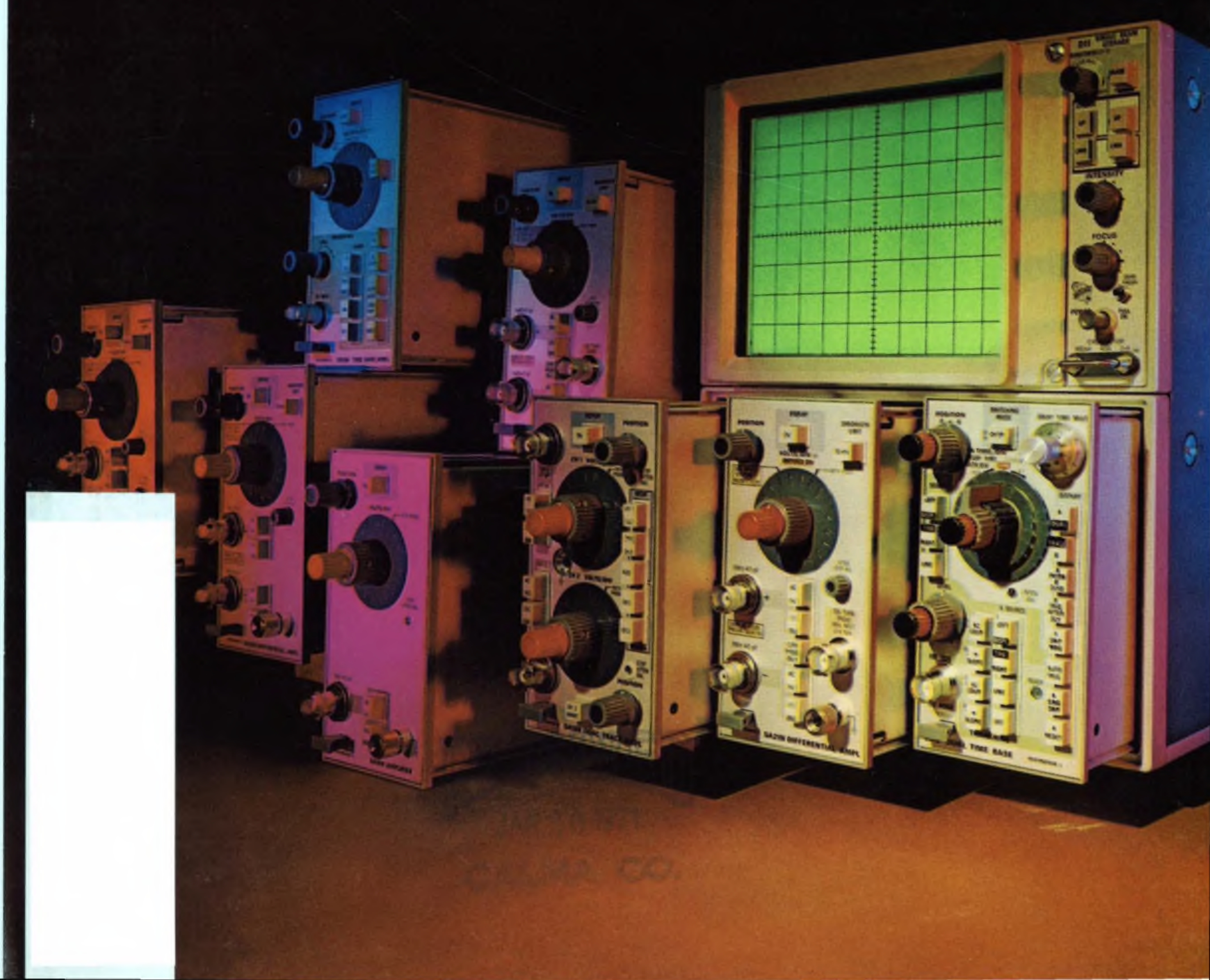
Electronic Design

VOL. 19 NO. 2

FOR ENGINEERS AND ENGINEERING MANAGERS

JAN. 21, 1971

Versatile scope system displays and stores with nine plug-ins that are interchangeable. Single and dual-beam modes are selectable. Up to four simultaneous signals can be viewed. Time-base and amplifier plug-ins allow high-gain delayed-sweep measurements. System converts from bench-top to rack-mount in seconds. P. 83



Would you waste your money on a screwdriver like this?

