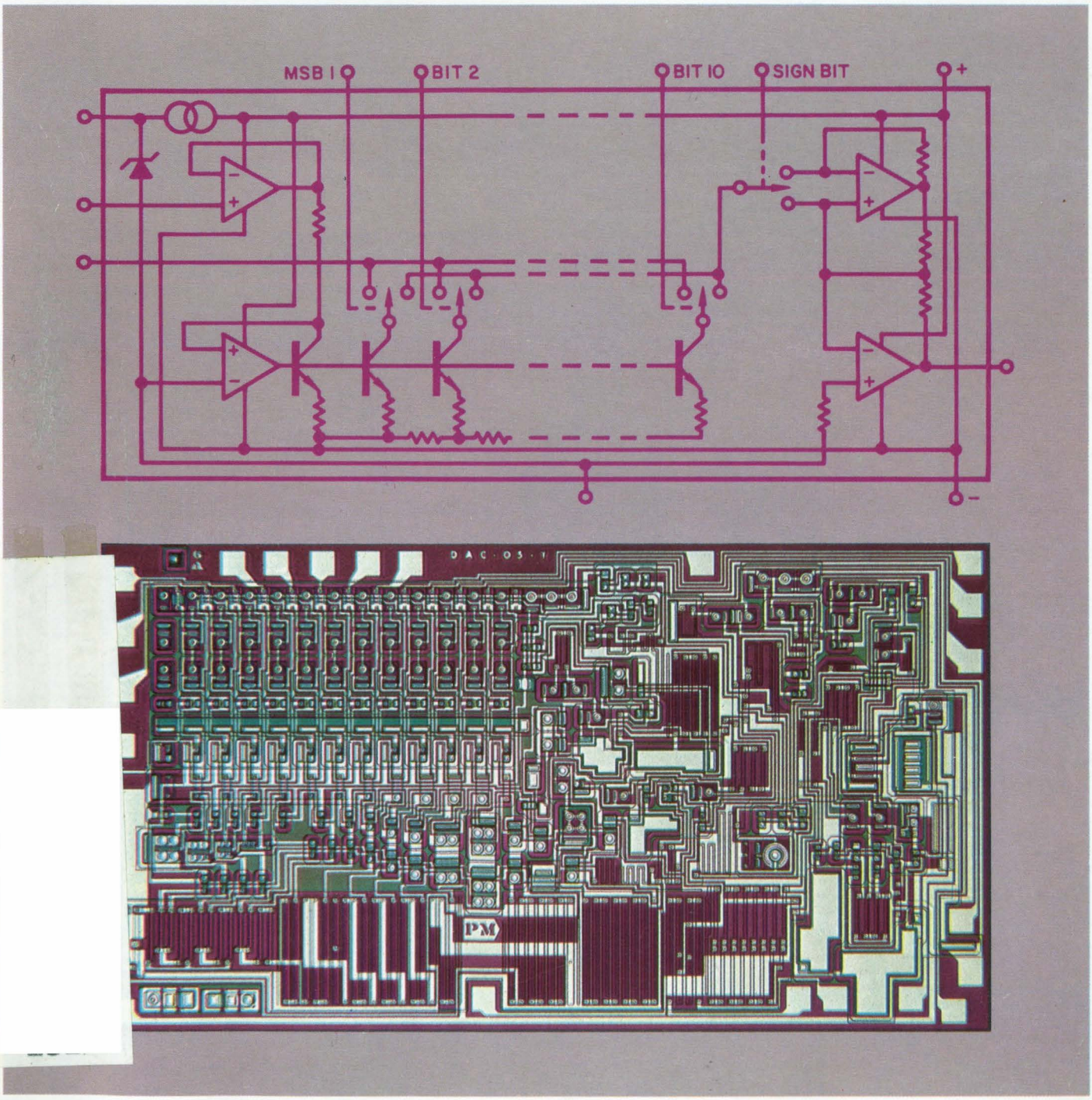
VOL. 20 NO. 9

Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 27, 1972

A one-chip 10-bit-plus-sign DAC offers the highest resolution of any IC. The chip includes an R-2R ladder network, precision voltage reference and high-speed, internally compensated op amp. With a linearity of 0.05%, the DAC also boasts a temperature coefficient of 15 ppm/°C. For more information, turn to pg. 79.



Everything you've always wanted to know about film resistors...but didn't know who to ask

You can do a lot more with Dale Film Resistors—and we're ready to send you a chart that proves it. Adding the Welwyn Group to our film resistor lines lets you rely on Dale for practically every resistance function in the book—and opens up new possibilities for saving time and cash.

Dale's expanded film resistor line now includes everything from the most exotic, to the least expensive. For example:

HIGHER VALUES—glass enclosed metal oxide film resistors to 1 billion ohms at 1% tolerance.

LOWER VALUES—down to .27 ohms at 1% tolerance.

HIGHER VOLTAGES—to 50KV pulse, 14KV continuous, with values to 150KM.

LOW-COST POWER—3 through 10 watt styles, 2%, 5% with flameproof coating.

CARBON COMP. COMPETITION—Beyschlag (W. Germany) carbon film resistors. Up to 2 watts in 2%, 5% tolerance.

Circle 3 for

FREE Film Resistor Reference Guide

or call 402-564-3131 for immediate information.

DALE ELECTRONICS, INC.

1300 28th Avenue, Columbus, Nebraska 68601

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Introducing the working man's signal generator.

It works in Production.
It works in the Lab.
It works in the Field.
It works in the Service Shop.
In fact it works just about everywhere.

That's because our new 8654A Signal Generator delivers big performance but is small in size — and price. It weighs just 16 pounds and costs only $1135. Yet you get all the functions you'd expect from higher priced instruments.

The 8654A is a 10 to 512 MHz VHF solid-state signal generator with leveled, calibrated output adjustable from +3 to −130 dBm. CW stability is 20 ppm/5 minutes, and you can AM or FM, internally or externally. A look at the front panel will give you an idea of just how easy it is to use.

For more information about this high-value RF signal generator, call your HP field engineer. Or write to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

SIGNAL GENERATORS

Domestic USA prices

INFORMATION RETRIEVAL NUMBER 2

04202A

The Fluke problem solver

The DVM you put together an option at a time, anytime

Because we use single main frame construction with all options field installable, you can configure the Fluke 8200A anyway you want when you buy it or anytime you want to change it. It's Fluke's way of giving you total flexibility for minimum money. It's one of the reasons Fluke has moved to DVM leadership in a scant two years.

Here's what you get for just $995: ☐ 4½ digits with 60% overranging for ±16000 count resolution ☐ Autoranging and autopolarity on all functions ☐ Switched input filter ☐ Full 1000 volt guarding ☐ ±0.01% accuracy ☐ Fluke's unique recirculating remainder* A to D conversion which combines low parts count and low power consumption to provide higher reliability.

To the basic unit you can add: ☐ Two ranges of millivolts, giving you autoranging from 1 microvolt resolution up to 1200 volts input ☐ Six ranges of ohms measurement, providing autoranging from 10 milliohms to 16 megohms ☐ Four ranges of ac volts ☐ Four ranges of true rms ac volts ☐ Isolated 4-terminal, real-time ratio measurement.

A real systems DVM too: ☐ Speeds up to 400 readings per second with full accuracy after only a 500 microsecond look at the input ☐ Isolated and buffered data output for digits, range, functions and polarity—with status flags ☐ Isolated remote control for continuous or buffered input commands ☐ Isolated and buffered printer output.

Ask for Fluke's 8200A Application Bulletin No. AB-10 for systems designers.

The 8200A's single main frame and field-installed options let you configure the most cost-effective 4½ digit DVM on the market.

To arrange a demonstration or get complete information, call your nearby Fluke Sales Engineer or contact us directly.

*Patent pending

Fluke, Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211. TWX: 910-449-2850/In Europe, address Fluke Nederland (N.V.), P.O. Box 5053, Tilburg, Holland. Phone: (04250) 70130. Telex: 884-52337/In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2, 4TT. Phone: Watford, 33066. Telex: 934583.

FLUKE

Electronic Design

VOL. 20 NO. 9

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 27, 1972

NEWS

TECHNOLOGY

PRODUCTS

Departments

Cover: Courtesy of Precision Monolithics, Santa Clara, Calif.

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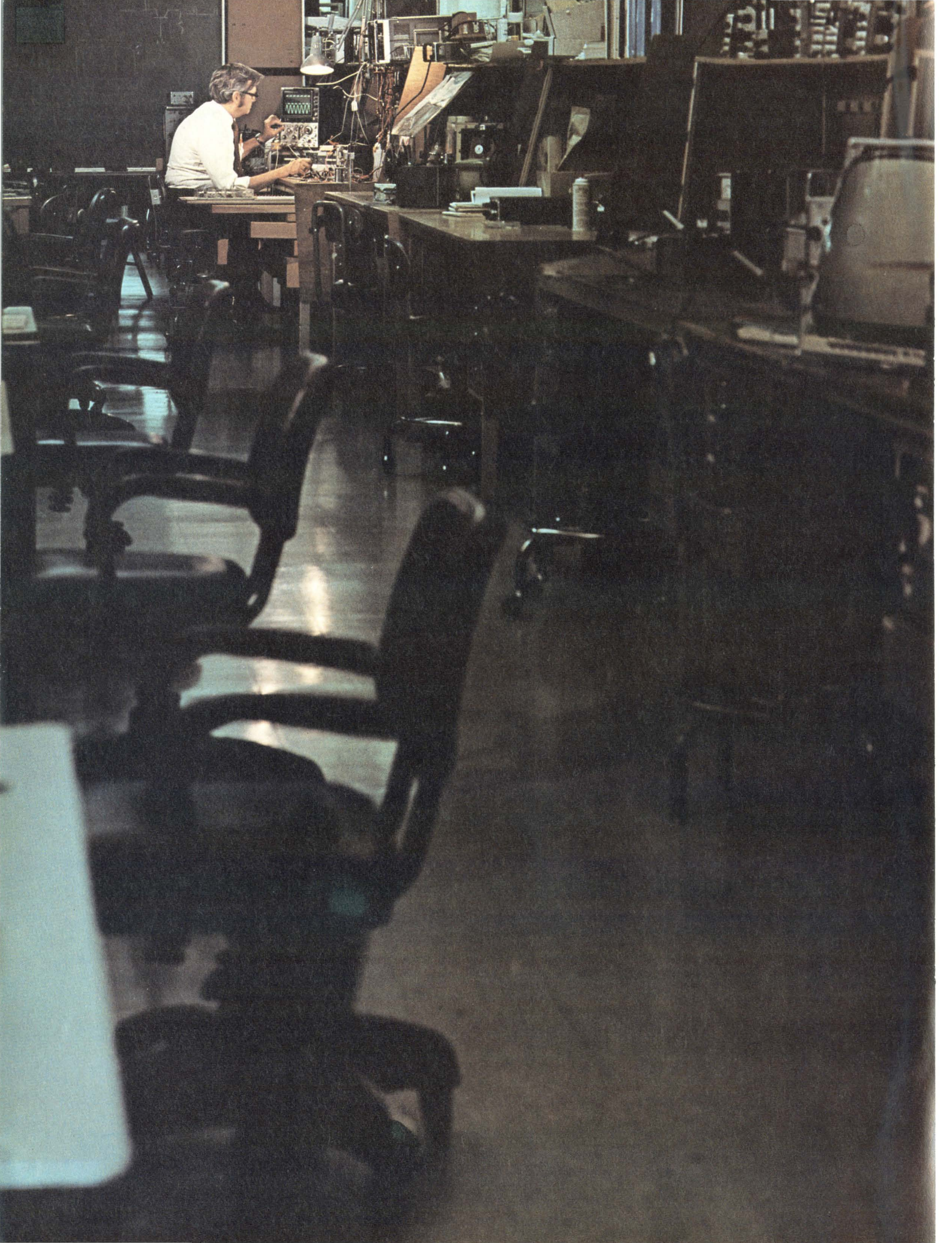

Think Twice:

Extra contribution is one way to the top. Specifying HP scopes will help you, too.

Here's why.

You're an engineer on the way up. Your ideas, your designs, your work all reflect the extra contribution you're making. (You might even slip back to "the shop" after dinner and on weekends.) Rewards won't be long in coming.

There's one more thing you can do for yourself and your management. Show them a way to cut operating expenses and boost profits. How? By being critical and downright hardnosed in making your cost/performance comparisons on instrument purchases.

Scopes Have Changed.

Take laboratory oscilloscopes for instance. In the past several years, scope design and performance have changed—for the better. Many companies, maybe yours, are in the process of replacing older scopes, to take advantage of the extra capability these new models offer. To get the best buy now, you're going to have to do more than look at the name tag and spec sheet. Plug-ins are not compatible. Calibration is completely different. Controls and operations have changed radically. It's a whole new ball game. *Little* that you learned or used on older scopes —*whether theirs or ours*—can be transferred to the new models. You need new techniques, new training materials, new parts. Here are three specific reasons why you should investigate the HP 180 Series...why you should think twice.

HP Scopes Cost Less To Buy

Analyze your total measurement needs, then ask both manufacturers to submit prices. On latest model plug-in lab scopes, you'll find that HP can consistently save you money — lots of it. For example on a 75 MHz non-delayed sweep, plug-in system, ours is 24% less (with delayed sweep, 18% less); at 100 MHz, ours is 16% less; for 1 GHz sampling, you'll pay 54% less if you buy ours.

HP Scopes Cost Significantly Less To Operate

Because scopes have changed, training, operation, calibration, and repair are expenses that you'll have to contend with—no matter which make you buy. HP's new scopes are supported by simplified operation and live or videotaped training and repair sessions that can substantially cut your start-up and overall operating costs.

Calibration? We've cut the number of adjustments by 50%—and eliminated interactive adjustments. Therefore, when you're comparing oscilloscopes be sure to include in that comparison the cost of calibrating each manufacturer's unit.

Our users are reporting shorter training periods, faster, surer measurements, and savings up to 50% on calibration time and costs. Some companies buying Hewlett-Packard, cite this as the main reason.

HP Technological Leadership. More Performance. Fewer Problems.

HP innovations in general purpose lab scopes include: the first scope with a real time bandwidth of >250 MHz; the first 18 GHz sampling scope; the first 100 MHz variable persistence and storage scope; and the first and only 100 MHz scope with a "big-picture" CRT (8x10 div, 1.3 cm/div). These are meaningful, functional innovations that boost your performance, not your costs.

Think twice! Once you make the comparison, we're certain you'll choose HP. Many engineers like yourself—engineers on the way up —have already made the switch. For more information on how you can help your company boost profits and how you can help yourself make faster, more positive measurements, write for our free "No Nonsense Guide To Oscilloscope Selection."

Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

Scopes Are Changing; Think Twice!

HEWLETT hp PACKARD

OSCILLOSCOPES

082/6

INFORMATION RETRIEVAL NUMBER 5

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across the desk

Reader is opposed to pressure by labor

Your editorial "Don't Be a 'Don't Know'" (ED 5, March 2, 1972, p. 39) was read with great interest. The writer of the editorial and I went through exactly the same mental process as we answered the questionnaire from IEEE headquarters. However, my recommendation to IEEE was the opposite of his. I sent a letter discussing the matter in greater detail.

Your editorial is correct in saying that we have a choice of whether or not to join the pressure groups in demanding more for our services than the free market is willing to pay—as do the labor unions and the doctors. But I would choose never to join them. Rather I would institute proceedings that would break their stranglehold on our society.

You are correct in that they are moving to destroy our civilization —just as they destroyed Roman civilization. But you ought never have elected to join them in hastening the destruction of our civilization.

R.O. Whitaker
Rowco Engineering Co.
4719 Squire Drive
Indianapolis, Ind. 46241

Typist boosts bandwidth

By simply striking the wrong typewriter key, we dramatically improved a scope's bandwidth. In the article, "Fastest portable scope shows 350 MHz at 5mV/div" (Electronic Design 5, March 2, 1972, p. 67), we compared the new Tektronix 350-MHz Model 485 with the Hewlett-Packard Model 1707. For the HP scope we intended 75-MHz bandwidth but our typewriter (and sleepy editor) gave us 750 MHz bandwidth. In the same article, we wrote that the Tek 485 offered input impedance of either "50 Ω of 1 MΩ." Please substitute "or" for "of." Sorry.

A competitor objects to New Products claim

In the Feb. 17, 1972 issue, ELECTRONIC DESIGN carried a New Products item on a Federal Scientific correlator ("512-Point Correlator Samples 1/2 μs," p. 105). The item reported that the manufacturer claimed this correlator was "the world's fastest and has the finest time resolution." Both claims are false. Saicor, a pioneer in digital correlation and probability analyzers, has a Model SAI-43A instrument, available for six months, that processes data at higher rates and also provides finer time resolution (0.2 μsec on our machine vs. 0.5 μsec on the machine described).

Frank Kasper Jr.
Sales Manager
Saicor
(Signal Analysis Industries Corp.)
595 Old Willets Path
Hauppauge, N.Y. 11787

Federal Scientific replies

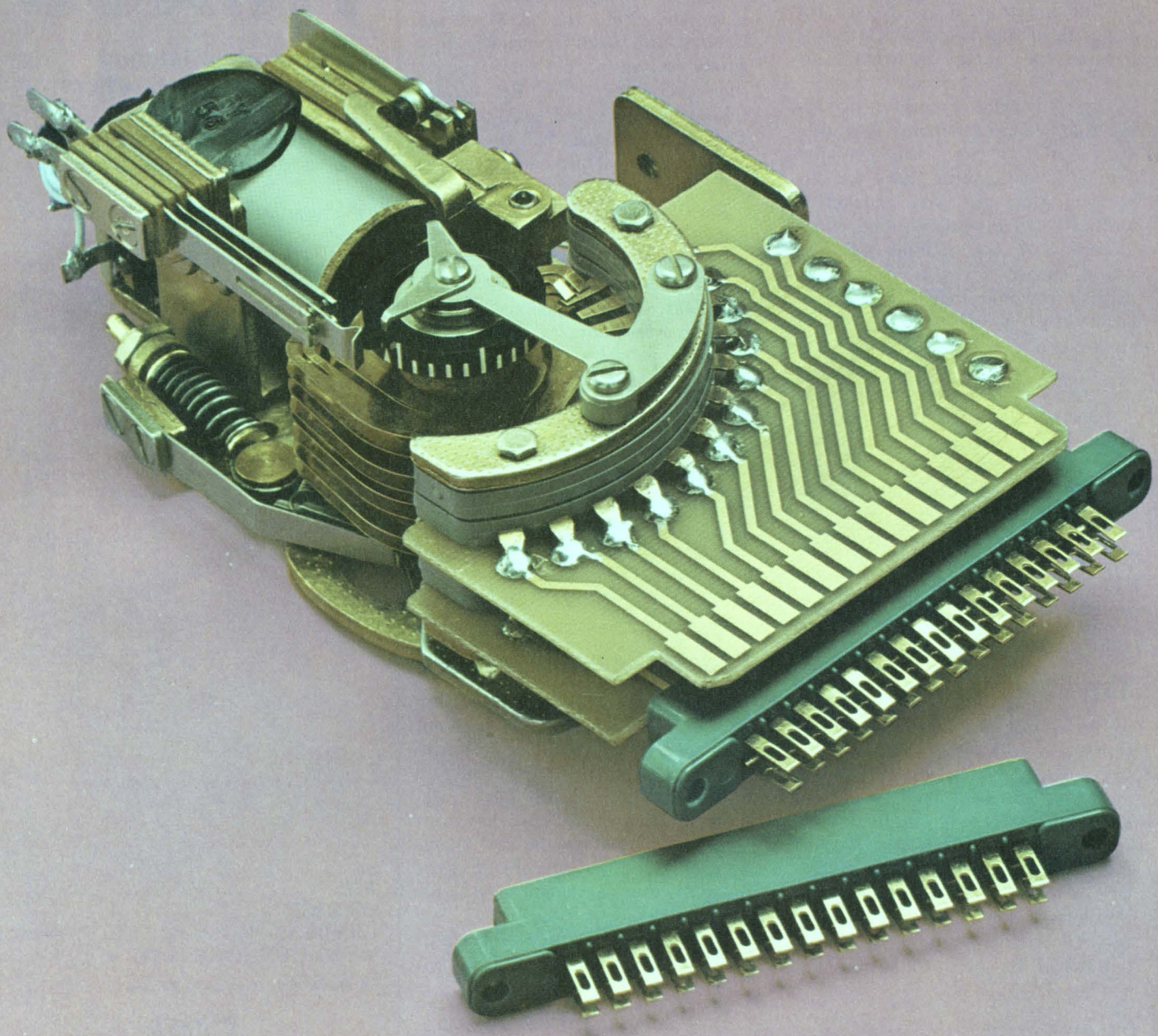
Regarding the various complaints by Saicor, we are not anxious to get into a long technical debate with them via secondhand letters through ELECTRONIC DESIGN. Suffice it to say, however, that I don't believe Saicor knows how fast we do actually process data in the particular correlator advertised.

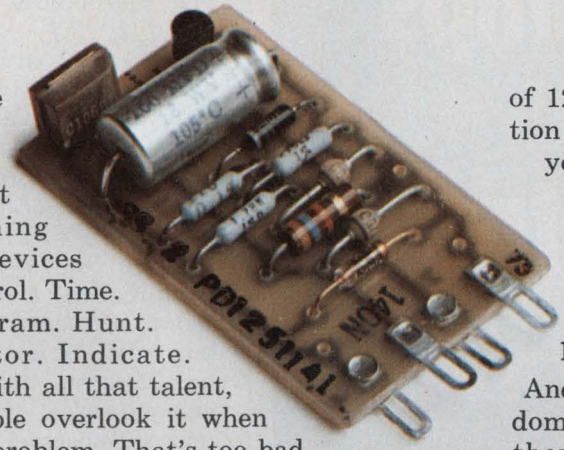
Time resolution in our correlator

(continued on p. 10)

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, 50 Essex St. Rochelle Park, N. J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

You can teach our stepping switch all the newest tricks.





You can make a rotary stepping switch do just about anything solid state devices can do. Control. Time. Count. Program. Hunt. Test. Monitor. Indicate. Select. Yet with all that talent, a lot of people overlook it when they have a problem. That's too bad because it's often the most practical solution.

Think of the stepping switch as a time machine.

It conserves what you have the least of. Time. That's because most of the logic you need is built right in. It's part of the mechanical construction, not something you have to create. And by adding our Series 300 Time Delay module, you'll practically have a complete control system in the palm of your hand. Lots of people have created exotic solid state circuits only to discover they could have done the same thing faster and easier with a stepping switch.

Ten cents a contact.

That same exotic circuit probably costs three to five times more than a stepping switch, too. For example, a type 45 with 8 levels of 52 contacts will cost you about a dime a contact. We don't know of any switching method that costs so little.

A better memory than an elephant. And just as tough.

A stepping switch never forgets after a power outage. When the juice comes back on, it starts up right where it left off. And it shrugs off doses of 1250 volts because of inherently high insulation resistance and dielectric strength. This gives you a system reliability that can't be matched by solid state. Should the day ever come when maintenance is necessary, a plug-in style, like the type 44 in the picture, can be removed or installed in minutes.

10 million laps around the track.

And maybe 10 million more. We've yanked random units off our production line and worked them to death. Many have lasted twice as long as their rated 10 million wiper sweeps across the bank. One reason is our "free floating" pawl. It can't possibly bind or overthrow because we don't use pawl or armature stops.

Sometimes a stepping switch isn't the answer.

If you need to switch in microseconds, or squeeze your system into a TO-5 can, forget it. But if you're looking for a simple, economical, reliable, easy-to-design solution to a switching problem, consider the stepping switch. We'll be happy to help you do it. If you want a head start, write today for a copy of our 40-page manual. GTE Automatic Electric, Industrial Sales Division, Northlake, Illinois 60164.

GTE AUTOMATIC ELECTRIC

INFORMATION RETRIEVAL NUMBER 8

(continued from p. 7)

refers to the fact that we provide 512 frequency points and therefore break up the time scale more finely than Saicor does with its 400-line unit.

Federal Scientific has been in business for a considerable length of time, has delivered reliable equipment throughout the world, and I believe has an excellent reputation for honesty and technical integrity. We have never knowingly given out false information on our products. I regret that ELECTRONIC DESIGN has been brought into what is an actively competitive sales situation betwen Saicor and ourselves. Our relatively recent introduction of a high-resolution correlator apparently has upset their sales picture.

Richard S. Rothschild
Vice President

Federal Scientific Corp.
615 West 131st Street
New York, N.Y. 10027

Market research needed

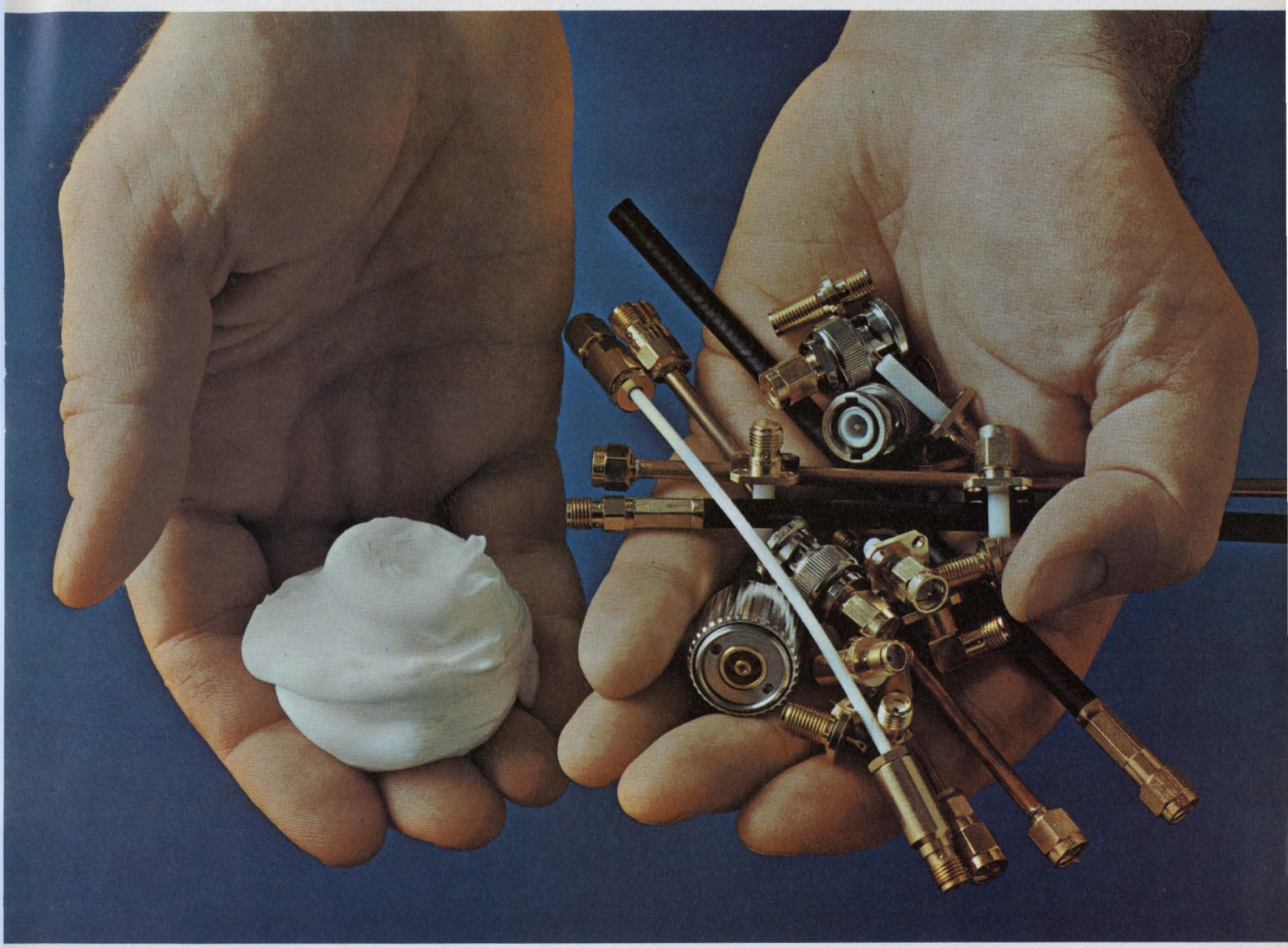
For a long time, Warren Schoonmaker has been urging us to publish material on marketing and, more specifically, on his newsletter, "Mainly Marketing," Larchmont, N.Y. We've always resisted on the grounds that it's ED's job to help engineers do their main job—engineering.

We were almost tempted when we read, in Schoonmaker's last letter: "Have you heard about the unemployed semiconductor production engineers who decided to use some photo-etch experience in a business of their own? They decided to counterfeit and enclosed is one of their bills. A little market research may have helped."

Interested?

CIRCLE NO. 474

You can assemble our SMA connectors



in less time than it takes to shave.

Five minutes. That's all it takes to assemble our SMA connectors for subminiature coax cables. A significant savings in production time.

You get your Amphenol SMA connectors factory preassembled, thus keeping loose parts at a minimum. And by using an inexpensive tool kit to prepare the cable, putting them all together is a snap. Parts loss is virtually eliminated.

Amphenol set the trend by making its SMA connectors of high-strength, heat-treated beryllium copper material, which is three times stronger than stainless steel. These superior connectors are, of course, completely intermatable and interchangeable with existing stainless steel designs. Amphenol was the first source qualified for MIL-C-39012 SMA connectors.

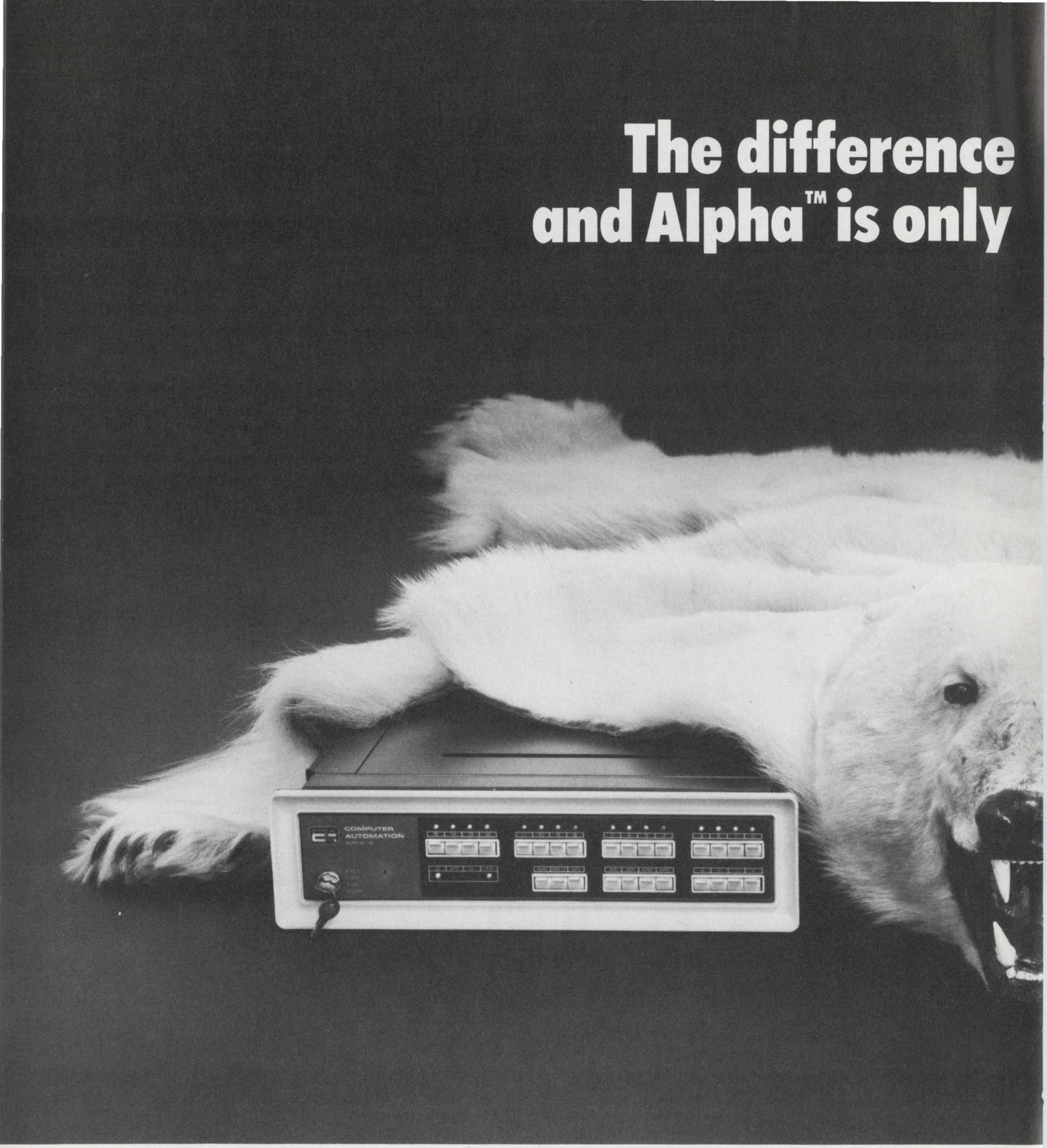
Available in a wide variety of flexible and semi-rigid cable connectors; receptacles for strip-line, MIC packages, and numerous other microwave components. And if you need SMA specials or complete cable assemblies, come to the world's largest manufacturer of coaxial connectors.

See your authorized Amphenol distributor or write Amphenol RF Division, Bunker Ramo Corporation, 33 East Franklin Street, Danbury, Connecticut 06810.

BUNKER RAMO AMPHENOL

INFORMATION RETRIEVAL NUMBER 10

The difference and Alpha™ is only



Actually the NAKED MINI is the ALPHA with its clothes off. We designed both with the same specifications for the same high performance. In fact, both are backed by the same one year unconditional warranty. The only difference is that the NAKED MINI is a computer that's really a component.

At first blush, you may think that the NAKED MINI is stripped. But it's not. It is just designed so that you can integrate a powerful mini-computer into your product and increase your profit margin.

How?

Because you don't get skinned by the NAKED MINI'S prices. In OEM quantities you get the NAKED MINI 8 for only $1450, and the NAKED MINI 16 for $1995. And that includes 4K words of memory.

If you already have power and controls in your system, you may not need a control console, power supply and fancy enclosure with your computer. You may simply want to bury the computer in your product as another component. Yet you do want a complete and powerful general purpose computer that will add performance and reliability to your product.

That is exactly what you get from the NAKED MINI. Full computer power at drastically reduced prices. Fully parallel byte and word processing, direct memory I/O channels. hardware multiply/divide, vectored priority interrupts, 4 K

between the NAKED MINI™ skin deep.

plug-in memory expandable to 32 K words. All this plus the industry's most powerful and straightforward instruction set, 156 basic instructions with many multi-function instructions.

What this means is simplified programming for producing shorter programs that take less core and run faster. And this saves you money in many ways. The NAKED MINI'S full broadside I/O and priority interrupt structure make it the easiest of all mini-computers to interface with your equipment — and this saves you money also.

We offer a complete line of standard software and options including power fail restart, real time clock, parity, memory protect, buffered I/O cards, communication controllers, and multiplexers as well as all types of peripherals.

The bare fact is, you'll be impressed by all of THE NAKED MINI'S vital statistics. To get better acquainted call or write the NAKED MINI Company today.

COMPUTER AUTOMATION, INC.
895 West 16th Street • Newport Beach, California
92660 • Phone (714) 642-9630 • TWX 910-596-1377

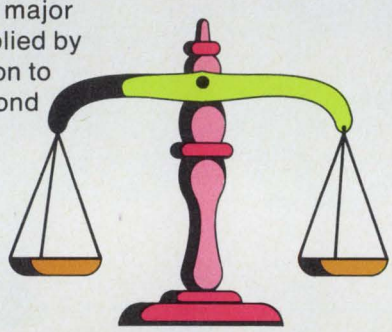
INFORMATION RETRIEVAL NUMBER 11

SPEED vs.

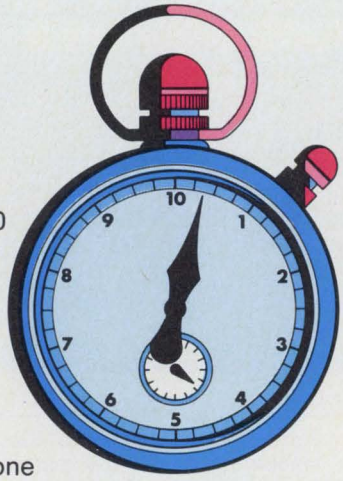
The one-nanosecond conundrum.

Schottky or ECL 10,000? How should you commit your engineers, your plant, your production, to get the faster logic that your next system will require?

It's a tough choice. Both major logic families volume-supplied by Signetics can be counted on to boost speed levels far beyond standard TTL. With each offering its own unique advantages, each with built-in drawbacks (sometimes more psychological than real).



PARAMETER	TYPICAL VALUES	
	74S/82S	ECL 10,000
Propagation Delay (per Gate)	3ns	2ns
Power Dissipation (per Gate)	20mW	25mW
Positive Volt. Supply (+V)	+5V	0V
Negative Volt. Supply (−V)	0V	−5.2V
Logic "1" Level	+2.7V	−.9V
Logic "0" Level	+0.5V	−1.8V
Output △V/△T	1V/ns	.25V/ns



Hands down, ECL 10,000 beats out Schottky 74/82 in performance—delivering the best high speed/low power tradeoff yet. But the crucial question facing users: just how critical to your individual designs is that one extra nanosecond knocked off by ECL?

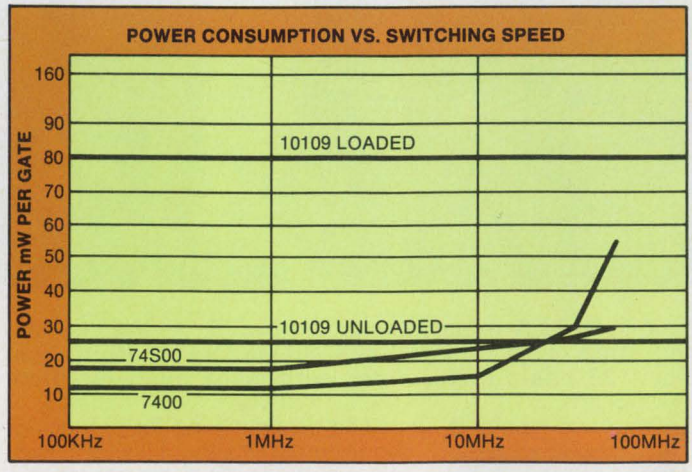
Unless you're into super scale or large scale computers, which have always utilized ECL's maximized performance, there's no pat answer to the question. You have to balance where you've been, and where you're going, with a careful probing of both technologies.

For all practical purposes, 74/82 Schottky is third generation TTL enhanced to allow the designer to increase his system speed by replacing present TTL circuits with their Schottky equivalents. Signetics uses a 3 micron epitaxial film thickness to produce extremely small geometries. Combining small geometries with Schottky diode clamped transistors results in optimized T^2L performance plus remarkable high-density MSI capability. Since gold doping is no longer required, you get higher betas—making PNP transistors available for innovative circuit ideas. All Signetics 82S circuits use PNP transistors to reduce input loading, to insure that fan-out rules are not violated when upgrading existing systems.

Schottky TTL is compatible with standard TTL circuits, with logic rules familiar to the vast majority of engineers. That's the good news.

The bad news: wiring rules may become more stringent due to the sharper signal edges of Schottky TTL compared to standard T^2. Careful attention must be paid to PC board geometries and line terminations, as with 74H type circuits. And, of course, there is that one nanosecond difference in gate delay.

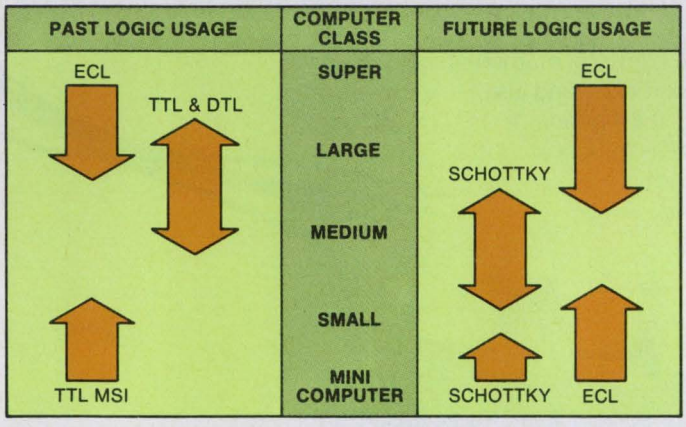
ECL 10,000 will drop propagation delay from 3 to 2ns per gate. With MSI frequently twice as fast. But it takes more than speed to make 10K so desirable.



SPEED

The constant current nature of ECL 10K is obvious. Properly loaded ECL gates show very flat power dissipation. This flat power curve means greater ease of power distribution. And the difference between loaded and unloaded curves offers termination freedom: this choice of resistor helps immensely in reducing internal dissipation to allow higher functional densities. ECL combines remarkable design/function flexibility with significant savings in gate and package count.

A fear of the unknown appears to be the key stumbling block to ECL. Probably the prime concern is the relative unfamiliarity with the NOR/OR logic. The system engineer or manufacturer often feels he has enough on his hands mastering the new usage techniques of 74/82 Schottky, where the basic logic is still TTL. Learning to cope with the sharp edge speeds of faster logic is one thing. Being forced to learn a whole new logic besides... that's often the last straw. Is one extra nanosecond worth it? Only you, the user, can tell.



Put yourself in this picture. Match usage to computer category. Match speed requirements to your own best interests, recognizing that the entire industry is trending toward ever-higher speeds. And before you commit to either Schottky TTL upgrading, or a switchover to ECL, consider both alternatives carefully.

74/82 Schottky. Or ECL 10,000. Signetics gives you both ways to go.

SCHOTTKY 82S MSI

82S30/31/32	8-Input Digital Multiplexer
82S33/34	2-Input, 4-Bit Digital Multiplexer
82S41/42	Quad Exclusive-OR/Quad Exclusive-NOR
82S50/52	Binary-to-Octal/BCD-to-Decimal Decoder
82S62	9-Bit Parity Generator and Checker
82S66/67	2-Input, 4-Bit Digital Multiplexer
82S70/71*	4-Bit Shift Register
82S90/91*	Presettable Decade/Binary Counter

SCHOTTKY TTL 74S

74S00	Quad 2-Input NAND Gate
74S03	Quad 2-Input NAND Gate (Open Collector)
74S04	Hex Inverter
74S05	Hex Inverter (Open Collector)
74S20	Dual 4-Input NAND Gate
74S22	Dual 4-Input NAND Gate (Open Collector)
74S112*	Dual J-K Edge-Triggered Flip-Flop
74S113*	Dual J-K Edge-Triggered Flip-Flop
74S114*	Dual J-K Edge-Triggered Flip-Flop
74S40*	Dual 4-Input NAND Buffer
74S140*	Dual 4-Input NAND Line Driver

ECL 10,000

10101*	Quad 1-Input OR/NOR Gate
10102	Quad 2-Input NOR Gate
10105*	Triple 2, 3, 2-Input OR/NOR Gate
10106*	Triple 4, 3, 3-Input NOR Gate
10107	Triple 2-Input Exclusive OR/NOR Gate
10109	Dual, 4, 5-Input OR/NOR Gate
10110	Dual 3-Input 3-Output OR Gate
10111	Dual 3-Input 3-Output NOR Gate
10112	Dual 3-Input 1-OR/2-NOR Gate
10113*	Quad Exclusive -OR Gate/Comparator
10115*	Quad Differential Line Receiver
10116	Triple Differential OR/NOR Line Receiver
10117	Dual 2-wide 2, 3-Input OR-AND/OR-AND Invert Gate
10118	Dual 2-wide 3, 3-Input OR-AND Gate
10119	4-wide 4, 3, 3, 3-Input OR-AND Gate
10121*	4-wide 3, 3, 3, 3-Input OR-AND/OR-AND Invert Gate
10131*	Dual D-Type Master-Slave Flip-Flop
10161	1 of 8 Demultiplexer/Decoder (Low)
10162	1 of 8 Demultiplexer/Decoder (High)
10170*	9 + 2-Input Parity Circuit
10171*	Dual 1 of 4 Demultiplexer/Decoder (Low)
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INFORMATION RETRIEVAL NUMBER 12

We regretfully announce that we were system into our old calculator box.

All we could get in were 52 times as many memory registers plus 16 times as many programming steps, a lot more logic, and a magnetic card reader. The rest of the stuff we had to leave outside.

Our box still weighs 22½ pounds, but it now holds

Up to 522 memory registers, in increments of 64. There's 4-rule arithmetic and special key functions into and out of all registers, and you won't destroy the contents when you turn off the machine.