Of course not. In this day of tight budgets, you don't want tools with a lot of unnecessary bells and whistles; you want tools that are functional—that give you the capabilities you need, without costing a fortune.

Hewlett-Packard understands. As electronic engineers ourselves, we know that an EE's "screwdriver" is his oscilloscope. And we know that the **last** thing you need at any time—and especially when your budget is pinched—is an expensive Buck Rogers Special loaded with non-functional extras.

That's why the key concept in our new scopes is **functionality.** State-of-the-art advances in measurement capability, but no chrome strips or foxtails. And that's also why a lot of people who used to just buy the first scope that came to mind are now taking a second look.

What they're discovering is that the HP 180 System is by far the best buy in general-purpose lab scopes today. If you don't believe it, look at these price/performance comparisons.

HP's 50 MHz dual-channel system, with an 8 x 10 cm display, 5 mV/div deflection factor, and 5 ns/div sweep, is only $2,035—12% less than its main competitor.

HP's 100 MHz dual-channel system, with 10 mV/div deflection factor, 5 ns/div delayed sweep, and variable persistence and storage, is $3,950—27% less than the competition.

HP's 250 MHz real-time dual-channel system, with 10 mV/div deflection factor, and 1 ns/div sweep time is $3,250. With delayed sweep, $3,750. Unfortunately, there's no comparable instrument to match price tags with.

And HP's 1 GHz dual-channel sampling scope, with 2 mV/div sensitivity and internal triggering is only $2,545—nearly 43% less than the competition's comparable model!

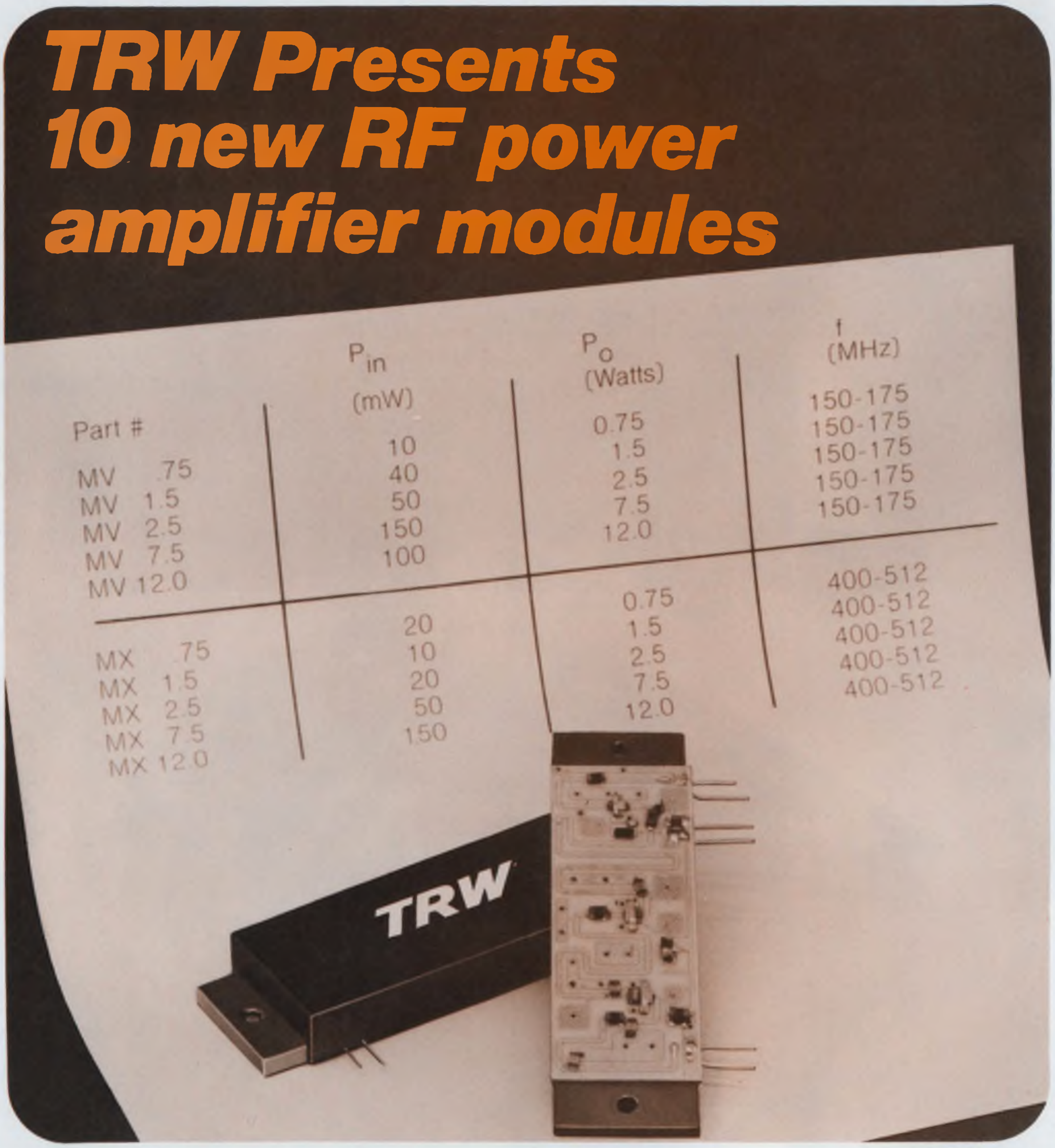
To get the full story on the functional, reasonably priced HP 180 System, call your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