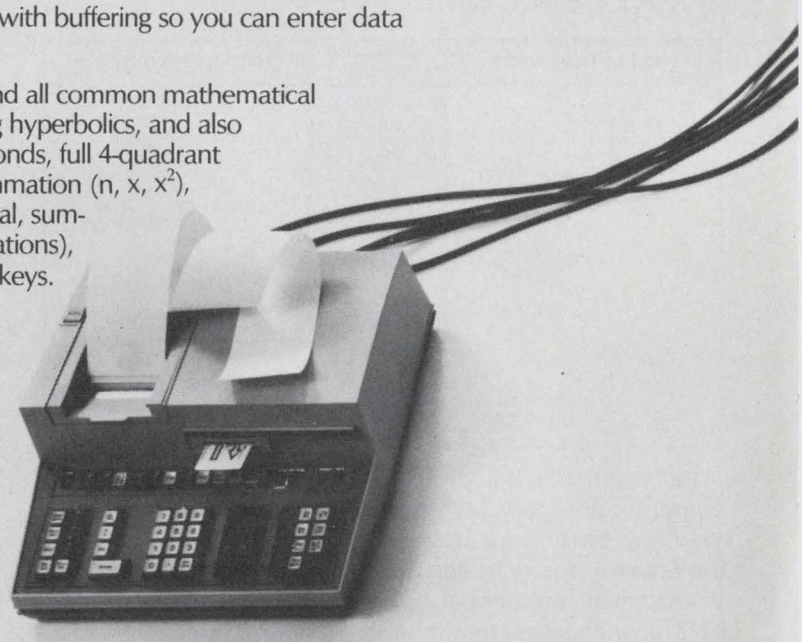
Up to 4,096 steps of programming, in increments of 512. You can do an entire program from the keyboard and see all your steps printed out for debugging. Symbolic addressing makes branching and jumping very simple. You can backspace, correct errors, and insert steps without having to re-enter the program. You can program the decimal-point printing format, do 16-level nesting.

A magnetic card reader/writer that lets you input programs, write programs, put data into memory, save programs and memory contents.

Fully algebraic keyboard arithmetic, with nesting of parentheses. You enter equations the way you write them, not the way the machine wants them.

Multiple key interlock and rollover, with buffering so you can enter data while the machine is calculating.

Labeled keys for logs, antilogs, a^x, and all common mathematical and trigonometric functions including hyperbolics, and also input/output in degrees-minutes-seconds, full 4-quadrant coordinate conversion, statistical summation (n, x, x^2), standard deviation and mean, factorial, sum-square backout (correction of summations), plus optional user-definable function keys.



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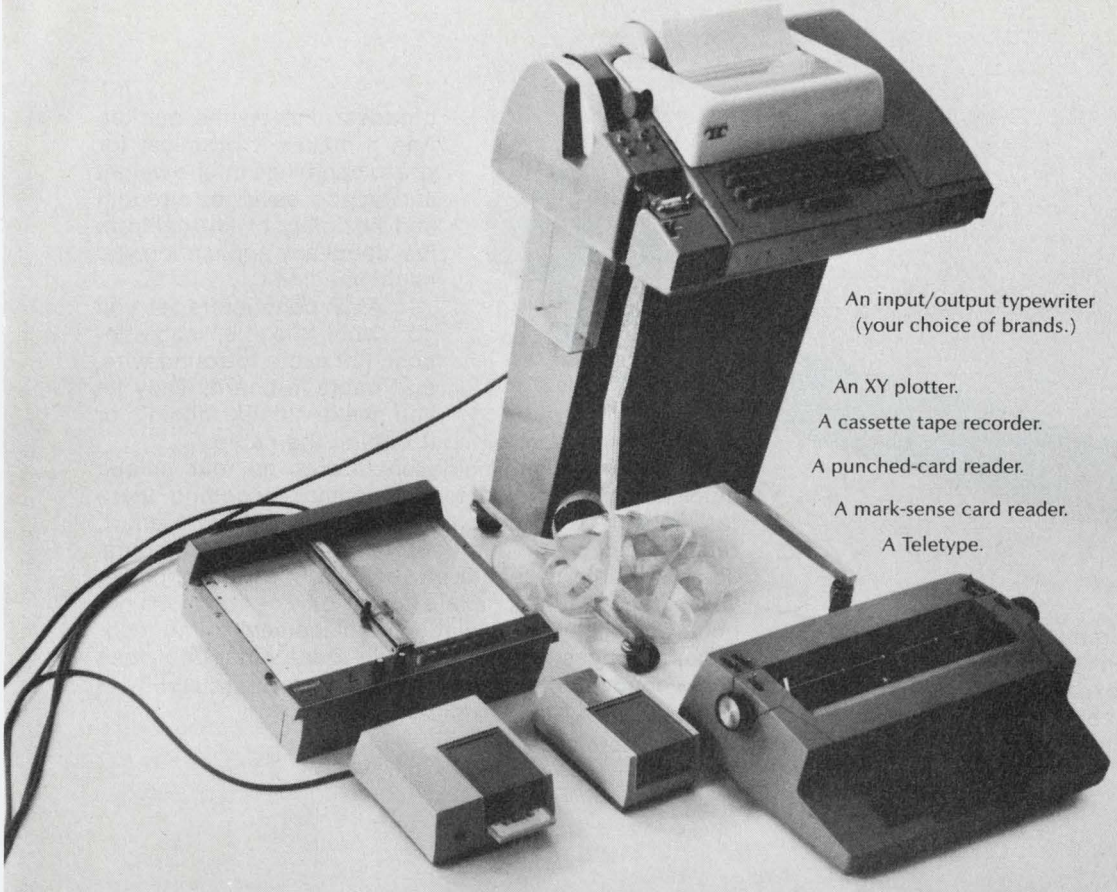


We're talking about the new 400 Series of desktop computers that complements and extends our Compucorp calculator line. The Model 425 is for engineers, scientists and surveyors, the 445 is for statistical folks.

We've made more than 30,000 of our other models in the last couple of years. They come in little boxes that sit on a corner of your desk. Each one has an array of powerful one-punch keys that solve the problems of a particular kind of user. They have up to 20 storage registers and 256 steps of programming.

There's a wide range of prices so you can buy enough power to do your job without having to pay for more than you need.

But many customers have said, "That's not enough machine for me." Hence the 400's.

The 400's are as easy to operate as our other models (easier, in fact.) They're enormously powerful and versatile, they interface with an array of peripherals, and they come in the same little box.

The 400's start at $3,750, our other models a lot lower.

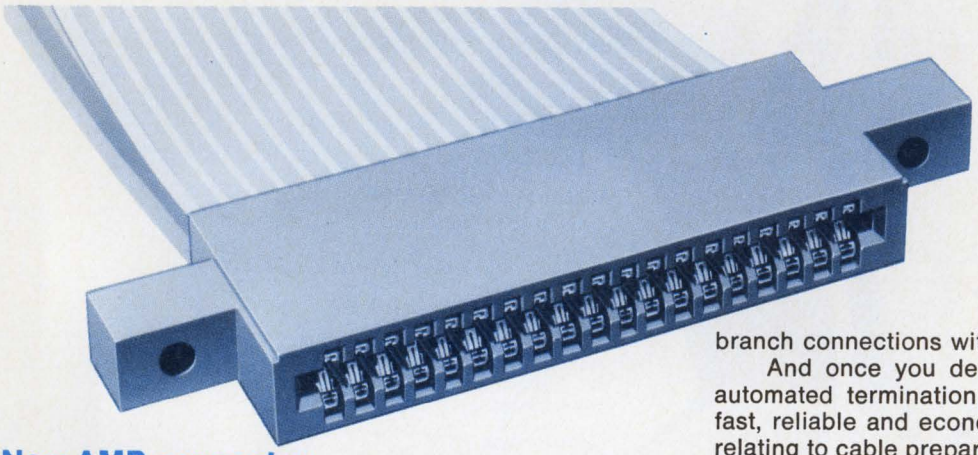
Write down what you need on your letterhead. We'll show you a calculator or a desktop computer that fits your problems and your pocketbook.

Computer Design Corporation 12401 West Olympic Boulevard, Los Angeles, California 90064 Telephone (213) 478-9761

INFORMATION RETRIEVAL NUMBER 13

AMPeconomation news

COST SAVINGS BY DESIGN WORLDWIDE



New AMP connector for flat flexible cable

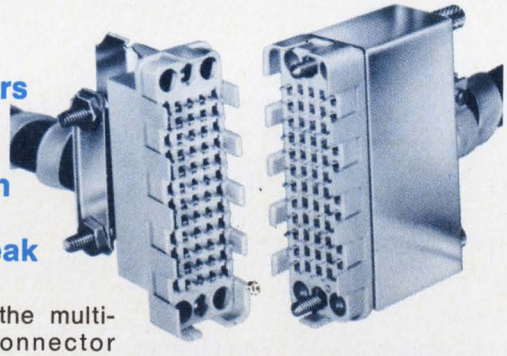
The one-piece printed circuit board-edge connector, with bifurcated contacts on .100″ centers, that we've just added to our line further expands the scope of AMP connectors for flat flexible cable applications. It's the broadest line on the market. And it makes it practical for you to capitalize on the weight and space savings, strength and flexibility of flat cable in just about any application you might imagine.

AMP connectors let you go cable-to-cable, cable-to-post, flat cable-to-round wire, and cable-to-board. They let you make "daisy chain" or branch connections without cutting the cable.

And once you decide on how to go, our unique automated termination technique makes getting there fast, reliable and economical. It works with zero effort, relating to cable preparation. No stripping, no soldering. Just cut cable to length and feed it into our machine, which dependably completes up to 3400 connections per hour. Our exclusive insulation displacement crimp technique produces positive, multiple-area contact between cable conductor and terminal, assuring top reliability.

CIRCLE 122 ON READER SERVICE CARD

Dualatch connectors reliably sustain more than 10,000 make-break cycles.



Here's the multi-position connector with the long make-break life... 10,000 cycles and beyond.

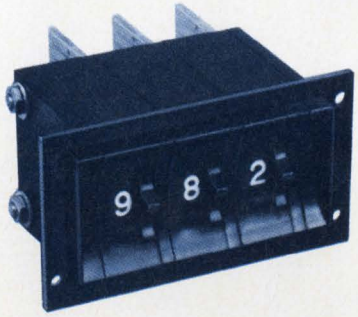
It has unique hermaphroditic contacts—reduces your inventory—requires 70% less make-break force. Housings are designed with positive polarization to prevent mismating.

DUALATCH connectors are available with 7.5 amp or 15 amp crimp contacts that can be applied manually. Or with automatic AMP machines for economical, reliable production in your plant at rates up to 3000 terminations per hour.

Also available with posts for automatic wiring, compatible with AMP TERMI-POINT* clip wiring. Or with manual, semiautomatic and automatic wrap methods. A variety of contact gold plating thicknesses are available for customer selection.

CIRCLE 121 ON READER SERVICE CARD

New thumbwheel switches for manual programming.



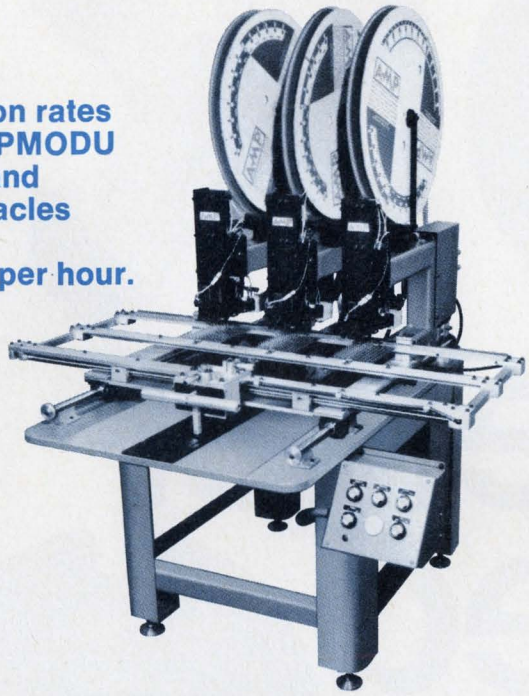
Use these long-life, compact, 10-position thumbwheel switches for data entry, control or programming applications. Decimal and BCD outputs are standard, plus a number of optional coded formats. They're ideal for both matrix and individual outputs.

We have human-engineered these switches to make them thoroughly effective as a man-machine interface. White numerals, 0.180″ high, are readable even in dim lighting. Available in both matte and gloss finishes. In ganged units, readout numerals appear in accurate horizontal alignment for goof-proof legibility. Rated for 115 VAC or 28 VDC. Contact current rating: nonswitching—3 amps, switching—125 milliamps. Tested life expectancy: 1 million detent operations.

Thumbwheel switch terminals adapt to solderless interconnection methods, including standard AMP card edge connectors.

CIRCLE 123 ON READER SERVICE CARD

Insertion rates for AMPMODU posts and receptacles reach 12,000 per hour.



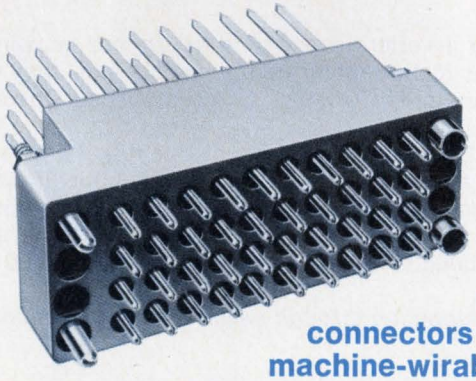
AMPMODU*, our post-receptacle interconnection system, now offers you even higher production capabilities than ever before. It's the ideal technique for modular-designed consumer or industrial electronics.

The secret is the AMP triple-head pantograph machine, which can insert AMPMODU contacts into three of your printed circuit boards at a time. Your operator uses a positioning pin and template . . . the three heads each move simultaneously, accurately. Rates up to 12,000 insertions per hour are readily achieved.

The machine will handle boards from .062″ x .125″ thick, with dimensions from 5″ x 13″ to 16″ x 13″.

And that all means simplified staking with maximum reliability and versatility at the lowest overall applied cost . . . AMPeconomation.

CIRCLE 124 ON READER SERVICE CARD



M-Series connectors now with machine-wirable posts.

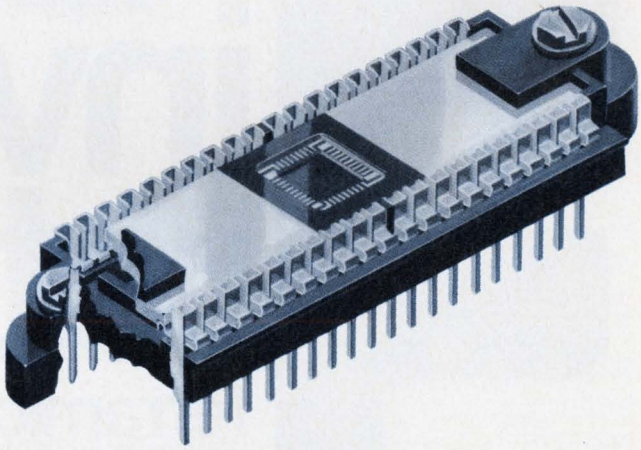
The latest addition to our M-Series connectors gives you real production economy. They have posts for automatic machine wiring . . . four sizes: .022″ x .036″; .031″ x .062″; .025″ square; .045″ square.

Post sizes are compatible with AMP TERMI-POINT* clip wiring. Or with manual, semiautomatic and automatic wrap methods.

These new post-type contacts are designed for AMP's standard M-Series housings, and will intermate with all M-Series connectors.

The posts also come in 1, 2 and 3 contact heights, and with all our standard platings.

CIRCLE 125 ON READER SERVICE CARD



Now—practical pluggability for leadless LSI packages

New leadless substrate LSI packages eliminate the problems of handling and inserting many delicate leads, and simplify field replacement.

AMP now has a line of special connectors designed to make pluggability of these leadless substrates practical and reliable. Our connectors feature zero entry force insertion, a contact design with stored spring energy to maintain reliable contact, and a low profile.

Two types are available for leadless LSI; one mates with top or bottom surface metallization, the other accepts packages with contact pads on the edge of the substrate.

CIRCLE 126 ON READER SERVICE CARD

For additional information on any of the above products write: **Industrial Division, AMP Incorporated, Harrisburg, Pa. 17105.**

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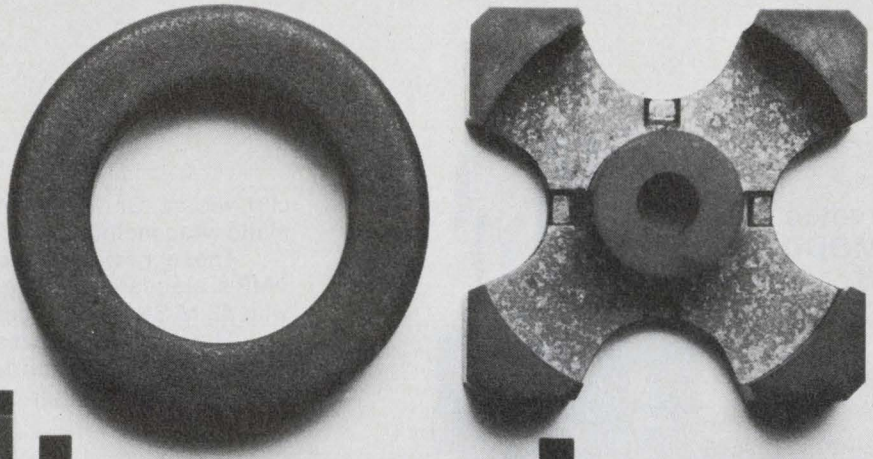

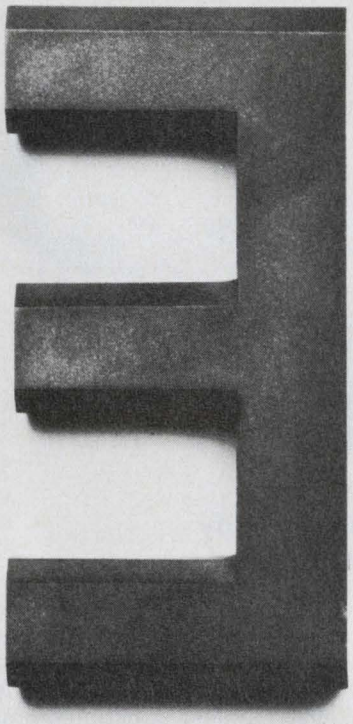

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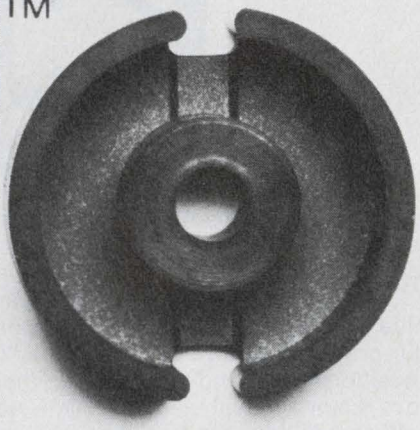
ferramic® components

instead of guessing a lot



■ *Inverter-Rated* components end guesswork in your inverter designs. They're tested under actual inverter conditions to give you guaranteed, relevant electrical parameters, not just routine magnetic material data.

Inverter-Rated Ferramic components not only make your design and selection more precise—they work. Developed, tested and specified for inverter applications. So the reliability you design in—stays in.

For applications with unipolar or bipolar switching of direct currents, *Inverter-Rated* Ferramic components deliver. No trial and error selection. No rejects due to cores that only meet a material spec.

Ferrites for inverters are the latest in our growing family of application-rated components. And they're available now in Pot Cores, U Cores, Cross Cores, E Cores and Toroids.

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INFORMATION RETRIEVAL NUMBER 15

news scope

APRIL 27, 1972

Domain-tip memories challenging discs

Domain-tip technology has come of age in two memory products that will be introduced at the Spring Joint Computer Conference in Atlantic City May 15-18. The memories combine the speed of core with the price and permanence of discs.

Cambridge Memories, Inc., is directing the products toward the disc-memory market. The devices are nonmechanical and nonvolatile suggesting wide applications as mass storage units, according to Dr. Robert J. Spain, director of research for Cambridge Memories. Since there are no moving parts, the control electronics are simple and require little power. The resulting compactness allows four million bits to be packaged in a unit 19 by 10 1/2 by 22 inches.

Domain-tip (DOT) technology is a relatively old idea, similar in principle to the bubble memories developed by Bell Telephone Laboratories. The monolithic magnetic domains use an inexpensive nickel-iron-cobalt compound that is vacuum-deposited on a glass substrate. The process uses only two masks and a tough polycrystalline magnetic film. It is less critical and produces higher yields than the process for semiconductors.

Problems in batch fabrication techniques have hindered production of DOT memories at a competitive price. By attaining a storage density of 10,000 bits/inch,^{2} Cambridge Memories has brought the cost down to 0.23 cent per bit—competitive with discs. The densities of 72,000 bits/inch,^{2} which are expected by the end of the year, should bring the price down to 0.09¢ per bit, according to Spain.

Cambridge Memories' DOTram-16, a disc memory replacement, is reported to rival the speed of core. It is a block-oriented, random-access memory and block access time is given as 1 μs. The information within the block is sequentially read, producing an average word access time of 1.75 ms, the company says. The capacity of the DOTram-16 is 65 k by 16, with expansion to 128 megabits projected. A 65-k-by-16 unit sells for $2300.

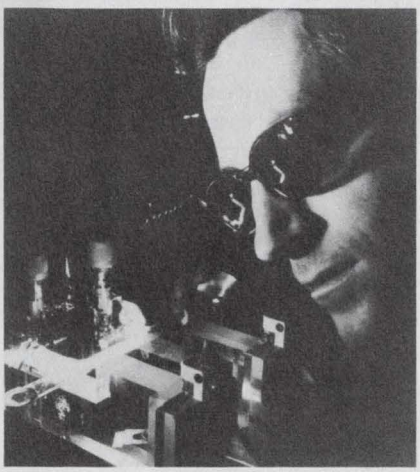
Comparable disc systems have word access times of 50 ms, as in the RK05 DECpack recently introduced by Digital Equipment Corp. A 2.45-megabit DECpack sells for $5100.

The DOTram-4, a smaller domain memory, replaces core when speed is not a factor. Capacity in initial models ranges to 320-k bits at a cost of 0.4 to 0.5¢ per bit. A 4-k-by-16 unit sells for $490 in "moderate" OEM quantities. Other characteristics are similar to the DOTram 16.

Deliveries of the two products begin in June.

Two-inch laser offers optical IC possibilities

A new technique for constructing gas lasers makes them small enough to be used in optical integrated circuits and communication systems.



A new gas laser developed by Bell Telephone Laboratories is only two inches long.

Developed by Peter Smith, a member of the technical staff at Bell Telephone Laboratories, Holmdel, N.J., the technique has resulted in a gas laser that is only two inches long.

The new laser uses a hollow-glass optical waveguide to propagate light in the laser resonator instead of letting the light travel in free space alone, Smith explains. As with conventional gas lasers, he continues, curved mirrors are used at the ends of the laser resonator.

The use of the waveguide as a transmitting medium, Smith reports, is the main reason why development of such a small laser is possible. The optical waveguide has an inner diameter of 0.02 inch, and its inner walls are very straight and highly polished. Light is transmitted through the waveguide by multiple reflections off the inner walls.

Tests of this new laser have been performed with several different types of gas, including helium-neon, heilum-xenon and carbon dioxide. The power output of the laser depends on the gas used; an output power of less than a milliwatt is reported for the helium-neon unit.

The power level for these units is, Smith says, greater per unit volume than in conventional gas lasers. Thus, he continues, if a repeater is required for a laser communications systems, it can be built in a much smaller space.

Smith sees the new technique being used to produce lasers for optical integrated circuits (see "Optical Waveguide Developed as Key to IC Light Devices," ED 8, April 13, 1972, p. 30). While semiconductor diode lasers are more efficient and have a higher power output, they have a comparatively short life and produce an output that oscillates over a large band of frequencies and is distorted, not uniform.

Military urged to alter its relay-testing specs

New military relay-testing specifications have been proposed to overcome what is described as a gap in present procedures.

Present specifications miss the intermediate contact current range

of about 10 to 500 mA, according to Arthur Siegal, senior applications engineer of Deutsch Relays, Inc., East Northport, N.Y., and Ed Thomas, a relay specialist with Grumman Aerospace Corp., Bethpage, N.Y. The two have suggested to the Army Electronics Command, Fort Monmouth, N.J., that Method 312 of Mil-Std-202—for testing intermediate current relays—be amended to include dynamic operation of contacts to 20,000 cycles and a pass-fail test of 3-Ω maximum resistance of contacts.

The amendment would substantially reduce failure rates for sealed relays, especially where the contact chamber is not separated from the coil, the proposal states.

In line with test spec tightening and the drive for lower failure rates, Deutsch Relay has announced the opening of a new clean room for the assembly and sealing of high-reliability relays.

"The semiconductor boys have had clean rooms for years," Thomas notes. "The problem is that relay manufacturers have not educated the public as to the necessity of cleanliness for satisfactory operation . . . As you know, you cannot replace a relay in flight."

IEEE pension plan under consideration

The IEEE is considering starting a pension plan for its members, according to the group's president, Robert Tanner. The idea has been discussed by the IEEE board, he says, but no firm details have yet evolved.

Tanner reported this at a meeting with trade-press editors in the Waldorf-Astoria Hotel in New York City earlier this month. The meeting was held to elaborate on the institute's announcement on March 24 that it planned to become more active in political and economic areas (See "IEEE Announces Major Changes for Next Year, ED 8, April 13, 1972, p. 23).

The institute will also become involved with engineering employment practices, salary surveys, public relations, technological forecasting and continued education and career guidance, according to Tanner.

Under career guidance comes a service the institute is already carrying out: searching for engineering jobs in industries that heretofore have not needed such service. For example, food-processing plants are using more electronic instrumentation and process-control systems that should require permanent jobs for engineers, and hospitals need accurately calibrated instrumentation for the safety of the patients.

While other professional groups carry out extensive lobbying—a practice that even the IEEE is legally permitted to follow—Tanner says the group's present board has no intentions of entering into this area. Also, Tanner says, the IEEE does not intend to become a labor union.

An amendment to the IEEE constitution is required before the group can expand its activities to the areas of pensions, employment and politics.

Ballots for voting on the proposed amendment are to be mailed out to members in September.

Computer show looking for drop in attendance

Like the recent IEEE show in New York, the Spring Joint Computer Conference is expected to suffer a decline in attendance.

According to a spokesman for the American Federation of Information Processing Societies, sponsor of the computer show, the number of exhibitors will be down about 25% and the number of visitors will drop between 10 and 30% compared with last year's 21,360 visitors and 195 exhibitors. The exhibition will be held in Atlantic City May 16-18.

None of the mainframe manufacturers—such as IBM, Control Data or Honeywell—is exhibiting at the show. Nor is Digital Equipment Corp., one of the biggest minicomputer manufacturers. IBM is strongly represented in the organizing committees and in technical sessions, however.

The reason that these manufacturers give for not exhibiting is economics. As a spokesman from Honeywell put it, it is difficult to justify two shows a year (Spring Computer Conference and Fall Joint Computer Conference). The show, he continues, is hardware-oriented, but the marketplace is now applications-oriented.

Norden signs agreement to build British missile

If the U.S. Army decides to buy the British-developed Rapier ground-to-air missile system, which it will field-test this spring, the missile will be built in the United States. The Norden Div. of United Aircraft Corp. in Norwalk, Conn., will build and sell the missile system in the United States under an agreement recently signed with the Guided Weapons Div. of the British Aircraft Corp., developer of the missile.

The McDonnell Douglas Astronautics Co. in Huntington Beach, Calif., will be responsible for building the missile.

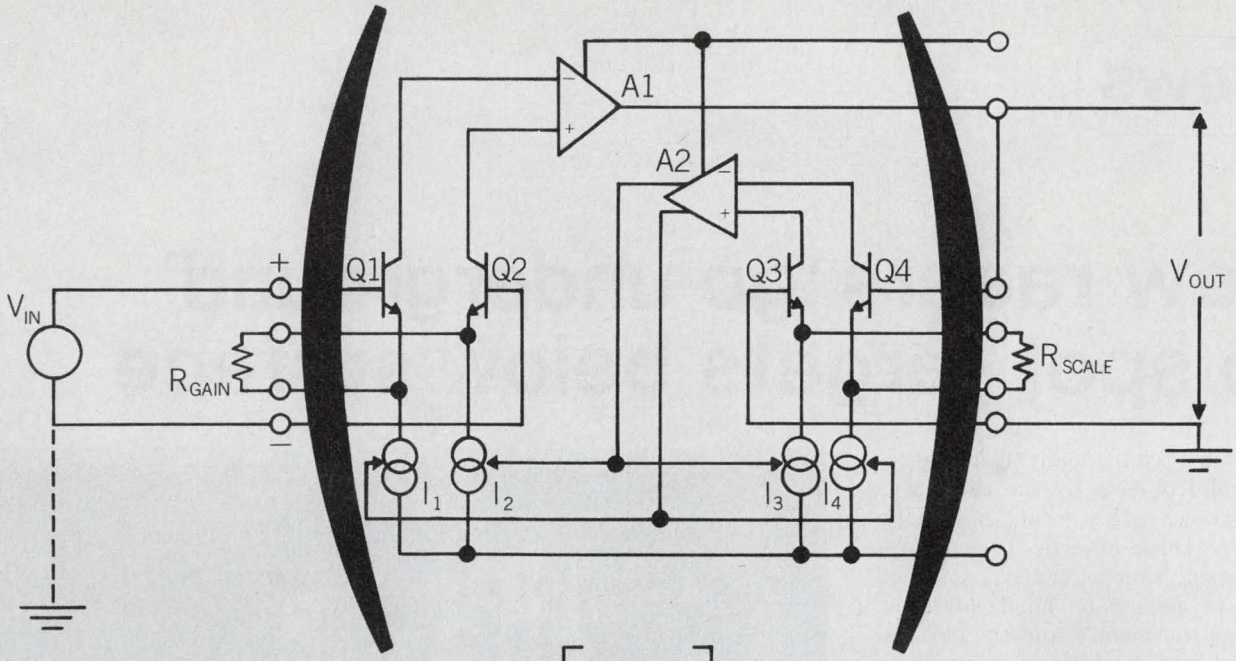
News Briefs

Field tests of a new waveguide glideslope antenna—designed to improve instrument-landing systems at airports where the surrounding terrain makes conventional glideslope equipment impractical—will be started this month by the Federal Aviation Administration.

The EIA Electronics 1985 conference, to be held in Chicago May 18-19, will offer an **overview of prospects for the electronic industries in the next decade,** covering world economics, social, political and technological matters as they bear on the electronics industry.

NASA's Skylab cluster, scheduled for launching in 1973, is to be 118 feet long and to weigh 181,300 pounds. A work area of 12,763 cubic feet is planned.

The first plated-wire memory scheduled to fly in space on a NASA vehicle will be delivered in several months to the Jet Propulsion Laboratory by Motorola's Government Electronics Div. The hardware consists of a pair of fully redundant 1024--by-8-bit memory planes with an access time of 1.3 μs. The memory is to fly on the MM-73 spacecraft to Mercury, Mars and Venus in 1973.



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This is the world's first and only I.C. instrumentation amplifier.
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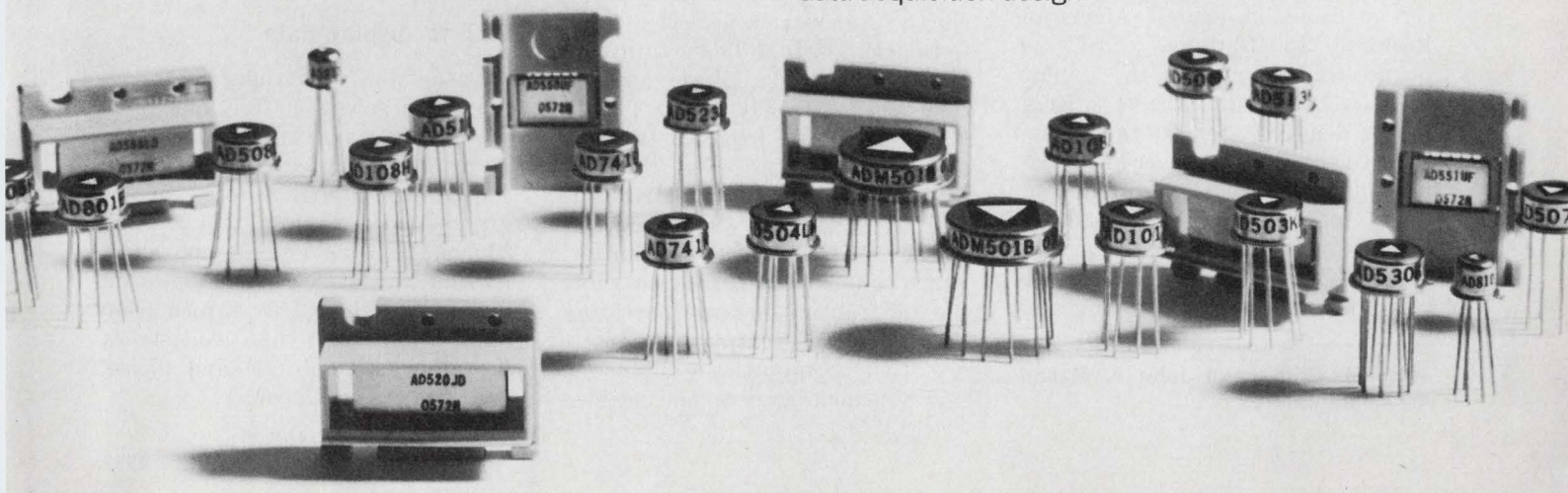


news

New radars 'go underground' to spot targets below surface

Radar—traditionally used to detect solid objects by the radio signals they reflect—can now look through these objects. Two radars, developed independently, will be used to penetrate hard surfaces, such as the moon's and the earth's, and to bounce signals back from targets buried deep below.

The more dramatic of the two radars is called the Lunar Sounder, scheduled to orbit the moon in December on the service module of Apollo 17. This radar will examine the moon's subsurface at various levels from 10 meters down to 1.3 km. NASA hopes to get pictures of lava flows, mascons—the mass concentrations of material on the moon's surface—underground caverns or hollows, soil composition, and—if there is any—water or ice.

On earth this radar could be used to look for oil, water and mineral deposits, make underground geological maps and analyze soil, according to the prime contractor.

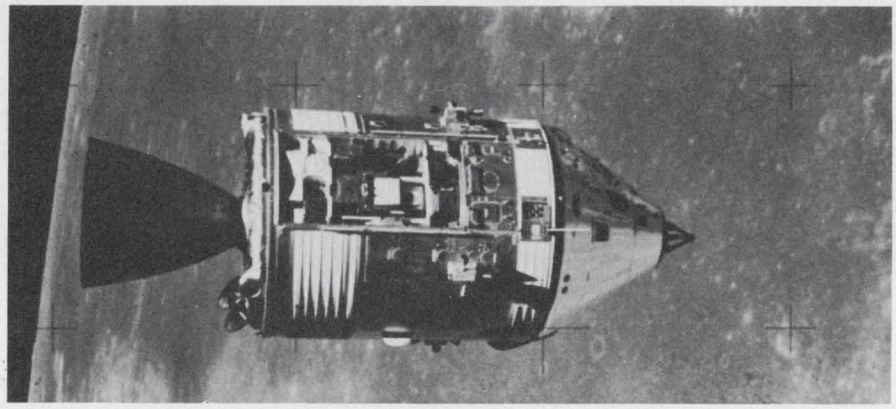
Less spectacular, but with many potential applications, is a Navy-developed radar being tested by the Navy than can look 25 feet below the earth's surface to display the presence of mines, tunnels, water and minerals.

Responsible for the moon radar is NASA's Manned Spacecraft Center in Houston. North American Rockwell in Downey, Calif., is prime contractor for the Lunar Sounder, with subcontracts to RCA in Camden, N.J., for the radar portion, Goodyear Aerospace in Phoenix for the optical recorder and Spar Aerospace Products Ltd. in Toronto, for the radar's two antennas—one vhf and one hf.

Responsible for monitoring the development of NASA's radar have been the Jet Propulsion Laboratory in Pasadena, Calif., and the Ames Research Center at Moffett Field, Calif.

The Navy radar has been developed by the Geophysical Survey Systems in North Billerica, Mass.

Jules H. Gilder and **John F. Mason**
Associate Editors



The Lunar Sounder radar will orbit the moon in Apollo 17's service module, similar to the Apollo 15 module shown here. Retrieval of the radar's film will require a walk in space from the command module and back.

3 frequencies for lunar radar

The Lunar Sounder is a coherent, synthetic, aperture system that will operate on three frequencies: 5 MHz, 15 MHz and 150 MHz. The 5 and 15-MHz beams will be transmitted alternately at a rate of 400 pulses a second, says North American's project officer, Gerald E. Garing. These transmitters will share a dipole antenna that looks straight down. The 5-MHz signals are expected to reach a depth of 1.3 km before they are attenuated, and the 15-MHz signals, approximately 800 meters.

The vhf 150-MHz transmitter, which will not be turned on while the hf transmitters are operating —for fear of creating data interpretation ambiguities—will use a seven-element yagi antenna canted about 20 degrees to the right. This will provide returns from the moon straight down, as well as a little to one side. Its signals will penetrate from 100 to 200 meters.

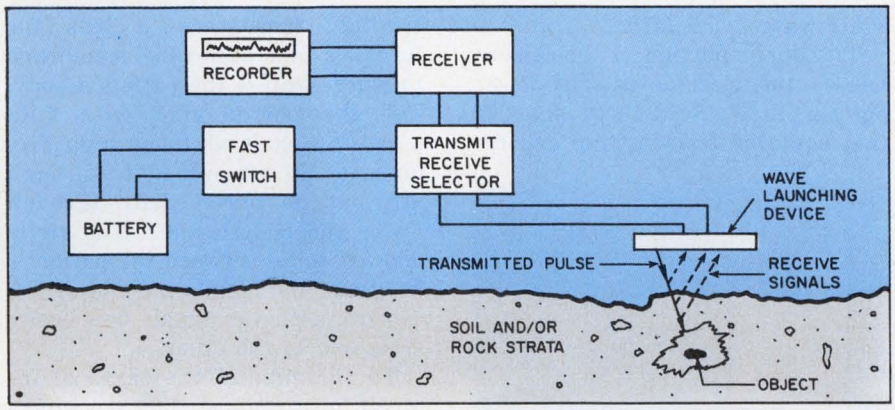
The bandwidth of each beam is 1/10th of the center frequency—0.5 MHz for the 5-MHz beam, 1.5 MHz beam for the 15-MHz frequency and 15 MHz for the 150-MHz beam.

A linear FM technique will be used with all transmitters to provide a chirped signal, which will enhance the resolution and get a better signal-to-noise ratio, Garing says.

CRT to display data

Data from each radar is to appear on a separate CRT, alongside the transmitter, in the form of an intensity-modulated echo or signal return. The signal is to be photographed on a moving strip of film, 200 meters long and 70 mm wide. In this way each echo becomes an individual line. The information contained in each line consists of the signal's amplitude and phase, or its range and doppler.

The film must be picked up by an astronaut who leaves the command module and walks in space to the service module, where the radar and recorders will be located. The information will not be intelligible until it is processed in an optical correlator. Data reduction, which will require approximately one year for completion after the space mission is completed, will be handled by the University of Michigan in Ann Arbor and the U.S. Geological Survey in Flagstaff, Ariz. The scientific objectives of the mission were formulated by the University of Utah in Salt Lake City.



Electromagnetic Subsurface Profiling system uses a fast switch to produce nanosecond, time-limited pulses, which are transmitted and received by a specially designed antenna.

Each radar in the lunar tests will show the surface of the moon and the objects beneath. The first step in determining the distance of objects beneath the surface is to use conventional radar-measurement techniques—converting to distance the time elapsed between transmission of a signal and the return of its echo. This figure must then be adjusted for the particular dielectric constant of the propagation medium of the moon.

"We don't know exactly what this dielectric constant is," says JPL's investigator for the program, Walter E. Brown Jr. "We'll have to make an estimate and try to close in on it in this way."

The NASA radar weighs 44 pounds, the recorder 107, and the antennas—with their ejection mechanisms, to be used in case they will not retract on command—weigh 68 pounds. The whole system checks in at 219 pounds.

The peak rf power is 100 W. Pulse-compression techniques are used, however, which make the effective power 12.8 kW. The raw power used from the spacecraft while the two hf radars are in use will be 126 W. The recorder uses 110 W, making a total of 236 W of maximum dc power at any time.

The radar is to be operational by May and in the air by June, Garing says. Tests will be made in an aircraft flying at 30,000 to 35,000 feet. To find terrain as similar as possible to that of the moon, the flights will be made over Death Valley, the Great Salt Lake, Grand Canyon and over ice formations in Greenland.

Navy radar is portable

The Navy's radar, known as the Electromagnetic Subsurface Profiling (ESP) system, is essentially a broadband pulse type. It is portable and requires only a few watts of power to operate, says Rexford Morey, president of Geophysical Survey Systems. The ESP system, he continues, can locate and describe pipes, mines, tunnels and water below the surface of the earth.

At present marine applications of the device are being studied under a contract with the Office of Naval Research.

The system operates in much the same way that conventional seismic equipment does, except that it uses transverse electromagnetic waves instead of longitudinal acoustic. This, Morey reports, results in a system that does not require close coupling to the ground, as is the case with seismic systems. In addition the antenna can be moved across the ground to scan a particular area—a technique that is not possible with seismic equipment.

In operation, the new radar system emits nanosecond, time-limited bursts of energy that are launched by a special antenna. This transmitted signal is then reflected by the various soil and rock strata in the earth and received by the same antenna. Once received, the nanosecond pulse is slowed to milliseconds and is then recorded on a magnetic tape or chart recorder, producing a continuous profile of the subsurface area. On the profile, high signal levels are represented as black, no signal as white and intermediate signal levels as varying degrees of gray.

The system's range or depth of penetration averages about 25 feet, says Morey. It is dependent on the strength of the signal and the strength of the signal and the frequency content of the pulse.

The narrow pulses emitted by the system contain a broad spectrum of frequencies. The lower frequencies can easily propagate through the earth, as in vlf communications systems. The higher frequencies, however, determine the resolution of the system. The spectral content of the pulses depends on the pulse width. Short pulses have a large, high-frequency content, and thus penetrate only short distances. Conversely wide pulses have a high, low-frequency content, and can penetrate large distances with a loss in resolution.

The idea of using radar to detect objects beneath the ground is not new, says Morey. It was, he notes, first proposed about 20 years ago. However, the components and equipment to do the job only recently became available.

As an example, Morey notes the antenna used in his company's system. While declining to give details, because of a pending patent application, he says it is one of the key factors in the development of the system. Details on the operating frequency and power consumption are also unavailable.

Looking into the future, Morey sees an ESP system with greatly increased penetration that could, installed on an aircraft, be used to locate missile silos. ■■

Acoustic camera to help doctors peer inside body in real time

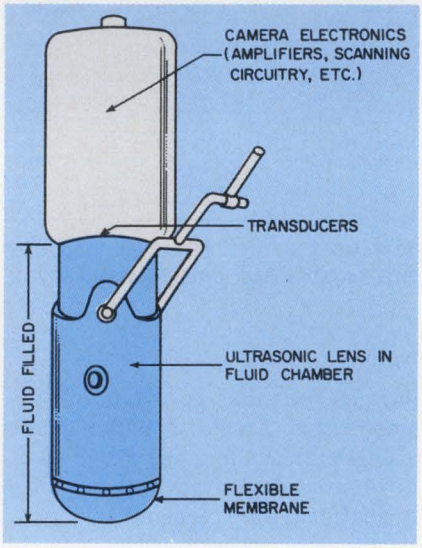
Soon a doctor should be able to look inside a patient's arteries to detect plaque or other signs of trouble quickly, without surgery and without causing pain or discomfort. He should then be able to move on to observe the valve and heart wall motion, the bladder, brain, thyroid, or any internal soft tissue body organ that needs inspection. Each will appear bright, clear and in real time on a television-like display in his examining room.

The instrument that will do this is an ultrasonic camera system now being developed at the Stanford Research Institute in Menlo Park, Calif., under a three-year, $244,000 grant from the National Institutes of Health.

"It's like a TV camera," explains Philip S. Green, SRI's principal investigator on the camera project, "except that its lens doesn't image light but instead a field of ultrasonic waves—3.5 MHz."

John F. Mason
Associate Editor

The upper portion of the camera houses the electronics. The lower portion is a fluid-filled chamber that contains transmitting and receiving transducers, a lens for focusing and a flexible membrane to place against the patient's body. The chamber is filled with fluid because signals at these high frequencies do not propagate through air, but do move easily through water and body tissue. If no air is allowed to lie between the patient's body and the membrane end of the camera, acoustic signals flow easily from one to the other.



The lower half of this ultrasonic imaging camera is filled with fluid to transmit the high-frequency signals to a patient's body.

To "illuminate" the organ of interest, ultrasonic signals are generated by a transmitting transducer in the camera or by one outside the camera. Signals from the camera are focused on the organ of interest, and they bounce back to receivers in the camera. If transmitting tranducers outside the camera are used, their signals pass through the organ and are received by transducers in the camera.

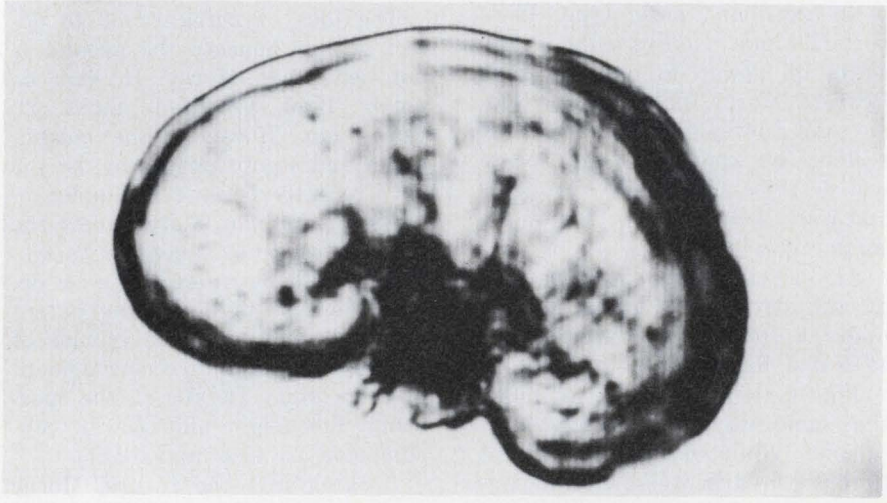
The higher the frequency, Green explains, the better the resolution.

"At 3.5 MHz, the wavelength in water is about 1/2 mm, which means you get good resolution," he notes. "But there's a catch. The higher you go, the greater the attenuation in water and tissue.

"If you try for too much resolution, you end up with no energy, especially if the organ is beneath a great deal of tissue."

Power can be increased to beat the tradeoff, but not indefinitely, since too much power can cause thermal damage. SRI's camera is sensitive enough to require an intensity of no more than 10^{-2} per square centimenter incident on the patient—well below the threshold at which thermal damage can occur.

SRI plans to have the critical components of the camera ready to test in a tank of water by the end of this summer. A complete camera will be ready a year later. ■■



This acoustic image of a lamb's kidney, suspended in water, is of high quality, but it took an hour to make. Stanford Research Institute is developing a new ultrasonic system that will provide images of soft-tissue organs in the body in real time on a television-type display located alongside the camera.

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INFORMATION RETRIEVAL NUMBER 17

Ultrasonic 'people finder' tracks users anywhere in a building

It's going to be tougher for key personnel to get away from it all at work by walking out of the room, if a new ultrasonic "people finder" is installed on the premises. Invented by Robert Lester, president of Recognition Devices, Inc., the system silently tracks an individual to where he is in the building.

The "targets" wear transducer pens in their lapels. In one version —called the Trackatron—the system displays the target's location and the closest phone number on the searching operator's console. In another version—the Trackascan—a computer-terminal CRT display continuously monitors the target.

Jim McDermott
Eastern Editor

The person's name, area location and telephone number are displayed, and should the target leave one area, the system automatically follows him and displays his position as he moves.

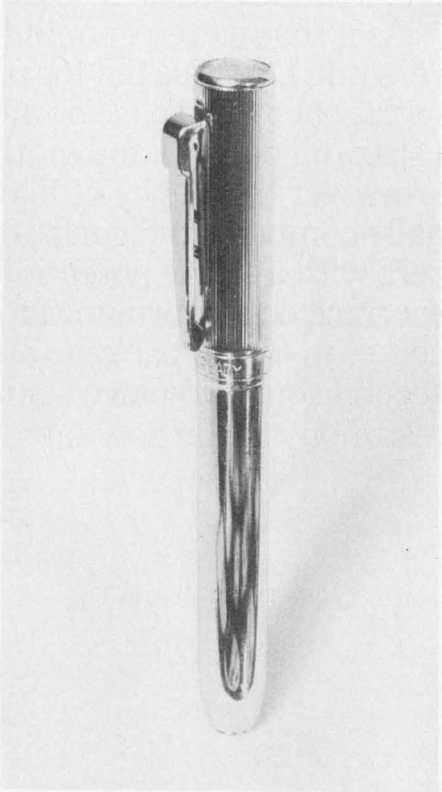
Still a third version—the Finderfone—keeps the target in touch with the nearest phone. If a phone call is placed to him, the unit on his desk (see photo) first silently checks to see if he is present. If he is, the phone rings; if he isn't, the main locator system automatically institutes a search and tracks him down, ringing the phone at his new location.

All versions eliminate the distraction of loudspeaker paging systems and are less costly than radio paging units. An ultrasonic pen transponder sells for about $50, compared with $200 to $300 for radio units. The audible beeps emitted by pocket radio pager units are also eliminated.

The basic element of the new system is an ultrasonic (30 kHz) transponder. The pen package has receiving and decoding circuits that respond only to the target's three-digit identifier code.

The transponder is comprised of a transducer that both receives and transmits 30-kHz signals; a receiver/transmitter integrated circuit; a decoder/reply IC, and a small, rechargeable battery (see figure).

The transponders in the system are queried by coded 30-kHz energy radiated from a network of transducers that are strategically placed throughout a building. The



The Finderfone version of the ultrasonic people-locator system has special phones at key locations. If a person is away from his own phone, the system automatically sends out an ultrasonic query from all phones. The pen transponder, worn by the person, replies to the query. This identifies where he is and causes the nearest phone to ring.

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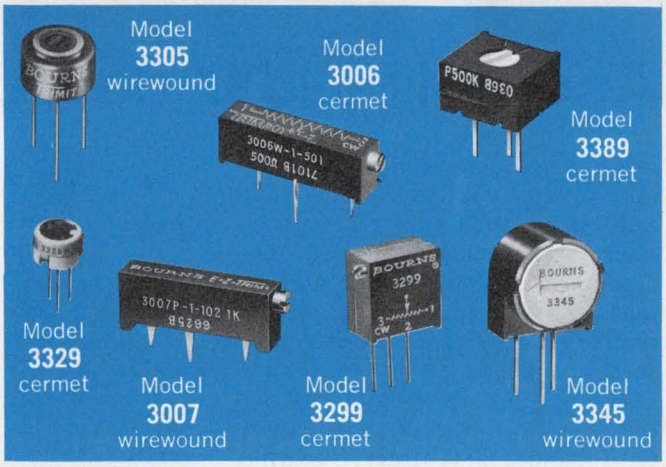

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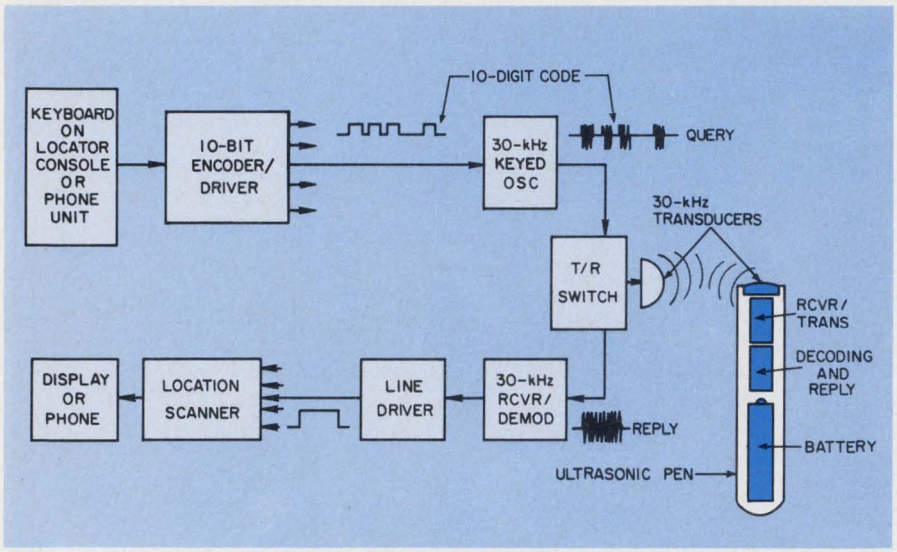
INFORMATION RETRIEVAL NUMBER 18



In the Trackatron finder system, entering a person's code in a seeker keyboard sends out a building-wide ultrasonic query. The person's transponder replies with a 30-kHz burst that identifies his whereabouts.

fixed transducers serve both to query and to receive the pen transponder's reply.

A query is transmitted in 30-kHz bursts of a 10-bit binary code. Each burst, or "one" of the code, lasts for 100 ms. A period of 50 ms is inserted between the bursts to permit room reverberations to settle, says Lester, thereby preventing coding errors in the transponders.

To locate a person, the system operator enters his coded number on a console keyboard. Or, for a phone call, the caller enters the code through the Finderfone keyboard.

The decimal digits of the code are translated into a binary code through an encoder. Then they are transmitted as on-off keying impulses, usually over a spare twisted-pair of telephone wires.

The keying impulses, arriving at the target's location, turn a 30-kHz oscillator on and off to match the target's code. The output of the oscillator is amplified and applied to the target-area transducer through a T/R circuit that first sends the query—which takes about one second—and then listens for two seconds.

For a general search, all transducers are energized together.

The pen transponder, on "hearing" its code, responds with a one-second, 30-kHz burst. This burst is then received by the nearest area transducer, is demodulated and amplified, turned into a keying pulse and sent back down the line to the central terminal.

The terminal scanner rapidly samples the locations and, finding the keyed circuit, identifies and displays it—or rings the phone.

While the various systems can get very complex, Lester says that the hardest job in the development was to design and reduce the required transmitting, receiving and decoding circuits for the pen to IC chip size.

Nominal battery drain of the transponder in the quiet mode is about 0.3 mA, Lester notes, with this value rising to about 2 mA when the device is being queried, and to 10 mA when it is responding.

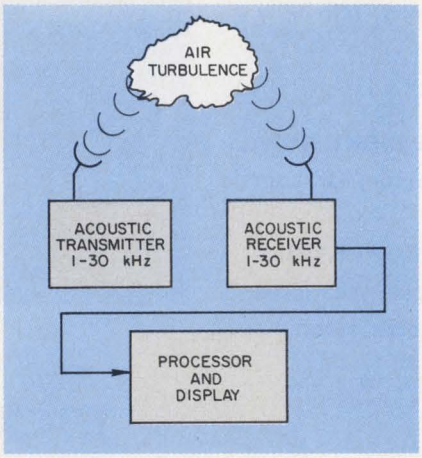
The original concept of discrete area location came to him, Lester says, when his son walked out of the living room with an ultrasonic control for the TV and then returned to ask his father why he couldn't change channels from the other room. ■■

Acoustic radar detects jet turbulence

When jetliners land at airports, they create wake turbulence that can buffet and endanger smaller aircraft that take off or land behind them. Recent studies suggest that acoustic radar may be better than microwave radar for detecting such turbulence.

The studies are being made by the Xonics Corp. of Van Nuys, Calif., under a contract from the Federal Aviation Administration.

In a preliminary test setup, a sonic-wave oscillator, driving a power amplifier and a 3-by-8 array of loudspeakers—all driven in phase to produce a single 3-kHz beam—directed energy towards the disturbance to be measured. Reflections from the turbulence were picked up by a receiver fed by a five-foot dish with an array of seven microphones in the focal plane.



Acoustic radar for detecting aircraft wake turbulence.

Each microphone fed a different channel in the receiver, whose output was then fed into a signal processor and tape recorder.

The output of the processor was interpreted directly in terms of doppler-velocity shifts in the wake vortex and turbulence region. For viewing on a scope, some incoherent integration was employed to decrease the speed and amplitude of the fluctuations at each frequency. ■■

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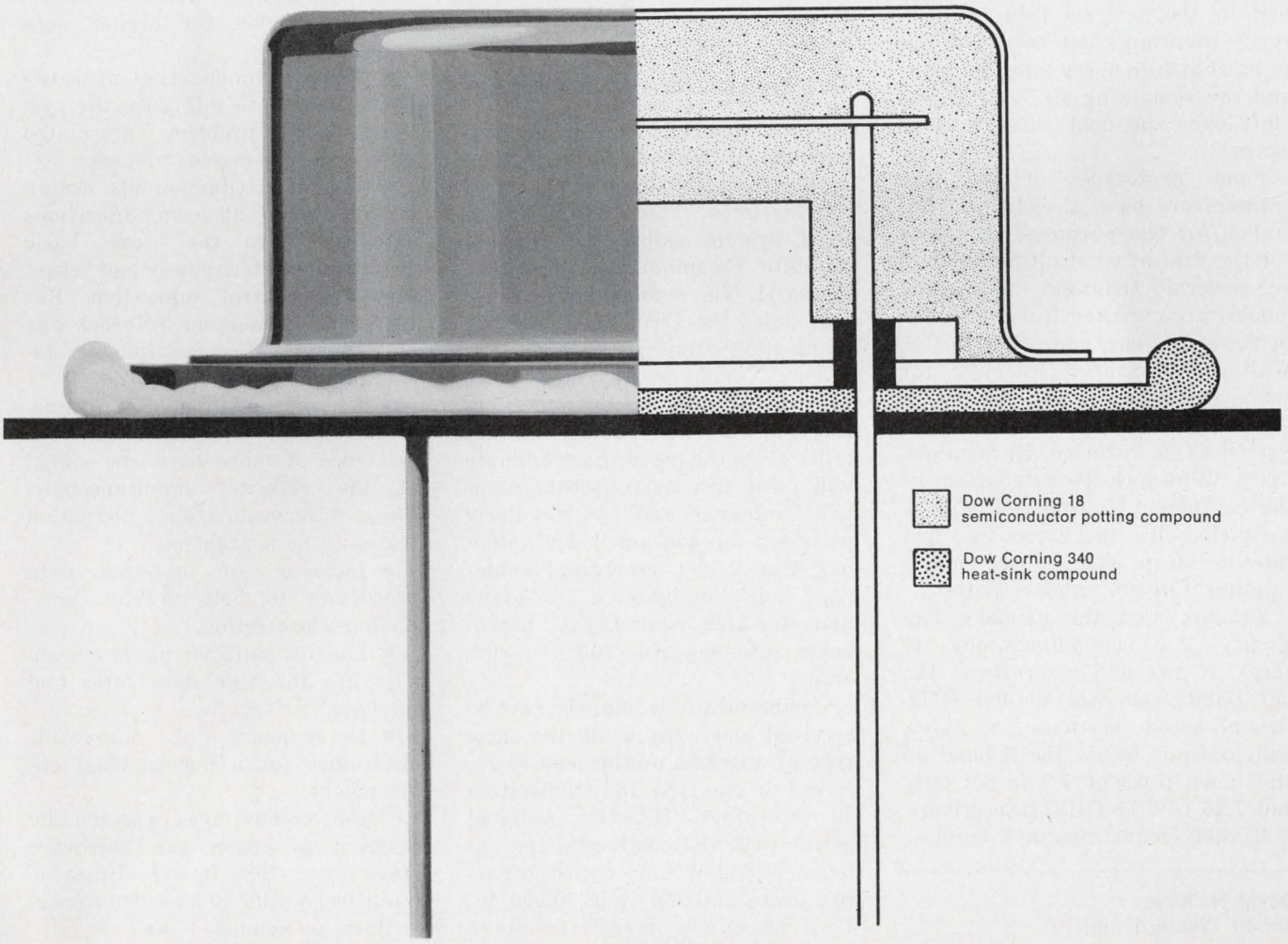


INFORMATION RETRIEVAL NUMBER 19

U.S. to put satcom transceivers in all military planes and ships

The widest deployment yet of transceivers for satellite communications is being planned by the U.S. military in conjunction with the launching of a new generation of communication satellites.

Every ship and aircraft, along with mobile and fixed ground installations, is to be outfitted with new transceivers. The equipment—operating at uhf, X band or higher—will be of different types, built by different companies. It will link all of the armed forces by communication satellites.

Eight satellites, in all, are planned in the system. Two have already been launched, two more are to be shot into space late this year, and the remaining six will be sent aloft over the next three to four years.

Some prototypes of the new transceivers have already been installed for test purposes. Contracts for the first of what ultimately will be several thousand production models are expected to be let within the next year, according to Col. Walter W. Sanders, deputy for space communications systems in the Air Force's Space and Missile Systems Organization, El Segundo, Calif. Widespread installation of the equipment, it is hoped, will be completed by the time the last satellite is up. The big question is funding, Colonel Sanders notes.

Sanders sees the primary frequency for communications to ships at sea and aircraft as the uhf band from 225 to 400 MHz. Ground-based stations, he says, will continue to use the X-band up and down links of 7.9 to 8.4 GHz and 7.25 to 7.75 GHz, respectively.

Higher frequencies in K band or beyond are not seen by Sanders until a 1980 generation of communications satellites is launched. The benefits of a move to higher frequencies include these:

- Availability of wider bandwidths to accommodate higher data rates.
- Relief from spectrum congestion at lower frequencies.
- Increased anti-jamming protection. Some frequencies in this range are greatly attenuated by the atmosphere and could be used for communications with high-flying aircraft without fear of jamming from the ground.

David N. Kaye
Senior Western Editor

Two systems for communicating

Being launched now is the second generation of military communications satellites, made up of two systems. The first is an X-band system called the Defense Satellite Communications System, Phase II. The second is a uhf system called the Fleet Satellite Communications System.

The X-band system will have four satellites in synchronous equatorial orbit about 22,500 statute miles from the earth. Each satellite will have two narrow-beam parabolic antennas and two circularly polarized broadbeam horn antennas. The 2.5° narrow-band antennas can illuminate a 1000-mile diameter area, while the 17° broadbeam antennas give full disc coverage.

Communications signals can be received and relayed via the same type of antenna, or they can be received on one type and transmitted on the other. Effective radiated power with the earth-coverage antenna is 630 W, and with the narrow-beam antenna it is 10,000 W. Two of these satellites were launched last Nov. 2, and the remaining two are expected to be lofted later this year. The satellites are being built by TRW Systems in Redondo Beach, Calif.

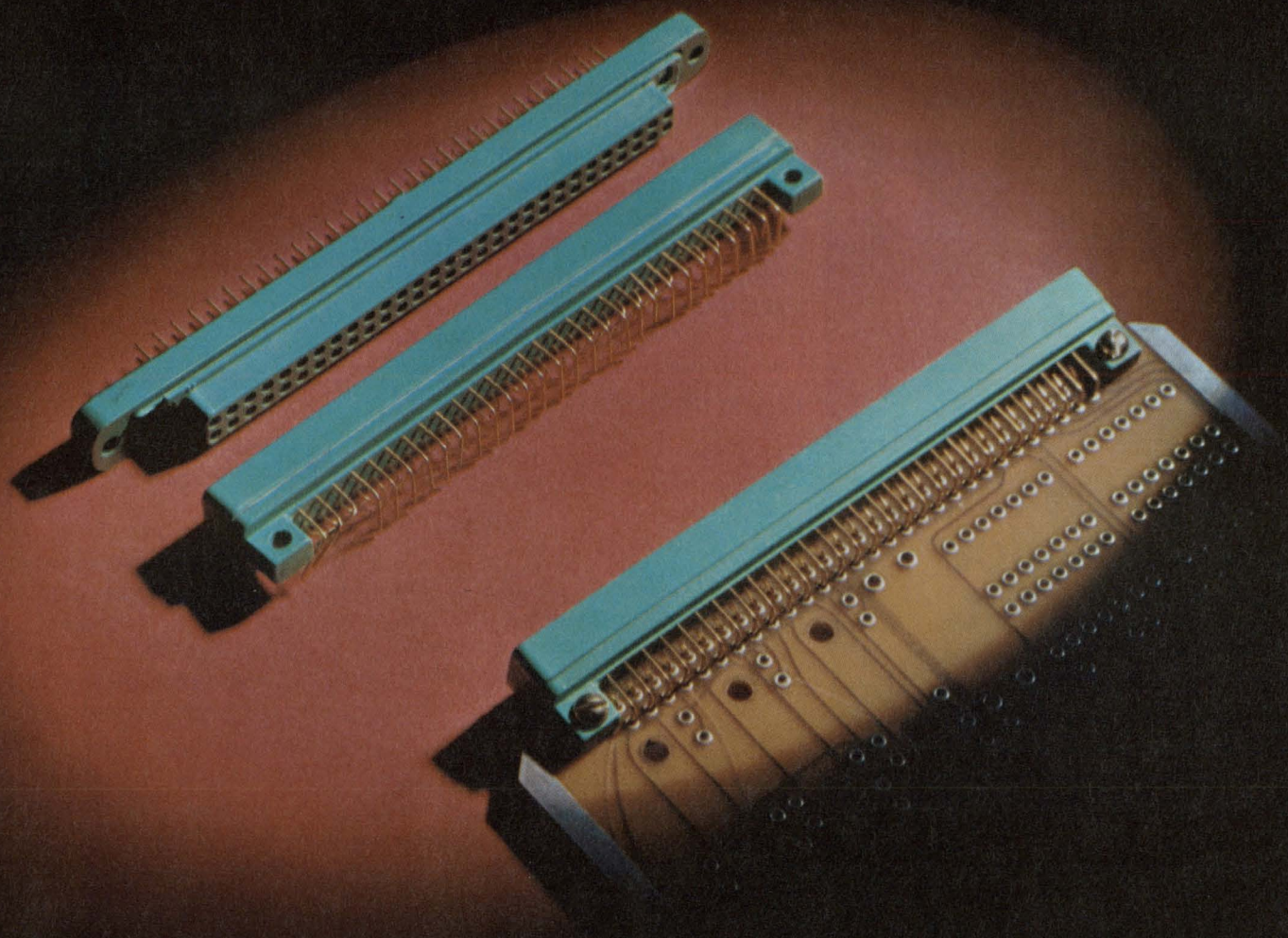
The uhf Fleet Satellite Communications System will also have four satellites in synchronous equatorial orbit. They will provide earth coverage, except for the polar regions.

In addition to higher-frequency operation, Sanders sees the following trends in satellite design:

- Higher-power transmitters to allow the use of smaller terminals and to provide for higher data rates.
- More channelization of satellite repeaters to minimize the system control problems associated with different classes of users.
- Use of a common-bus design concept when all communications satellites have the same basic structure, electric power and telemetry and control subsystem. But there may be several different sets of communication equipment, including antennas.
- Use of time-division, multiple-access operation to eliminate the existence of more than one signal at the receiver simultaneously. Thus intermodulation distortion ceases to be a problem.
- Inclusion of on-board data processors to help provide anti-jamming protection.
- Use of multiple narrow-beam antennas for high data rates and increased privacy.
- Development of survivable electronics for a nuclear-blast environment.

These trends are expected by Sanders to reach the hardware stage about 1980 in a program he tentatively calls "The 1980 General-Purpose Satellite." ■■

Bendix printed circuit board connectors put an end to close order drilling.



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technology abroad

A new photosensitive material for holographic information storage has been developed by Czech scientists. The material is lanthanum-doped photochromic calcium difluoride. Single crystals are thinly sliced and made photosensitive with a short burst of long-wavelength light from a low-pressure mercury lamp. Information can then be stored in the material with a helium-neon laser and erased, when desired, with the mercury-lamp irradiation. The material is reusable and reported free from the grain, or "noise," typical of photo emulsion. The sensitivity of the new material—which was developed at the Laboratory of Monocrystals, Turnov, Czechoslovakia—increases with applied laser power.

CIRCLE NO. 440

A new technique of hybrid-chip bonding—alloy bonding—will not degrade the low-current characteristic of chips, as present methods. The technique will also allow a wider quality range of chips to be employed in hybrid microcircuits. The process is to be developed by Newmarket Transistors under a British Ministry of Defense contract.

CIRCLE NO. 441

A computerized system that gives up-to-the-minute information of bus locations on urban routes has been devised by Britain's Marconi Co. A helium-neon laser beam, projected from the bus above the heads of pedestrians, scans coded reflective strips mounted on buildings and power poles flanking the bus route. The coded pattern is sensed by photodetectors on the bus and stored for radio interrogation from the computer control center. In a pilot project, 40 buses will be fitted with the laser tagging devices. When confronted with a traffic jam, the central-station controller can assess the situation and redirect drivers to alternate routes via the radio link.

CIRCLE NO. 442

An electrolytic diode for reading the oxygen content of liquids and gases has been produced by the WTW Co. of Weilheim, West Germany. Analysis of current flow from a gold-cathode and silver-anode diode configuration yields the oxygen concentration (in milligrams per liter) in seconds, compared with 15 to 20 minutes for other devices. The temperature of the anode-cathode gap is controlled by a built-in thermistor, permitting automatic compensation for temperature variables. Five models of the diode system have been produced, ranging from an operated laboratory system with a digital display to a hand-sized, battery-operated field unit.

CIRCLE NO. 443

A new monolithic IC that extends the range of off-the-shelf counting instruments up to 1 GHz has been designed by Plessey of England. The circuit uses a Plessey process in an ECL configuration to perform a divide-by-two function at these frequencies. Earlier Plessey ICs, capable of dividing by two up to 500 MHz, are already in counters recently introduced by Advance and Racal, English instrument makers.

CIRCLE NO. 444

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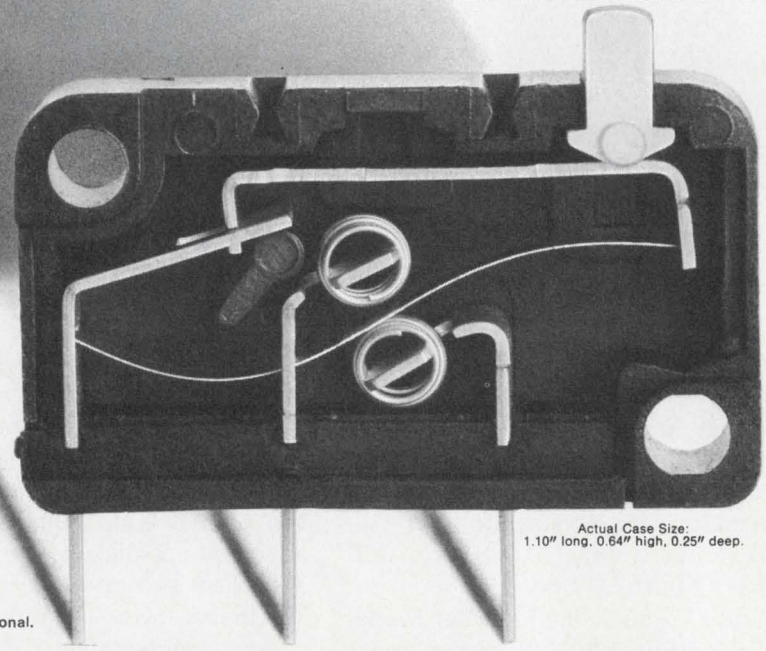

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INFORMATION RETRIEVAL NUMBER 23

washington report

Don Byrne
Washington Bureau

NASA in line for extra funds

The House Space Committee has authorized $3.43-billion for NASA for the coming fiscal year, an increase of $49.95-million over what the agency had asked for. Most of the additional money would go for extra R&D work, especially a study of a short-takeoff-and-landing aircraft. Meanwhile NASA has already appeared before the House Appropriations Committee, which has the final say on money matters, and reportedly was well received.

The Appropriations Committee expects to have its NASA money bill available for floor action early in May. Most observers expect the space agency funds to be pared a bit, just as a matter of routine, but as it stands now, NASA should get most of the extra $49.95-million the House Space Committee has authorized.

FCC to go to court on computer decision

The Federal Communications Commission expects to go before the U.S. Court of Appeals for the Second Circuit in New York sometime this summer to defend its action in turning down petitions for reconsideration of its computer communications decision. The decision bars common-carrier affiliated computer firms from serving both the carriers and outsiders with data processing. Last year the court stayed the implementation of the rules, pending further action before the FCC by the carriers, but it ordered the federal agency to file the record of the case five days after it had ruled on the petitions to reconsider. Action on carrier appeals to the court will now proceed.

Money war embroils services

Reports of bitter interservice fighting over defense spending are surfacing in Washington with great frequency, and when asked if the reports were true, an extremely reliable legislative source told ELECTRONIC DESIGN, "You bet they are," and added: "Up until recently they were too busy fighting McNamara to fight each other, but now its back to normal. They seem to be using their best brains to attack each other's programs."

The Army and the Air Force each received about a $1/2-billion budget increase this year, as opposed to the Navy's increase of $2-billion. The Army and Air Force fear, the source said, that the country is shifting to

a Navy-dominated, "blue water strategy."

There is heavy fighting going on over whether the Air Force F-15 fighter can be substituted for the Navy's F-14. The Navy, of course, wants to keep its own aircraft.

The Minuteman, B-1 bomber and Ulms programs are "all in good shape" as far as funding is concerned, the source says, although some members of the Armed Services Committee seem to feel that the Navy has not really been convincing on the reality of a Russian naval threat. They add, too, that the approximately $900-million requested for Ulms this year was a political matter. It was intended to show the Russians that if no agreement was reached in the disarmament talks the United States would not sit idly by and watch the Russians build up a missile superiority. The same committee sources also said they felt that President Nixon would return from Moscow in May with a disarmament agreement. It remains to be seen whether the missile-carrying submarines are included in the arms limitations, a position the United States has been pushing in the talks.

Defense Dept. opposing satellite limits on AT&T

The Defense Dept. has told the Federal Communications Commission it would be unduly burdened and restricted in its purchase of military communications service if the FCC limits AT&T to providing only interstate and wide-area telephone service (WATS) by satellite. Such a limitation was recommended by the FCC's Common Carrier Bureau.

In oral arguments, which began this month, the Defense Dept. is expected to point out that it purchases virtually all of its domestic commercial communications from AT&T and that if it offered only limited services, the defense agency's flexibility would be impared and economies in the private-line services it purchases would be reduced. Some 26 parties will be heard in the oral arguments.

Capital Capsules: FCC Chairman Dean Burch and consumer activist Ralph Nader will address **the National Cable Television Association's annual convention in Chicago May 14-17.** David H. Foster, executive vice president of the Data Transmission Co., will be named new president of the association. . . . Apparently the howls from U.S. electronics manufacturers are being heard in Japan. Kakuei Tanaka, Minister for International Trade and Industry, **has warned Japanese manufacturers that they may face tight restrictions in the U.S.** if they don't restrain their export policies. He ordered "administrative guidance" tightened on Japanese manufacturers. . . . The FCC **has approved construction of the sixth trans-Atlantic telecommunications cable,** TAT-6. AT&T, ITT World Communications, RCA Global Communications and Western Union International will build the 4000-circuit, $145-million cable from Rhode Island to France. It's to be in operation by 1976. . . . The Dept. of Transportation **has awarded a little over $3-million to three firms for a battery of computer programs that will allow transportation planners to judge the effect of a proposed system on any city in the country.** The contracts are part of the Administration's over-all $4.1-billion program to improve mass transit. . . . **The FCC has given a construction go-ahead to the Data Transmission Co. for a nation-wide microwave communication system.** The network will cost approximately $300-million.

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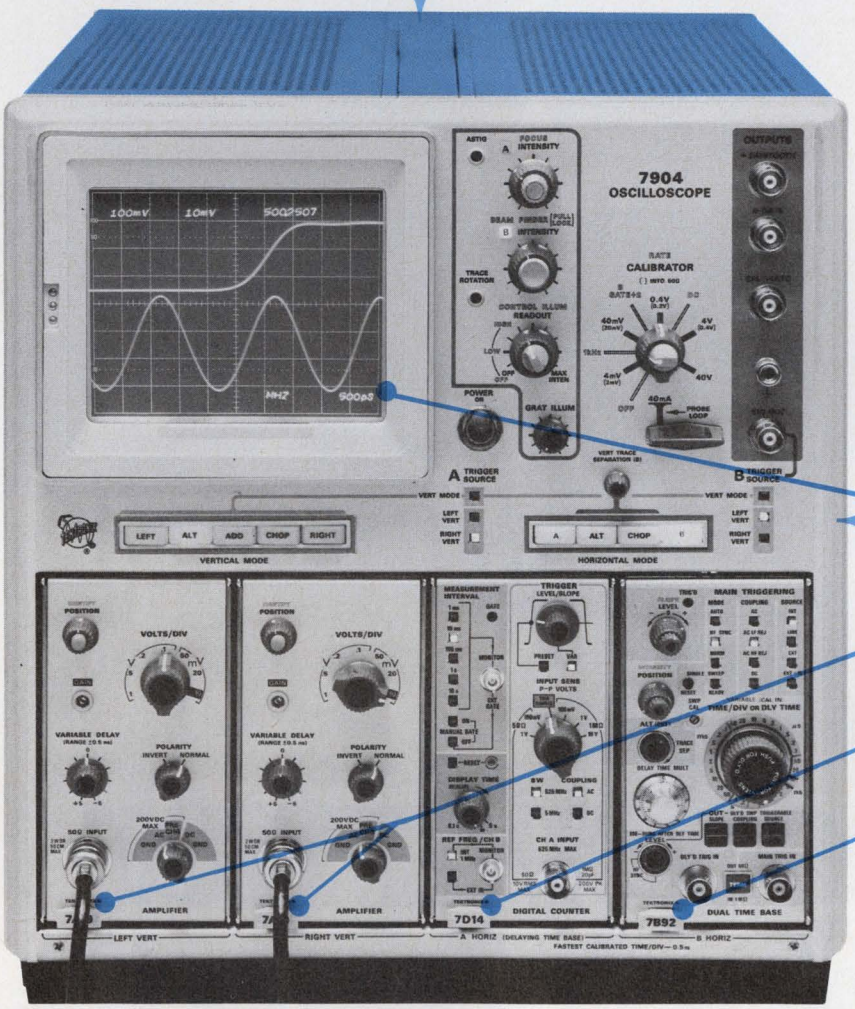

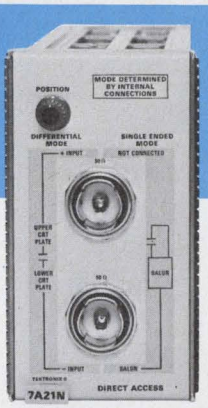

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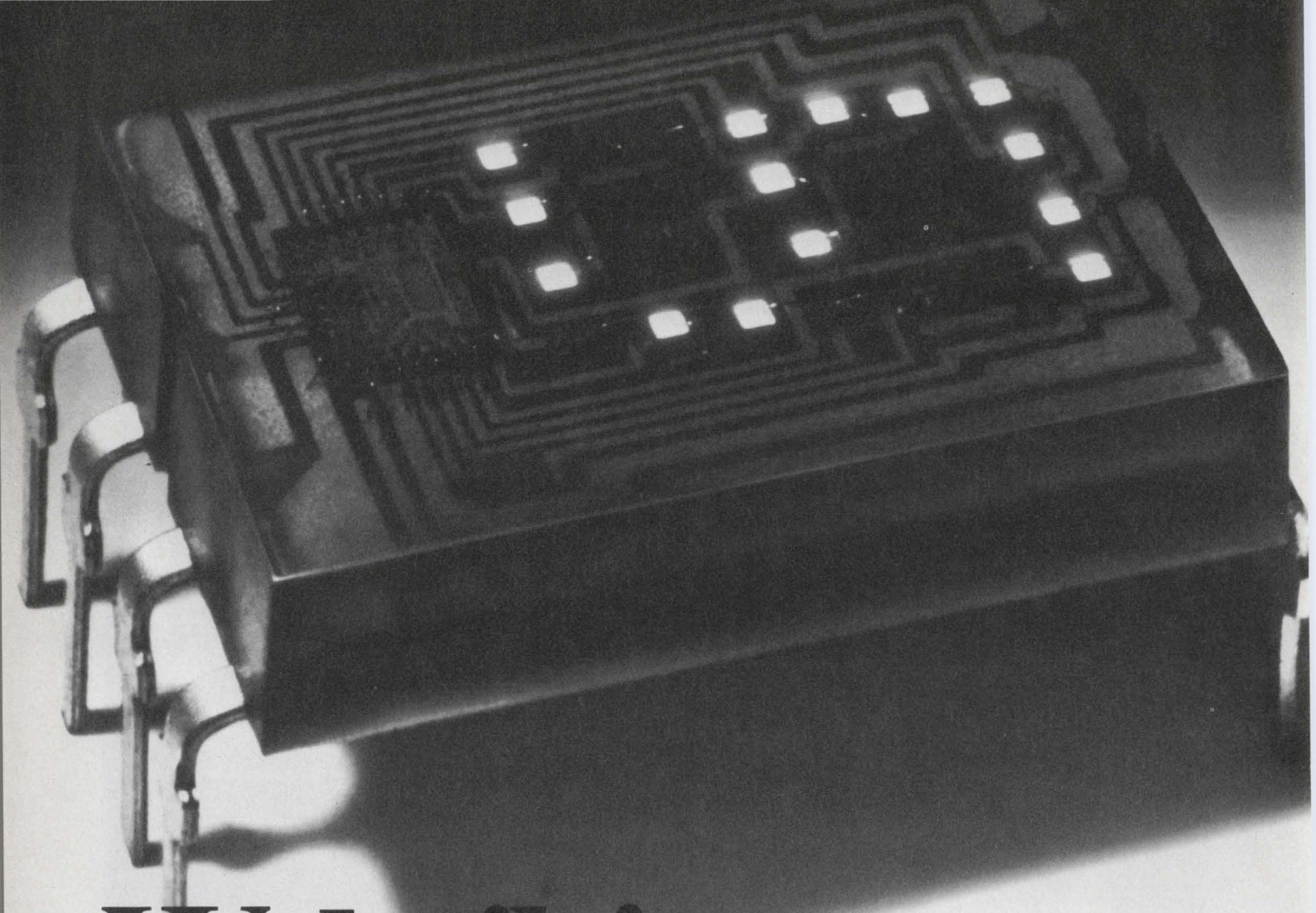

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INFORMATION RETRIEVAL NUMBER 25

editorial

Playing the game without knowing the rules

A fellow popped in the other day with a fascinating story. "George, old buddy," he began, after we'd guzzled some coffee and traded some worn-out jokes, "we've got the most sensational product this industry has ever seen. We use state-of-the-art components throughout the box, and we have unbeatable design.

"We have an engineer locked up in a back room at our shop, and he's the most brilliant guy you'll ever meet. He has a computer for a brain, and our new box is his baby. We know we'll take the industry by storm. This thing measures voltage, current, resistance and ratio with astounding accuracy."

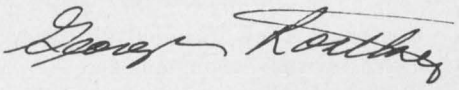
After we kicked some of the specs around, I asked him, "Who's going to buy this thing and why?" Well, he stammered a bit and told me more about his brilliant engineer and spectacular instrument. But he never told me why more than a handful of engineers would buy an extravagantly expensive instrument to replace less costly instruments that do the same job.

I have a strong feeling his instrument will prove a stunning failure. About a year from now, he's going to feel rather bitter about the stupidity of engineers who didn't storm him with purchase orders. Unfortunately his case is common. Almost every week someone trots into my office with a comparable story. In most cases, the man comes in with the sensational product designed by the brilliant engineer and *he* asks *me* where the market is.

This really happens. I'm not making it up. Companies spend thousands of dollars developing products before figuring out who needs them.

And that violates one of the important rules of the game: To survive in business, you've got to make a profit. It's hard to make a profit when people don't buy your product. And they're not likely to buy the product if it's not what they want or need.

It's a pleasant fact that most of us enjoy engineering. It's pleasant, too, that many of us have electronics as a hobby as well as a profession. But as our industry becomes more competitive, we must not let our hobby interests interfere with our professional interests. We can't design products to please ourselves if they don't please the customers.



GEORGE ROSTKY
Editor

Compare your career with your peers.

See how you compare with other engineers in this survey, and if you agree with them on what's wrong with your profession and country.

Richard L. Turmail, Management Editor

Are you suffering from middle-age letdown? Or put-down? Have your idealistic standards faded into oblivion because you've lost close contact with the world outside your job?

And if you're under 30, does it seem as if your career is stagnating—that those over 30 are getting all the promotions because "they have more experience?"

Why not see how you stack up against the competition—by age, job title, industry, location, salary and education. To help you compare your job growth, opinions and operating philosophy with those of your colleagues, ELECTRONIC DESIGN has just completed a comparative identity survey.

Aside from standard-pedigree questions on age, job title, salary, etc., the survey asked for information like this:

Please state your job objectives.

Describe your most satisfying career accomplishment.

What are the three most pressing problems of your profession? What are your solutions?

What is the most pressing national problem?

What is the most impressive book you've read?

Who is your hero?

Briefly state your operating philosophy.

If you're married, how much say does your wife have in your career decisions?

Are you "moonlighting"?

The results are interesting in two ways: First, most engineers and managers are not empire building; they're hanging onto their jobs without too much thought about taking the boss' job or going into business for themselves. Second, their choice of books and heroes and their opinions place them on the conservative side. Most sincerely despair over today's problems, whether professional or national but they do not see themselves as contributing to the general unrest.

About this survey

This article reports the findings of a survey conducted in December, 1971, among subscribers to ELECTRONIC DESIGN. We mailed 1000 questionnaires to a randomly distributed domestic sample of our circulation: 324 replies were returned in time for analysis. Respondents were asked to reply anonymously.

The questionnaire contained 20 items. The respondents were told that the information they supplied would be used in a management article designed to inform them how they compared with their colleagues in career progression.

He's young and design-happy

Who is the average respondent? He's apt to be young—nearly two-thirds of those replying to the questionnaire were less than 40 years old (see Profile on opposite page), and one in every three was a manager. Half of the sample was working in the computer, aircraft or communications industries. Slightly over half was working on either the East or West Coast, with the Midwest the next choice of location (Fig. 1). Nearly three of every five respondents had an annual salary of $15,000 or more (Fig. 2).

By age groups: Four of every five in their 20s was earning less than $15,000; two of every three in their 30s, and three of every four in their 40s, was earning $15,000 or more. And one of two in their 50s earned $20,000 or more.

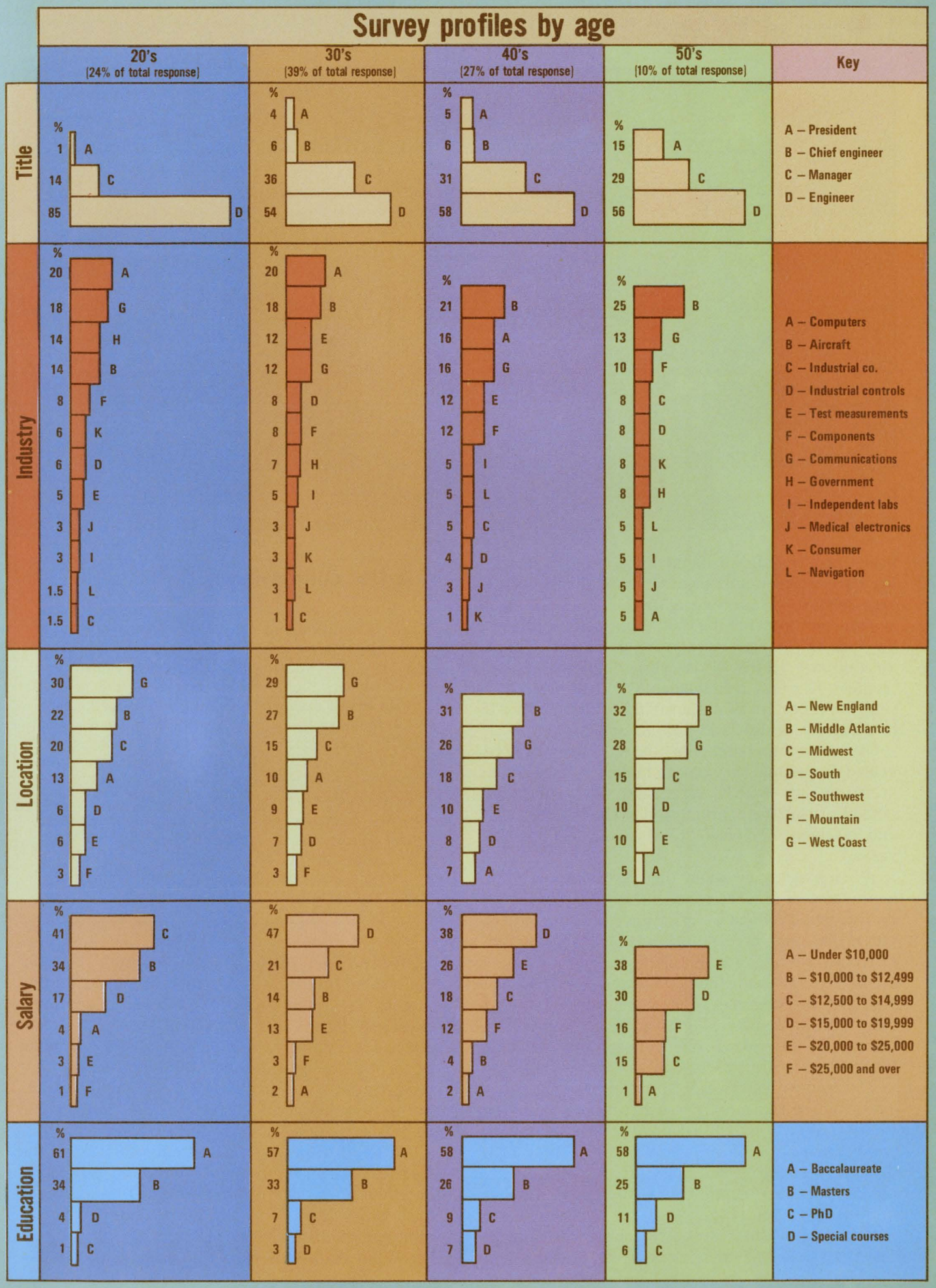
Our engineering man is educated and then some. One in every three has a master's degree, and one in every 20 a PhD (Fig. 6).