Scopes are changing.
Are you?

081/5

HEWLETT hp PACKARD

INFORMATION RETRIEVAL NUMBER 242



16 to 21 dB gain... 0.75 to 12 W output... ∞ VSWR

A new series of broadband 12-volt amplifier modules developed by TRW covers the 150-175 MHz and 400-512 MHz mobile bands. They provide from 0.75 to 12 watts output power, and contain the entire amplifier function in a single microelectronic module. They are capable of 16 to 21 dB of gain, and can withstand infinite VSWR at 15 volts.

Compared to discrete components, these new modules offer the designer significant savings in size as well as design and production costs. They are stable under all operating conditions, and have a high level of harmonic rejection (—30 dB min.).

Delivery is immediate on the standard units. Custom modules are also available for any band between 135 and 520 MHz. For complete information and technical data, contact TRW Semiconductor Div., 14520 Aviation Blvd., Lawndale, Calif. 90260. Phone: (213) 679-4561, Ext. 631. TWX 910-325-6206.

TRW®

INFORMATION RETRIEVAL NUMBER 3

Electronic Design

VOL. 19 NO. 2

FOR ENGINEERS AND ENGINEERING MANAGERS

JAN. 21, 1971

NEWS

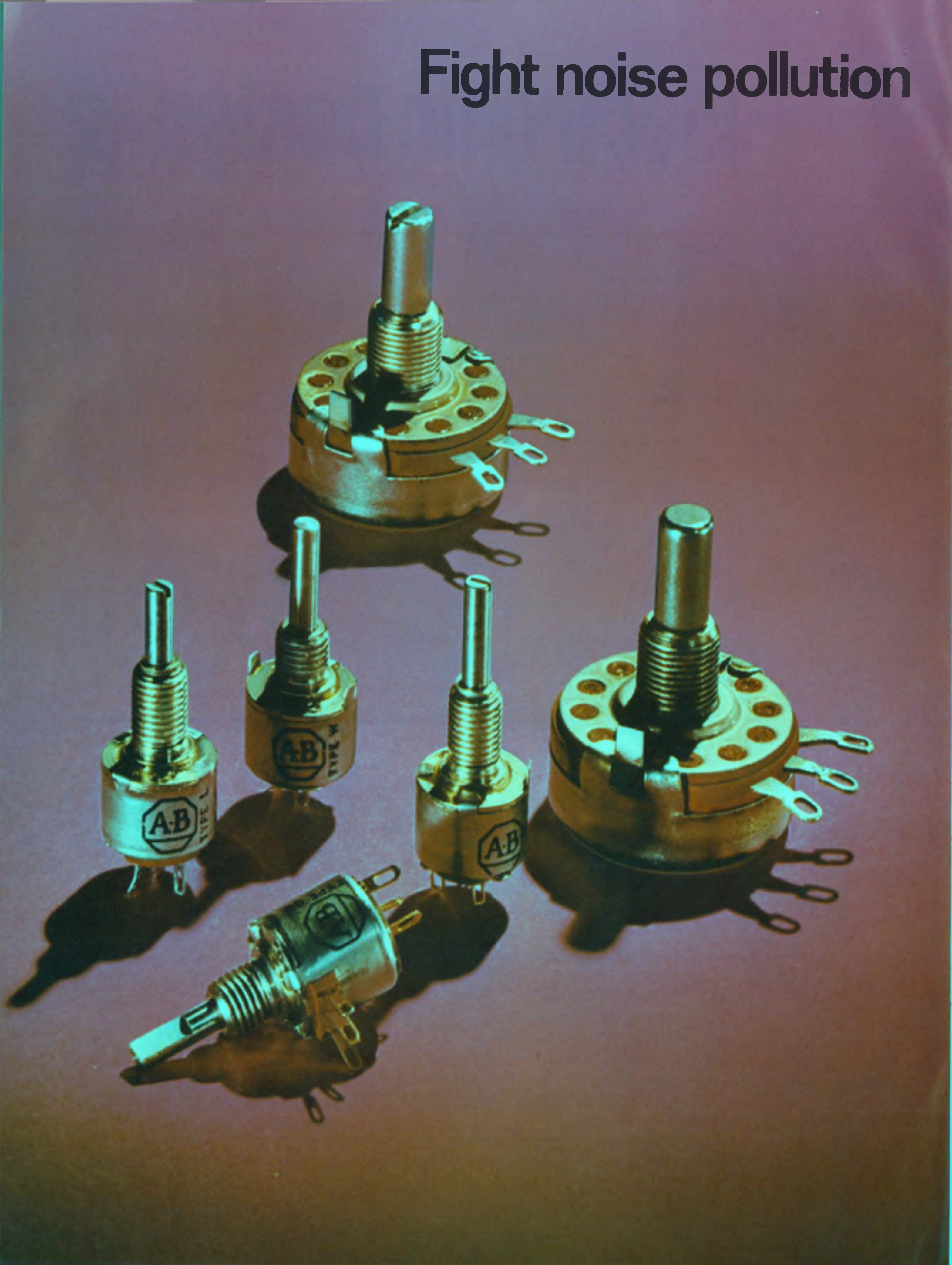
TECHNOLOGY

PRODUCTS

Departments

Cover: New modular oscilloscope system photographed by Larry Jackson of Tektronix, Inc., Beaverton, Ore.

ELECTRONIC DESIGN is published biweekly by Hayden Publishing Company, Inc., 850 Third Avenue, New York, N.Y. 10022. James S. Mulholland, Jr., President. Printed at Brown Printing Co., Inc., Waseca, Minn. Controlled circulation postage paid at Waseca, Minn., and New York, N.Y. 82,501 copies this issue.


Fight noise pollution
A-B
TYPE W
A-B
TYPE L
A-B
A-B

with this quiet family.

Hot Molding with Allen-Bradley's exclusive technique, gives these composition variable resistors an unusually low noise level. And importantly, this low noise level actually decreases in use. Under tremendous heat and pressure the resistance track is molded into place. A solid element with a large cross-section is produced.