About two in every five respondents considered "better design" to be their most important job objective, with the 20s age group emphasizing design evaluation; the 30s, development; the 40s, application; and the over 50s, reliability. About one-third of the engineers said that management was their most important career goal; the emphasis was on advancement and owning their own business.

Other career objectives were: keeping pace with the technology; making a contribution; and earning more money (Fig. 3). One engineer in his 40s in computer work in the Southwest spoke for many of his peers by summing up his career objective this way: "To perform a service; to learn a little; to teach a little; to keep my job!"

Predictably, the majority of responding engi-

Survey profiles by age



1. Where are the respondents located by industry?

Industry	New England	Middle Atlantic	South	Midwest	Southwest	Mountain	West Coast
Computers	19%	27%	13%	12%	4%	–	25%
Aircraft	10%	23%	6%	13%	10%	2%	36%
Industrial companies	–	60%	10%	20%	–	–	10%
Industrial controls	9%	35%	14%	26%	–	–	16%
Test measurement	8%	16%	11%	8%	16%	3%	38%
Components	4%	17%	12%	13%	17%	4%	33%
Communications	14%	24%	10%	14%	–	2%	36%
Government	7%	33%	7%	22%	7%	–	24%
Independent labs	8%	15%	–	8%	23%	8%	38%
Medical	–	30%	10%	–	50%	–	10%
Consumer	7%	32%	7%	32%	–	7%	15%
Navigation	–	55%	9%	27%	–	–	9%

neers and managers listed under "most satisfying career accomplishments" those that were design-related—improving a product, developing a system or confirming an application theory. Typical of the responses was this comment from an engineer in his 30s working in medical electronics: His best achievement, he said, was "cutting the labor in manufacturing a part from $15 to $0.05 by design and automation."

Other accomplishments listed, however, revealed a personal struggle to make good. Such as: "Getting my BSEE after six years of night school"; "Getting a promotion without a degree"; and, a timely response, "Changing fields after 20 years."

When questioned about their professional problems, most engineers consistently listed the same half-dozen problems, including growing unemployment; lack of recognition; keeping pace; lack of challenges; not enough money for decent wages or R&D; and poor management (Fig. 5). The younger the engineer, the more worried he appeared to be about losing both his job and recognition. As he grows older, however, his main concern is keeping pace with the state of the art.

Electronics engineers and engineering managers figure the most pressing national problem to be the state of the economy, with unemployment placing fourth in headache size behind poor national leadership and pollution. An uninformed public and the Vietnam war round out the top six national worries (Fig. 7).

Concerning the economy, many respondents felt that raises should not be given without productivity. One oft-mentioned solution to help neutralize inflation was "curtailment of union power." A middle-Atlantic computer company president in his 40s put it this way: "For all American industry, the most pressing problem is the failure of the labor force to realize that rewards must be proportional to performance, not to personal needs or desires; the whole world is in competition."

An engineering manager in his 30s from the Midwest summed up the thoughts of many respondents who were worried most about poor leadership. He said: "There's no common commitment, no feeling of working together, from the White House down to the man in the street.

A few comparisons . . .

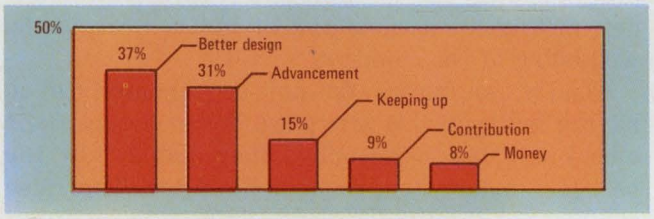
The results of a similar ELECTRONIC DESIGN survey appeared in an article, "Are You Engineering Your Career?" (ED 22, Oct. 25, 1969, p. 98). At that time the electronics industry—particularly the aerospace segment—had peaked with man's first moon landing. Considering how the industry has cut back since then, we thought a few comparisons would be enlightening.

In two and a half years engineers average $2500 more annual salary; 16% more (40% compared to 24%) earn master's degrees; 4% more (15% compared to 11%) work in computers; and 9% less (9% compared to 18%) work for the Government. The geographical distribution of engineers, and average age group (under 40), are the same.

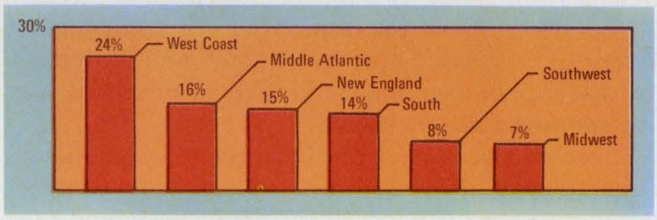
2. Navigation, aircraft, and middle Atlantic offer highest salaries.

Title Industry Location	Under $10,000	10,000 to 12,499	12,500 to 14,999	15,000 to 19,999	20,000 to 25,000	Over 25,000	15,000 and Up
President, V.P.	–	–	7%	31%	31%	31%	93%
Chief engineer	–	28%	–	36%	18%	18%	72%
Manager, director, leader	4%	1%	10%	40%	28%	17%	85%
Engineer	2%	19%	33%	35%	10%	1%	46%
Computers	–	13%	27%	33%	21%	6%	60%
Aircraft	–	7%	28%	48%	16%	1%	65%
Industrial companies	–	28%	28%	16%	28%	–	44%
Industrial controls	5%	9%	36%	32%	9%	9%	50%
Test measurement	4%	28%	28%	24%	12%	4%	40%
Components	4%	16%	16%	30%	22%	12%	64%
Communications	–	12%	26%	35%	20%	7%	62%
Government	–	18%	18%	50%	11%	3%	64%
Independent labs	8%	8%	23%	38%	15%	8%	61%
Medical	–	50%	25%	17%	–	8%	25%
Consumer	23%	15%	9%	23%	15%	15%	53%
Navigation	–	–	20%	40%	20%	20%	80%
New England	–	16%	30%	40%	10%	4%	54%
Middle Atlantic	–	12%	23%	35%	20%	10%	65%
South	17%	8%	13%	50%	12%	–	62%
Midwest	4%	18%	34%	32%	8%	4%	44%
Southwest	–	24%	24%	32%	16%	4%	52%
West Coast	1%	14%	23%	40%	13%	9%	62%

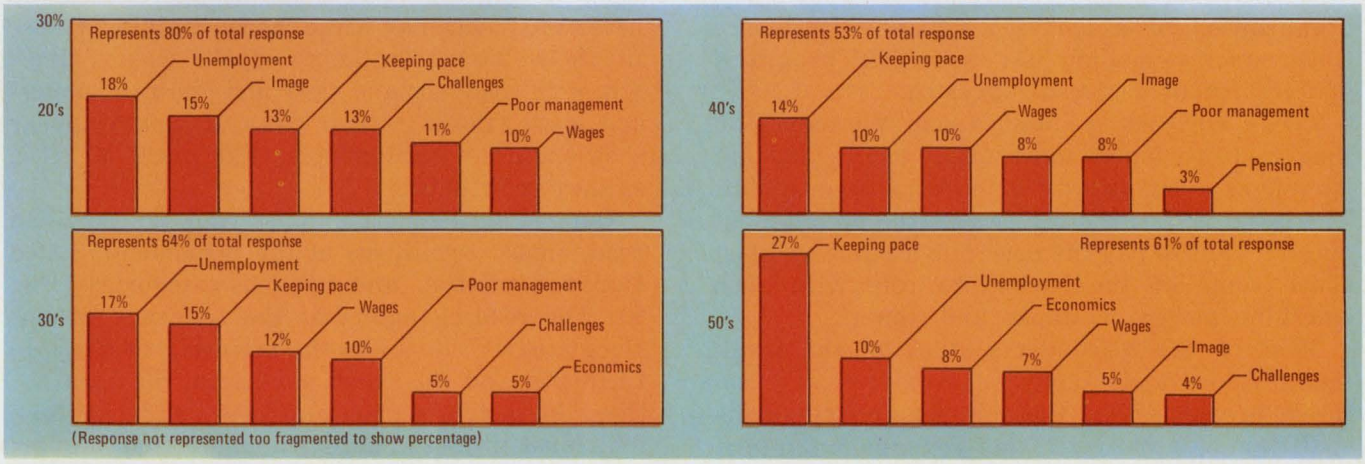
3. Better design and advancement are top job objectives.



4. How many moonlighters coast to coast?



5. Professional problems by age: unemployment and keeping pace top worries.



6. How educated is the EE and his manager?

Title Industry Location	Special courses	B.S.	Masters	PhD
President, V.P.	8%	58%	17%	17%
Chief engineer	–	58%	42%	–
Manager, director, leader	6%	48%	37%	9%
Engineer	14%	33%	47%	6%
Computers	4%	64%	30%	2%
Aircraft	3%	65%	30%	2%
Industrial companies	33%	50%	–	17%
Industrial controls	7%	60%	33%	–
Test measurement	12%	46%	42%	–
Components	16%	58%	16%	10%
Communications	10%	50%	40%	–
Government	–	71%	21%	8%
Independent labs	22%	22%	44%	12%
Medical	12%	38%	50%	–
Consumer	10%	60%	–	30%
Navigation	–	40%	40%	20%
New England	3%	50%	40%	7%
Middle Atlantic	10%	57%	25%	8%
South	20%	70%	10%	–
Midwest	12%	57%	26%	5%
Southwest	–	45%	55%	–
West Coast	8%	55%	33%	4%

Each person seems concerned only for himself; political gain is the only motivation of our leaders."

Solutions given for improving our environment were to "recycle," "convert waste" and "intensify research," but no one could offer a practical way to sponsor those activities.

Two of the better solutions given to help avoid unemployment caused by Government contract terminations included Government assistance for contractors in developing commercial products and the issuing of contracts only to those who have half their work in the commercial field. The organization of a lobbying group to influence Government spending for scientific programs and equipment was also suggested.

Those who worry most about Vietnam said that the Government must adjust to the fact that its role as a superpower is too expensive to play. The belief is that the U.S. wants the prestige but doesn't want to pay the price for it; that we must share some of the leadership role with such emerging powers as Japan and China.

Most of the respondents stuck to the traditional values and virtues in assessing, say, national problems. But there was a feeling of despair among many of the younger engineers. Many just didn't believe there were any solutions to some of the country's problems. They felt that everyone was out for himself, regardless of how detrimental his actions and attitudes were to the well-being of the country.

Clearly, engineers do not see themselves as having irresponsible attitudes. When listing their own operating philosophy, they listed "do the best job" most often, regardless of age. They also emphasized the Golden Rule—"live and let live," "never work a hardship on another person"—and knowledge—"adapt," "profit from the mistakes of others." The only decipherable trend here was, "make hay while the sun shines" (those in their 20s); "organize—don't waste time" (those in their 30s and 40s) and "be fair, honest and just" (those in their 50s). It would appear that engineers mellow, just like everyone else, as they grow older.

Quizzed on the most impressive books they had read, almost two-thirds of the respondents listed fiction, nonfiction, and religious categories (Fig. 8). The reading habits of the four age groups fluctuated: Fiction was the mainstay of those in their 20s and 40s, and nonfiction the meat of those in their 30s, 50s and over. Half a dozen individual titles accounted for more than a quar-

To the respondents: Thanks!

To the more than 300 subscribers who took the time and trouble to complete our rather detailed questionnaire: Thank you. Your effort is of service to all electronics engineers and engineering managers. You've given them some useful benchmarks against which to compare their own careers.

Many thanks also to Mrs. Marjorie Duffy, Editorial Assistant at ELECTRONIC DESIGN, whose tabulation of most of the survey response made the article possible.

ter of the response. The titles, and the reasons most often given for reading them, were:

"The Bible" (13%), "because it has all the answers."

"Atlas Shrugged" (6%), "because it offers an alternative to our present altruistic society."

"Future Shock" (3%), "because it questions man's ability to adapt."

"1984" (2%), "because it shows where we are going, unfortunately."

"Up The Organization" (2%), "because it makes sense."

"The Source" (2%), "because it shows the individual's role in making progress."

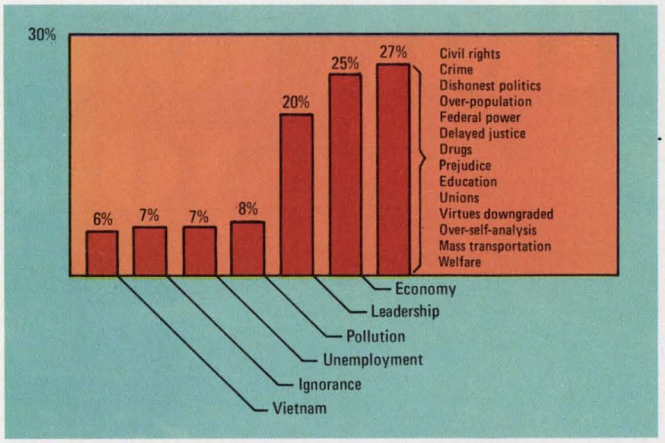
What about moonlighting? Most electronics engineers tend to make do on their salary. Only one in five respondents in each of the four age groups earned a second income. Most oft-mentioned outside jobs were teaching, consulting, electrical contracting and operating a small business. The highest percentage of moonlighters (24%) was on the West Coast (see Fig. 4).

When asked how much say their wives had in their career decisions, one engineer said: "None, except in the usual subliminal influence of females," while another, more harried, respondent commented: "Anyone who says anything less than 'considerable' just isn't telling it the way it is." Most agreed that their wives had at least *some* say in their career directions (Fig. 9).

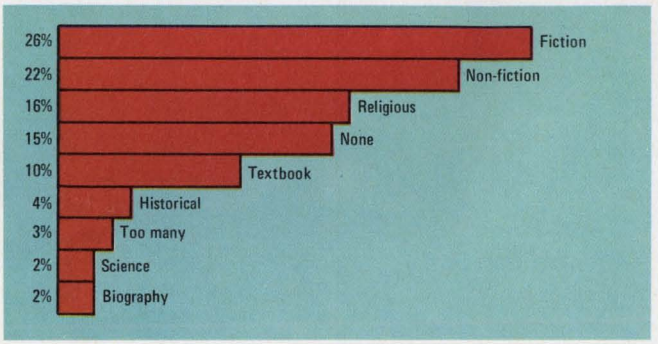
When it came to naming a hero, the answer was simple for some respondents, who said: "He's a friend who's happy," or "My father," or —an answer that more nearly reflects the times —"Anyone who does a good job." A negative influence was also noted—such as, "He's dead," or "He's not born yet," or "I'm too old to have any heroes left." There was also this philosophical note: "In an age of no heroes, you ask this?"

The most mentioned categories and heroes were religion (Jesus Christ); politics (President Nixon and John F. Kennedy); and science (Edison and Einstein). Those three categories accounted for nearly one-third of the total response. The

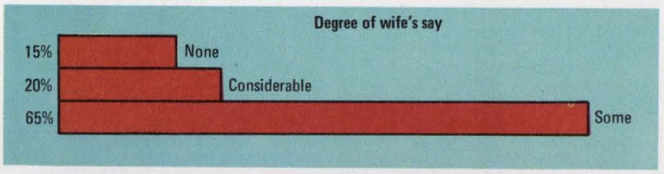
7. The most pressing national problems.



8. Books: 1 in 4 prefer fiction.



9. Can 8½ wives in 10 be wrong?



remaining, most-mentioned categories and heroes were in order of selection: military/aerospace (any astronaut); cartoon (Snoopy); great leader (Lincoln); show-business personality (John Wayne); the arts (Ayn Rand); entrepreneur (Hugh Hefner); and watchdog (Ralph Nader).

In short, then, the electronics engineer and his manager are aware of much that is wrong, but they have few solutions for the problems. Frustrated by their own impotence in this, they try to find satisfaction in their work. One Southern manager in his 30s, put it this way: "My challenge is trying to find satisfaction when 80% of the time is required for trivialities, such as checking parts lists for accuracy, while management inhibits inventive approaches."

Another engineer commented on today's overemphasis of youth orientation. He said: "I've decided not to recommend electronics to my son, except as a hobby. It's difficult to deal with young engineering managers who have no experience and judgment, but one must because the mentality of the times is geared to 'being young'." ■■

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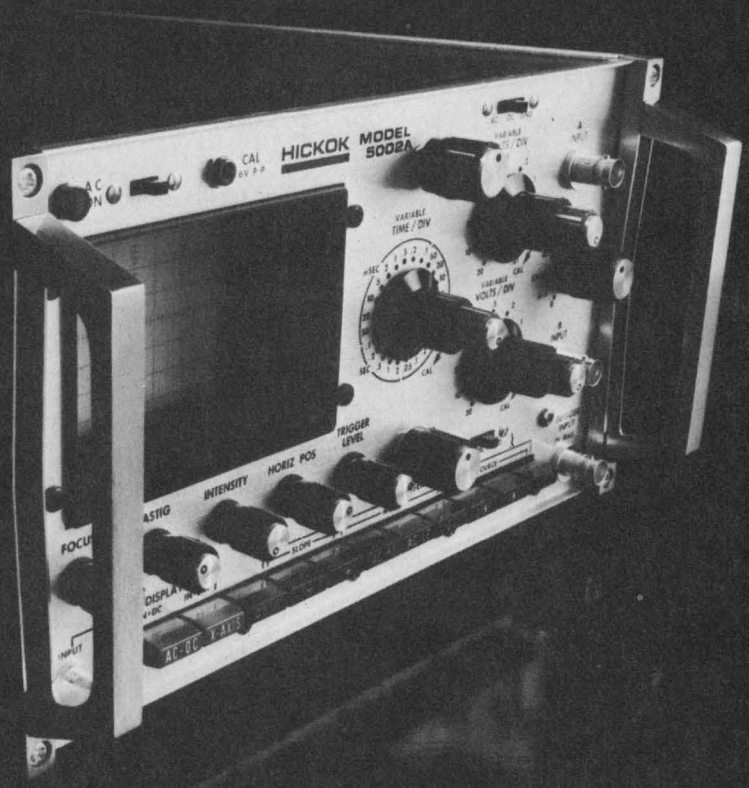

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INFORMATION RETRIEVAL NUMBER 27

Cut transients in FET analog switches.

Data sheets don't help much, but measuring transferred charge is helpful and neutralizing is still better.

Though FETs are now almost always used in analog switching circuits, they have an important drawback. Capacitance couples switching transients from gate to output.

In a sample-and-hold circuit, for example, a turn-off switching transient represents direct error. In a time-division, data-multiplex system, switching transients can limit the sample rate. Manufacturers' FET analog-switch specifications tend to sidestep the question of switching transients and settling time.

Fortunately, one can calculate needed values from simple measurements of charge transfer and neutralize circuits to reduce transients.

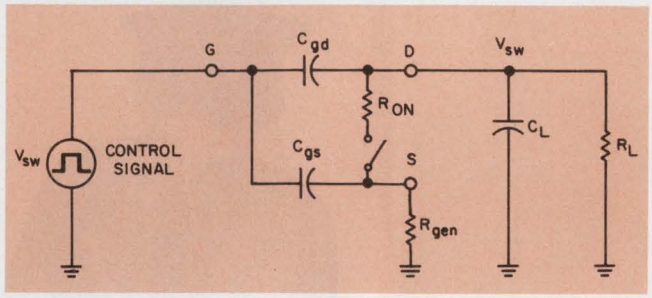
First, however, it's necessary to understand the mechanism of transient coupling. In Fig. 1 the control signal is viewed as the input and the FET is redrawn as an equivalent switch to show how it couples the control signal to the load. The switching transient at the load is directly proportional to C_{gd}, R_L and the control-signal amplitude. It's inversely proportional to C_L.

The switching transient may best be described as a total charge transferred to the data circuit. This is particularly useful in error calculations with sample-and-hold circuits. In a multiplexer circuit the transient may be described by a photo of the waveform appearing on the data circuit. Both methods are most helpful if given at zero and at several positive and negative signal levels. Using the photos, the user can predict the transient magnitude and duration and thus determine circuit settling time.

Calculating transients from given data

If the user attempts to calculate transients from manufacturer-supplied C_{rss} capacitance data, he will likely come close to the actual transferred charge (see table), but there is room for standardization of specifications. Data sheets for the most popular FET switches, the 2N4091-93 and 2N4391-93, all specify C_{iss} at $V_{DS} = 20$ V, $V_{GS} = 0$ and C_{rss} at $V_{GS} = -20$ V, with $V_{DS} = 0$. The 2N4856-61 and 2N5432-34 data sheets specify C_{iss} at $V_{DS} = 0$, $V_{GS} = -10$ V and C_{rss} at $V_{DS} = 0$, $V_{GS} = -10$ V.

James S. Sherwin, was formerly IC Applications Manager, Siliconix, Inc., Santa Clara, Calif. He is now FET Applications Manager, National Semiconductor Corp., Santa Clara, Calif.



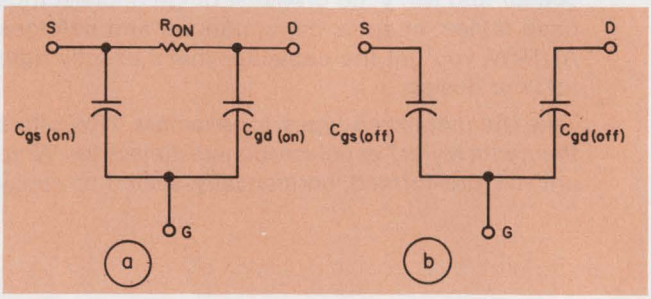
1. **Gate-pulse edges form switching transients** as they are coupled to the load through FET capacitances.

Examining the ON and OFF equivalent circuits of a JFET switch (Fig. 2), we find:

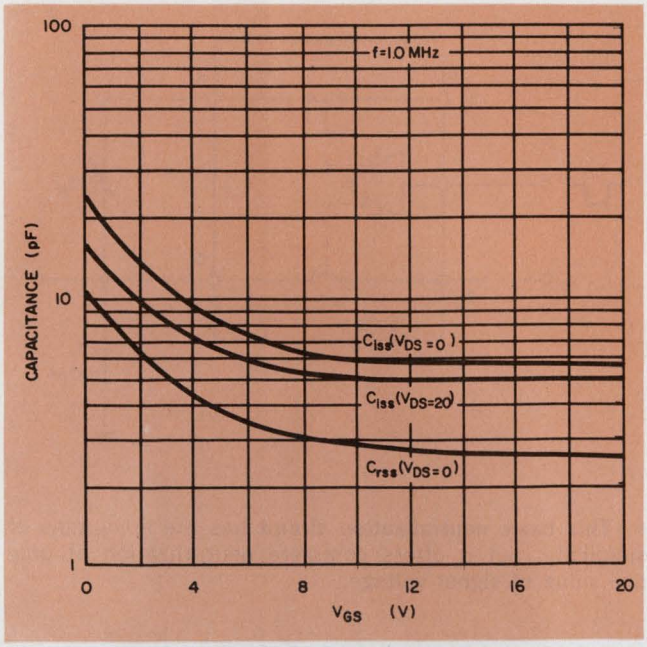
- Switch ON, gate-to-channel capacitance is $C_{gs} + C_{gd}$, measured at $V_{GS} = 0$. This is equivalent to C_{iss} measured at $V_{DS} = 0$, $V_{GS} = 0$. No such specifications exist on any of the data sheets for the devices referenced.
- Switch OFF, gate-to-drain (output end of channel) capacitance is C_{gd} measured at $V_{GD} = -10$ to -30 V, with -10 V being worst case. This is equivalent to C_{rss} at $V_{GS} = -10$ V, and $V_{DS} = 0$. Only two data sheets list this.

For the 2N4091-93, the appropriate capacitances may be calculated from the data sheet:

- Switch ON, gate-to-channel capacitance, $C_{d(on)}$ is $C_{gs} + C_{gd} \approx 2\ (C_{iss} - C_{rss})$ where: C_{iss} is measured at $V_{DS} = 20$ V, $V_{GS} = 0$, and C_{rss} is measured at $V_{DS} = 0$, $V_{GS} = -20$ V.



2. **The ON (a) and OFF (b) equivalent circuits** of a JFET are useful in the noise analysis.



3. **Capacitance vs gate-to-source voltage** for 2N4091, 4391 and 4856 JFETs. C_{rss} is the gate-to-source capacitance; C_{iss} is the sum of gate-to-source and gate-to-drain capacitances.

■ Switch OFF, gate-to-drain capacitance, $C_{d(off)} \approx C_{s(off)}$ is approximately C_{rss}.

For the 2N4856-61 and 2N5432-34, the calculations may be made as follows:

■ With the switch ON, there is no means of calculating capacitances from the given information. However, typical values may be taken from a curve on the data sheet (Fig. 3) given for C_{iss} at $V_{DS} = 0$, $V_{GS} = 0$.

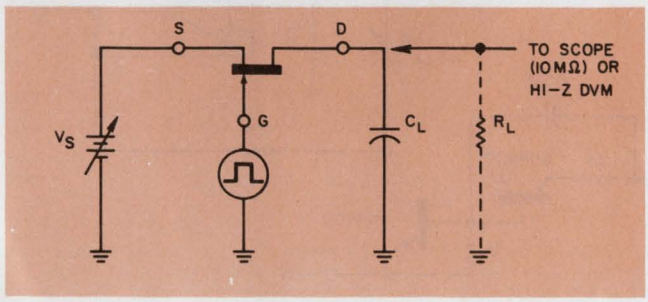
■ Switch OFF, $C_{d(off)} \approx C_{s(off)} = C_{rss}$ at $V_{DS} = 0$, $V_{GS} = -10$ V. The manufacturer should specify $C_{d(on)}$ or C_{iss} at $V_{GS} = 0$, $V_{DS} = 0$ and $C_{gs(off)}$ and $C_{gd(off)}$ or C_{rss} at $V_{GS} = -10$ V, $V_{DS} = 0$. Only with this set of specifications can the user learn actual circuit capacitances.

Now that the ON and OFF switch capacitances are known, the user can calculate C_{gd} and the total parasitic C_L in Fig. 4. Approximate or exact calculations of switching transients can also be made. The exact calculations however will be elusive because C_{gd} and C_{gs} are nonlinear voltage-sensistive capacitances which vary during turn-on and turn-off. C_{gd} and C_{gs} are actually distributed capacitors, and are variably-coupled to the drain through changing R_{DS} as the FET is controlled from ON to OFF.

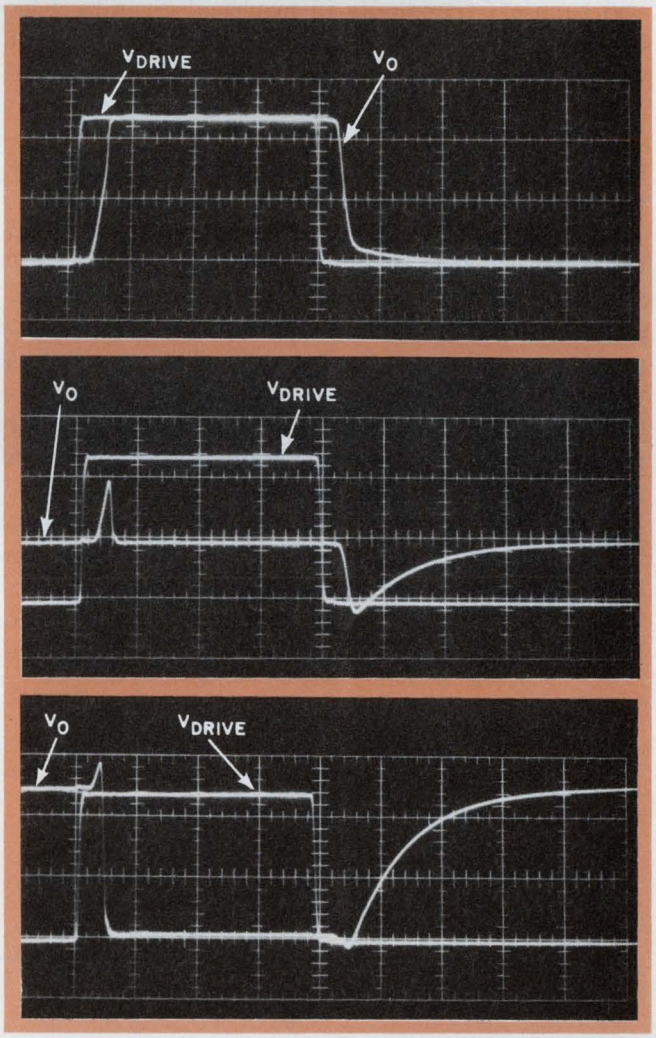
Because calculations involve nonlinear circuit elements, the data which the manufacturer can and should supply are the total charge transferred at turn-off, and photos of switching transients at several positive and negative values of analog voltage (transferred charge can be estimated from appropriate photos taken at $V_S = 0$).

These data probably can be presented only as typical because it's difficult or impossible to program automatic test equipment for such tests. Typical data are reasonable, since capacitance values (unlike β or leakage) vary only slightly from typical in normal FET processing.

Settling time is a different story altogether, since it is mainly influenced by the external circuit. At best, the manufacturer can provide only switching times under test conditions that show switch performance—less than 1-kΩ load resistance and the smallest possible load capacitance. The tests then indicate switching speed of the



4. **Basic circuit for measuring transients** by the charge-transfer method.



5. **Transients in a typical fast JFET switch,** the GD187. Here R_L = 10 kΩ, C_L = 30 pF and the scales are 2 V/div and 500 ns/div. From top to bottom, V_A = +5.0, and −5 V.

device itself; settling time is a function of the external R and C. The manufacturer cannot specify settling time, but should specify switching time under worst-case conditions of the analog signal, if compatible with the selected load resistance. For example, the turn-off time for a PMOS switch is greater at $V_s = +10$ V than at $V_S = -10$ V; the inverse is true of turn-on time. Conditions are reversed for n-channel JFETS.

Measuring transients

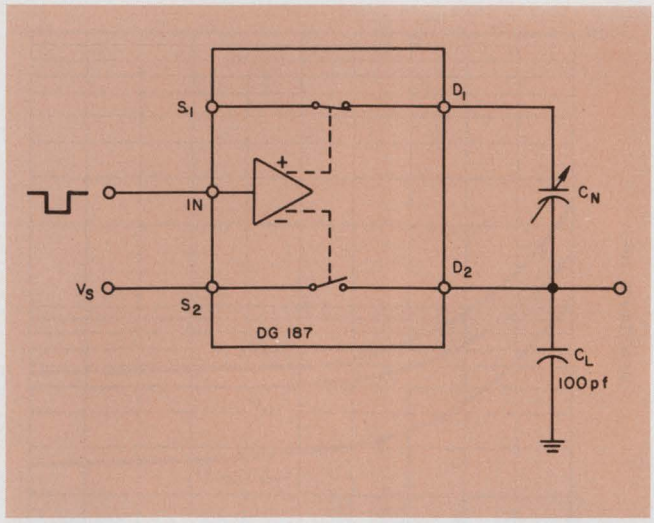
Transients can be measured by the charge-transfer method with the circuit in Fig. 4. The scope trace at the drain terminal will appear as in Fig. 5, where the error signal, E_o, is the difference between the input signal, V_S, and the level to which the capacitor is charged by the turn-off transient. The transferred charge is:

$$\triangle Q = C_L E_o$$

The switching transient can also be observed as a pulse in circuits of moderate impedance. When this is done, say with $T = C_L R_L$ less than a few microseconds, it is possible to predict turn-on and turn-off transients in practical circuits. Fig. 5 shows transients as they occur in a circuit with $R_L = 10$ kΩ and $C_L = 30$ pF. These are typical of the transients to be expected in a fast JFET switch. Transferred charge can be calculated from Fig. 5 with a fair degree of accuracy ($\Delta Q = C_L E_{(pulse)}$).

The observed transient depends not only upon the analog signal level, but upon the type of FET switch. The waveforms in Fig. 5 are for an n-channel JFET switch which requires a negative-going control signal for turn-off. The waveforms would be inverted for a p-channel JFET requiring a positive-going turn-off signal. The popular p-channel MOS (PMOS) switch also requires a positive-going turn-off signal.

The transients aid or oppose the apparent settling time, depending on the relation between transient and signal polarities. The turn-off "settling time" is merely the run-down time of the load RC circuit. In a multiplex operation, as the next channel is switched ON, the generator resistance would parallel the load resistance and greatly decrease the settling time.



6. **This basic neutralization circuit** has the advantage of simplicity, but it offers complete neutralization at only one value of signal voltage.

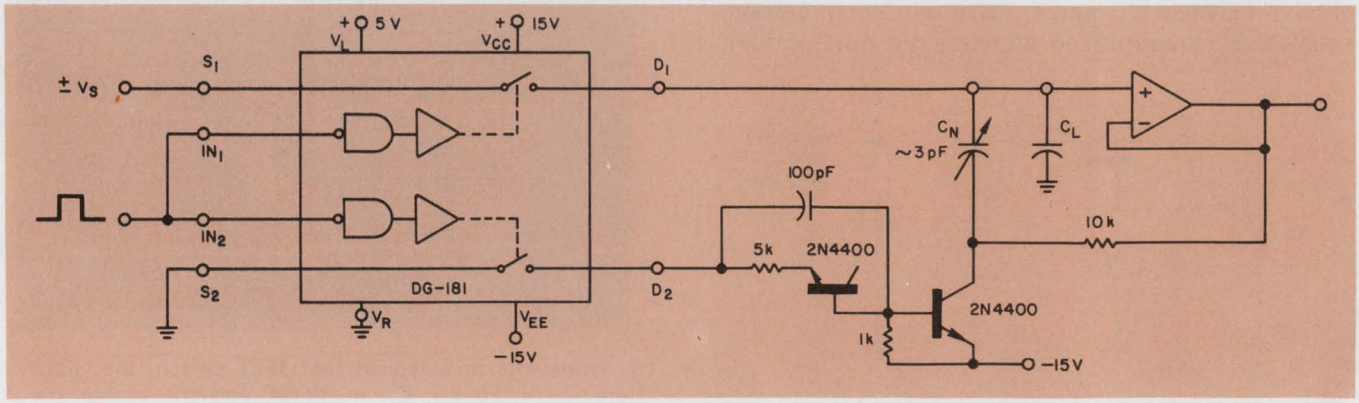
Reducing transients

Switching transients can be reduced by several methods, but they cannot be eliminated. Total charge transferred in a sample-and-hold circuit can be reduced to insignificant levels by compensation.

The methods of reducing transients are: (1) Keep turn-off voltage swing to the minimum required, (2) Use FETs with low V_P (to reduce required voltage swing), and (3) Use FETs with low gate-to-channel capacitance.

Besides these, the effects of transients may be minimized, especially in sample-and-hold circuits, by increasing full-scale signal voltage, increasing holding-capacitor size, and neutralization.

The FET gate voltage swing need only be a pinch-off voltage, V_P, greater than the maximum peak-to-peak signal voltage. A -20 V supply is unnecessary in a ± 5 V system. With FET $V_P \leq 10$ V, a -15 V supply is adequate. Similarly a



7. **This neutralization circuit** is almost perfect over a ±15-V signal range. It uses a dual driver and the DG181 JFET switch. The charge transferred from the second switch is opposed to that from the main channel.

−10 V supply is adequate in a 0 to +5 V system.

Using FETs with low V_P yields some improvement within a given FET family because the gate voltage swing can be reduced. The FET ON resistance increases and produces in longer charge time in sample-and-hold systems or reduced bandwidth in multiplex circuits.

FETs with low gate capacitance offer direct one-to-one reduction in transferred charge. Low-capacitance FETs exhibit high ON resistance, so the result is the same as with low V_P FETs. A change from JFET to MOS at equivalent values of R_{ON} offers little or no reduction in capacitance, depending on the MOS and JFET designs. Silicon-gate and ion-implanted MOS designs promise the lowest capacitances.

Increasing full-scale signal voltage provides less than one-to-one improvement, but is effective in reducing the signal-to-transient ratio.

An excellent means of decreasing transient effects in sample-and-hold circuits is to make the holding capacitor as large as sampling-speed limitations permit. This will be done at the expense of slower sampling speed, but high accuracy may demand it. For example, a typical 2N4091 switching FET may remove 85 pC of charge from the holding capacitor when the gate is switched 30 V (typical in ±10 V signal systems). To achieve an accuracy of 0.1% f.s., a ±5 V system requires a capacitor of 4200 pF.

The table summarizes the relative effects of these transient-reduction methods. The ΔQ listed in the table may be converted to transient peak-pulse amplitude by the expression:

$$E_{pk} = \frac{\Delta Q}{C_L}$$

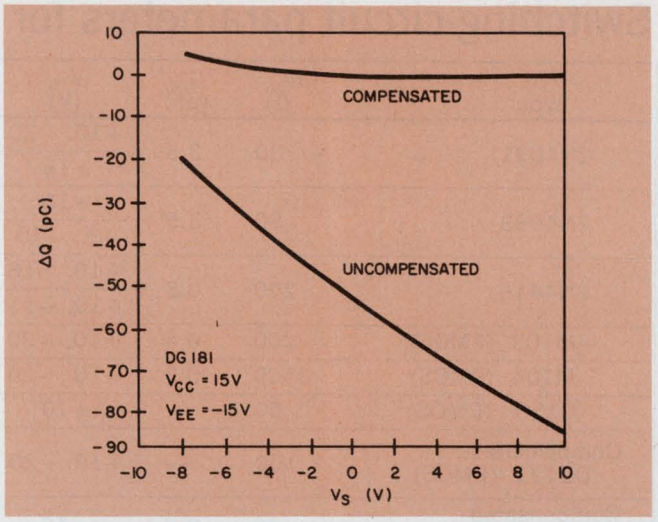
Neutralizing transients

One additional technique, neutralization, offers important advantages. Sample-and-hold circuits are the principal application since neutralization adds a second transient in a multiplex system. This second transient occurs because perfect synchronization of the neutralizing pulse is difficult or impractical. The simple neutralization circuit of Fig. 6 is useful with JFETs. The prime advantage of this circuit is its simplicity.

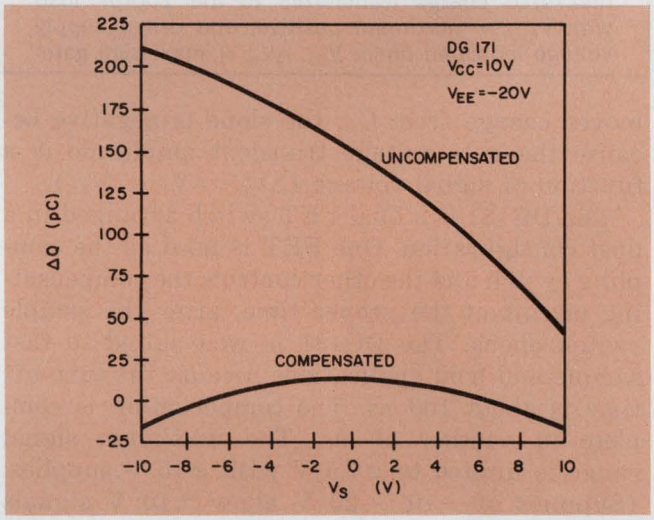
Its use is limited, however, because neutralization is complete only at one selected value of analog signal, V_D, and is imperfect at other values. The neutralizing signal is derived from a complementary signal coupled through C_{gd} of another FET switch.

The better, albeit more complex, compensation circuit of Fig. 7 provides near-perfect neutralization over a ±7.5 V signal range. The maximum ΔQ is 3 to 5 pC over this range.

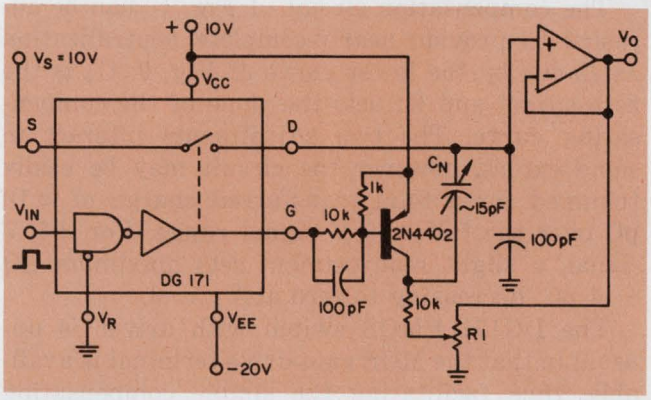
Fig. 8 shows the transferred-charge variation with signal level for a 30 Ω JFET switch. The negative turn-off transient at the JFET gate re-



8. **Compensation with the circuit** in Fig. 7 drastically reduces the change in transferred charge with signal level for the DG181, a 30-Ω JFET switch.



9. **Compensation with the circuit** in Fig. 10 reduces transferred-charge variation for PMOS FETs like the DG171, with ON resistances of 40 to 100 Ω. Variation in transferred charge is greater for the uncompensated DG171 than for the uncompensated DG181 (Fig. 8) and full compensation is not as complete.



10. **The single-switch PMOS DG171** is easily neutralized because the driver output is available at a terminal pin. A pnp transistor provides charge transfer to the neutralizing capacitor C_N.

Switching-circuit parameters for typical FETs.

FET type	R_{ON} (Ω)	C_{gd} (pF)	V_{PS} (V)	V_{sig} (V)	ΔV_G (V)	ΔQ (V)	C_L (pF)	5T (μs)	R_L (kΩ)
2N4091	30	3.5	+10, −20	±10	30	−85	4250	0.7	30
			±15	±5	20	−65	6500	1	
2N4093	80	3.5	±15	±10	25	−75	3750	1.5	80
			+5, −10	±5	15	−49	4900	2	
2N4416	250	0.8	+10, −16	±10	26	−35	1750	2.2	250
			+10, −11	±5	16	−23	2300	2.9	
M103 (PMOS)	200	0.4	+10, −20	±10	30	+21	1050	1.1	200
M104 (PMOS)	2500	0.5	+10, −20	±10	30	+15	750	9.5	2500
G150 (CMOS)	50	—	±10	±10	20	−250	12,500	3.1	50
Compensated DG171 (PMOS)	100	—	+10, −20	±10	30	±10	500	0.25	100
				±5	30	−4	400	0.2	100
Compensated DG181 (JFET)	30	3.5	±15	±5	20	±5	500	0.075	30

R_{ON} = maximum $R_{DS(ON)}$ listed in manufacturer's specifications. With MOS devices R_{DS} is for worst-case signal voltage. C_{gd} = maximum C_{rss} or C_{gd} listed in manufacturer's specifications. ΔQ = measured charge transferred to the 100-pF load with V_{sig} = maximum positive, and driver supply voltage indicated under V_{PS}. ΔV_G = maximum gate-voltage swing. C_L = minimum value of sample-and-hold load capacitor required for 0.1% f.s. accuracy. 5T = minimum sample time ($5R_{ON}C_L$) required for 0.1% f.s. accuracy in sample-and-hold circuits. R_L = minimum load resistance required for 0.1% accuracy in multiplex systems.

moves charge from C_L; the slope is negative because the gate voltage transient amplitude is a function of signal voltage ($\Delta V_G = V_D - V_{EE}$).

The DG181 is a dual FET switch arranged in a dpst configuration. One FET is used as the sampling switch and the other controls the compensating circuit at the proper time, after the sample switch opens. The DG181 is well suited to fast sample-and-hold applications because the turn-off time is about 100 ns. The compensation is complete in another 50 ns. The maximum signal range is limited to ±7.5 V with ±15 V supplies. (Supplies of +10, −20 V allow ±10 V signals but compensation is less satisfactory.)

Fig. 9 shows the transferred charge due to the turn-off transient of a 40 to 100 Ω PMOS switch. The positive turn-off transient at the PMOS gate adds charge to C_L; the slope is negative and only slightly nonlinear.

The compensation circuit of Fig. 10 can be adjusted to provide nearly-complete neutralization as shown by the lower curve of Fig. 9. C_N is the zero-adjust and R1 sets the slope of the compensating curve. The two adjustments interact to some extent, however the circuit may be easily trimmed for a total transferred charge of ±10 pC over the full ±10 V signal range. For ±5 V signal, a slight readjustment sets maximum ΔQ = 4 pC, decreasing to zero at $V_D = 0$.

The DG171 PMOS switch with driver is unusual in that the MOS gate-drive terminal is available, thus facilitating the simple compensation circuit. The delay provided by Q1 insures that the neutralizing pulse is not dumped back into the signal source before the switch is fully open. The DG171 is additionally suited for use as a sample-and-hold switch because of its low R_{ON} of 40 Ω maximum at V_D = +10 V and 100 Ω maximum at V_D = −10 V. This is less than half the usual PMOS switch resistance.

Though the DG171 is not a particularly fast switch/driver, the technique serves to illustrate the methods applicable to faster circuits. The DG171 circuit is quite stable with changes in V_{CC} and V_{EE}. A 10% change in each results in a ±5 pC and a ±2 pC change in compensation at V_S = 0. Temperature variation from −55 to +125 C can cause ±20 pC change unless the temperature coefficient of C_N is selected for an appropriate positive temperature coefficient.

Either PMOS or JFET analog switches can be successfully neutralized for near-zero charge transfer in sample-and-hold circuits. The neutralization technique is not especially applicable to multiplexers since transients still exist in the compensated circuit. The two circuits shown in Figs. 7 and 10 are representative of the compensation technique necessary. Individual circuit details may vary depending on the FET and driver circuit employed.

Using either the DG181 or DG171, a neutralized sample-and-hold circuit with C_L = 300 to 500 pF, will operate at 0.1% accuracy over a ±5 V signal range.

The table shows the comparison with uncompensated techniques. The sample time is the turn-on time plus turn-off time plus 4 RC charge times. This total sample time for the DG181 is less than 350 ns while the DG171 has less than 1.2 μs due to its slow internal driver. ■■

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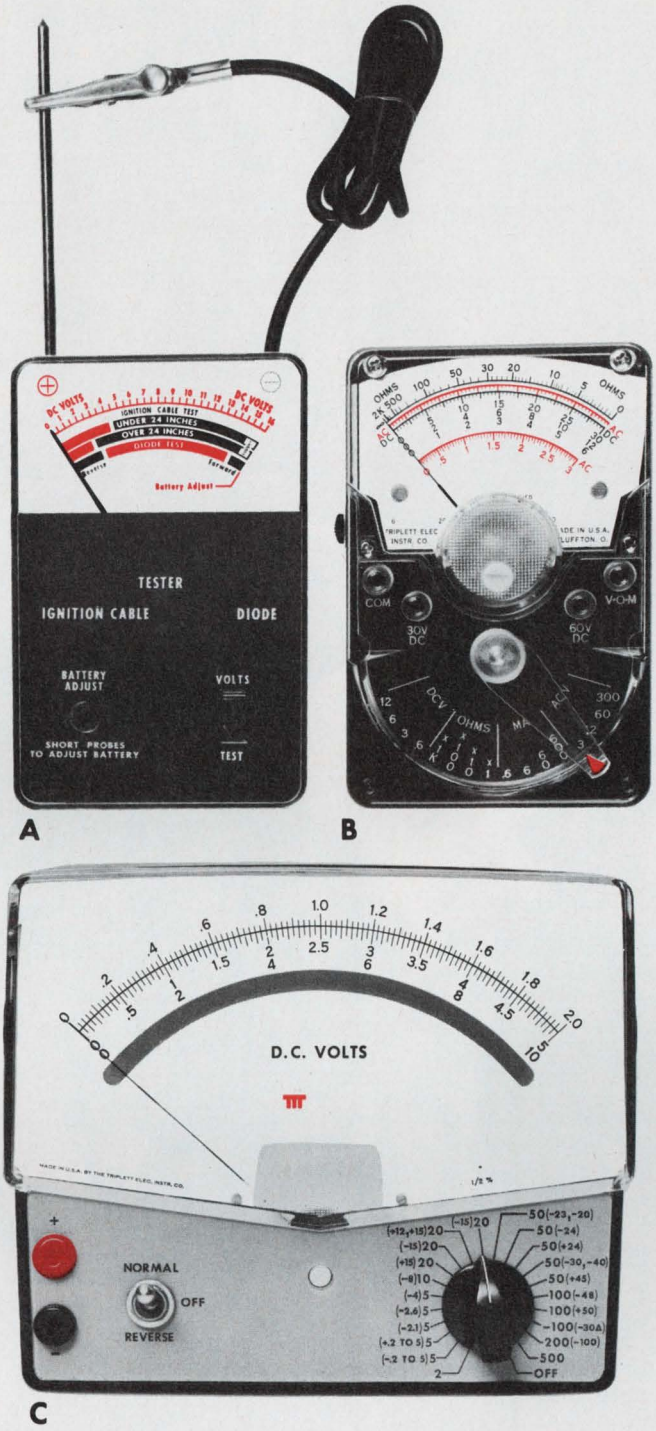

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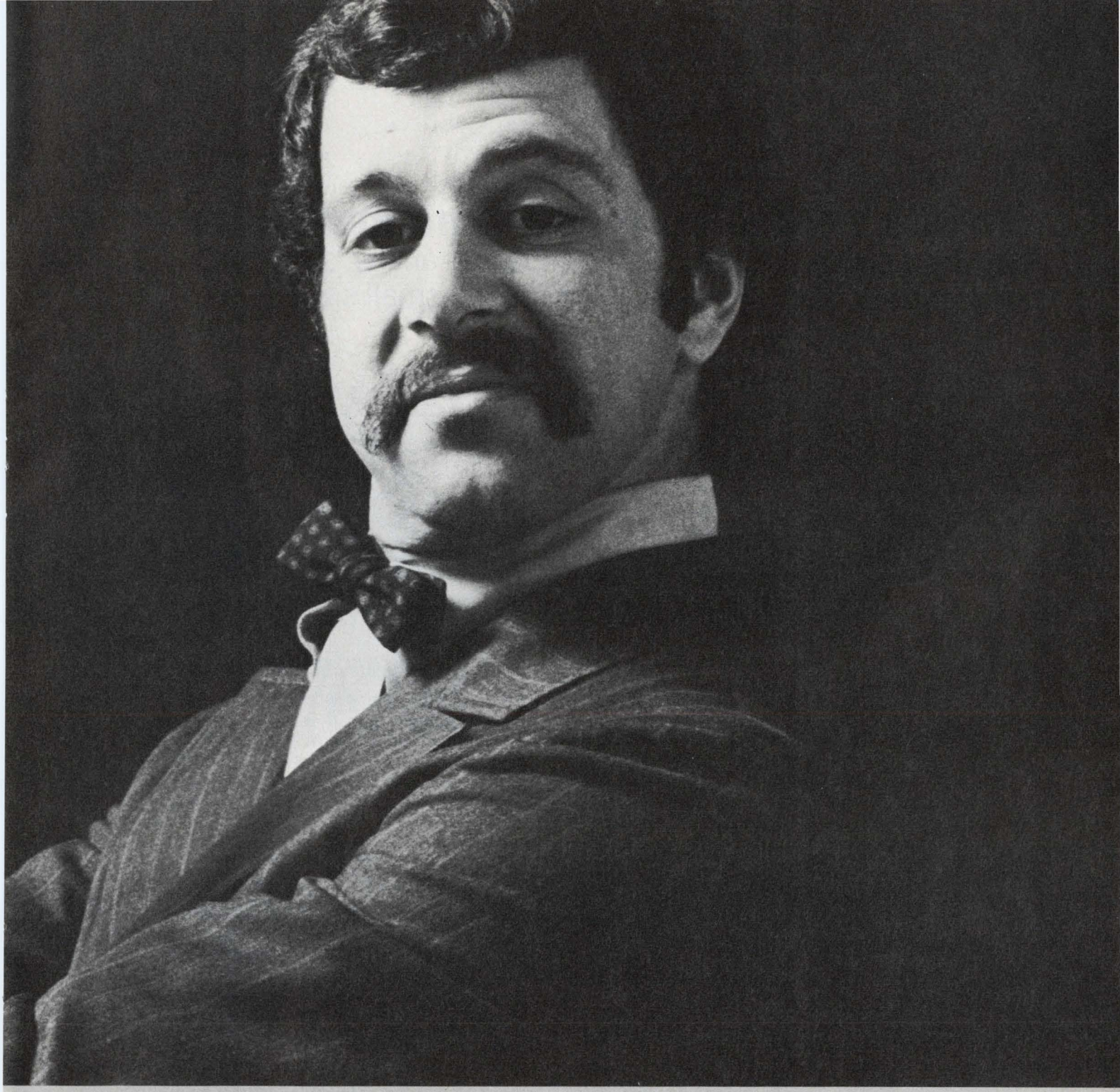

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INFORMATION RETRIEVAL NUMBER 29

Build a precision pulse-time multiplier

that also divides. The circuit uses bipolar analog switches, and features high accuracy, low cost and small size.

With a few standard components that cost less than $20, you can build a precision multiplier/divider that gives greater accuracy than most off-the-shelf units. Either a discrete or hybrid version can be constructed.

Although its bandwidth is low (less than 100 Hz), the accuracy of the custom-made module is two orders of magnitude higher than that of a monolithic transconductance multiplier.[1-6] And only zero offset needs adjustment. You get dc accuracies of ±0.01% at 25 C, and ±0.1% from −55 to 125 C.

If you use hybrid microelectronic packaging techniques, you can get a circuit that is no larger than a monolithic unit.

Applications for the multiplier include multiplication and division in dc or low-frequency analog computers, coordinate conversion, signal normalizing circuits, squaring, square-root, root-mean-square and power-measurement circuits. It should be noted that while the bandwidth of this multiplier is low, bandwidths up to 100 kHz are possible with the pulse-time technique.[7]

How a pulse-time multiplier works

A typical pulse-time multiplier consists of a servo loop and two multiplying elements (Fig. 1). The input to the servo loop is one multiplication variable, V_x. The other, V_y, is entered into one multiplying element. Reference voltage V_r serves as the input for the multiplying element connected in the feedback of the servo loop.

The output of such a multiplier can be derived as follows.

$$k = G(V_x - V_f) = G(V_x - kV_r). \quad (1)$$

Solving for k, we get

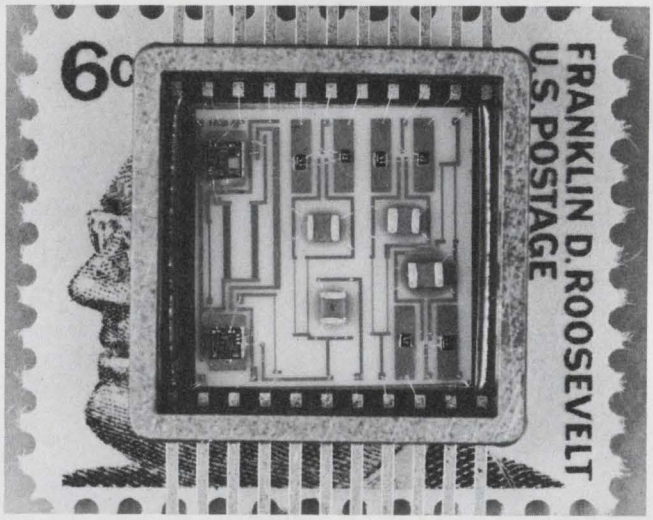
$$k = GV_x/(1 + GV_r), \quad (2)$$

or, if $G >> 1$,

$$k = V_x/V_r. \quad (3)$$

Thus

Herman Schmid, Senior Engineer, General Electric, Aerospace Instruments and Control Systems Dept., Binghamton, N.Y. 13902.



This dual muliplier/divider (5/8 by 5/8 flatpack) is used by General Electric's AICS department on several aerospace programs for precision analog computation.

$$V_z = kV_y = V_xV_y/V_r. \quad (4)$$

The pulse-time multiplier we will build is a special version of the servo-loop multiplier (Fig. 2a). It uses semiconductor voltage (or current) switches as multiplying elements. The signal k is a variable pulse-width signal. It is obtained by converting the output of the summing amplifier with a comparator.

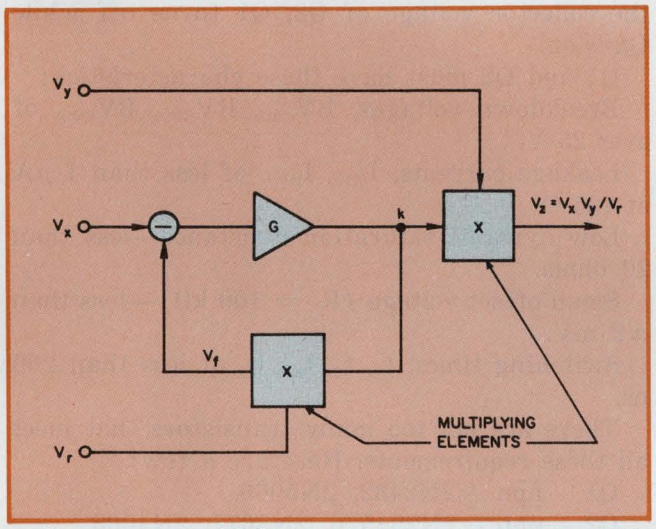
The pulse-time multiplier of Fig. 2 consists of a pulse-width modulator and a pulse-amplitude modulator. The pulse-width modulator generates the pulse-width signal, t_x, as a function of the input voltages, V_x and V_r (Fig. 2b). Its integrator, comparator and analog switch, S1, are connected in a feedback loop. The pulse-amplitude modulator consists of analog switch S2, a low-pass filter and an inversion-buffer amplifier. Its output, V_z, is given by

$$V_z = t_xV_y/T, \quad (5)$$

where T is defined in Fig. 2b. Since $t_x/T = V_x/V_r$, the expression for the output becomes:

$$V_z = V_xV_y/V_r. \quad (6)$$

When the multiplier/divider is used as a multiplier, V_r is a constant reference voltage. As a divider, V_r is a variable (divisor).

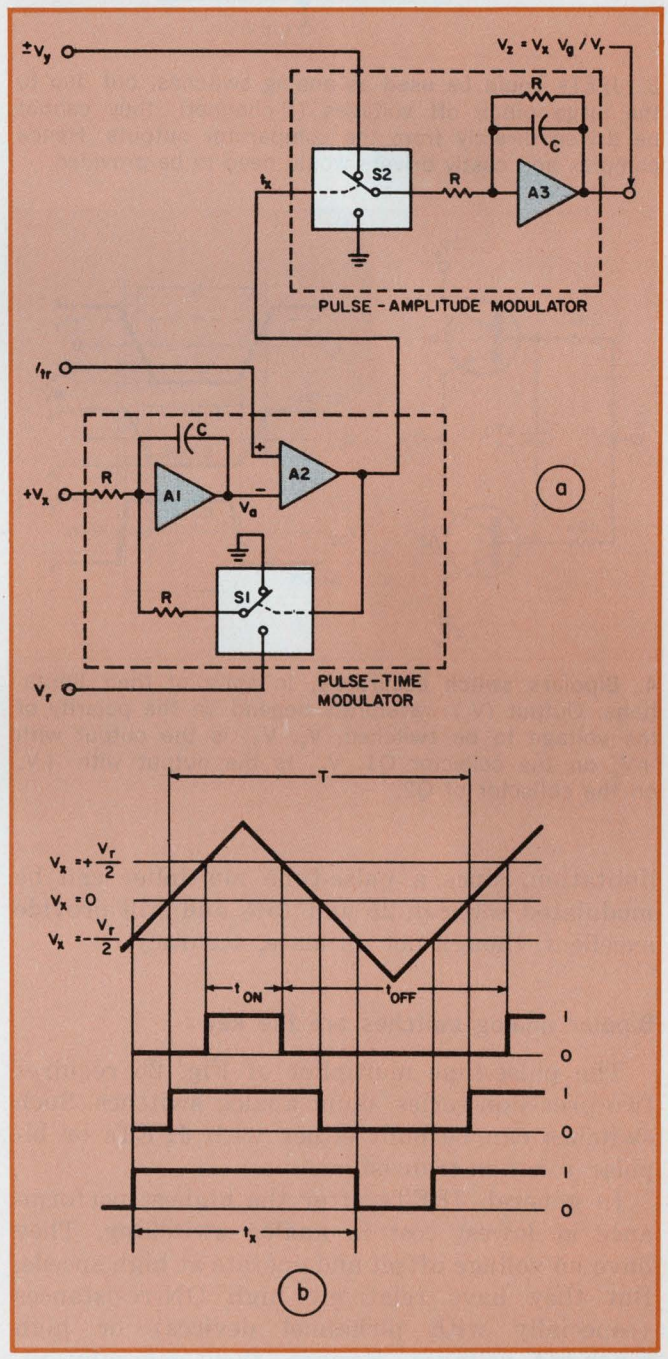


1. **Every servo multiplier** employs two elements to multiply two signals V_x and V_y. The element in the feedback loop normalizes the product with respect to V_r.

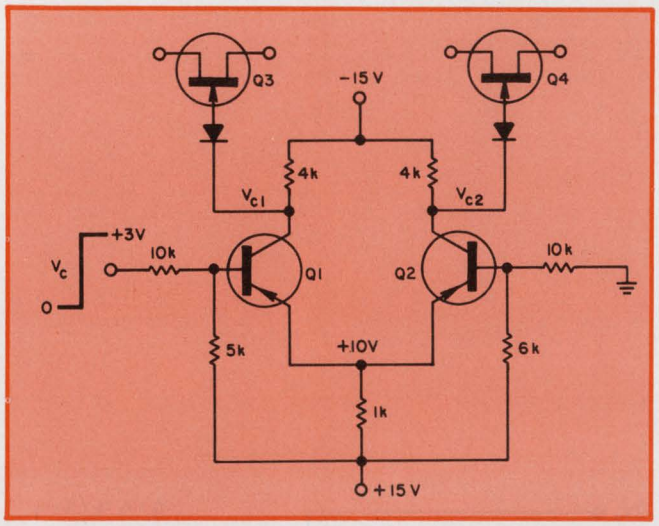
If the non-inverting comparator input is driven by a triangular wave (as in Fig. 2b), the pulse-width modulator is forced to operate at the triangular-wave frequency. With the integrator output voltage, V_a, connected to the inverting input, the comparator output, t_x, is "high" when the triangular-wave voltage, V_{tr}, is larger than V_a. When V_{tr} is less than V_a, t_x goes "low." The comparator switches at V_a. When the comparator has no offset, $V_a = V_x$. Consequently the ratio t_{on}/t_{off} of the t_x pulse train, varies linearly with the amplitude of V_x. This is demonstrated in Fig. 2b for three values of V_x.

If the comparator input is grounded, the circuit will oscillate at a frequency determined by the integrator time constant and the amplitudes of V_x and V_r. The period T is now a function of V_x, as with the triangular wave input. When V_x is positive and t_{on} is larger than T/2, the carrier frequency is high. But as V_x approaches its full-scale negative value and t_{on}/T approaches zero, the carrier frequency also goes to zero.

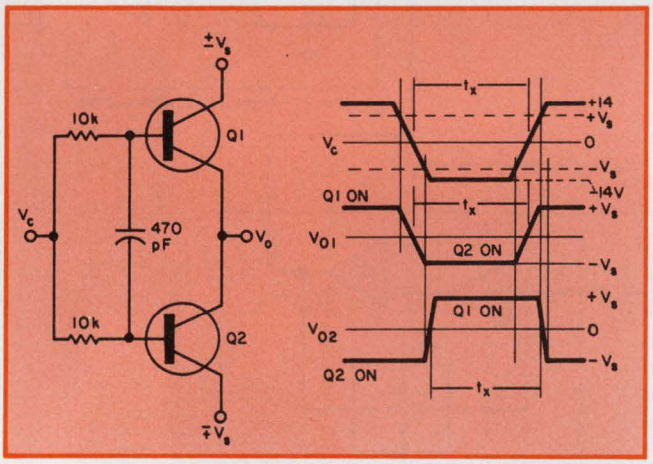
Consequently the modulation of the pulse-time signal, t_x, must be limited to less than 100% when the triangular wave is used. This is not a serious



2. **Using analog switches** as multiplying elements (a), we can build a very accurate pulse-time multiplier. The pulse-width signal, t_x, is a linear function of one multiplication variable, V_x, and of the voltage reference V_r.



3. **JFETs could be used** as analog switches, but due to the large pinch off voltages (P-channel), they cannot be driven directly from the comparator outputs. Hence complex and costly drivers would need to be provided.



4. **Bipolars switch accurately**, in spite of their limitations. Output (V_o) waveforms depend on the polarity of the voltage to be switched, V_s. V_{01} is the output with $+V_s$ on the collector Q1. V_{02} is the output with $+V_s$ on the collector of Q2.

limitation, since a pulse-time multiplier can be modulated between 25 and 75% and still provide excellent, though not ultimate, accuracy.

Bipolar analog switches are the key

The pulse-time multiplier of Fig. 2b requires two precision series/shunt analog switches. Such switches can be built either with JFETs or bipolar junction transistors.[8]

In general, JFETs offer the highest performance at lowest cost in analog switching. They have no voltage offset and operate at high speeds. But they have relatively high ON-resistances (especially with p-channel devices) or high pinch-off voltages. Besides, they generally require fairly complex drive circuits (Fig. 3).

In general, bipolar junction transistors are less advantageous for analog switching. Even in the inverted mode, they have considerable offset voltages if the load impedance is not very high (less than 100 Ω). Besides, the controlling base current flows into the signal source, thus requiring a very low impedance from it. When driven by low voltages (TTL levels), bipolar switches also call for complex driving circuitry.

But in the specific case of the pulse-time multiplier, the bipolar switches offer excellent performance at the lowest possible cost (Fig. 4).

The operation of this switch is very simple. When the control voltage, V_c, is more positive than the collector voltage of Q1, Q2 turns off while Q1 is on. When V_c is more negative than the collector voltage of Q2, Q1 turns off while Q2 is on.

Q1 and Q2 must have these characteristics:

Breakdown voltages, BV_{CBO}, BV_{EBO}, BV_{CEO}, of over 25 V.

Leakage currents, I_{CBO}, I_{EBO}, of less than 1 μA at 125 C.

Low dynamic saturation resistance—less than 20 ohms.

Small offset voltage (R_L = 100 kΩ)—less than ±2 mV.

Switching times, t_r, t_d, t_{st}, t_f, of less than 200 ns.

There are not too many transistors that meet all these requirements. Here are a few:

Q1 — npn — 2N2432, 2N5066.

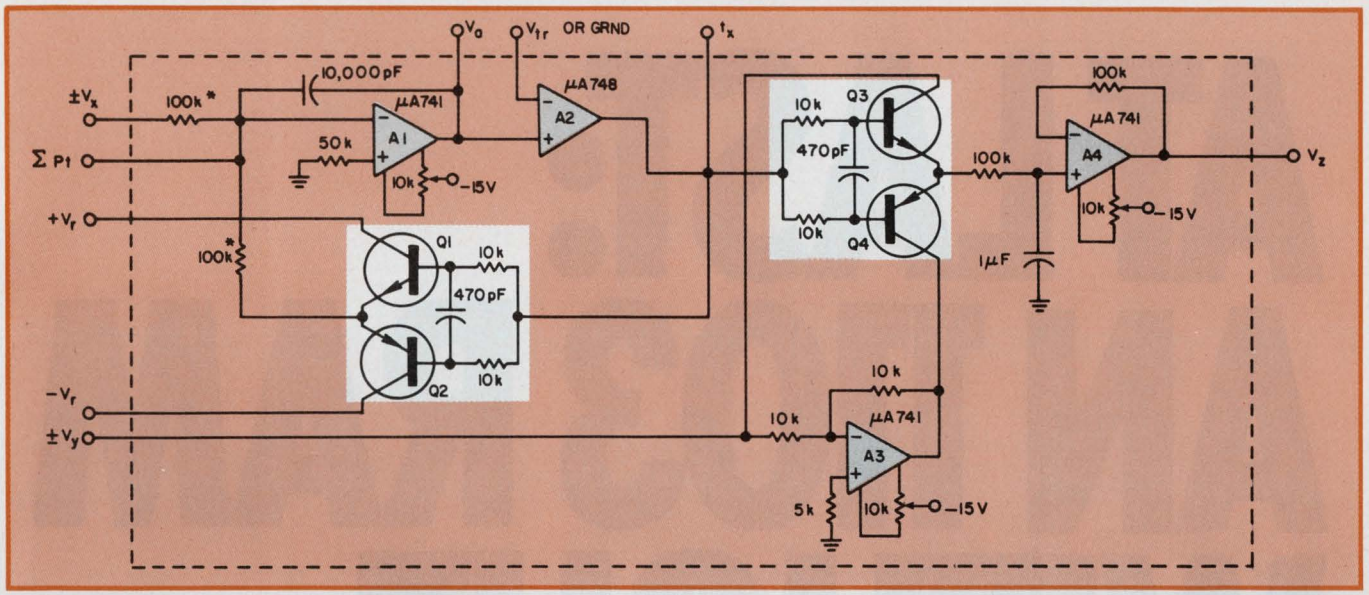
Q2 — pnp — 2N2945/6, 2N3677, 2N4008.

The dc performance of the switch in Fig. 4 is excellent. With a 100-kΩ load, the offset voltages are typically ±1 mV (for a ±10-V signal range). The ON resistance is typically less than 5 Ω.

The dynamic performance of the switch is a function of the rise and fall times of the control voltage, V_c, the polarity of the switched voltage, V_s, and the match between the transistor turn-ON and turn-OFF times.

The slew rate of the comparator determines the rise and fall times of V_c. The faster they are, the less they need to be matched. The proposed circuit (Fig. 5) uses a low cost μA748. Its rise and fall times are typically less than 1 μs. But since they are well matched, timing errors as low as ±0.005% are possible with a 1-kHz carrier (triangular wave) frequency. Higher speed (at higher cost) can be obtained with such comparators as the LM 111.

The output-voltage waveforms of the switch change with the polarity of the voltage to be switched, V_s. When $+V_s$ is connected to Q1 and $-V_s$ to Q2, the output voltage, V_{01} (Fig. 4), follows the control voltage, V_c, as long as V_c is between $\pm V_s$. When $-V_s$ is connected to Q1 and $+V_s$ to Q2, the switching action is more abrupt. Q1 turns OFF when $V_c < (-V_s + V_{BE})$, while Q2 turns OFF for $V_c > (+V_s - V_{BE})$. Without the capacitor between the transistor bases, Q1



5. **This precision four-quadrant multiplier/divider** can be built discrete or hybrid (in a single flat pack). It requires low-cost components, with few adjustments, and needs die-attachments for only twelve components.

would turn ON whenever $V_c > -V_s$, and Q2 would turn ON whenever $V_c < +V_s$. The capacitor ensures that the transistors cannot be on simultaneously.

The delay, rise, storage and fall times of the transistors should be short, but their absolute values are not very critical, as long as the turn-on times are approximately equal to the turn-off times.

The complete four-quadrant multiplier

Fig. 5 depicts the complete four-quadrant multiplier/divider together with its implementation in hybrid form. The hybrid approach results in small size, and it also permits zero-adjustment of the amplifier offsets.

With supply voltages of +15 V dc and −15 V dc, the circuit accepts input signals of ± 10 V on all three inputs (V_x, V_y, V_r). Only four precision resistors are required, and only the ratios of the two pairs must be accurate.

The circuit does not provide internal reference voltages, since in most cases a more accurate external reference is available, Besides, if the circuit is used as a divider, V_r becomes a variable.

Several input signals can be summed, since the summing point of the integrator is available on one of the pins. This also permits scaling of input signals. The integrator time constant can also be changed, since both capacitor terminals are connected to the external pins.

A standard op amp, μA748, used as a comparator, provides the the ±12-V drive required by the analog switches. This op amp is used because it has input over-voltage protection which is not available in a μA710 comparator.

Low-cost μA741 amplifiers are used in the integrator, the V_y inverter and the output buffer. Their offsets are typically ±3 mV at 25 C and ±5 mV from −55 to 125 C. For better accuracy, the offsets must be zero-adjusted (Fig. 5).

To keep the timing errors small, the carrier frequency must be kept low (1 kHz). With a 10-kHz carrier frequency, the multiplier has a 3-dB bandwidth of 100 Hz. ■■

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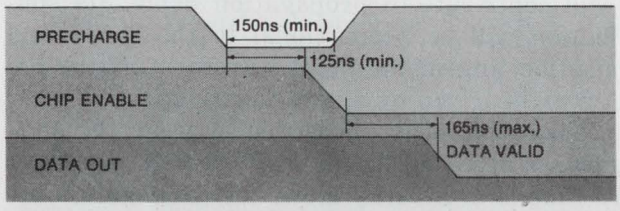
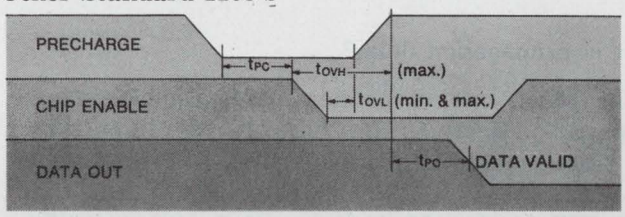


No Precharge and Chip Enable overlap requirements. The 3534 requires only that the Precharge pulse stays low for a minimum of 150ns and that at least 125ns delay occur from the start of Precharge to the start of Chip Enable. The Data Out is valid 165ns after the Chip Enable goes low but is independent of Precharge.

There are no other restrictions on the Precharge pulse. It can go high immediately or it can stay low throughout the entire cycle. Or it can remain low for successive cycles.

Other Standard 1103's



With other 1103's, the Precharge pulse not only must stay low for a precise Precharge interval but its transition from low to high must occur within a time interval which has a *minimum* as well as a *maximum* limit. As a result, the designer must stay within very tight boundaries of these maximum and minimum values. All control circuitry must be extraordinarily precise, and system costs rise sharply.

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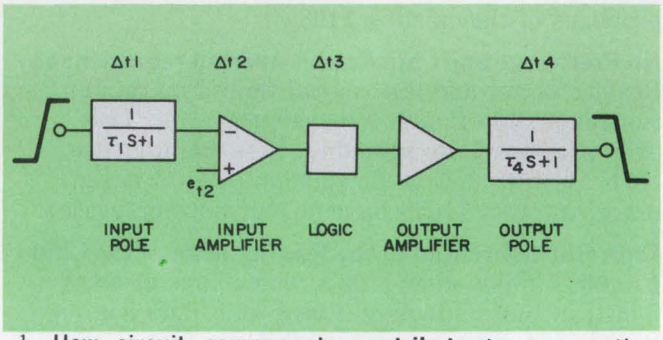
INFORMATION RETRIEVAL NUMBER 30

Accurate IC logic delay measurements

can be elusive, unless you use the right input pulse and voltage-reference level — and good instruments.

Propagation delay, though treated like a physical constant on data sheets, can be an elusive parameter to define, measure and, ultimately, correlate with system performance. The problem is that switching thresholds and input waveforms directly affect the value of the delay.

Proper selection of input pulse transition time and voltage-reference level are essential to obtain accurate measurements of the circuit contributions to propagation delay. And recent improvements in pulse generators, oscilloscopes and other instrumentation can help you get the right answers quickly at your lab bench by providing such features as adjustable rise and fall times, electronic complement and fast response.



1. **How circuit components contribute** to propagation delay. The input-pole contribution depends on input-waveform transition times.

What is propagation delay?

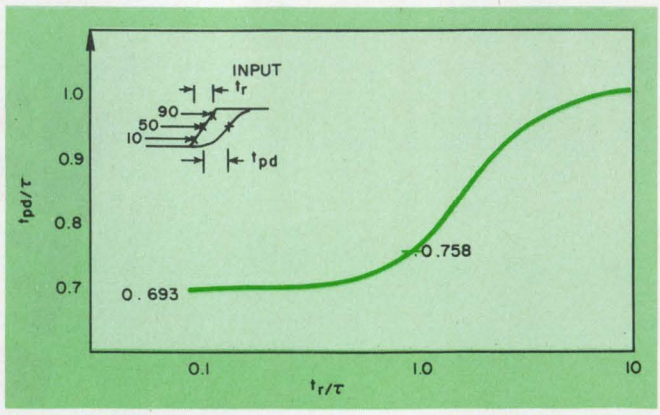
The Electronic Industries Association defines[1] propagation delay as that between input and output transitions when measured at a level of 1/2 (V_{ILmax} + V_{IHmin}). This is about 1.4 V for the 7400 TTL series. Manufacturers usually specify either 50% of the logic swing or 1.5 V as the measuring point. Usually the input waveform is specified as that from either a gate of the same logic family or a recommended pulse generator.

To make the measurement meaningful, two questions must be answered before you consider instrumentation: What is the proper input waveform to use? And what is the proper amplitude point at which to make the measurement?

The simplified timing model of Fig. 1 shows why actual and measured propagation delay may not be the same. The model assumes that the circuit contains the following basic elements: an input pole (RC network); a high-gain, limiting, input amplifier with switching threshold e_{t2} (+ 1.5 V, for instance); some internal logic; an output amplifier; and an output pole. All of these components, except the output amplifier, will contribute to propagation delay.

If the time constant of the input pole is significant, compared with the delay being measured, it will contribute to propagation delay. Its contribution will be proportional to the shape and transition time of the input waveform. If the RC network is driven by a step function, it will have a propagation delay, measured between the 50% points, of RC (log 2), or 0.692 RC. If the input rise time is arbitrarily slow, the propagation delay of the network will asymptotically increase to RC. Fig. 2 shows what happens in-between. In general, the faster the input rise time, the less the propagation delay; it is not a constant even for a simple RC network!

The input amplifier—supposedly perfect, with

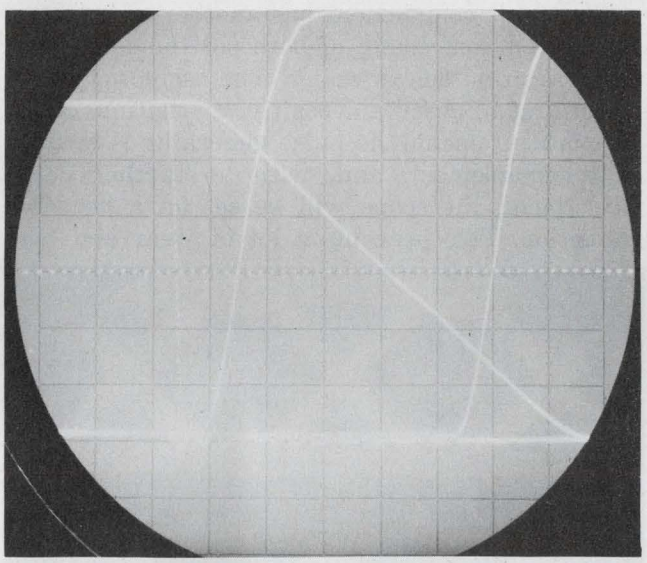


2. **Propagation delay is minimum** for a zero-rise-time (step) input pulse, and it approaches a maximum value of τ for infinite rise time.

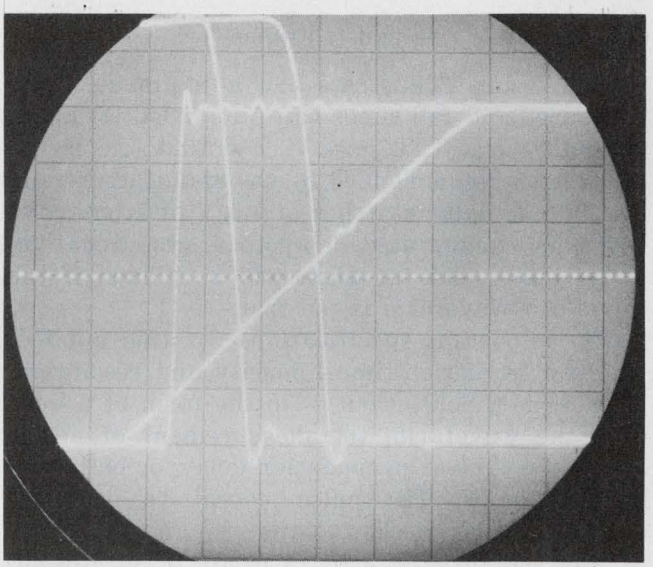
Edward S. Donn, project manager, Hewlett-Packard Co., Colorado Springs, Colo. 80907

infinite gain, no-saturation and no internal delays—can, in fact, contribute a great deal to actual propagation delay and to inaccuracies in the measured delay. The reason is that the threshold voltage may be improperly set, or it may be different than the voltage level (50% point or 1.5 V) used for measurement.

Suppose that the threshold is set to 3.6 V and the input to the amplifier is an exponential whose final value is 4.0 V. The amplifier will respond very slowly to a positive transition and much more rapidly to a negative transition. This delay will thus be proportional to the input rise and fall times.



3. **The t_{PLH} of a typical TTL gate increases** from 10 ns to 20 as the input fall time increases. The dotted line in this double exposure is the 1.5-V reference level.



4. **The opposite delay, t_{PHL}, decreases** as the input rise time increases. Deflection factors are 10ns/div and 0.5 V/div.

The range of possible threshold voltages is given on device spec sheets as V_{ILmax} and V_{IHmin}. For TTL, the mean is about 1.4 V, and the range of levels specified by different manufacturers varies from 0.7 to 1.2 V for various TTL families. Physically the threshold voltage is determined by two pn junctions in TTL or by a resistive divider in ECL. The latter is more likely to be out of spec.

The buffering action of the input amplifier will prevent any further influence of the input transition times upon propagation delay. There will be a relatively constant delay through the internal logic circuitry because of additional poles, electron transit times, and stored charge effects.

The output pole will be affected by fan-out, so during tests of propagation delay it should be loaded by some realistic loading network.

Because the input waveform can affect the measured propagation delay, use pulses with transitions similar to those that will occur in the actual circuit. The most convenient source is a pulse generator with adjustable rise and fall times. Such an instrument can easily be set to simulate worst-case conditions and then adjusted whenever the measurement requirements change. The pulses can also be obtained from a typical logic cell. But don't forget to load the input as well as the output of the device under test, to make sure the input waveform is typical.

The next question is the reference level to use for the delay measurement. For this, the EIA spec is recommended. However, be sure to measure the actual threshold voltage, and make sure it is within the specified limits, V_{ILmax} and V_{IHmin}. (This is easier than setting up the two input voltages and monitoring for proper output.) If the actual threshold is out of spec, problems can occur which may be difficult to find later.

If the typical rise and fall times are equal, then minimum over-all delay in the logic system will occur when the threshold is set to 50% of the expected input swing. If the threshold is moved up, t_{PHL} will decrease and t_{PLH} will increase; if the threshold is moved down, t_{PLH} increases and t_{PHL} decreases. The average of the two values may or may not remain the same. Logic circuits are not limited by averages, however, but by specific propagation delays which may not cancel each other.

What instrumentation do you need?

To measure propagation delay, all you need is a pulse generator and a scope. A measurement will be more accurate and easier to make if the

pulse generator has variable rise and fall times, offset control, electronic complement and external width provisions. For accurate results, the scope should have a rise time of less than the propagation delay of the logic family being tested. But it need not have a very high input resistance.

The addition of a psuedorandom generator will allow dynamic measurements of propagation delay through many stages of logic. And a digital voltmeter in combination with the scope will allow faster measurements of the pulse levels.

Use adjustable rise and fall times

Figs. 3 and 4 illustrate how adjustment of the input rise and fall times can pinpoint difficulties with a typical TTL gate. The dotted line is the 1.5-V level recommended by the manufacturer. If the gate actually switches at 1.5 V, it is going to cause an exaggerated delay to a slow negative-going input. This problem will be hidden if the input test waveform is too fast.

The important specifications for this application are transition-time linearity and resolution. If there is a nonlinearity—in the form of a knee—in the waveform, the measurement of either transition time or propagation delay, or both, will be ambiguous. The pulse-generator's performance should be checked at the rise and fall times of interest—usually 5 to 15 ns for TTL. Resolution is hard to specify, so it's best to try before you buy. Check settability and the interaction of the controls.

Adjust amplitude and offset

The pulse generator should have an adjustable, calibrated offset voltage. All logic families require a certain amount of baseline offset to simulate a worst-case pulse. Though TTL and DTL can be driven from a zero-offset pulse, a worst-case pulse would be offset about +0.3 to +0.4 V at the limit because of V_{sat}.

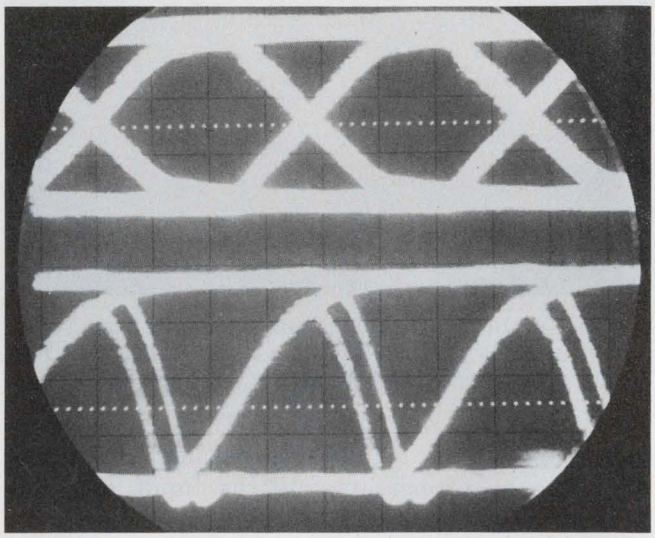
The top and bottom of a pulse can be measured to around 3% with a real-time scope, but this requires some interpolation. Absolute calibration with a sampling scope is difficult because of the instability of the sampling diodes—for example, if you lean on the cable, the dc level will shift. Another method uses a pulse generator to calibrate the waveform at dc.

Electronic complement a desirable feature

A useful feature, found on some new pulse generators, allows the top and bottom of the pulse to be measured with a DVM at dc. The DVM is connected to the node under test (don't disconnect anything; use the actual test circuit with its 56-Ω, 10% load or whatever) and the clock is turned off. The pulse generator will put out a steady voltage that corresponds to the pulse bottom. Now if the generator is switched to "complement," it will put out a steady voltage that corresponds to the pulse top. The only inaccuracies will be those caused by duty-cycle-induced variations in the pulse amplitude and by rf perturbations.

Typical accuracy is 2%

Electronic complement has another advantage: It makes measurement of both positive and negative transition delays easier. The oscilloscope can be set first to observe a positive transition. After that measurement, the pulse generator is switched to complement, and, with no further delay adjustment, the scope will be set on a negative transition. This prevents a lot of wear and tear on the delay vernier knob of the scope. It also allows the user to set up on the leading edge of the pulse for both measurements. This is desirable because the leading edge of the pulse contains only the jitter of the clock circuits, whereas the trailing edge has the jitter of both the clock circuits and pulse-width circuits.



5. **Eye patterns reveal the dynamic response of the logic.** A random input waveform is at top and the response at bottom. The output lacks the clearly defined "eye" of the input. Clock rate is 50 Mb/s.

Measure switching threshold

Switching threshold is usually measured with a precision power supply driving the input of a gate and a DVM monitoring the output. The input voltage is adjusted to produce an output at about the 50% point. This value of input voltage should be between V_{ILmax} and V_{IHmin} and is taken

to be the switching threshold.

Again, some newer pulse generators can be used to accomplish the same thing more simply: The input pulse amplitude is decreased until the corresponding point on the output waveform goes to the 50% point. The pulse top is then measured with the electronic complement technique previously described.

When checked against a precision power supply, the typical error with this method was about 2%. Most of the inaccuracy can be traced to duty cycle-vs-amplitude variations caused by the pulse generator circuitry.

Eye patterns reveal dynamic response

Up to now we have considered static methods of evaluating the performance of a logic circuit. The eye pattern method is a dynamic test that can be easily made using a scope and any pulse generator having external width capabiilty. This technique has long been used in the communications industry to reveal the dynamic response of circuits and transmission lines to random digital signals.

The only extra test equipment needed is a pseudorandom generator. The pulse generator is set up as before, except for the width, which is switched to external. The pseudorandom generator then drives the pulse generator and determines the timing between logic levels. The oscilloscope is triggered from the clock waveform and is not synchronized to the digital pattern.

The resulting display (Fig. 5) will show all the possible transitions of the input and output data. So long as the eye is open (distinct ONE and ZERO levels), the output of the gate can be detected by another logic element without error. But if the levels begin to smear into each other, the output will become undetectable.

In this photo a TTL output at 50 Mb/s is seen to be on the verge of undetectability. Notice that the ZERO level has become very narrow, indicating that the logic gate would not be very reliable at this speed. Notice also how easy this is to see with an eye pattern.

Fig. 6 shows how the eye pattern technique can be used to check the delays through many levels of logic in an operating system.

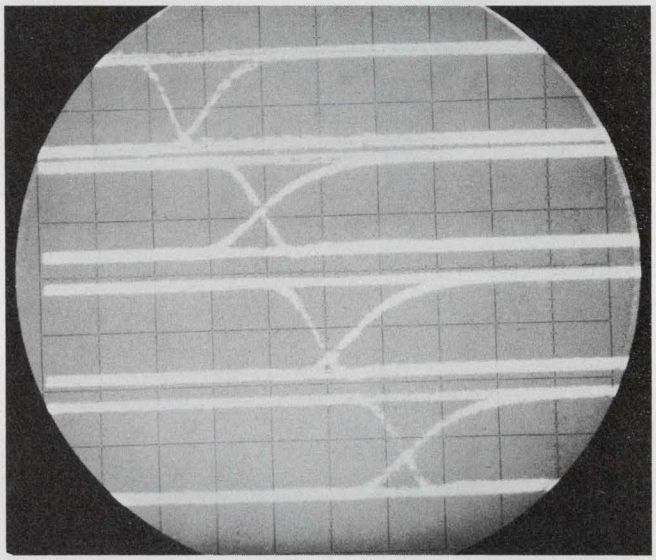
How fast should scope be?

The scope is an essential part of the propagation delay measurement. It is not as accurate as a computing counter, but it is less expensive and widely available.

How fast an oscilloscope do you need? If you know the rise and fall times you expect to encounter and the rise time of the scope, you can calculate the theoretical error using Fig. 2. A slow scope will have more error than the theory predicts, because of limited resolution. A slow scope usually has a slow sweep speed.