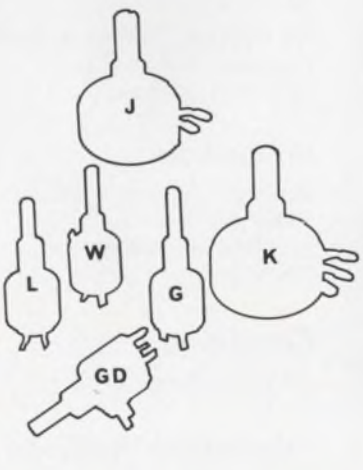
This important Allen-Bradley difference means better short-time overload capacity and a long operating life. Control is smooth, resolution almost infinite. These variable resistors are ideal for high frequency circuits. Why should you trust the performance of your designs or your reputation to anything less than Allen-Bradley quality? Use the most thoroughly "field tested" (over 20 years) variable resistors available today. Quantity stocks of popular types J, G, W and GD available for immediate delivery from your appointed A-B industrial electronics distributor.

For information write: Marketing Department, Electroniçs Division, Allen-Bradley Co., 1201 South Second Street, Milwaukee, Wisconsin 53204. Export office: 1293 Broad Street, Bloomfield, N. J. 07003, U.S.A. In Canada: Allen-Bradley, Canada Ltd., 135 Dundas Street, Galt, Ontario.

SPECIFICATIONS

	TYPE J— STYLE RV4	TYPE K	TYPE G— STYLE RV6	TYPE L	TYPE W	TYPE GD
CASE DIMENSIONS	5/8" deep x 1-5/32" dia. (single section)	5/8" deep x 1-5/32" dia. (single section)	15/32" deep x 1/2" dia.	15/32" deep x 1/2" dia.	15/32" deep x 1/2" dia.	35/64" deep x 1/2" dia.
POWER at + 70°C	2.25 W	3 W	0.5 W	0.8 W	0.5 W	0.5 W
TEMPERATURE RANGE	−55°C to +120°C	−55°C to +150°C	−55°C to +120°C	−55°C to +150°C	−55°C to +120°C	−55°C to +120°C
RESISTANCE RANGE (Tolerances: ±10 and 20%)	50 ohms to 5.0 megs	50 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs	100 ohms to 5.0 megs
TAPERS	Linear (U), Modified Linear (S), Clockwise Modified Log (A), Counter-Clockwise Modified Log (B), Clockwise Exact Log (DB). (Special tapers available from factory)					
FEATURES (Many electrical and mechanical options available from factory)	Single, dual, and triple versions available. Long rotational life. Ideal for attenuator applications. Snap switches can be attached to single and dual.	Single, dual, and triple versions available. Long rotational life.	Miniature size. Immersion-proof. SPST switch can be attached.	Miniature size. Immersion-proof.	Commercial version of type G. Immersion-proof.	DUAL section version of type G. Ideal for attenuator applications. Immersion-proof.

ALLEN-BRADLEY



NEW DIMENSION ELECTRONICS

INFORMATION RETRIEVAL NUMBER 4

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letters

Federal aid suggested for jobless engineers

(Editor's note: The following letter is one a reader sent to President Nixon, with a copy to Electronic Design.)

Mr. President:

The waste of our natural resources is a matter of prime concern to the nation. This is a healthy sign, since awareness of a problem is required before a solution can be found.

There is one resource presently being dissipated, however, about which few seem to be aware. This resource is the engineer—especially the engineer formerly employed by the large aerospace companies—who is presently unemployed or has been forced to engage in such diverse activities as selling insurance or operating a gasoline station or a tavern.

A tremendous number of these men can now be described as unemployable. They have worked for one company 10, 15, 20 years or more. They haven't the slightest notion of how to look for a job. Secure in their positions over the years, making fairly decent salaries, they constitute the middle class and upper-middle class of America. Now, with responsibilities heavy on their shoulders—children in school and college, heavily mortgaged homes and car payments to make—they suddenly find their services no longer required.

These people are truly an unemployable minority!

The writer, in the process of experiencing the frustration described, has a plan that could conserve this very valuable resource, provide countless benefits to the entire nation and, at the same time, would encourage students to return to the science and engineering classes from which they fled when the mass layoffs began.

Many of us have the ability and desire to become entrepreneurs. We have ideas for new products, which could create new enterprises, industries and job opportunities—products created for man's improvement rather than destruction.

Let funds be made available so that those of us who desire can convert these products to reality. We have the technical ability to develop products to help medicine, law enforcement, agriculture and transportation. We lack the money for facilities and equipment. Our skills and interests have been directed to technical creativity and innovation, and we lack general know-how in marketing and business management.