Both experiments and theory verify that a 50-MHz, 6-ns-rise-time scope can resolve delays within 1 ns. A 20-MHz, 22-ns-rise-time scope can resolve delays within 2.5 ns, but this takes some squinting. Too, ringing and discontinuities, which may be important, may not show up on the slower scopes. In general, the best results are obtained if the rise time of the oscilloscope is equal to the minimum propagation delay to be measured.

Other features that make measurements easier are fast sweep and two channels. Channel A can be connected to the input, while Channel B is connected to the output. That way you can see any drift of the trigger point and don't have to memorize points on the CRT. However, any differential delay between the two channels will make this technique inaccurate. If active probes are used, they must meet the same requirements —fast rise time and small differential delay.



6. **Stage-by-stage delays of a four-gate Nand circuit** are checked with a pseudorandom generator. The "Xs" depict both positive and negative transition delays. Deflection factors are 10 ns/div. and 2 v/div.

Resistive divider probes can also be used on TTL logic. If the resistance is kept at greater than 1000 Ω (20:1), the measured propagation delay will not change more than 3%, though the pulse top will be somewhat attenuated. Note that a sampling scope can also be used. ■■

Reference
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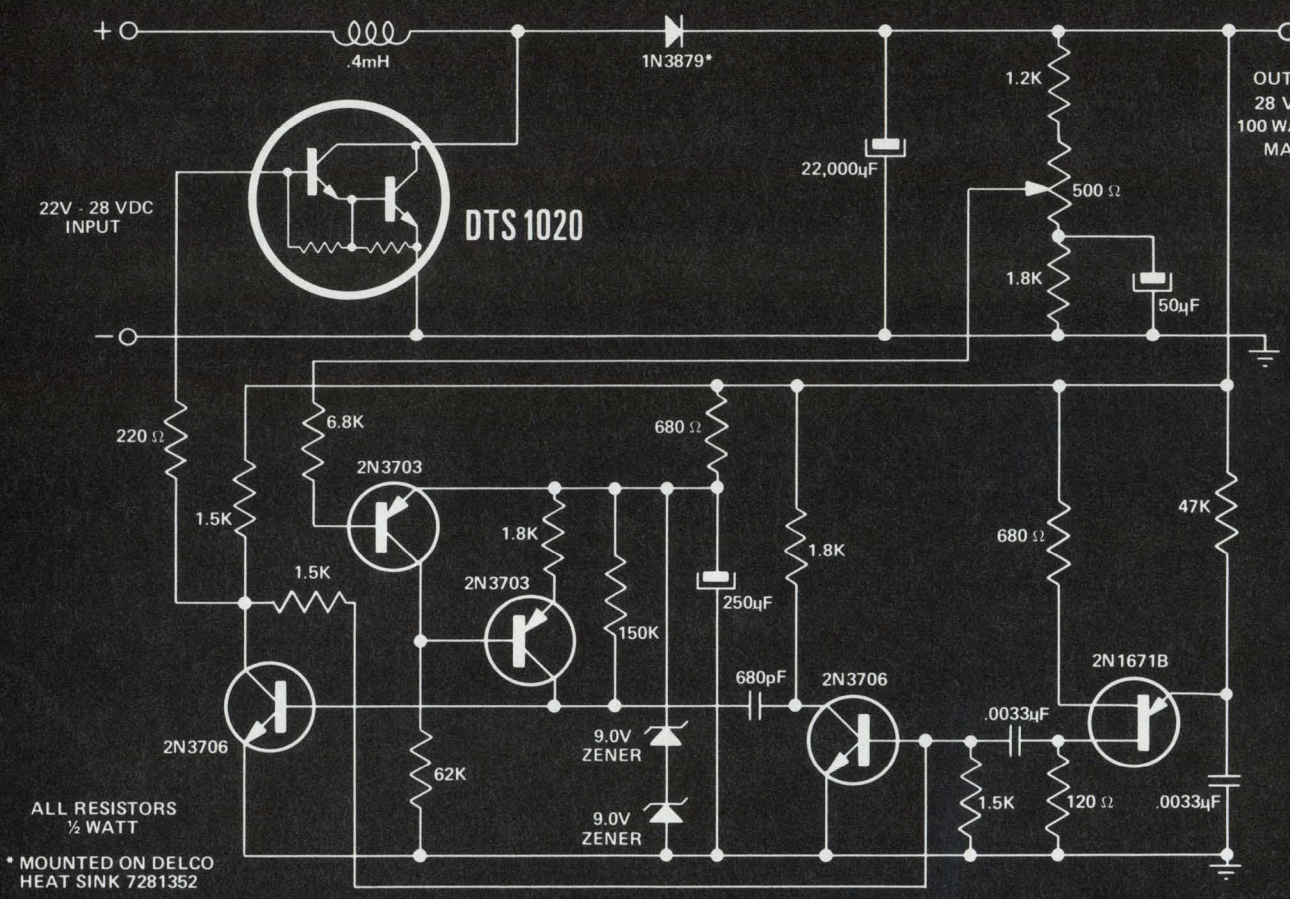

SWITCHING REGULATOR

	V_{CEO} @ 0.1 mA	V_{EBO} @ 50 mA	$V_{CE(SUS)}$ @ 500 mA	h_{fe} @ 1 MHz (V_{CE}=10V, I_C=200 mA)	h_{FE} (V_{CE}=5V, I_C=10A)	$V_{CE(SAT)}$ @ 5.0 A	I_C	P_T @ 75°C
DTS-1010	120V	7V	80V	12	200	1.8V	10A	100W*
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*100 percent tested at 2.5A, 40V.

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For details on the switching regulator circuit, ask for Application Note 49.

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INFORMATION RETRIEVAL NUMBER 31

ideas for design

Add a synchronous sawtooth output to your function generator

A sawtooth output, synchronous with the usual concurrent sine, square and triangle waveforms, is not commonly offered by commercial function generators. A simultaneous sawtooth can be derived from square and triangle waveforms by two-quadrant multiplication, or chopping of the triangle wave, with a JFET (see diagram). Proper scaling of both the triangle and square waves with an op amp produces the desired output.

A μA709C op amp, with either a 2N5459 or a 2N5462 JFET, generates a sawtooth that has a 2-μs rise or fall time and a 2-μs, 2-V, glitch at the ramp midpoint. Faster op amps and JFETs decrease the rise time and glitch width.

To insure stable operation of the circuit, neither of the inputs should contain an offset of more than a volt. The square-wave source impedance should be less than 20 kΩ and the amplitude between 6 and 25 V peak to peak.

The triangle-wave amplitude should be two to five times smaller than that of the square wave. To attenuate the triangle wave, the input resistor, R, should have a value, in ohms, given by:

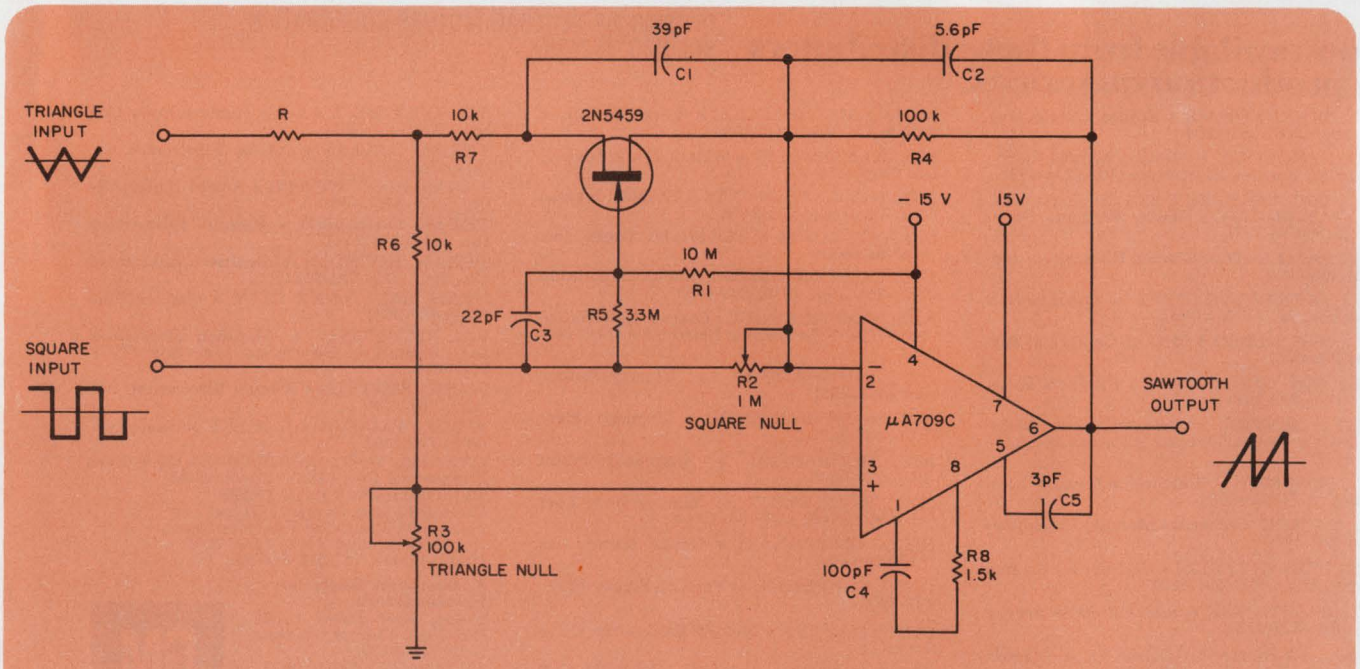
$$R = 30{,}000\ (\alpha - 1) - Z_s,$$

where α is the attenuation factor and Z_s is the source impedance in ohms. The sawtooth amplitude will then be about twice the triangle amplitude.

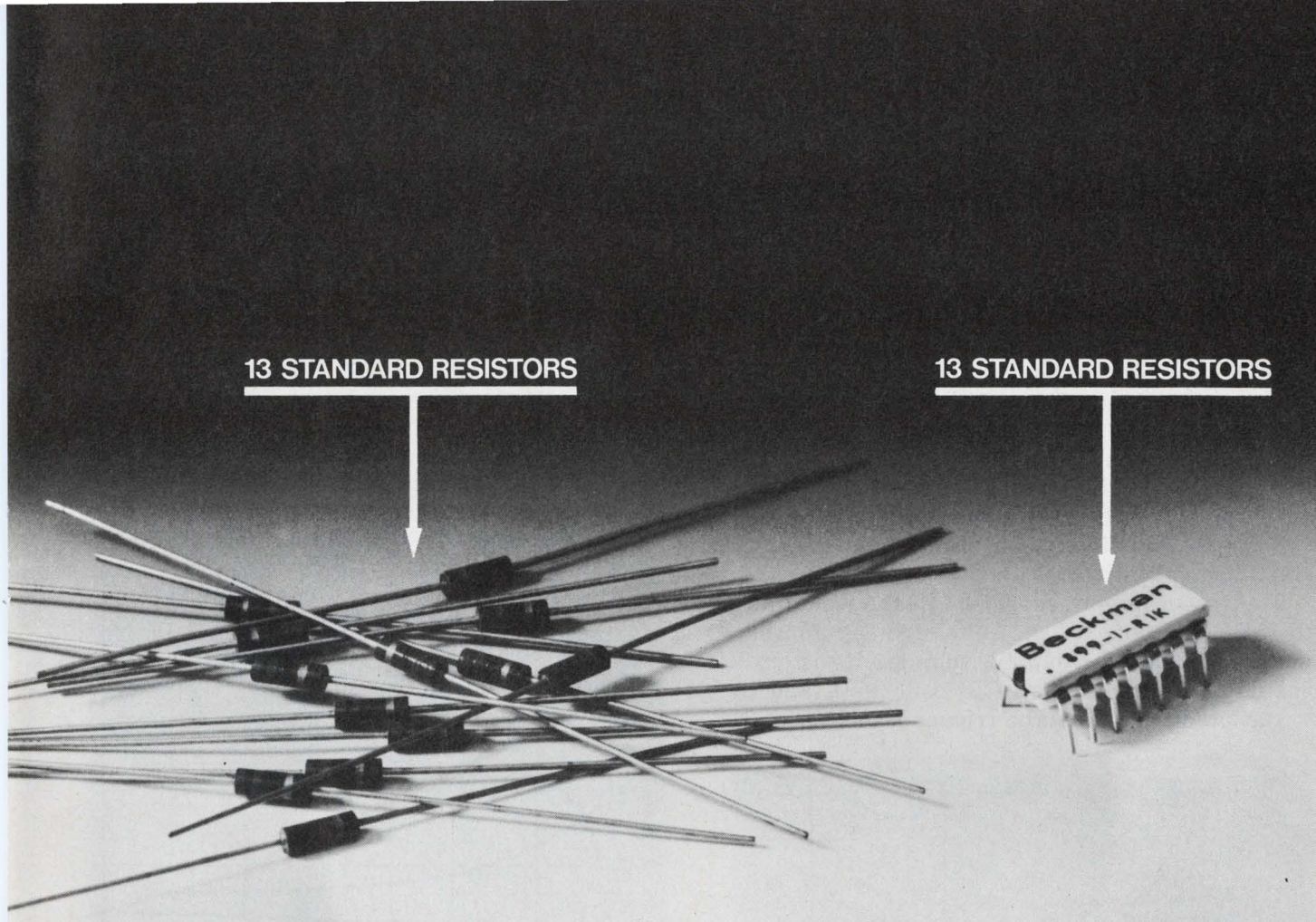
Scaling potentiometers, R2 and R3, are initially adjusted to eliminate square and triangle components in the output. Capacitors C4 and C5 and resistor R8 provide phase compensation. The 5.6-pF capacitor, C2, across R4, insures rate-of-closure stability. Capacitor C3, shunting R5, compensates for the FET input capacitance. The 39 pF-capacitor C1, across the FET channel, prevents oscillation that could occur with the chopper open (low closed-loop gain) if the layout is faulty.

David B. Peck, Chemistry Dept., University of California, San Diego, P.O. Box 109, La Jolla, Calif. 92037.

CIRCLE No. 311



An n-channel JFET chops a triangle input to generate a sawtooth that is synchronous with concurrent square and triangle inputs. The op amp achieves proper scaling of the two inputs.



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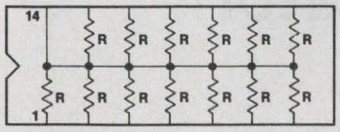

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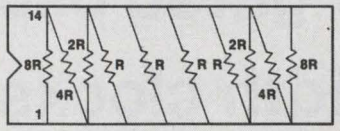

MODEL SERIES 899-2
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Standard Tolerance: ± 2%

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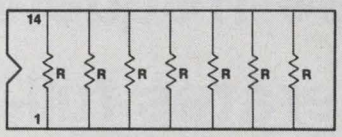

MODEL SERIES 899-3
Resistance Values (ohms): 68, 100, 110, 150, 220, 330, 470, 680, 1K, 1.5K 2.2K, 3.3K, 4.7K, 6.8K, 10K, 15K, 22K.
Common Applications: Line termination; long-line impedance balancing; power gate pull-up; ECL output pull-down resistors; LED current limiting; power driver pull-up; "wired OR" pull-up; TTL input pull-down.
Standard Tolerance: ± 2%

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INFORMATION RETRIEVAL NUMBER 32

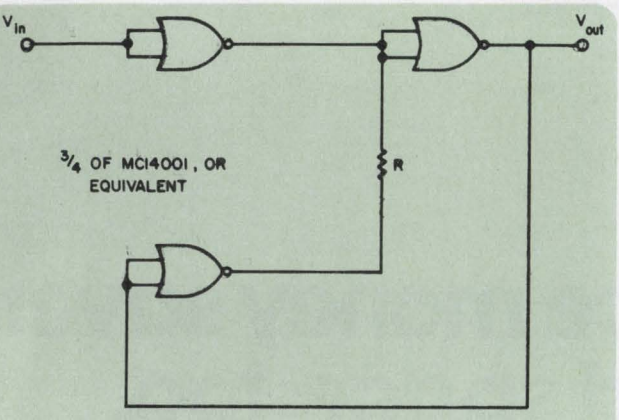
Schmitt trigger design uses CMOS logic

Three-fourths of a standard CMOS quad-2 gate, such as the MC14001, can be connected to form a Schmitt trigger. The resulting circuit (Fig. 1) offers negligible loading to high-impedance sources, because the CMOS control-line inputs require only picoamps of current. For waveform-squaring applications, the circuit has a voltage gain of at least 100. When the circuit is used as a dc level detector, the trigger levels can easily be adjusted over 30% to 50% of the supply range. The circuit can also be used in level-shifting applications.

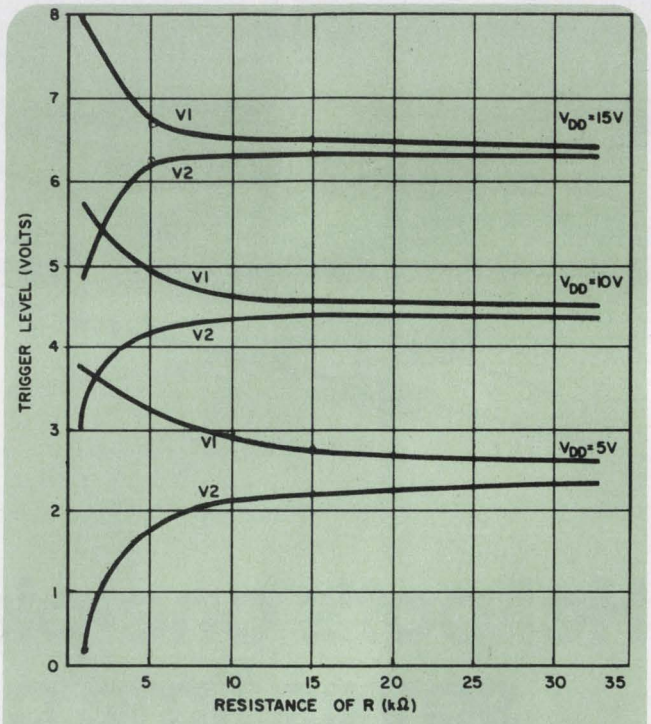
The power supply should be in the range of 3 to 18 V. The output-logic voltage swing approximately equals the supply voltage. Resistor R should be in the range of 5 to 35 k Ω, and by variation of its value, the trigger levels (Fig. 2) and hysteresis range can be adjusted. Hysteresis ranges of up to half of the supply voltage can be achieved.

Bernie Schmidt, CMOS Design Engineering Manager, Motorola Semiconductor Products, Inc., 5055 E. McDowell Rd., Phoenix, Ariz. 85008

CIRCLE NO. 312



1. **A low-cost, versatile Schmitt trigger** requires only three logic-gate elements and one resistor.



2. **Trigger levels plotted against resistance of R** for three values of dc supply voltage V_{DD}. V1 is the ON trigger, V2 is the OFF.

Three-frequency gated oscillator generates full-width clocks

A gated TTL oscillator provides an inexpensive, stable circuit for generating an integral number of synchronous clocks at one of three selectable frequencies. Each frequency is completely independent and may range from 2 Hz to 4 MHz.

The circuit in Fig. 1 is based on a 7413 Schmidt trigger. In the quiescent state, with the disable input high, the clock signal is held low through positive feedback through the disable gate. The C nodes are held high by the low-clock output via the frequency enable gates.

When the disable goes low, the clock goes high. Node A is held high as long as disable is held low. The selected node C begins to discharge from its quiescent 5 V. When it reaches 0.8 V—the low Schmidt trigger level—the clock goes low.

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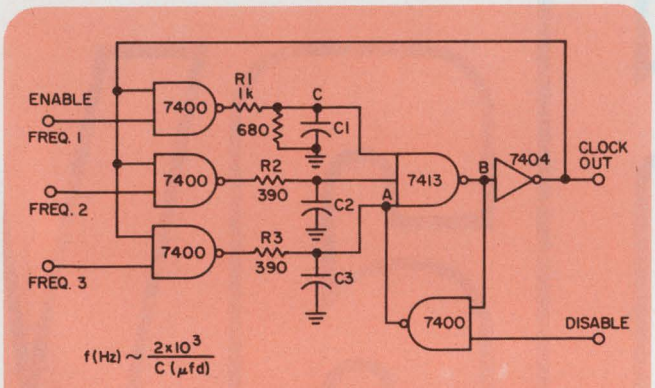
Node C charges until it reaches the high trigger level of 1.6 V. The clock then goes high, and the cycle repeats.

The first clock pulse is longer than subsequent ones because node C must discharge from the 5-V quiescent level to 0.8 V. This initial pulse may be used for keying in serial data transmission. The stretching of the first pulse can be minimized by lowering the node-C voltage to around 2 V. If R1 is replaced with a 1-kΩ resistor, and a 680-Ω resistor is connected between node C and ground, the node-C voltage will be lowered.

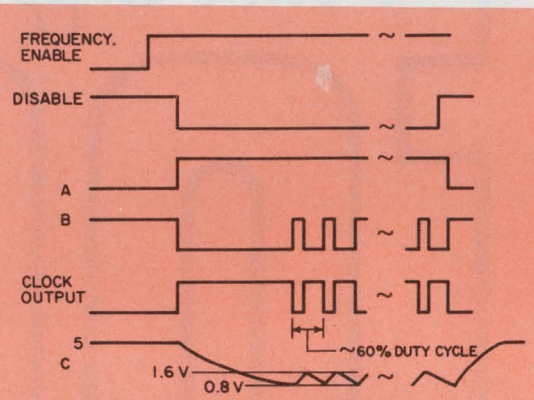


1. **TTL oscillator is based** on a 7413 Schmidt trigger with three enable input gates.

The clock runs until the disable input goes high. If disable goes high when the clock is low (node B high), the positive feedback maintains this state. If disable goes high when the clock is high (node B low), nothing happens until the clock is again low. The system is then latched in the quiescent state. This insures that an integral number of full-width clock pulses is generated, thus eliminating chopped pulses.

R. R. Osborn, Roberts Enterprises, 723 W. Aspen, Flagstaff, Ariz. 86001

CIRCLE NO. 313



2. **Timing diagram shows how the three-frequency clock generator** is gated by the disable input.

Precision limiter minimizes 'rounding'

The transition from linear to saturated condition in most limiters occurs gradually because of the nonlinear nature of diode characteristics. The circuit in the diagram minimizes "rounding" by using a second amplifier, A2, across the feedback path of the main amplifier, A1. This sharpens the clamping action of diode D1.

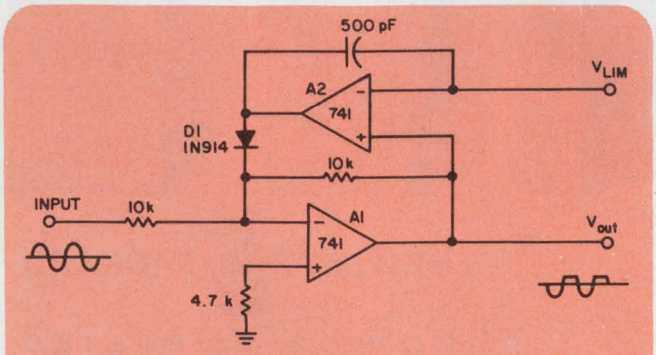
Input V_{lim} sets the saturating level. If V_{lim} is more positive than V_{out}, the output of op-amp A2 will be around −10 V. Diode D1 is then reverse-biased, and A1 acts as a unity-gain inverter.

If V_{out} tries to go more positive than V_{lim}, A2 forward-biases D1 with enough current to keep V_{out} equal to V_{lim}. The gain in the limited condition is very low (≈1/50,000), so there is little rounding. The capacitor provides frequency compensation of the double-amplifier feedback loop in the limited state.

Negative limiting occurs if the diode is reversed. Adding another op amp and a reversed diode forms a bipolar limiter, with separately adjustable saturation levels for the positive and negative limits of V_{out}.

Yale E. Goldman, University of Pennsylvania, Dept. of Physiology, 37th and Hamilton Walk, Philadelphia, Pa. 19104

CIRCLE NO. 314



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Logic probe responds to TTL pulses of less than 10 ns in width

A simple logic probe responds to TTL pulses—singly or in trains—even when the width of the ONE or ZERO state is less than 10 ns. It also indicates simple logic-level shifts. A single ONE or ZERO pulse causes a wink, with a duration of around 30 ms, from the ONE or ZERO lamp, respectively. A logic-level shift results in indication of the dominant logic level.

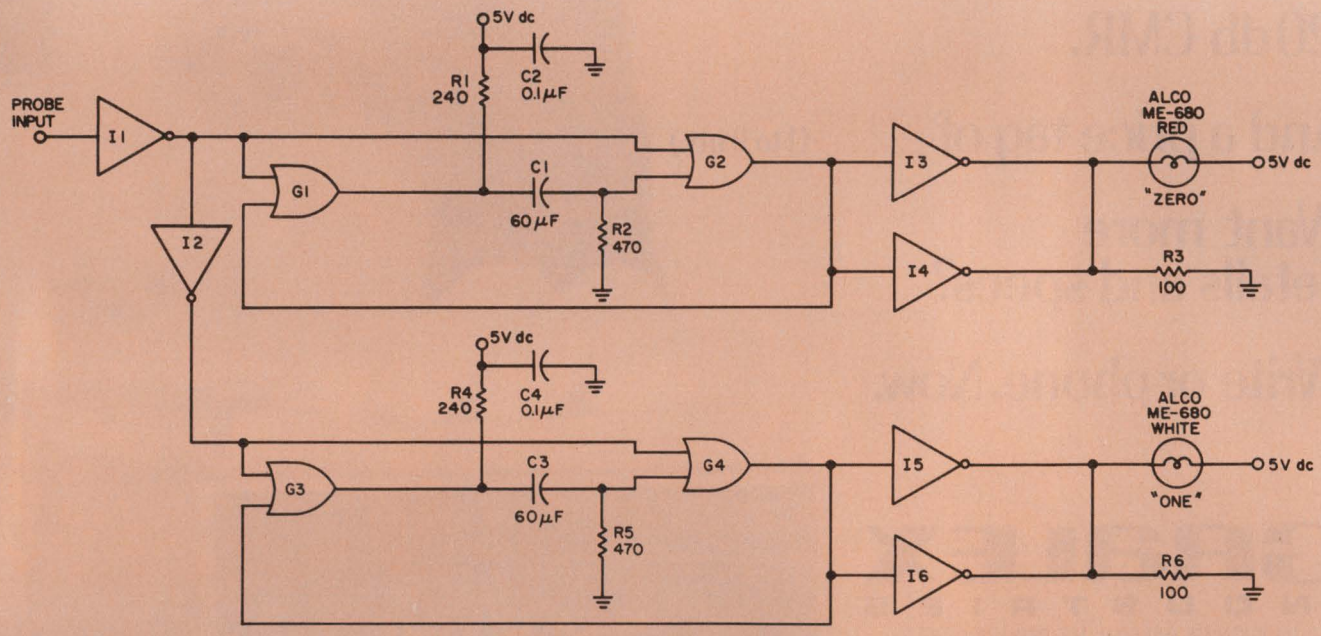
The circuit shown consists of two ICs, an RC network, and two lamps, and may be assembled in a pen-like container at a parts cost of around $15. All wiring should be kept as short as possible, and C2 and C4 should be wired close to the power and ground terminals of their respective ICs.

Capacitors C1 and C3 are 20-V electrolytics with lengths of about 5/8-inch. To shorten the wink period, simply use lower value capacitors. The single-phase ON period for either lamp is approximately R2 · C1 for the ZERO lamp and R5 · C3 for the ONE.

The two lamps are 60-mA T-1 types, with a rated life of 100,000 hours. They are kept in a barely ON state at all times by R3 and R6, to help prolong their life and reduce the current handling demands on the output transistors of I3 through I6. Red and green LEDs can be used with appropriate resistors instead of incandescent lamps, but their cost will be higher.

Michael Sinutko, Dept. of Defense, Div. R-51, 9800 Savage Rd., Fort Meade, Md. 20755

CIRCLE NO. 315



With TTL input pulses, the white bulb winks to indicate the ONE state. Similarly, the red bulb indicates a ZERO. The circuit also indicates logic-level shifts, with the lamps indicating the dominant level.

IFD Winner of December 23, 1971

C. L. Stansberry, 20521 Debbie Lane, Saratoga, Calif. His idea "Compute Laplace transform and Bode response with BASIC" has been voted the Most Valuable of Issue award.

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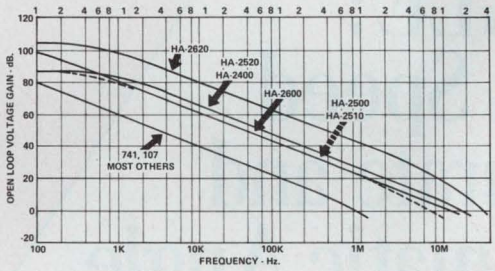

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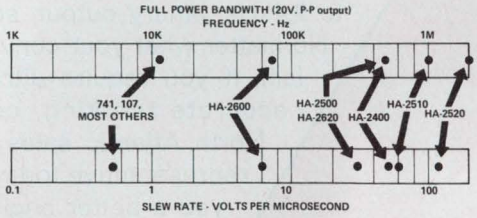
- Hundreds of times better DC performance (for example, the HA-2600/2620 has a 5nA bias current, 300MΩ input resistance, and 100K minimum open loop gain).



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INFORMATION RETRIEVAL NUMBER 35

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MODEL 545/100

If you're converting synchro/resolver data to digital format, you need both speed *and* accuracy to keep pace with today's data explosion. Only one converter meets both these requirements without compromise. And for under $4K. . . . North Atlantic's Model 545/100.

The solid-state Model 545/100 converts both resolver and synchro data with 0.01° accuracy and resolution. And continuously digitizes input angle data at 20,000° per second in the face of real-life noise, harmonics and quadrature levels. BCD output is available at the rear connector. Conversion can be stopped by a data freeze command. If multiplexed signals are your bag, acquisition time is less than 30 ms.

Options? Other models offer many options, including 0.001° resolution with 10 arc-second accuracy; data frequencies from 60Hz to 2.4kHz, binary output, small size.

No matter what your conversion problem, if you require ultra-fast, ultra-accurate tracking, contact your North Atlantic sales engineering representative today. He'll show you a better angle.

WHAT'S YOUR ANGLE?

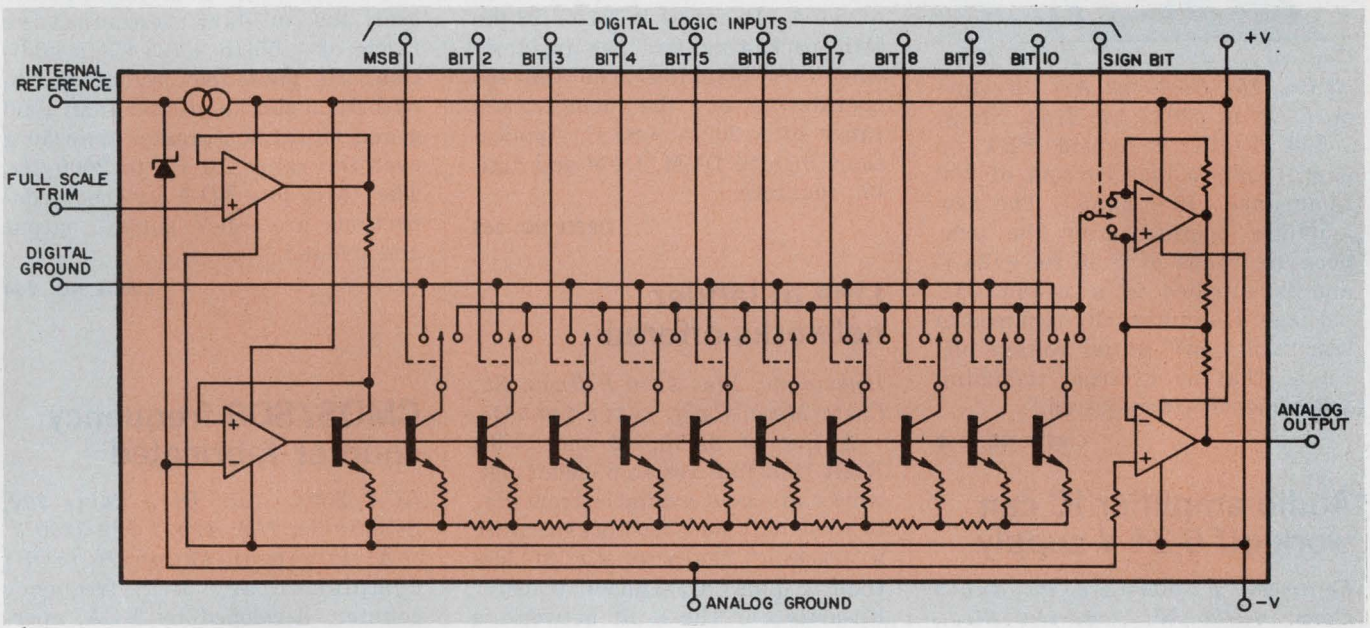
NORTH ATLANTIC
industries, inc.

200 TERMINAL DRIVE, PLAINVIEW, NEW YORK 11803
cable: noatlantic / twx: 510-221-1879 / phone: (516) 681-8600

INFORMATION RETRIEVAL NUMBER 36

new products

Monolithic d/a converter achieves 0.05% linearity with 10-bit resolution



Precision Monolithics, Inc., 1500 Space Park Dr., Santa Clara, Calif. (408) 246-9222. Around $45 (100); 4 wks. (prototype quantities).

A complete 10-bit-plus-sign d/a converter on a chip, the monoDAC-02, offers the highest resolution of any single-chip converter. And Precision Monolithics guarantees 0.05% linearity and 1 μs settling time over the entire 0 to 70 C temperature range.

On the 82 $\times$ 148 mils chip are all the elements needed for a complete 10-bit DAC. These include a high-stability voltage reference, an internally compensated high-speed output op amp and a diffused R-2R resistor ladder network matched to better than 0.05% over the temperature range. The monoDAC-02 comes in an 18-pin dual-in-line package.

Basically, the circuit works as follows: A voltage reference sets up a regulator amplifier that provides voltage drive to the base of ten constant-current source transistors (see diagram). The binary-scaled currents are generated by connecting each current source's emitter to a tap on the R-2R ladder network.

Current-steering logic routes each bit current either to ground or to an output summing line. A logic-controlled current-polarity-inverting amplifier drives the output op amp. The amplifier converts the summed currents to a low impedance output voltage.

A current-regulated zener diode generates the temperature-stable 6.7 V reference—its output is available on an external pin. A reference-voltage input pin allows the user to either select the internal reference or to apply an optional external reference. The monoDAC-02 can accept reference voltages varying from +6.7 V down to nearly zero volts, allowing operation as a moderate-speed two-quadrant multiplying DAC.

The regulator tracks variations in V_{be} of the current-source transistors. It is able to do this because a current source, operating at the third bit's current, is included in its feedback loop.

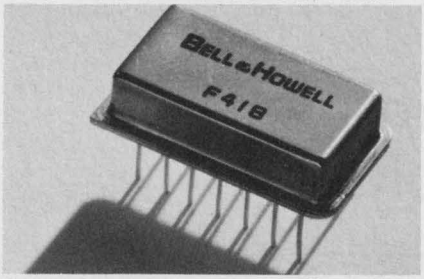
The regulator op amp supplies the base currents for the current sources, thus compensating for the finite betas of the transistors. Because the voltages of all emitters are equal, a simple R-2R scaled ladder network can be used to provide the currents.

The monoDAC-02 uses positive logic for both the magnitude and sign switches. The initial or "sign" bit determines output polarity. The logic input levels of 2.0 V and 0.8 V allow TTL and DTL compatible operation with full noise immunity. Also the maximum acceptable logic input levels of +15 V to −5 V allow direct interface with MOS and CMOS logic elements. The maximum logic input current is only 10 μA at any logic level.

The output amplifier uses an internal feed-forward compensation network to provide 40 V/μs slewing and 0.1% settling within 1 μs. The output amp draws only 50-nA bias current and is capable of driving 2-kΩ loads yet has a standby power drain of only 35 mW. The output op amp includes short-circuit protection.

CIRCLE NO. 259

Hybrid FET op amp has 100 fA bias current



Control Products Div., Bell & Howell Co., 706 Bostwick Ave., Bridgeport, Conn. (203) 368-6751. Stock.

The F-418, a hybrid FET op amp, boasts a bias current of 100 femtoamps (10^{-15} amps). The new amplifier operates over the temperature range of −55 to +125 C and is supplied in a 14-pin DIP package. It is internally trimmed to less than 1 mV initial voltage offset so that no external trimming adjustments are required.

CIRCLE NO. 260

Audio amplifier IC can work off 6-24 V supply

European Electronic Products Corp., 10180 W. Jefferson Blvd., Culver City, Calif. (213) 838-1912. $3 (100 up).

The LM354, a monolithic IC audio amplifier for television sets, has a usable range of supply voltages of 6 to 24 V. Additional features include self-centering bias, input impedance exceeding 100 kΩ and maximum power dissipation of 4 W. The LM354 is assembled in a 14-lead plastic split-DIP with a shaped heat-sink soldered on a copper bar.

CIRCLE NO. 261

3-1/2-digit counter display device in CMOS

Solitron Devices, Inc., 8808 Balboa Ave., San Diego, Calif. (714) 278-8780. $18.50 (1-99).

The CM4100, a 3-1/2-digit counter display device in CMOS, features BCD data storage, and 7-segment decoders and drivers. The device has a power rating of 2 mW typical and single supply voltage of 5.0 V. It comes in 24 or 28-pin DIP packaging and has insignificant zero blanking. The CM4100 operates over the temperature range of −20 to +85 C. Applications include DVM, DPM and digital counters.

CIRCLE NO. 262

Line of ladder networks offered

Hybridyne, Inc., 3150 Pullman St., Costa Mesa, Calif. (714) 540-5935.

A line of 8, 10, 12 and 14-bit R-2R thin film resistor ladder networks are now available from Hybridyne. All four networks feature a tracking characteristic of less than 1 ppm/°C. Ladder transfer linearity for the 8-bit network is 0.05%, 10-bit 0.03%, 12-bit 0.01% and 14-bit 0.005%. The 8 and 10 bit networks are packaged in a standard 16 pin DIP. The 12 and 14 bit networks are in a 20 pin DIP. Characteristic resistance of all networks is 1% at −55 C to +125 C max. Settling time to 0.1% of full scale is extremely fast at less than 50 ns typical. Storage temperature rating for all is −65 C to 150 C with operating voltage at 100 V.

CIRCLE NO. 263

Crystal oscillators in TO-5 cans

Statek Corp., 1200 Alvarez Ave., Orange, Calif. (714) 639-7810. $84 (1-9), $11 (5000); stock to 4 wks.

Miniature crystal oscillators, covering the range of 10 kHz to 100 kHz, are the first low-frequency oscillators in TO-5 packages, according to the company. They are TTL-compatible and can operate over the military temperature range of −55 to +125 C. In addition, the packaged oscillators can withstand shocks greater than 1000 g and vibrations greater than 50 g over the range 10 Hz to 2000 Hz. The three-pin TO-5 external connections are +5-V supply, output and ground.

CIRCLE NO. 264

CMOS/SOS frequency counter fabricated

RCA Solid State Div., Route 202, Somerville, N.J. (201) 722-3200.

A silicon-on-sapphire (SOS) complementary MOS frequency counter, developed by RCA, operates at frequencies up to 40 MHz. The seven-stage binary counter contains 162 transistors of both conductivity types on a 114 by 104 mil chip. Like other circuits in the COS/MOS line, the counter has the application advantages of low power, high noise immunity, and wide allowable power supply voltage range. The use of SOS extends the frequency range of COS/MOS to where it is competitive with bipolar TTL arrays.

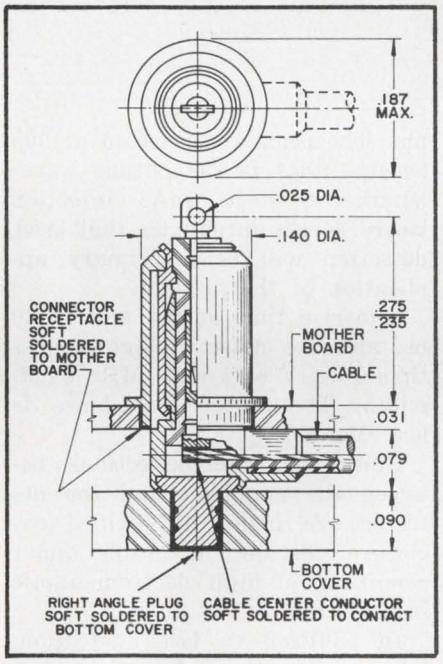
CIRCLE NO. 265

SMALLEST IN THE INDUSTRY

THEIR PRICE IS, TOO!

Solitron/Microwave's new 8100 Series of "push-on" coaxial connectors solve application problems where micro-miniature size and limited space are of prime concern. These low cost quick disconnect connectors are available in straight plugs and jacks, right angle plugs and recessed receptacles. Write today for complete information.

TYPICAL PC BOARD PACKAGING REQUIREMENT:



MATERIALS:

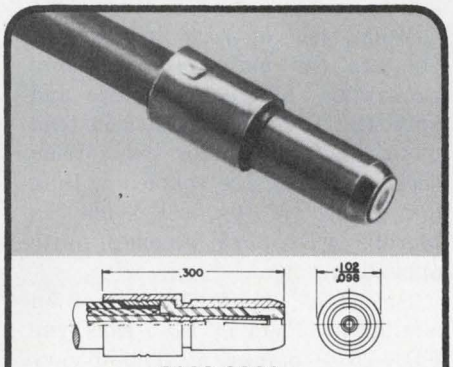
1. **All metal parts** except female contacts: Brass per QQ-B-626, Composition 22, ½ hard
2. **Female Contact:** Beryllium copper per QQ-C-530, Condition HT
3. **Insulation:** Teflon per MIL-P-19468
4. **Finish** (all metal parts): Gold Type II, Class 2 per MIL-G-45204

ELECTRICAL:

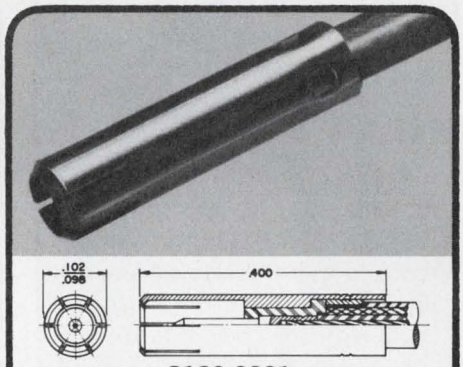
1. **Operating Voltage:** 50 Volts
2. **Contact Resistance:** 4 MV. max
3. **Dielectric Withstanding Voltage:** 100 VRMS @ sea level, 50 VRMS @ 50,000 ft.
4. **Direct Current Rating:** .50 Amp
5. **Impedance:** 50 ohms nominal

MECHANICAL AND ENVIRONMENTAL:

1. **Disengaging force of mated pair:** 1 pound minimum
2. **Cable retention force:** 10 pounds minimum
3. **Temperature Range:** —50°C to +125°C
4. **Corrosion Resistance:** per MIL-C-39012



8100-0001
STRAIGHT PUSH-ON
CABLE PLUG for RG-178B/U



8120-0001
STRAIGHT PUSH-ON
CABLE JACK for RG-178B/U

Solitron/Microwave
CONNECTOR DIVISION

Telephone (305) 287-5000 - TWX (510) 953-6010
Cove Road, Port Salerno, Florida 33492

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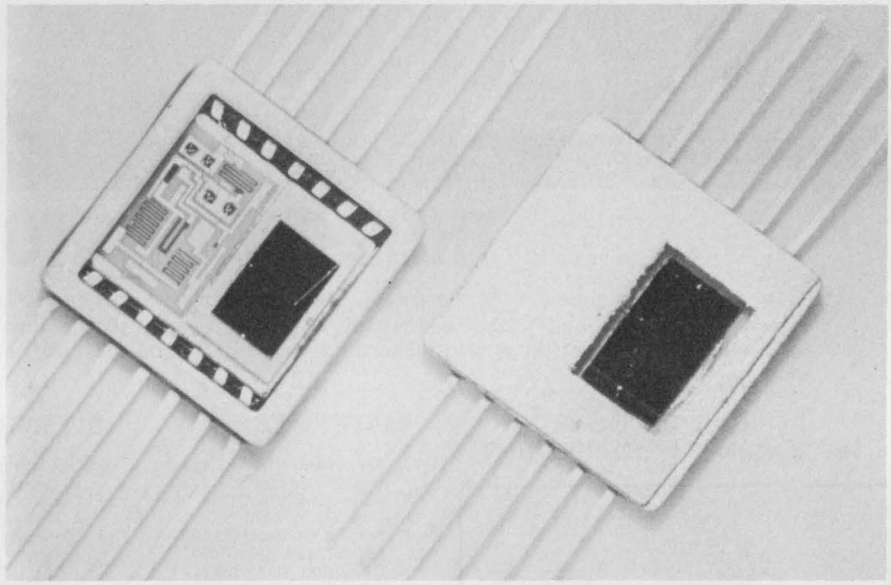
INFORMATION RETRIEVAL NUMBER 38

Flatpack photodetector / amp has wide field of view



Meret, Inc., 1815 24th St., Santa Monica, Calif. (213) 828-7496. $97.50 (10-99); 2 weeks.

Wide field of view and ease of use are the main benefits from packaging a photodetector and amplifier in an IC flatpack instead of a TO-5 transistor can. When these features are coupled with a low price, a product such as Meret's FDA-25/4 becomes quite appealing.

Priced at about 25% less than similar products in TO-5 cans, the FDA-25/4 offers a field-of-view cone angle of 160°. This compares with about 100° for TO-5 units.

Packaged in the flatpack are a 4.5 mm^2 planar silicon photodetector and a thin-film hybrid amplifier. Although the flatpack has 14 pins, only three are connected. They are for B+, output and ground. The B+ voltage requirement of the unit is only 12 V at 6 mA. TO-5 units on the market commonly require eight to 10 pins and a B+ voltage of up to 45 V.

The responsivity of the unit is 15 mV/μW at a wavelength of 905 nm. It is usable from 400 to 1100 nm. The peak was selected at 905 because that is the output wavelength of most GaAs injection lasers. Meret anticipates that laser detection will be a primary application of the product.

The rise time of the unit is 40 ns, and the noise voltage is less than 100 μV over a 10 MHz bandwidth. The output impedance is less than 50 Ω.

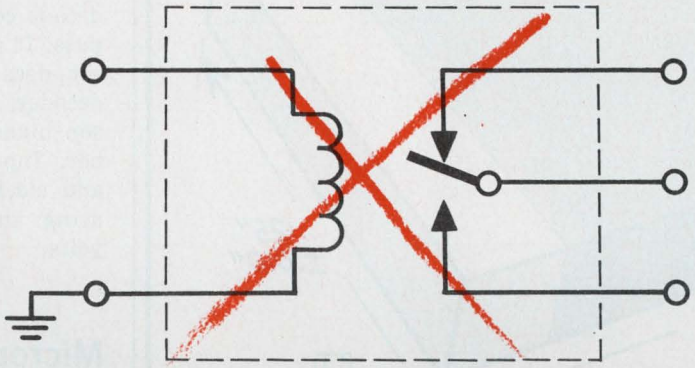
Since the interconnections between the amplifier and the detector are inside a shielded enclosure, the unit is usable under conditions of high electromagnetic interference.

In addition to laser detection, other applications of the unit are expected to include communications, optical fuzes, ranging, proximity detection, intrusion alarms, automotive rear-observation devices and data transmission links with fiber-optic coupling.

Options include 905-nm filtering for maintaining a wide field of view and temperature-tracking the laser emission spectrum and standard interference filters. A larger area detector can also be provided.

CIRCLE NO. 266

Get it out of your system:

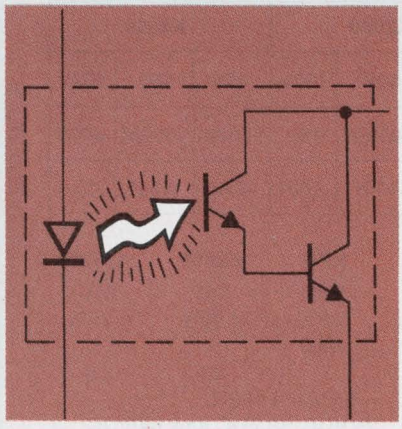


Replace it with a solid-state relay built around a Monsanto opto-isolator.

An all-semiconductor relay has a lot of sex appeal. No contact bounce, because there are no contacts. No coil. No reed. No transformer, either. Turn-on and turn-off times of less than 50 μsec are easily achieved. It will take the severest Mil-Spec mechanical shock and vibration tests without blinking. It will operate in ambient temperatures from −55°C to +100°C. Best of all, it gets a component with a built-in failure mechanism out of your system.

New Application Notes

It's easy and inexpensive to find out how the Monsanto line of opto-isolators (alias photo-coupled pairs) can help you build an all-solid-state relay into your system.



The MCA-2 photo-Darlington does the switching.

Send for our new application notes AN501 and AN502. The first shows you a DPDT 125 mA semiconductor relay, the second how to build a low cost ($7.06) solid state AC relay that will switch a wide range of voltage and current levels. Very interesting reading. Use the bingo card or call us at (408) 257-2140. Monsanto Commercial Products Co., Electronic Special Products, 10131 Bubb Road, Cupertino, California 95014.

Monsanto

INFORMATION RETRIEVAL NUMBER 40

ICs & SEMICONDUCTORS

Decade counter/divider for 5 MHz operation

Solitron Devices, Inc., 8808 Balboa Ave., San Diego, Calif. (714) 278-8780.

A CMOS decade counter/divider, the CM4017A, features medium speed operation—5 MHz, typically at 10 V—fully static operation and MSI complexity on a chip. The decade counter has 10 decoded outputs. It consists of a 5-stage Johnson decade counter and an output decoder, which converts the Johnson binary code to a decimal number. Inputs include a clock, reset and clock-enable signal. The operating supply voltage is 3 to 15 volts.

CIRCLE NO. 350

Micropower LED flasher eases supply needs

Lithic Systems, Inc., P.O. Box 869, Cupertino, Calif. (408) 257-2004. $1.18 (100 up); stock.

The LP1000— a monolithic stored-energy regulator for LEDs, and other power-consuming devices—conserves available power through intermittent storage and release of energy at low duty cycles. With a single external resistor and capacitor, the three-terminal microcircuit can drive 30 mW and larger LEDs from sources as weak as 30 μW (peak).

CIRCLE NO. 351

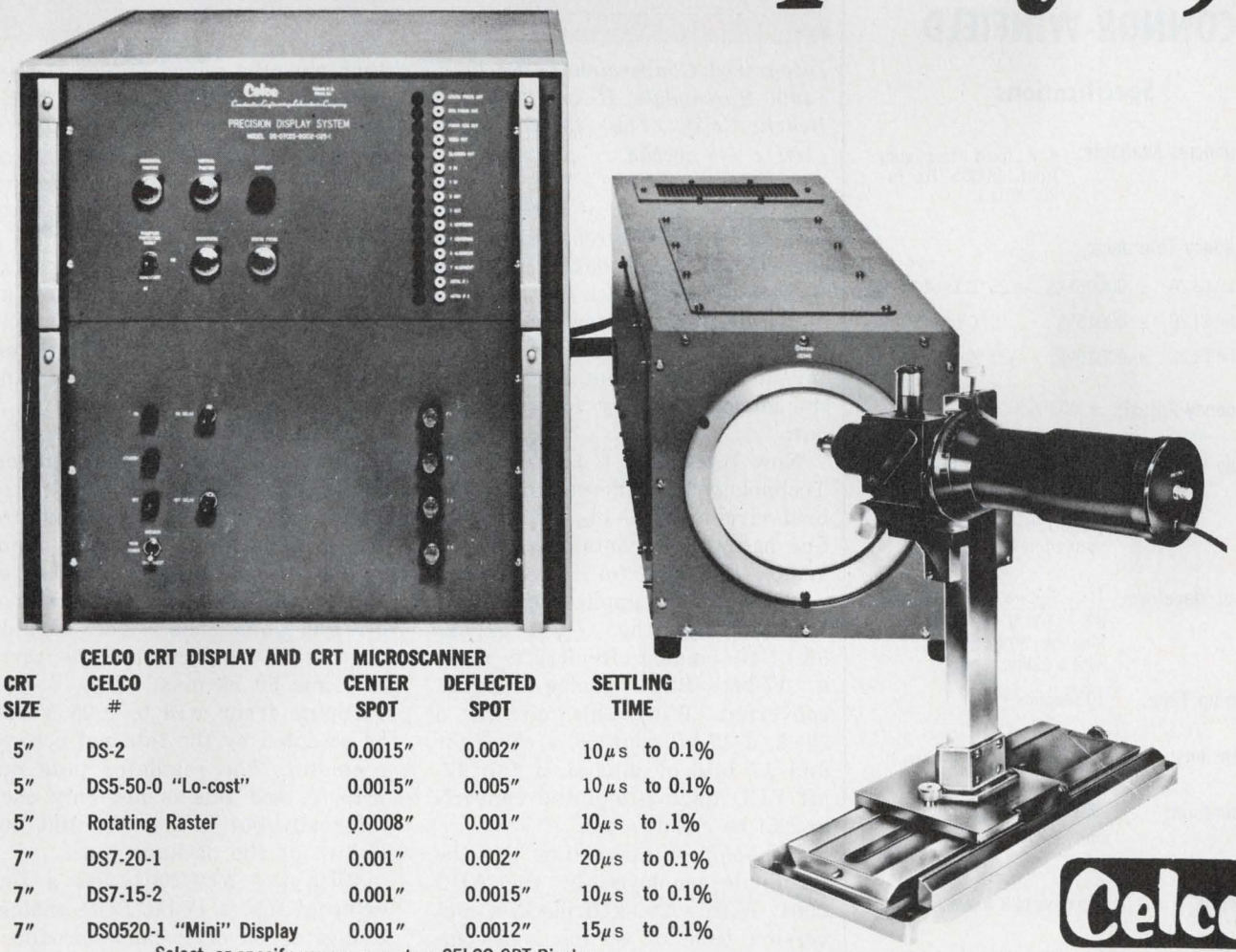
Photodiode array offers direct digital output

North American Rockwell Microelectronics Co., P.O. Box 3669, 3430 Miraloma Ave., Anaheim, Calif. (714) 632-2321.

A 16-bit MOS/LSI photodiode shift register, developed by NR-MEC, provides direct digital output. In addition, light intensity can range from 0.1 mW/cm^2 to 25 mW-cm^2 (2800 K tungsten) over the temperature range of −55 to 70 C. The 16 diodes, arranged along a 140 mil line of 8.8 mil centers, evaluate light patterns over an integration period. This is adjusted to achieve thresholds such that an equivalent ONE or ZERO is parallel shifted into the shift register.

CIRCLE NO. 352

If You Didn't Know CELCO Makes CRT Displays,



CELCO CRT DISPLAY AND CRT MICROSCANNER

CRT SIZE	CELCO #	CENTER SPOT	DEFLECTED SPOT	SETTLING TIME
5″	DS-2	0.0015″	0.002″	10μs to 0.1%
5″	DS5-50-0 "Lo-cost"	0.0015″	0.005″	10μs to 0.1%
5″	Rotating Raster	0.0008″	0.001″	10μs to .1%
7″	DS7-20-1	0.001″	0.002″	20μs to 0.1%
7″	DS7-15-2	0.001″	0.0015″	10μs to 0.1%
7″	DS0520-1 "Mini" Display	0.001″	0.0012″	15μs to 0.1%

Select, or specify your own custom CELCO CRT Display.

Celco

MAHWAH, N. J. 07430

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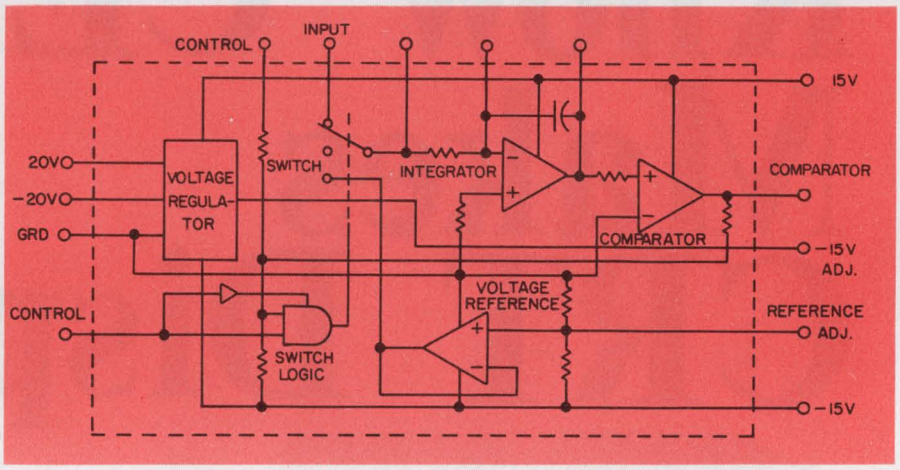
you should.

CONSTANTINE ENGINEERING LABORATORIES COMPANY

INFORMATION RETRIEVAL NUMBER 42

Analog portion of 17-bit A/D is offered in a 14-pin DIP



Integrated Conversion Technology, 14900 Springdale, Huntington Beach, Calif. (714) 892-2070. $32 (100); 4-6 weeks.

With the advent of digital voltmeter MOS/LSI circuits—such as the Mostek MK5002P and the Fairchild 3814, which contain most of the digital circuitry for a multidigit readout—a need has arisen for an IC that contains most of the analog circuitry for the readout.

Now Integrated Conversion Technology has developed a hybrid circuit in a 14-pin, dual in-line package. It contains all of the analog circuitry for a 4-1/2-digit voltmeter. For applications other than displays, the ADC 2001 has all of the analog circuitry to make a 17-bit BCD analog-to-digital converter. With this circuit, a clock, a 17-bit counter, a capacitor and 17 bits of latches, a full 17-bit BCD analog-to-digital converter can be constructed.

Dual-slope integration is the technique employed by the ADC 2001. With a 200-kHz clock, a conversion time of 80 ms is accomplished. The circuit will also work with up to a 10-MHz clock, yielding 1.6-μs conversion time. The stability of the circuit when used in a 17-bit A/D configuration is 5 μV/C max. The linearity depends upon an external capacitor that must be added across the integrating amplifier in the package. If a low dielectric hysteresis capacitor—such as a polystyrene or Mylar type—is used, the linearity is ±1-LSB (least significant bit).

The package contains a dual-tracking voltage regulator, an integrator, a comparator, a switching element, a stable voltage reference and several resistors and capacitors.

It accepts an input voltage of 0 to 20 V and works over a temperature range of 0 to 70 C.

One key to the performance of the unit is the integrator input switch. It has an OFF current of 100 pA max and an ON resistance of 100 ohms max. The turn-on time is 35 ns max, and the turn-off time 50 ns max.

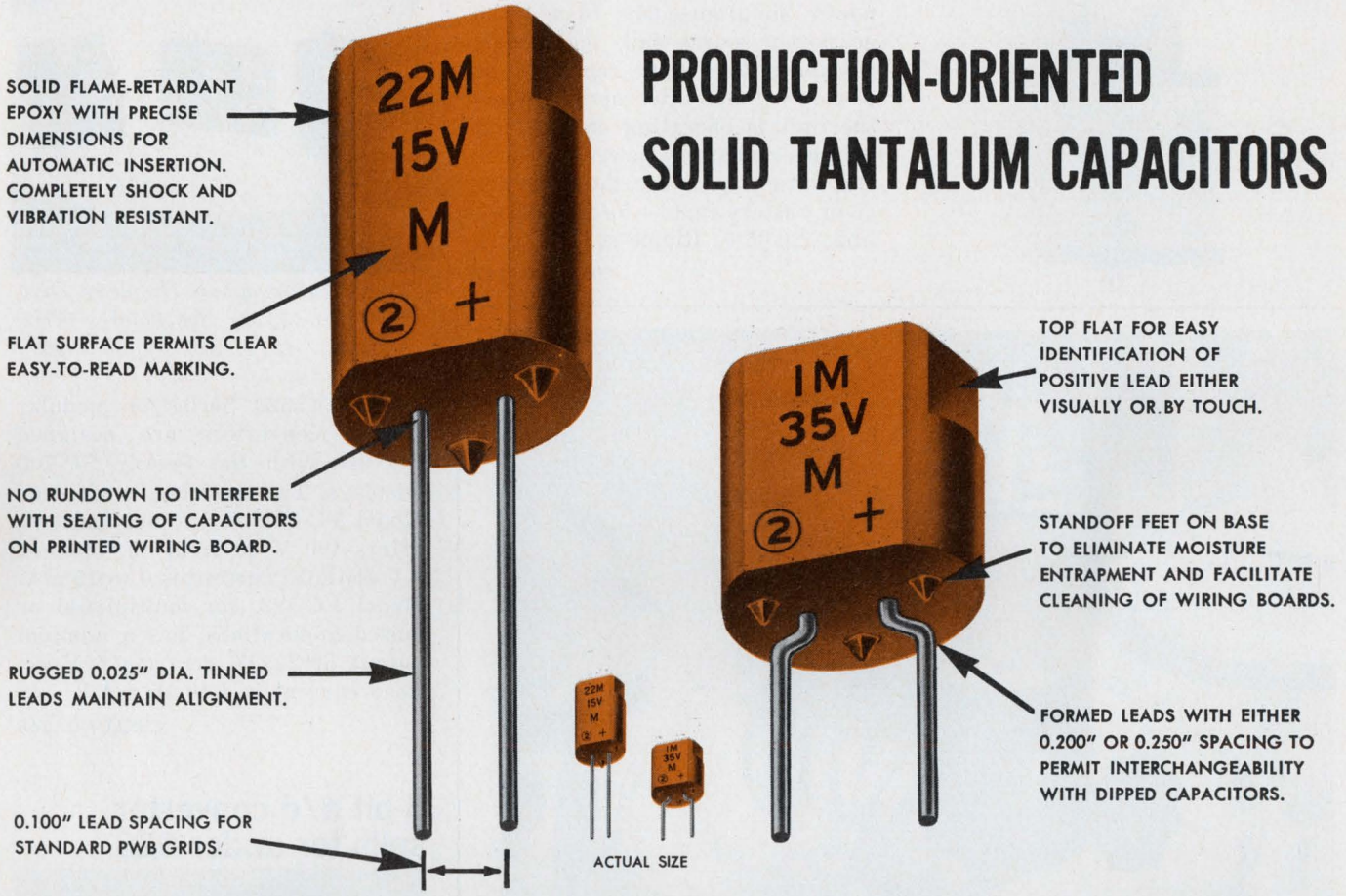
Inputs from ±18 to ±25 V can be accepted by the internal voltage regulator. The regulator puts out ±15 V, and this is not only used internally but is also brought out to two of the package pins.

With the ADC2001 and a few external ICs, a 17-bit BCD analog-to-digital converter can be produced far less expensively than the several-hundred-dollar cost of modules now on the market.

For Integrated Conversion Technology **CIRCLE NO. 250**
For Mostek **CIRCLE NO. 251**
For Fairchild **CIRCLE NO. 252**

Another Sprague Breakthrough!

PRODUCTION-ORIENTED SOLID TANTALUM CAPACITORS



Type 198D Low-cost Econoline* Tantalum Capacitors Lead in Performance!

When it comes to low-cost solid tantalum capacitors, the *new* Sprague Type 198D Econoline Capacitors outperform all other designs. Here are some additional advantages:

- Low d-c leakage
- Low dissipation factor
- Wide voltage range, 4 to 50 VDC
- Capacitance range from 0.1 to 100μF
- Withstand severe temperature cycling and temperature shock over −55 C to +85 C
- Speedier handling for insertion
- Easier-to-read markings

The *new* Sprague Type 198D epoxy-encased Econoline Capacitor is tooled for mass production and priced competitively with imported dipped units. Investigate this new Sprague breakthrough without delay.

Call your nearest Sprague district office or sales representative, or write for Engineering Bulletin 3546 to: Technical Literature Service, Sprague Electric Co., 347 Marshall Street, North Adams, Mass. 01247.

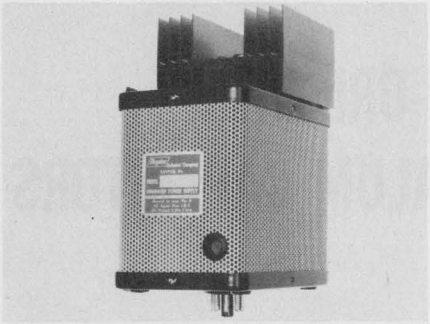
★ Trademark

SPRAGUE®
THE MARK OF RELIABILITY

***THE* BROAD-LINE PRODUCER OF ELECTRONIC PARTS**

INFORMATION RETRIEVAL NUMBER 44

Supply keeps operating when power fails

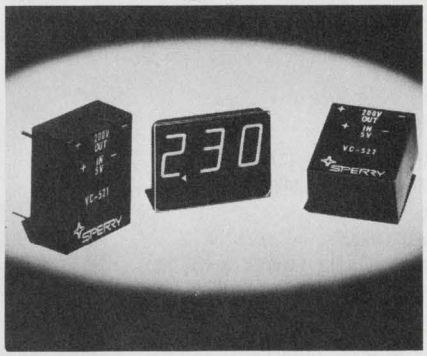


Acopian Corp., Easton, Pa., (215) 258-5441. $195 less battery.

The Model 1567 provides an output of 5 V dc at 2.5 amps. The supply accepts ac and battery input power simultaneously. Should the ac power source fail, the module continues to supply regulated dc power, without interruption. When the unit is operating on ac input voltage, no battery power is drawn. Regulation specs are the same for ac or battery input—load: ±0.5%; line: ±0.05%. Ripple is 1 mV rms.

CIRCLE NO. 267

Voltage Converter takes 5 V, gives 200 V

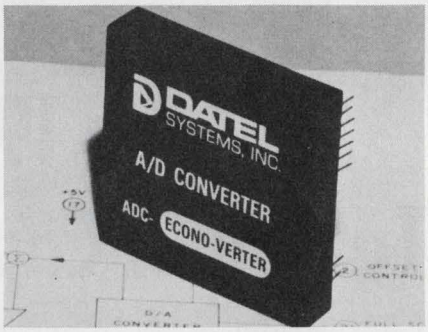


Sperry Information Displays Div., P.O. Box 3579, Scottsdale, Ariz. (602) 947-8371. $11 (1000-4999); stock.

The VC-520 Series of modular voltage converters are designed for use with the Sperry SP-700 Displays. Two models are offered: Model VC-521, for dc applications, offers 190 V dc from an input of 5 V dc. Load current is 0 to 15 mA. Model VC-522, for multiplexed or pulsed applications, has a nominal output of 225 V dc from 5 V dc. Load current is 4 to 15 mA.

CIRCLE NO. 268

6-bit a/d converter sells for under $23



Datel Systems, Inc., 1020 Turnpike St., Canton, Mass. (617) 828-6395. $22.95 ea; stock.

The Model ADC "Econoverter" is claimed to be the most inexpensive a/d converter available. The unit contains its own clock generator, output counter/register, d/a converter, and high speed precision comparator in a 1.6 in.^{3} humidity/shock resistant module. Accuracy is ±1.5% and linearity is ±0.8%. Long term stability is 0.1%/year, and temperature coefficient is ±100 ppm/°C. The unit is TTL compatible. Total power drain is 700 mW from ±15 and +5 V supplies.

CIRCLE NO. 269

50 watt signal generator

10 to 2,500 MHz with six heads

solid state for high reliability

frequency stability ±0.003%/10 minutes

power stability ±0.2 db/hour

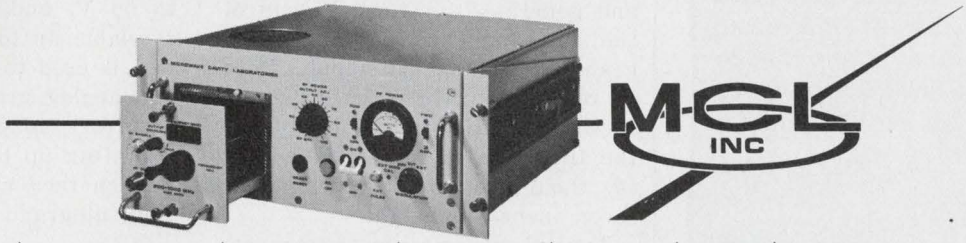
Pick a frequency between 10 and 2,500 MHz and the Model 15022 will deliver the reliable power you need for amplifier drive, component testing, calibration, and antenna pattern measurements.

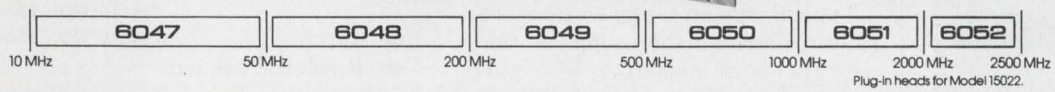
Reliability is built in with conservative design and all solid state components (except osc. tube). So you get frequency and power stability at low cost. Easy servicing. And full protection against mismatch or loss of load.

Front panel meter reads forward power in 10 and 50 watt scales. Single control tuning to 1% of actual frequency can be read directly for rapid setup.

Model 15022 has an internal and external modulation capability. An isolated RF output 20 db down is available for error-free monitoring. Meets MIL specs for RFI shielding.

For complete specifications on today's newest RF power source, call (312) 354-4350 or write: MCL, Inc., 10 North Beach Avenue, La Grange, Illinois 60525.



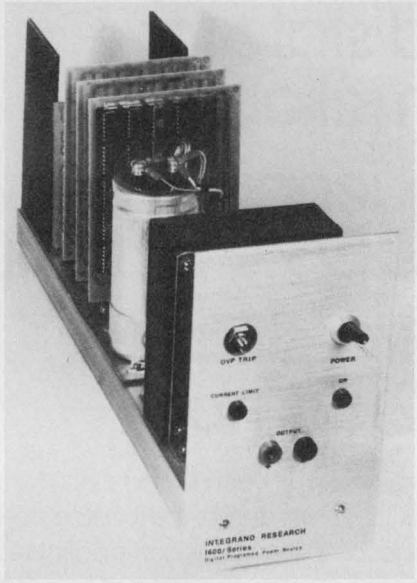


Plug-in heads for Model 15022.

Opportunities developing now for RF engineers at MCL, Inc. — an equal opportunity employer.

INFORMATION RETRIEVAL NUMBER 46

Programmable slot supplies get smaller and cheaper



Integrand Research Corp., 4266 Los Angeles Ave., Santa Susana, Calif. (805) 522-1507. $695; 30-45 days.

Packing 50 W of programmable output, as a single module, into a rack slot only four inches wide by seven inches high, the Integrand Research 1605 Programmable Power Sources are said to be the most compact on the market.

The closest competitior in size and features is Kepco, Inc. However, Kepco requires two modules to do the same job. Most Kepco slot supplies are voltage-programmable and require the addition of an SN series programmer. The programmer is a digital-to-analog converter, with memory, that accepts signals from the computer and generates a voltage to control the slot supply. Including the programmer and the slot supply, Kepco requires six to eight inches of rack width to do the same job that the 1605 does in four inches. Kepco, though, is a little less than seven inches in height.

Typical systems applications require programmable supplies that are capable of resolution of 1 part in 1000, absolute accuracy of 0.1% and regulation of 0.01%. These are the characteristics of the 1605. Programmable supplies are on the market—such as the Hewlett-Packard 6130B and the John Fluke 4250A and 4265A—that are an order of magnitude better in all of these specs. But they cost about $1800 instead of $695.

Kepco offers the greatest selection of programmable supplies. For similar performance, the Kepco supplies (including programmer) sell for close to the price of the 1605. However, the 1605 offers some features that Kepco doesn't. These include programmable current limiting and a faster data acquisition time.

Either BCD or binary data can be accepted by the 1605 series.

The 1605 accepts a full 12-to-16-bit command word from the computer in less than 1 μs. All data in the command word are stored within the supply. The computer time to program the supply is thus minimized, leaving the computer free for other tasks. An optional byte-oriented interface is available for computers that operate with fewer than the 12 or 16 bits required for a full command word.

Status signals available from the supply to the computer include these:

- Not ready, or not up to voltage.
- Current limit. Supply is regulating current, not voltage.
- Data accepted.

Voltage ranges are available up to 50 V, and current ranges are available up to 5 A. Optical isolation is used to separate the digital and analog grounds.

A rack adapter is available for mounting up to four supplies in a 19-inch rack width for $350.

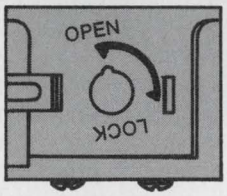
For Integrand Research
CIRCLE NO. 255
For Kepco
CIRCLE NO. 256
For Hewlett-Packard
CIRCLE NO. 257
For Fluke
CIRCLE NO. 258

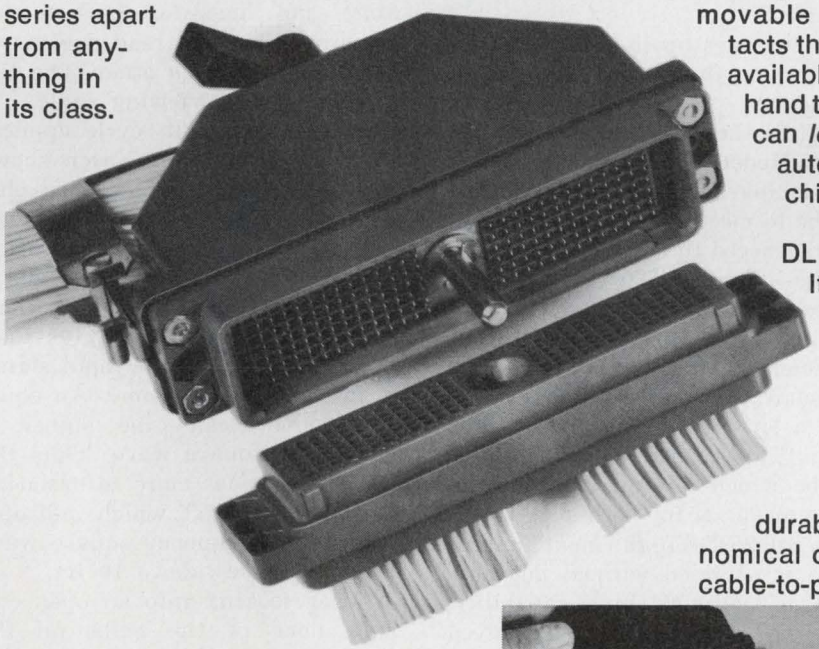
CANNON® ¢ENTSIBLE CONNECTORS.

The performance you need, at a price you can afford.

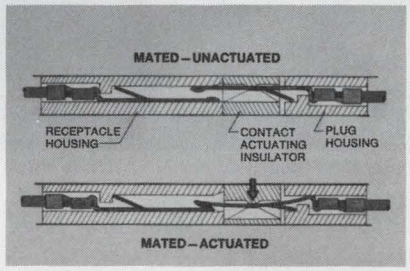
DL INSTAMATE

Zero contact mating force. Quick, positive coupling. Exceptional durability. Adaptable to mate directly with .025″ sq. wire wrap posts. These are some of the superior features that place the DL *Instamate* series apart from anything in its class.

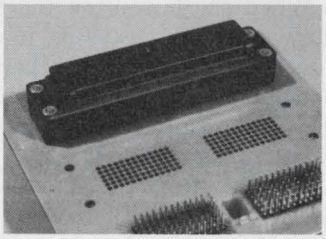


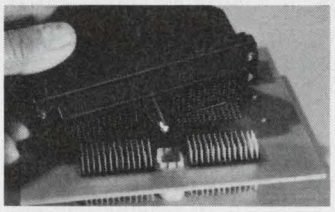


And there's more. The DL *Instamate* contact accommodates #20 through #30 AWG solid or stranded wire. The contact mating life exceeds 10,000 cycles—20 times the norm. There are contact arrangements with 96 or 156 positions on a .100″ grid. Removable contacts that can be crimped or wire wrapped are available for either machine or hand tool terminations. You can *lease or buy* a semi-automatic crimping machine, capable of 3,000 terminations per hour. And DL uses U.L. approved materials.



It all adds up to true, low cost-per-line economy. If your application requires a versatile, durable, yet economical connector for your data input/output, cable-to-panel or cable-to-cable needs, look into the DL *Instamate,* a ¢entsible connector. For a catalog and the name of your nearst distributor, write Dept. DL, ITT Cannon Electric, International Telephone and Telegraph Corporation, 666 East Dyer Road, Santa Ana, California 92702. (714) 557-4700.





CANNON ITT

INFORMATION RETRIEVAL NUMBER 48

Logic pulser and probe simplify in-circuit logic functional tests

Hewlett-Packard, 5301 Stevens Creek Rd., Santa Clara, Calif. (408) 246-4300. P&A: see text; stock.

With the announcement of the Model 10526T Logic Pulser and a new Logic Probe, the Model 10525T, Hewlett-Packard's Santa Clara Div., has nearly eliminated the oscilloscope and pulse generator as the only possible way of functionally checking out digital ICs on the PC board.

When the button on the side of the pulser is pressed, a 400-ns pulse is injected into the device under test. The probe detects pulse widths down to 10 ns and pulse train rates of 50 MHz.

By connecting the logic pulser to the existing +5-V logic supply, the user has at his fingertips a powerful one-shot pulse generator with these main features:

- A short 400 ns pulse insures against IC destruction.
- Current capability of ±750 mA allows the driving of outputs as well as inputs.
- Proper polarity pulses are automatically injected into test point.
- Pulser output appears to be an open circuit when it is not generating a pulse.
- Current drain is only 25 mA from a +5-V power supply, protected against incorrect connection to ±7 V.
- Voltages up to ±50 v may be applied to the output tip without damage.

With the introduction of the new Model 10525T logic probe, HP is upgrading its earlier 10525A probe to meet and, in many parameters, exceed the nearest competing probe—the LP-520 from Kurz-Kasch Inc., Dayton, Ohio. In comparing these probes, one obvious deficiency of the LP-520 is its standard Schottky-TTL gate which has a low-level input current of 2 mA. This contrasts with HP's probe which has an input impedance of 25 kΩ for both logic levels. The 10525T's high input impedance is attained without degradation of pulse-catching capability. The HP unit's 10-ns guaranteed pulse recognition compares with the typical 5 ns listed for the LP-520. Both units require use of a ground clip to achieve these speeds.

Any test equipment which is to be used in a production environment must be able to withstand substantial abuse—both electrical and mechanical. Electrically, the HP logic probe, which consists of one IC and eight discrete components, can take +7 V to −15 V at the power supply input versus Kurz-Kasch's reversal protection (no voltages called out) and ±70 V at the probe tip versus +50 V to −20 V for the LP-520.

In HP's logic probe and pulser, the heavy-duty coaxial power cord is strain-relieved at the molded plastic probe and terminated at the other end with a standard BNC connector. This contrasts with the LP-520 in which the only strain relief on the separate wires for the power leads, probe ground and gating logic inputs is a rubber grommet. The three colored lights near the probe tip (red for a high logic state, clear for a low logic state and blue for pulses) are sometimes hard to read due to reflections from each other. The HP unit has a 360° viewing angle.

In pulse and duty-cycle applications, however, Kurz-Kasch shows its colors. The red, clear and blue lights provide the user with not only a pulse activity indication (blue bulb) but also some duty-cycle information; if the clear light appears to be brighter than the red light, then the input signal is low most of the time. An equal brightness means the signal is close to a square wave. Thus the LP-520 provides more information than HP's 10525T which indicates only a low-frequency square wave for frequencies above 10 Hz.

When looking into an open circuit, none of the bulbs on the Kurz-Kasch probe light, whereas the HP probe goes to half brightness.

HP has priced the Model 10525T at $95.00 each. The "S" option for the Kurz-Kasch LP520 probe has comparable functional capabilities and sells for $79.95. ■■

Hewlett-Packard **CIRCLE NO. 253**
Kurz-Kasch **CIRCLE NO. 254**

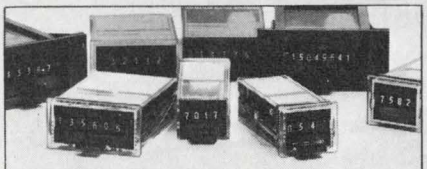
Or better. When other counters have long since given up, Sodeco RG series counters keep right on counting. Don't be surprised if they reach more than 250 million pulses.

We've built in Swiss engineering efficiency at no extra cost. The RG Series' compact size is compatible with most equipment specifications; with fast plug-in installation and easy-to-read numerals. And while the counters look good they help your equipment perform better.

Their standard 15% voltage tolerance and capacity to operate with a wide variance of pulse waveforms provides for an extremely wide safety margin. Low power consumption (as low as 0.8W) makes them ideal for solid state applications. And now they're available in 3, 4, 5, 6 and 8 digit models—in 3 sizes—and 3 mounting styles for greater flexibility of design. Most are in stock now for off-the-shelf delivery.

For more detailed information, send for our new brochure. Sodeco, 4 Westchester Plaza, Elmsford, New York 10523. Tel: (914) 592-4400; TWX: (710) 567-1219; Telex: 137345. In Canada, 2063 Chartier Street, Dorval 760, Quebec. Tel: (514) 631-9069.

You can count on us longer.

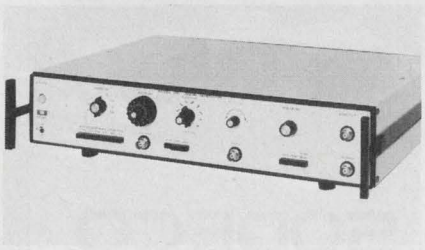


SODECO

A Division of LANDIS & GYR

Life expectancy: 200,000,000.

Function generator synthesizes digitally

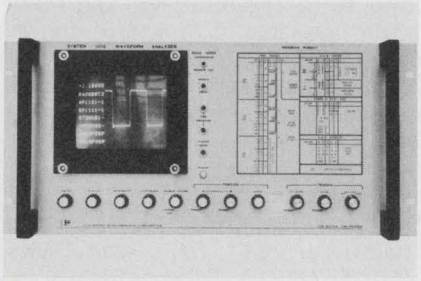


Exact Electronics, Inc., 455 S.E. 2nd Ave., Hillsboro, Ore. (503) 648-6661. $1250; stock to 2 wks.

The Model 335 digitally synthesizes every cycle of each waveform with nearly 2000 bits. Typical frequency and amplitude stability are 0.01% for 10 min, 0.02% for 24 hours. The unit has a range of 0.00001 Hz to 50 kHz. Waveforms that can be caught and held at any of the bits are: sine, square, triangle, ramp, pulse, haversine, havertriangle; continuous, single shot, or burst in the trigger and gate modes.

CIRCLE NO. 270

Waveform analyzer is programmable



Automated Measurements Corp. Subsidiary of E-H Laboratories, Inc. P.O. Box 1289, Oakland, Calif. (415) 834-3030. 120 days.

A fully programmable waveform analyzer designated the AMC System 1010, is a high-speed, 1-GHz bw unit intended for automatic test systems. It measures risetime, falltime, delay time, width, period, and amplitude of pulse, rf, or complex waveforms. Accuracy is 1% of full scale ranges from 2 ns to 1 s. Voltage accuracy is 2% of full scale ranges from 20 mV to 2 V.

CIRCLE NO. 271

Digital meter gives true capacitance

The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio. (216) 541-8060. $780 with display & printout, $690 without; stock.

The Model DP200/3202P gives 3-1/2 digit, true capacitance readings using a charge transfer method. Eight decade ranges from 1000 pF to 10 mF are available. Overranging on the six most sensitive ranges is 40%. Twelve-month accuracy is 0.1% of reading ±1 digit, except the 10-mF range, where it is 0.9% of reading ±2 digits.

CIRCLE NO. 272

$485 buys 10-512 MHz frequency prescaler

Newport Labs, Inc., 630 E. Young St., Santa Ana, Calif. (714) 540-4914. $485; stock to 30 days.

A panel-mounted frequency prescaler, the Model 6300, extends the frequency range of any 5 MHz or higher counter to 512 MHz. The unit can be used in oscilloscope countdown for maximum utility of vertical amplifiers, or as a frequency divider for high-frequency phase-locked loops. Sensitivity is adjustable from 5 V pk-pk to 100 mV pk-pk. The unit has high-frequency dividers that yield dual outputs of f/10 and f/100. Output is one V into 50-Ω load.

CIRCLE NO. 273

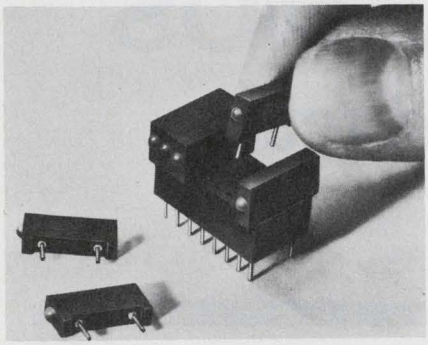
Fog film four times faster

Tektronix, Inc., P.O. Box 500, Beaverton, Ore. (503) 644-0161. $125 to $175.

Four photographic writing speed enhancers (WSENs) are available for Tektronix oscilloscope cameras, C-12, C-27, C-30A, C-31, C-50, C-51, C-53, and C-59. They provide controlled, repeatable film fogging for increasing film writing speed about four times. The unit is a battery-powered (one year battery life) control box mounted on the side of the camera with an LED light source mounted between lens and film. Both manual and automatic triggering are featured.

CIRCLE NO. 274

LED indicator displays logic state

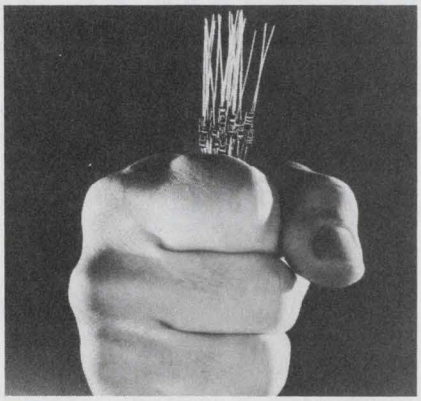


Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. (212) 497-7600.

As many as 10 LED indicators can be inserted into a DIP socket to signal the logic states of digital circuits. This two-pin device, containing a light-emitting diode and a built-in series resistor, can also be used to pin-point circuit faults. Devices can be driven directly from DTL and TTL logic. They are available in voltages from 7 to 14 V, and currents up to 20 mA.

CIRCLE NO. 275

Varactron high-Q diodes replace tuning capacitor

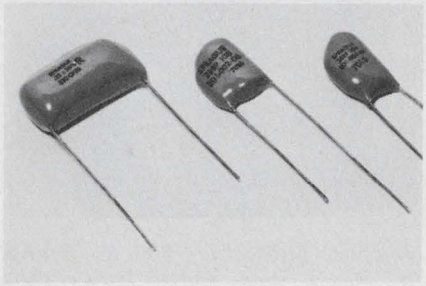


Teledyne Crystalonics, 147 Sherman St., Cambridge, Mass. (617) 491-1670. $0.59 (quantity lots); stock.

Series CV5000 high-Q varactron voltage-variable capacitance-diodes provide a combination of broad tuning ratios, high Qs, and high working voltages. Ideal for tuning applications under severe environmental conditions.

CIRCLE NO. 276

R-C unit suppresses contact arcing

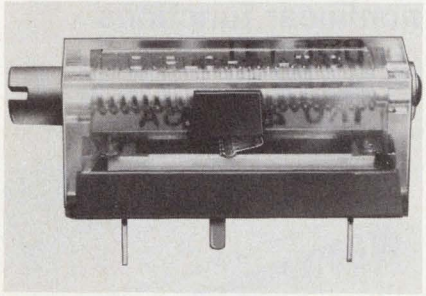


Sprague Electric Co., 347 Marshall St., North Adams, Mass. (413) 664-4411.

R-C combinations comprising low-cost metallized polyester-film capacitors in series with 1/2 W composition resistors are provided in single low-profile packages. Rated at 200 V dc (125 V rms) or 400 V (250 V rms), Type 288P arc-suppression networks have both a resistance and capacitance tolerance of ±10%. Standard units include most popular R-C combinations.

CIRCLE NO. 277

Know where you are with see-through trimmer

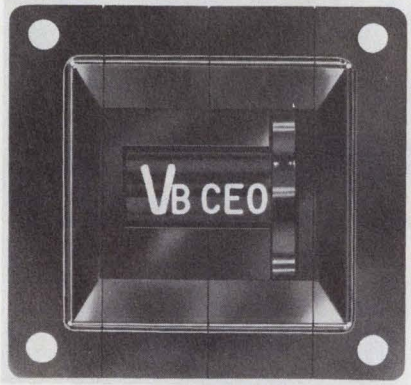


Diplohmatic Div., Harry Levinson Co., 1211 E. Denny Way, Seattle, Wash. (206) 323-5100. $1.23 (100); stock.

A cermet-element 18-turn Type 131 trimming potentiometer features a four-contact wiper for reliability. The entire assembly is mounted in a see-through polycarbonate case. Supplied with printed circuit terminals, the unit is 0.75 × 0.33 × 0.25 in. It is available in standard resistance values from 100 Ω to 1 MΩ ±10%, at 1/2 W. Maximum linearity is 0.5%.

CIRCLE NO. 278

Function switch offers wide window readout

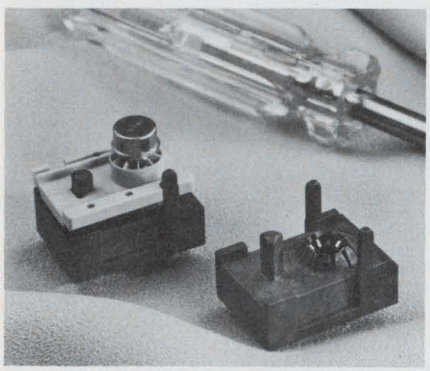


Cherry Electrical Products Inc., 3600 Sunset Ave., Waukegan, Ill. (312) 689-7600.

The thumbwheel function switch is the same height as Cherry's conventional thumbwheels. The 0.700 in. wide window will accommodate a variety of character legends or readouts. Max character height is 0.250-in. in the 10-position miniature, 0.12-in. in the 10-position subminiature, and 0.150-in. in the 16-position miniature switch. Stops can be added for such combinations as ON-OFF, SELECT-TRANSMIT-MONITOR, etc.