This plan could be implemented in the same manner as the GI Bill for ex-servicemen. It is no secret that the GI Bill was one of the most profitable ventures in which the Government has ever engaged.

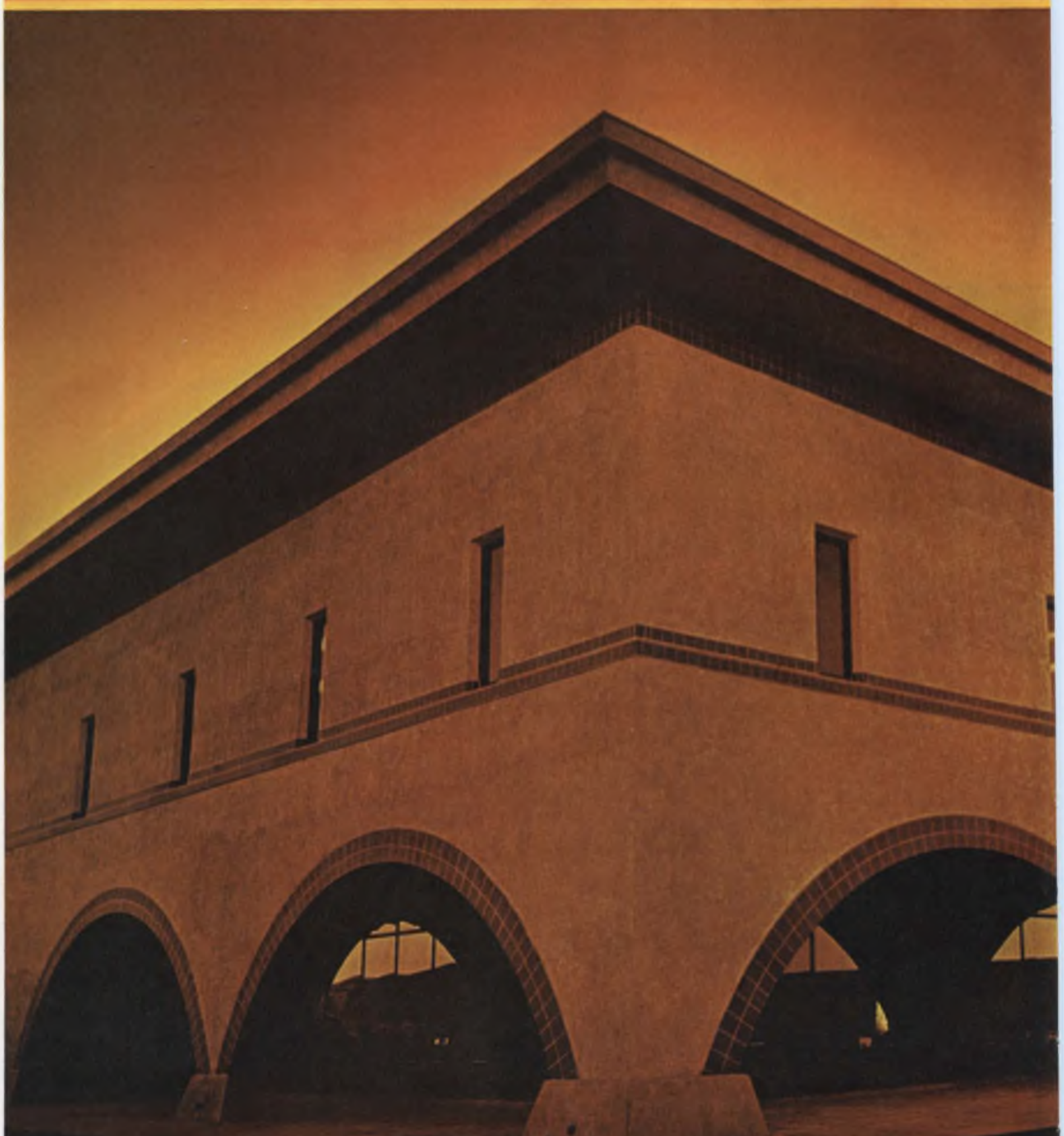
Machinery to put this plan into action already exists within the federal Government. The Small Business Administration could review presentations or applications prepared by the engineers. Experts such as the Service Corps of Retired Executives could critique and advise engineering applicants on the preparation of their plans and proposals. Creative and managerial talents could be brought together by means of computers, using data available from previous employers, state unemployment offices and the applicants themselves.