CIRCLE NO. 279

Contactors for TO-5 devices reduce damage

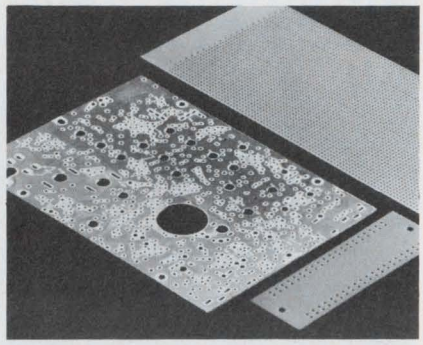


Barnes Div., Bunker-Ramo, 25 N. Lansdowne Ave., Lansdowne, Pa. (215) 622-1525.

Contacts are located behind the barrier to reduce damage in the 133-10021 contactor, for TO-5 devices mounted in Barnes 132-01 series protective carriers. The contactors are made of glass-filled polysulfane for operations from −65 to 150 C.

CIRCLE NO. 280

Rigid epoxy laminate may be cold punched

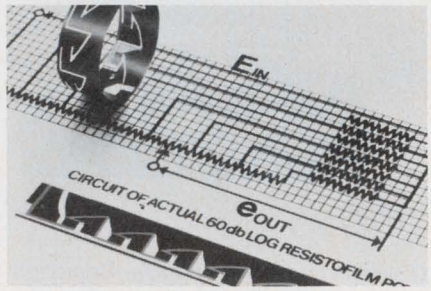


Spaulding Fibre Co. Inc., Tonawanda, N.Y. (716) 692-2000.

A rigid, punchable, epoxy-glass, flame-retardant laminate called PEG-FR is essentially an epoxy matrix, reinforced with glass fibers. The core is composed of a paper form of 100% glass fibers and the surfaces are woven glass —the whole being saturated with epoxy resin and laminated with heat and pressure into flat sheets.

CIRCLE NO. 281

Resistance film offers nonlinear functions

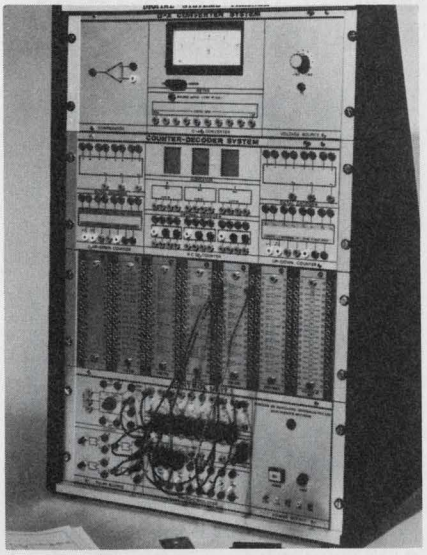


New England Instrument Co., 18 Alpha Rd., Chelmsford, Mass. (617) 256-3711.

Resistofilm, a conductive plastic film, simplifies designing and producing complex nonlinear functions such as a 60-dB log pot (a precision potentiometer with a 1000:1 slope ratio). Users can make pots of Resistofilm, which have been dithered over small rotational angles for up to 200 million cycles with no noticeable degradation in electrical characteristics.

CIRCLE NO. 300

Al extrusions offer inexpensive heat sink



E-Tronics, 5901 Noble Ave., Van Nuys, Calif. (213) 787-5581. $3 to $6.50/ft.; stock.

Inexpensive aluminum extrusions, combining integral heat-sinking features with simple, flexible PC card packaging, come in seven different configurations with mating tongue and groove construction. All of the extrusions are furnished with several 1/16-in. slotted card guides. The thermal coefficient of 0.8 C/W/ft, provided by the aluminum, makes these extrusions ideal for packaging of electronic assemblies utilizing most popular SCRs, TO-3 transistors and other stud-mounted devices.

CIRCLE NO. 301

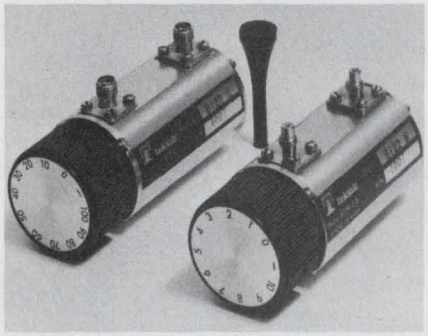
Digital logic lab accepts DIP TTL devices

Teaching Devices, Inc., P.O. Box 169, Carlisle, Mass. (617) 369-7390. $795.

The TDI logic lab is constructed of the latest TTL digital logic—and is packaged in an attache-size carrying case. The basic lab consists of 40 individual ICs, each mounted on its own PC board with appropriate symbology and truth tables clearly annotated. Included in the lab is a switching capacity of 40^6 combinations, two clocks ranging from single step to 9 MHz in 8 ranges (each with fine adjust), two channel audio output, 18 indicator lamps and two bounceless SET-RESET buttons and two push-button normally 1 or 0 switches.

CIRCLE NO. 302

Miniature pads with thick-film resistances

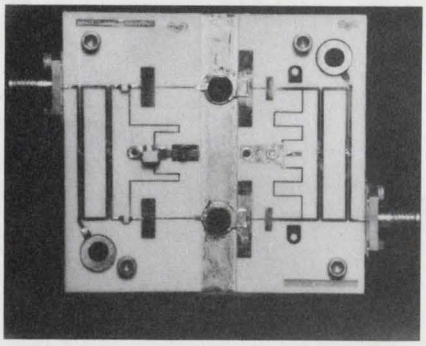


Telonic Industries, Inc., 21282 Laguna Canyon Rd., Laguna Beach, Calif. (714) 494-9401. $78; June 1972.

The 8120 series is a line of miniature rf and microwave attenuators that use thick-film substrates for accuracy and power handling. The new attenuators can operate from dc to 2 GHz at a power level of 3 W. Three models are presently available with attenuation ranges of 0 to 100 dB in 10 dB steps, 0 to 60 dB in 10 dB steps and 0 to 10 dB in 1 dB steps.

CIRCLE NO. 303

Transistor power amp gives 5 W in L-Band



Vectronics Microwave Corp., 276 Lincoln Blvd., Middlesex, N.J. (201) 356-2377. $950; 4-6 wks.

The Model MPA 1217 transistor power amplifier provides 5-W cw output over the 1.4 to 1.55 GHz range with a flatness of 1 dB. The unit has 7-dB gain and requires an input of 550 mA at 28 V dc. Consisting of two parallel, hybrid-coupled stages with impedance matching and biasing networks, the amplifier is mounted in a metal enclosure measuring 2.25 × 2.25 × 0.75 in.

CIRCLE NO. 304

Wideband oscillators with mechanical tuning

Texscan Corp., 2446 N. Shadeland Ave., Indianapolis, Ind. (317) 357-8781. $395 to $415; 4-6 wks.

A family of mechanically tuned transistor and Gunn-effect oscillators feature octave tuning in the 10-MHz to 4-GHz range and full waveguide band tuning through X-band. The Model MTO-104 transistor oscillator tunes from 2 to 4 GHz with 50 mW output power and 5% average efficiency. The Model GTO-123 Gunn-effect oscillator tunes from 8.0 to 12.4 GHz with 50-mW output power and 1% average efficiency. The transistor oscillators require −20 V bias; the Gunn-effect oscillators, +10 V.

CIRCLE NO. 305

Miniature, 2 to 12 GHz nanosecond switch

Hyletronics, Newton Rd., Littleton, Mass. (617) 486-8911. $95; stock to 4 wks.

The frequency range of the Model SSX-712P microwave switch is from 2.0 to 12.4 GHz. The physical size is 0.5 × 0.6 × 0.8 inches, excluding connectors. Typical switching speed is 15 nanoseconds, with isolation in excess of 40 dB over much of the bandwidth. The insertion loss is typically between 1.2 dB and 3.0 dB, and rf power capabilities are 1 W cw and 50 W peak.

CIRCLE NO. 306

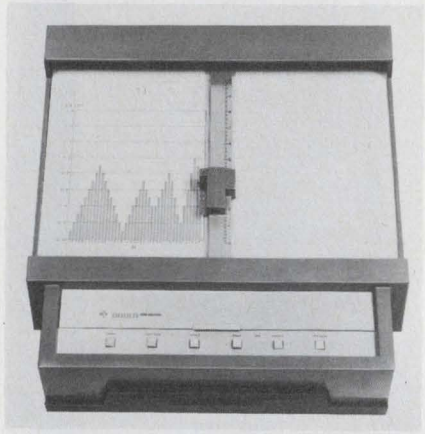
Transistor VCOs cover octave bandwidths

Micromega Div., Bunker Ramo Corp., 12575 Beatrice St., Los Angeles, Calif. (213) 391-7137.

A family of transistorized voltage-controlled oscillators cover octave bands from 500 to 4000 MHz. Standard frequency ranges for the 34849 series of VCOs are 500 to 1000 MHz, 1000 to 2000 MHz and 2000 to 4000 MHz. Rf output power is in the 50 to 150 mW range. Other features include frequency stability of ±1.5%, harmonic rejection greater than 20 dB and operating temperature from −30 to +71 C.

CIRCLE NO. 307

Graphic plotter accepts ASCII code



Gould Inc., Instrument Systems Div., 3631 Perkins Ave., Cleveland, Ohio. (216) 361-3315.

The Brush 511 graphic plotter is suited for time-share plotting of computer-generated data. It accepts 8-level ASCII code and plots at rates of 5 strokes per second at 30 characters per second. Software includes eight basic subroutines in Fortran IV. Plotting errors are non-cumulative.

CIRCLE NO. 308

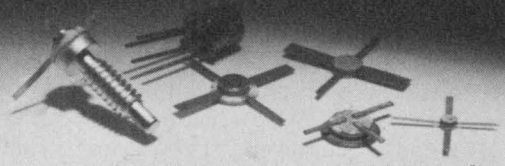
N/C tape prepared on minicomputer system

Data General Corp., Southboro, Mass. (617) 485-9100. $5950 (basic); $7450 (expanded).

The Datapoint II system built around the Nova 1210 minicomputer uses Data General's Datapoint two-axis, point-to-point, programming language. The basic configuration has 4096 16-bit words of core memory, a Teletype, a turnkey console and a full set of geometric-pattern, supervisory, and editing commands. An expanded system provides for contouring commands that can produce any arc.

CIRCLE NO. 309

Why the best high frequency transistors cost less than the second best.



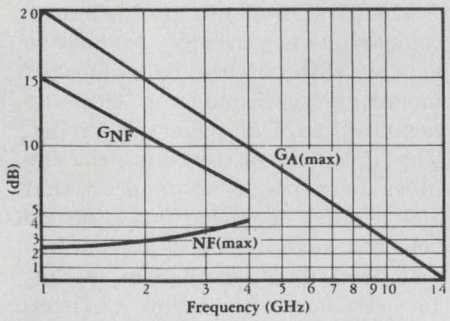
It doesn't happen often. But in the case of microwave transistors, you don't have to trade off performance to get the lowest price. That's because we've combined advances in silicon semiconductor technology with efficient mass-production. The result to date has been:

The workhorse: HP 21.

This small signal transistor is the backbone of any RF/microwave amplifier design. It has a 12 dB gain at 2 GHz (useable to 5 GHz), a noise figure of 4.2 dB at 2 GHz and a price of only $19 each in small quantities. So you won't be making tradeoffs in your design.

Really low noise.

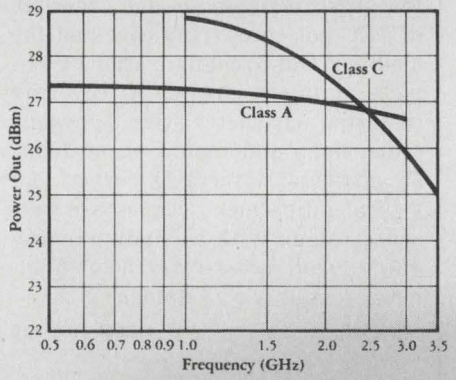
The HP 22, a significant new high frequency device, has a maximum



guaranteed noise figure of 4.5 dB at 4 GHz with 6.5 dB gain when biased for optimum NF (10 V, 5 mA). With 3 dB more gain across the band than the HP 21, the HP 22 is useable to 8 GHz in its stripline packages. All for just $75 each. No other transistor can make that statement.

More power out.

That's the function of the new HP 11. It fills the power gap between the HP 21 and high power devices. As a preamp



output or linear driver, it offers low distortion from 2 to 4 GHz. Yet it costs the same as the small signal HP 21.

The low price of success.

You've seen the kind of performance our transistors offer. Now let's get down to the cost factor.

Quantity	HP 21	HP 22	HP 11
1-99	$19	$75	$19
100+	15	65	15

(Domestic USA prices for stripline packages.)

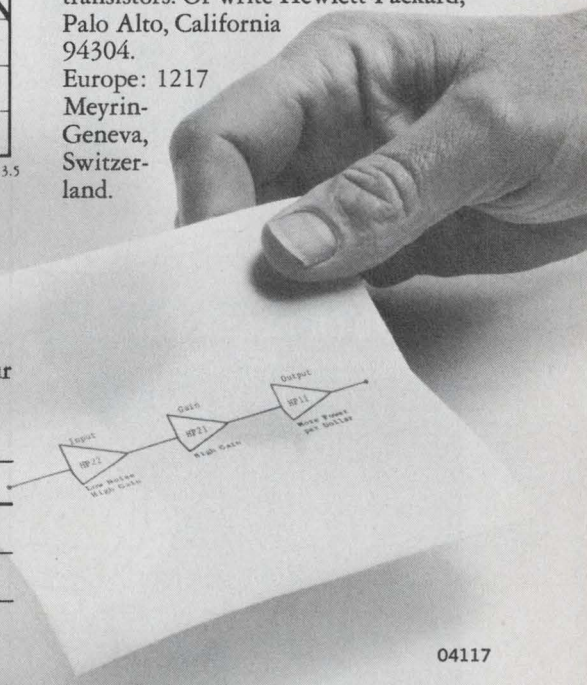
Can you afford not to use them?

Firm delivery and great reliability.

We can deliver most orders from stock.

And you can count on device reliability. Our proven manufacturing process not only provides excellent parameter stability from batch to batch but insures healthy devices. Like 10 million hours MTBF for the HP 21.

An HP field engineer is nearby to answer your questions and handle your orders promptly. Why not give him a call for complete information about our transistors. Or write Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.



04117

HP transistors: a small price to pay for performance.

HEWLETT hp PACKARD

COMPONENTS

INFORMATION RETRIEVAL NUMBER 59

application notes

Silicon readout cells

Technical Information Bulletin RC-72 offers practical information on electrical and mechanical design for the use of silicon readout cells. The bulletin lists a wide range of "standards," including scribed and etched cells with from 2 to 12 segments in both p-on-n and n-on-p configurations. Also featured is M7's new narrower "13" series that permits both cost and technical advantages. M7, Inc., Arlington Heights, Ill.

CIRCLE NO. 310

Ferrite core design

A ferrite core design manual features manganese-zinc ferrites of IEC pot cores, ring core and the modular SM-6 configuration. Complete data is presented covering material characteristics, physical dimensions and mounting systems. In addition, typical Q curves and typical adjustment curves are presented along with a handy winding guide and cross-reference. Magnetic Metals Co., Camden, N.J.

CIRCLE NO. 320

Heat dissipator

A data sheet contains specifications of the new Kooler-Koil heat dissipator, for cooling heat producing power transistors or other components in various size can cases, such as TO3, TO5, TO8. Unitrack Div., Calabro Plastics, Inc., Upper Darby, Pa.

CIRCLE NO. 321

Polishing IR crystals

Detailed instructions on how to cleave, grind, and buff infrared crystals are illustrated in a 10-page booklet. Polishing techniques include both the alcohol/felt and aqueous solution/glass methods. Techniques on how to clean and buff cavity cells are also discussed. Properties, merits, and limitations are listed for 11 different transmitting materials. Barnes Engineering Co., Stamford, Conn.

CIRCLE NO. 322

Infrared manual

A 16-page booklet lists the advantages of electric infrared as a processing tool. Detailed description of infrared and its use have been combined with engineering data covering such topics as air handling, ways to figure heat losses, and factors affecting heating requirements. Fostoria-Fannon, Fostoria, Ohio.

CIRCLE NO. 323

Bus bar design

A five-page booklet describes design considerations of bus bars and interconnect systems. Comparisons are made between a laminated bus and wire cable. Capacity and impedance considerations are also given. Chem Aero Inc., Wilmington, Calif.

CIRCLE NO. 324

Facts on silvercopper

Creep strength, elevated temperature strength and long-term annealing effects are described by comparison graphs of SilverCopper vs ordinary copper in an eight-page booklet, Quick Facts on SilverCopper. Copper Range Co., New York, N.Y.

CIRCLE NO. 325

Epoxy test report

The first in-depth test program comparing electrically conductive epoxies with eutectic techniques of mounting semiconductor chips is described in a 20-page test report. The independent testing program gives conclusive evidence that 100% solid epoxies containing no solvents have emerged as the fastest, lowest-cost method of mounting semiconductor chips in mass production applications. In the program, three advanced epoxies were subjected to serialized mechanical and electrical testing after undergoing environmental stresses. The epoxies were Epo-Tek H41, a single-component gold epoxy; Epo-Tek H31, a single-component silver epoxy; and Epo-Tek H20, a two-component silver epoxy. Test results indicated that the bonding strength of epoxy-mounted chips was equivalent in all respects to eutectially-bonded chips. Epoxy Technology, Inc., Watertown, Mass.

CIRCLE NO. 326

Log Amplifiers. It was between theirs and yours. Now it's either yours or ours.

Place yours here.

(yours). (ours. actual size)

Our little module outstrips any log amp you've been able to buy before.

In size.

Price.

And performance.

And it should make you think twice if you're now making your own.

Our 755 is a complete logarithmic amplifier with both log and antilog ability. And we make it for either positive or negative input signals.

The plug-in module is only 1.5" wide, 1.5" high, and .4" deep.

It offers exceptionally low bias current of 10pA max. 15μV/°C offset voltage drift. 0.5% log conformity. And works over six decades of input current (1nA to 1mA) and four decades of voltage (1mV to 10V).

We give you this flexibility and performance at a unit price of only $55. Which makes it useful and practical for transducer linearization, data compression, and for clinical and laboratory designs.

What more can we say?

We even make our own monolithic components which reduce temperature variation and costs. And offer you the two models we use to build our 755 log amp.

Our 751 provides the basic log transfer, scaling and temperature compensation. And our 752 is the 751 with an internal current reference.

Both can help optimize your design for voltage or current stability, and economy if you still prefer to make your own log amp.

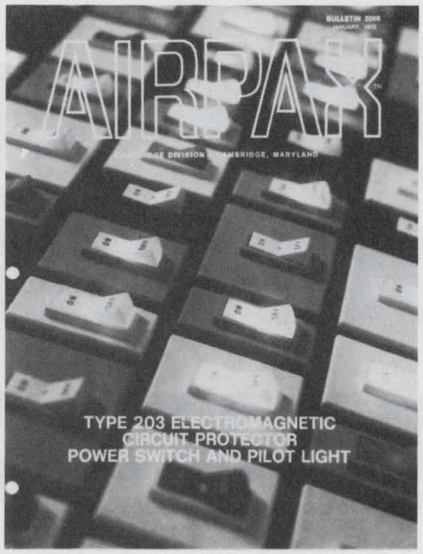
So it's either ours or yours. Or yours with ours.

If you'd like to know more we can send our log amp application note and data sheet. And our 1972 Product Guide, which shows all the things we make to solve more of your problems better than anyone else.

Analog Devices, Inc., Norwood, Mass. 02062.
Tel. (617) 329-4700.

ANALOG DEVICES

new literature



Circuit protector

This 12-page Bulletin 2009 contains description, application information and specifications for Airpax Type 203 electromagnetic circuit protectors. Line of rocker arm breakers function as a switch, pilot light and as an overload protector for electronic circuits. Airpax Electronics/Cambridge Div., Cambridge, Mass.

CIRCLE NO. 327

Recorders

A new condensed catalog provides brief product descriptions of the company's portable 1, 2, 4, 6 and 8 channel oscillographic analog recorders, 60 channel event recorders and analog/event recorders. The main features are provided for a new line of recorder building blocks and a new portable 18 channel light beam recorder. Gulton Techni-Rite, East Greenwich, R.I.

CIRCLE NO. 328

Capacitors

Engineering bulletin 1010C lists standard ratings and complete performance characteristics on the type 91M low-cost dipped single-film silvered-mica capacitors. Eight physical sizes are offered to insure minimum size and cost. Standard ratings are from 10 pF to 560 pF for operation at 500 WVDC over the temperature range of −55 C to +85 C. Sprague Electric Co., North Adams, Mass.

CIRCLE NO. 329

Communications products

A 4-page pamphlet provides a brief description and technical specifications for all major products in GTE Lenkurt's line of video, voice and data communications systems. The pamphlet is divided into seven sections covering microwave radio systems, cable carrier systems, multiplex systems, subscriber carrier systems, data transmission systems, supervisory and control systems, and auxiliary equipment. GTE Lenkurt Inc., San Carlos, Calif.

CIRCLE NO. 330

Data terminal

A new 16-page brochure provides information about the hardware, peripherals and all standard software available with the 88-23 data terminal. The brochure also includes systems information which enables the reader to establish the architecture for a terminal system that could be integrated with his present operation. Compat Corp., Westbury, N.Y.

CIRCLE NO. 331

Product guide

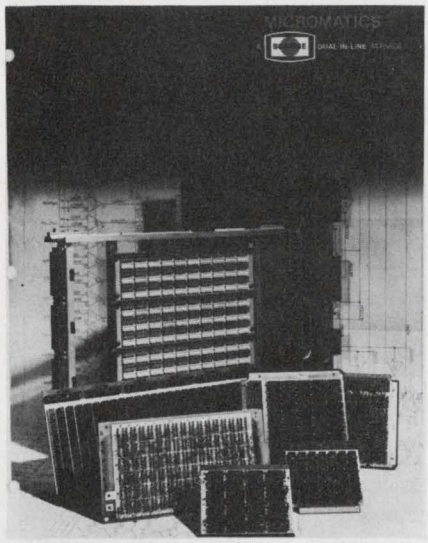
This 48-page multi-color-coded product guide includes information on new products, linear modules, nonlinear function modules, data conversion modules, power supplies and regulators, testers, and other technical information as well as operating facilities and customer service information. Teledyne Philbrick, Dedham, Mass.

CIRCLE NO. 332

Read/write heads

A data sheet describes the new Hard Coat read/write heads. The patented Hard Coat process reduces head replacement costs and eliminates the time-consuming amplifier adjustments normally associated with gradual head wear. Described in data sheet 1-310 are complete specifications for this new line of read/write heads. Potter Instrument Co., Inc., Melville, N.Y.

CIRCLE NO. 333



Wiring/software

A 6-page catalog describes a complete wiring and software system which provides all the steps necessary to convert wire lists or logic equations into assembled and wired hardware. The catalog explains the different software programs available to produce error-free wired hardware and a flow diagram illustrates the steps from wire list or logic equations to the Update program which allows revisions of the originial wire list. Scanbe Manufacturing Corp., El Monte, Calif.

CIRCLE NO. 334

Data transmission system

An 8-page brochure describes a new multi-purpose data transmission system. Functional drawings and accompanying descriptions show the system's basic capabilities, which include multiple FSK modems, a multiplex system, a serial/parallel conversion system, a receive time recovery system, and a speech plus data system. Tele-Dynamics Div., AMBAC Industries, Fort Washington, Pa.

CIRCLE NO. 335

Recorder/reproducer

A 12-page brochure describes the company's VR-3700B precision magnetic tape recorder/reproducer. The VR-3700B combines advanced techniques with simplicity of operation and reliability, and features heads capable of recording and reproducing 2-MHz frequency responses at 60 in./s. Bell & Howell, Electronics & Instruments Group, Pasadena, Calif.

CIRCLE NO. 336

NEW LITERATURE

Transformer catalog

Catalog #207 is now available listing over 1900 standard transformers for design engineers. The new catalog includes full technical data, mounting dimensions, photographs and other specifications on the complete Stancor line of audio transformers, power transformers, chokes and inductors. Essex International, Inc., Controls Div., Stancor Products, Chicago, Ill.

CIRCLE NO. 337

Wire identification system

A 6-page brochure describes the advantages of the MazeMaster system for fast wire identification. The system features a compatible line of six, low-cost, solid-state identification units. Each unit is designed to resolve a particular production line situation. Identification is presented visually by a 7-segment LED display in only 1/100 of a second. Addison, Mountainside, N.J.

CIRCLE NO. 338

Miniature manual switches

A 12-page product brochure describes the division's new Series 8 commercial miniature manual-switch-line. The illustrated publication details the features, electrical ratings, mounting dimensions, lever variations, color combinations, terminals, relamping procedures, hardware, contact action and ordering information for the seven major switches in the new line. Micro Switch, Freeport, Ill.

CIRCLE NO. 339

Recorder building blocks

A new line of OEM recorder building blocks is detailed in this 4-page bulletin. Basic electrical and mechanical specifications are provided on eight basic models, and separate specifications are provided for the integrated circuit pen/motor amplifier used in the recorders. Gulton Techni-Rite, East Greenwich, R.I.

CIRCLE NO. 340

Pot core material

A new pot core material with an exceptionally linear permeability characteristic over a wide temperature range (−40 to +70 C) is described in a new product bulletin. The bulletin provides complete data for SIFERRIT material N32, including two graphs, one showing initial permeability as a function of temperature and the other charting relative temperature coefficient. Siemens Corp., Iselin, N.J.

CIRCLE NO. 341

High performance lubricants

A 4-page brochure describes the many forms of the company's specialty lubricants, ranging from aerosol sprays and liquid suspensions to exotic powders. The folder provides for addition of application reports, technical bulletins and other data as they are available. Bemol Corp., Willimantic, Conn.

CIRCLE NO. 342

Alumina substrates

A 4-page data sheet, bulletin 602, covers alumina and beryllia substrates. The publication gives detailed physical, thermal and electrical specifications of the materials employed, and design criteria for engineers wishing to determine application feasibility. Microstrate Div., National Beryllia Corp., Haskell, N.J.

CIRCLE NO. 343

Computerized control system

A concise introduction to Taylor 1010 computerized process control systems is presented in a 12-page booklet. Subjects covered include system definition and design, software and hardware integration, and Taylor system support services. Taylor Instrument Process Control Div., Sybron Corp., Rochester, N.Y.

CIRCLE NO. 344

bulletin board

Armour Electronics is offering a **ten-year guaranty** on all standard model **power modules.** This guaranty covers the complete line of pre-engineered power supplies, including a PC series, a dual tracking series and an MIC series.

CIRCLE NO. 345

A **line of capacitors** ranging from 0.001 to 20.00 μF with tolerances up to $\pm 1\%$ and voltage ratings as high as 600 V dc has been introduced by **Elpac Components,** a division of Elpac, Inc. The new Elpac capacitors have the same ratings and dielectrics as well as the same form factors as the equivalent Electrocube units.

CIRCLE NO. 346

Price reductions

RCA has increased prices, effective April 1, 1972, averaging from 7 to 8% on approximately 200 types of **industrial tubes** including selected microwave devices, power tubes and electro-optics products which are sold in the equipment market. The increases reflect the cumulative effect of increased labor and material costs.

CIRCLE NO. 347

Data General's Nova computers now average 20% cheaper in their field service maintenance contract rates, prices for warranty extension contracts, and because of the elimination of fixed-price installation charges.

CIRCLE NO. 348

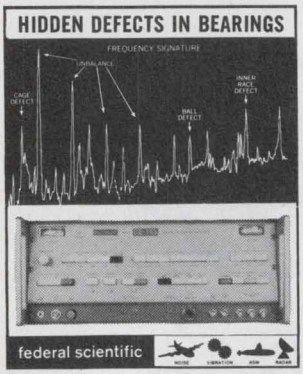
A pricing structure based on the extent of quality control inspection lets users of **Corning borosilicate IC mask substrates** save up to $2 per substrate. For example, substrates 2.5 × 2.5 × 0.060-inch thick cost $3.75 each in quantities of 10,000 or more with lot inspection. At 100% eye inspection, they cost $4.50, while the price for 100% inspection under magnification is $5.70.

CIRCLE NO. 349

Design Data from Manufacturers

Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card.
(Advertisement)

Instant Diagnosis Of Ailing Bearings

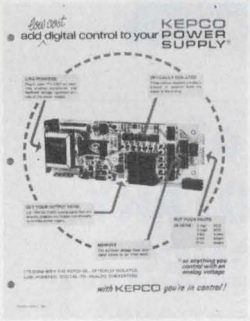


Mechanical occurrences in a bearing create concomitant frequency signatures. Free new 4-page "Application Note 3" shows how real-time frequency analysis can isolate the tell-tale frequencies of such specific defects as: cage and ball defects, unbalance, and inner/outer race defects. The readouts shown of typical defective jet engine bearings were obtained by an **on-line** Ubiquitous® Real-Time Frequency Analyzer and an oscilloscope. The Analyzer has no critical adjustments, is easily operated by non-technical personnel. For production, a Minicomputer/Analyzer System can automatically classify a bearing by comparison of its frequency signature to a known reference.

CIRCLE NO. 171

Federal Scientific Corporation
Subsidiary of Elgin National Industries, Inc.
615 West 131 Street, New York, N.Y.10027

Add Digital Control To Your Equipment



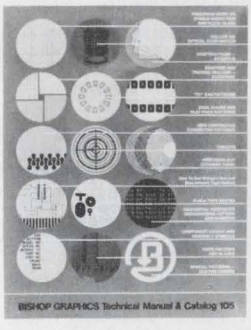
The Kepco SN programmers are a uniquely simple and low-cost way of adding digital compatibility to your product. A 0 to 10V or ±10V analog signal is produced with 2- or 3-digit BCD or 8-, 10-, 12-bit binary resolution. The digital input instructions are optically coupled and stored in a register "memory" so that the analog output can be floated up to 1000 volts from the digital common. After data transfer, the output slews to its new value at 1V/μsec. All the power is, of course, built-in. All **you** need is 115/230V a-c, 50-60 Hz.

For details on the various SN converters and their housing accessories, request Kepco Brochure No. 146-1266.

CIRCLE NO. 172

Kepco, Inc.
131-38 Sanford Avenue
Flushing, New York 11352 (212) 461-7000

1972 Electronic Components Drafting Aids Catalog



Free Catalog! Free Samples! Exciting innovations in pressure-sensitive electronic component drafting aids and methods are detailed in the new 1972 edition of the combined Bishop Technical Manual and Catalog 105.

84 illustrated pages of over 15,000 multi-pad configurations, symbols, tapes, sequential reference designations plus hundreds of time-and-money saving hints in making artwork for PC boards. Includes instructions for using the industry's only red and blue tape system for making two-sided boards in perfect registration.

Send now for free Catalog 105 and free samples.

CIRCLE NO. 173

Bishop Graphics, Inc.
7300 Radford Avenue, North Hollywood, California 91605
(213) 982-2000 Telex: 674672

Electronic Design

ELECTRONIC DESIGN's function is:

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- To give the electronic design engineer concepts and ideas that make his job easier and more productive.
- To provide a central source of timely electronics information.
- To promote communication among members of the electronics engineering community.

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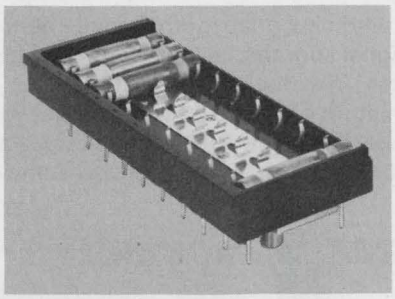
BPEA BPA

AMERICAN BUSINESS PRESS, INC.

advertiser's index

quick ads

New and current products
for the electronic designer
presented by their manufacturers.



TII-700 series multiple pair arrester assemblies — available up to 30 arresters in wire-wrap pin, coated for solder, high density package. For use in signaling, data processing, carrier and security equipment. Telecommunications Industries Inc., Copiague, N.N.Y. (516) 842-5000.

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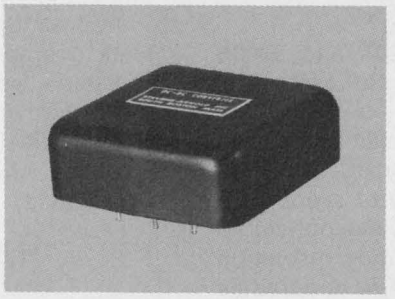

Isolated dc/dc converters. Isolation 10 pF and 8 k V dc max. Inputs from 5 to 36 V dc available. Outputs single or dual 8 to 15 V dc 4.5 watts. Noise 5 mv peak (BW 10 M Hz). Regulation 0.05% (Line or Load). Custom Designs no charge. Stevens-Arnold, Boston, Mass. (617) 268-1170.

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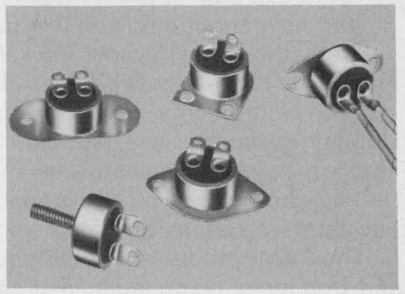

Precision snap-action thermostats from Elmwood, widely specified for quick, reliable response; proven industrial and military performance record. Environ. expos. −85° to 550° F; narrow or wide diff.; rated to 15 amps. Prototypes from stock. Wide choice of brackets, terminals. Elmwood Sensors, Inc. (401) 781-6500. TWX 710-381-6413.

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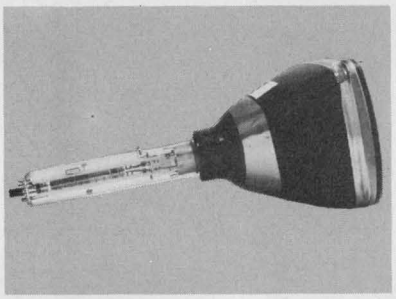
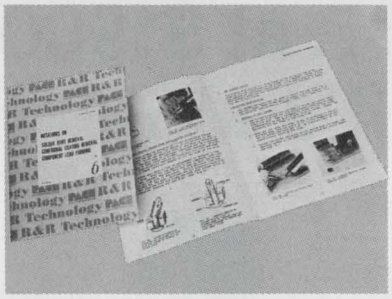
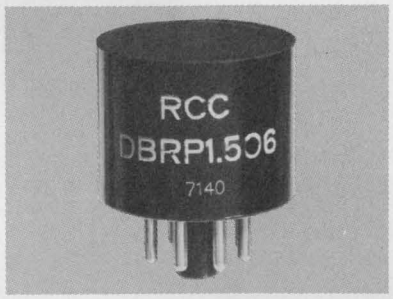


New PDM Cathode Ray Tube. 12" rectangular electrostatic deflection crt incorporating post deflection magnification for high sensitivity and low distortion. Write for full details of PDM line up to 23" diam. size. Contact Thomas Electronics, Inc., Wayne, N.J. (201) 696-5200 for design application assistance.

INFORMATION RETRIEVAL NUMBER 184

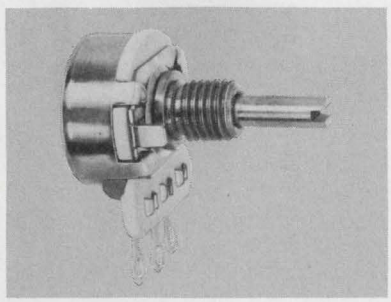


Application/Procedure data for solder extraction, conformal coating removal and component lead forming on electronic assemblies are defined in comprehensive new 24-page brochure. Please request on company letterhead. PACE, Incorporated. 9329 Fraser Avenue, Silver Spring, Md. 20910. (301) 587-1696.



RCC DBRP1.500 series silicon single phase bridge rectifiers — Two 1.5 Aav bridge rectifiers in one standard 8 pin octal "plug-in" base. 50-800V., High Rel., Max. Service Appl. 1-99 $2.95 to $6.00. Rectifier Components Corp., Freeport, N.Y. (516) 868-0470.

INFORMATION RETRIEVAL NUMBER 185



New CTS series 205 5/8" dia. Cermide® thick-film variable resistor. Excellent environmental char.; and immediate design versatility. 1 w power @ 70°C; 50Ω-5meg-Ω resistance; ±20% tol.; dust shield; many mounting styles and shaft types. Only 82¢ in quantity. Power switch available. CTS Keene, Inc., Paso Robles, Calif. 93446. (805 238-0350.

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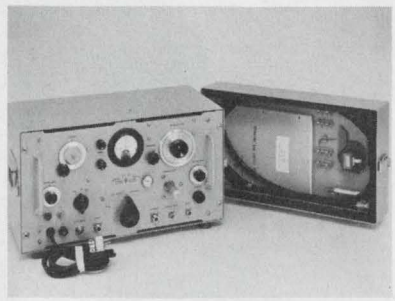

HP 623B RF test set. Completely reconditioned and guaranteed. A complete test package for communications station equipment. Choice of 3 klystrons in 5925-7750 MHz range. Send for free catalog listing thousands of instruments. $1395.00. Tucker Electronics Company, P. O. Box 435, Edison, New Jersey. (201) 225-2900.

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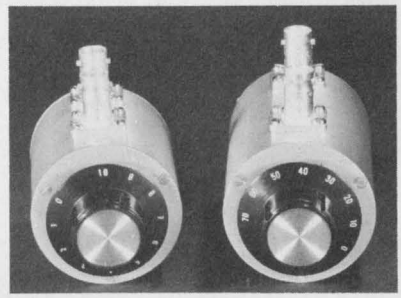

Variable - Step Attenuators, available in 50 and 75 ohm impedances. A variety of attenuation ranges, attenuation steps, and connector options are available over the frequency range of DC-2GHz. Each unit incorporates a 250,000 cycle, low torque index mechanism. Alan Industries, Inc., Box 1203, Columbus, Indiana. (812) 372-8860.

INFORMATION RETRIEVAL NUMBER 188

Can you imagine what the signal source of the future will be like?

Will it have excellent frequency accuracy and stability?

Better amplitude characteristics?

Systems capability with inexpensive interfacing and software you can handle yourself?

And how about a reasonable price tag?

Well, the new Hewlett Packard 3320A and 3320B Frequency Synthesizers give you all this—plus a lot more!

Both instruments give you frequency accuracy and stability measured in a few parts per million per year. That's a thousand times better than any RC oscillator.

They both give you the signal purity of a good RC oscillator—a new feature for a frequency synthesizer.

The 3320B offers you amplitude accuracy, resolution and frequency response measured in a few hundredths dB over a 100-dB attenuation range. So it is both a frequency standard and a very precise level generator.

The 3320A and 3320B have optional remote control and the 3320B can even be controlled directly from most tape readers or card readers (like the new HP 3260A Marked Card Programmer).

And to top it off, the 3320 has the widest frequency range of any test oscillator, programmable oscillator or low cost frequency synthesizer on today's market, 0.01 Hz to 13 MHz.

How about the price tag?

The 3320A, priced at $1900, and the 3320B at $2400 give you two great buys in signal sources—both today and in the future.

We call the 3320 "the new price/performance benchmark for precision signal sources." *Electronics* magazine called it a "pacesetter." You'll call it "a steal."

For further information on the 3320A/B, contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

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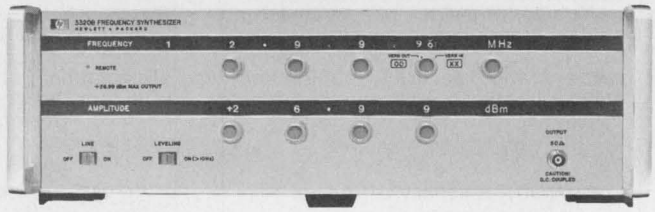
SIGNAL SOURCES



091/18

...at $1900, It's a Steal!

INFORMATION RETRIEVAL NUMBER 71

Do you face a make or buy decision on power supplies?

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>50% efficient, 20 KHz switching, 50mV P-P ripple, 0.1% line or load regulation

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5 VOLTS 30 AMPS WITH OVERVOLTAGE PROTECTION BUILT-IN

DUAL OUTPUT

$380

±15 TO ±12 VOLTS 8.5 AMPS EACH OUTPUT

TRIPLE OUTPUT

$395

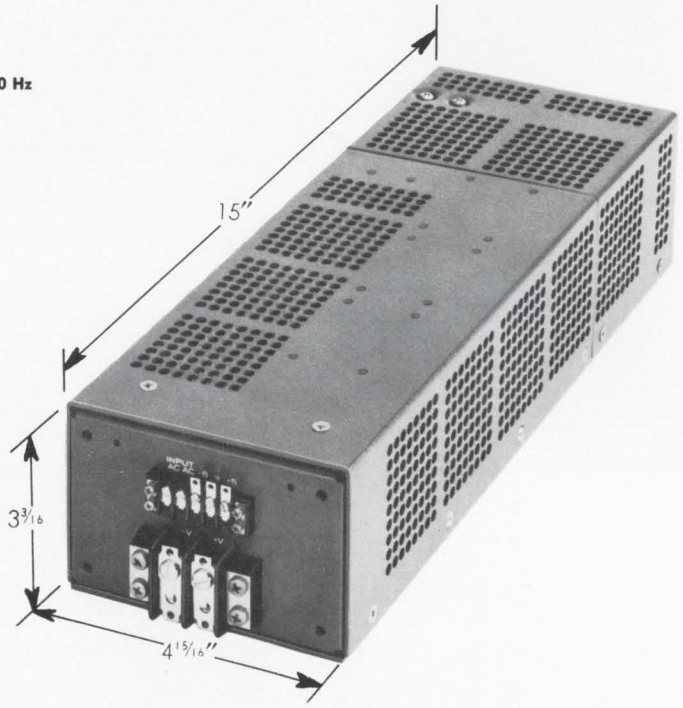
5 VOLTS 18 AMPS DUAL ±15 TO ±12 VOLTS 2 AMPS EACH OUTPUT

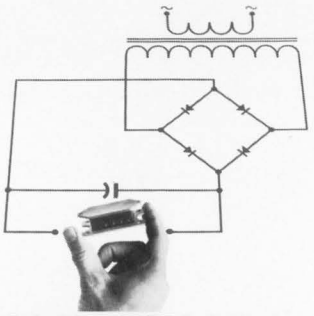
QUADRUPLE OUTPUT

$450

5 VOLTS 16 AMPS DUAL ±15 TO ±12 VOLTS 1.5 AMPS EACH OUTPUT 24 TO 28 VOLTS 1.0 AMPS

AC input: 105-132 VAC, 47-440 Hz
DC input: 145 VDC ±10%





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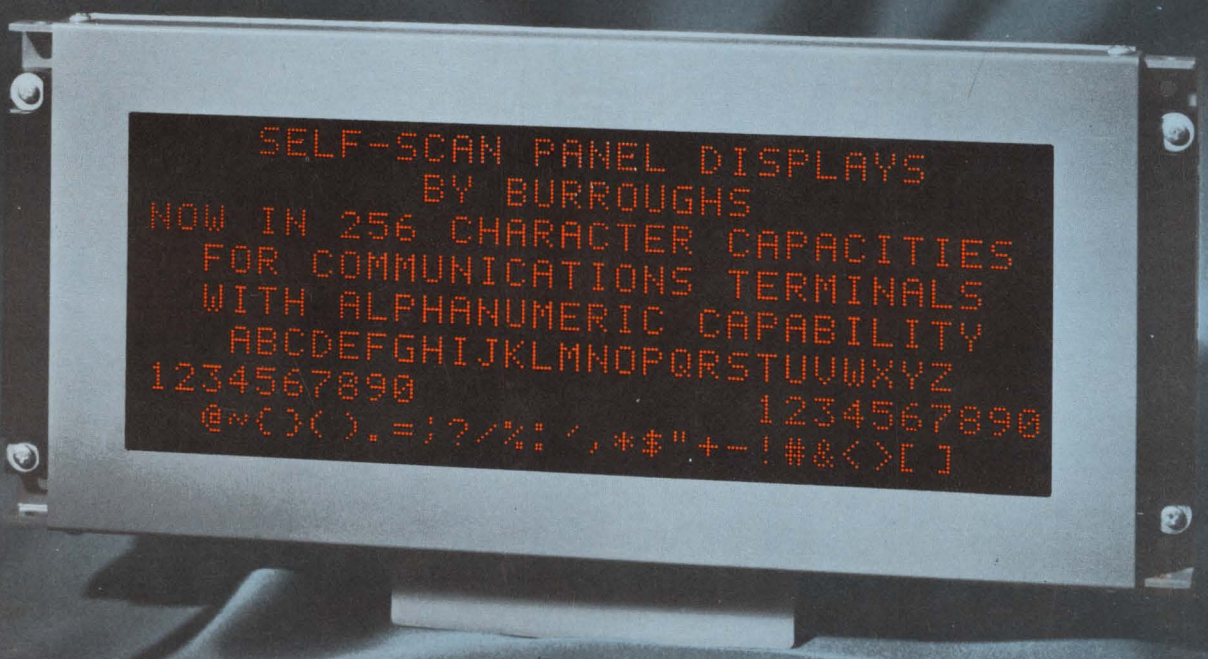
INFORMATION RETRIEVAL NUMBER 112

SELLS ON SIGHT



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Burroughs

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