Some enterprises will fail, but the majority can succeed. The resulting benefits to the nation could be astronomical.

Milt M. Silverstein
6392 Tucker Drive
San Jose, Calif. 95129

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

In MOS/LSI, we're one-of-a-



Garrett

MICRO-CIRCUITS CORPORATION

-kind

Back in the '60's, everyone predicted MOS would come of age by 1970. And it has. Right in our new one-of-a-kind MOS plant. In fact, it's the best facility in the world for high-volume manufacturing custom MOS devices — backed by the financial stability of The Garrett Corporation.

New designs. New processes. New ideas for an emerging MOS/LSI technology. You'll find them all in our 35,000-square-feet of floor space. We are currently the exclusive second source for American Micro-systems, Inc., supplying everything from design to delivery under one roof.

All our fabrication and assembly areas are in Class 100, laminar flow clean rooms and have poured electrically conductive floors (the kind you usually find only in hospitals or ordnance plants).

We use completely deionized water that's purified by reverse osmosis. It's 10 times purer than the water used to make pharmaceuticals. And when we're finished with it and put it back into the environment, it's three times purer than ordinary tap water.

And we have a temperature control system in critical areas that keeps everything at plus or minus ¼ °F. And a humidity control system that keeps everything at plus or minus 2%.

You name it, we have it. Including a new one-of-a-kind diffusion furnace that has all the controls on the front . . . inside the clean room so operators don't have to enter unclean areas just to turn a couple of knobs.

We are establishing a complete and comprehensive set of computer aids for our design program. One of the benefits resulting from this effort is total and maximum interaction for the designer in all phases, including logic verification, placement and pattern generation.

We have all these things (and a lot more) so we can deliver a guaranteed product. Everytime. At the agreed upon price. On the specified date. Whether you're a medium or high-volume customer. You wouldn't buy from a substandard MOS house twice, and we know it. So we deliver.

And just for the record: every process and piece of equipment we have is devoted exclusively to MOS. Not bipolar *and* MOS. Our commitment to MOS is total. (Our new brochure tells the whole story.)

We're in business. We're in production. We invite your inquiries and will welcome your visit. Simply phone (714) 487-3000. Or write Garrett Micro-Circuits Corporation, 16701 West Bernardo Drive, San Diego, California 92127.

INFORMATION RETRIEVAL NUMBER 7

Designers' Choice: 13 Motorola monolithic IC voltage regulators priced from 90¢ to $10.00

TYPE −55°C to +125°C	TYPE 0°C to +70°C	V_{in} Range (Vdc) Min.	V_{in} Range (Vdc) Max.	I_{out} (mAdc) Max	P_D (Watts) Max $T_C = 25°C$	P_D (Watts) Max $T_A = 25°C$	Load Regulation (% V_o) Max	Price 100-up
POSITIVE VOLTAGE REGULATORS								
	MC1460G MC1460R	2.5	17	200 500	1.8 17.5	0.68 3.0	0.13 0.05	$2.50 3.50
MC1560G MC1560R		2.5	17	200 500	1.8 17.5	0.68 3.0	0.13 0.05	7.00 8.50
	MC1461G MC1461R	2.5	32	200 500	1.8 17.5	0.68 3.0	0.13 0.05	3.50 4.50
MC1561G MC1561R		2.5	37	200 500	1.8 17.5	0.68 3.0	0.13 0.05	8.50 10.00
	MC1469G MC1469R	2.5	32	200 500	1.8 17.5	0.68 3.0	0.13 0.05	2.00 2.50
MC1569G MC1569R		2.5	37	200 500	1.8 17.5	0.68 3.0	0.13 0.05	4.50 4.95
	MC1723G MC1723L	2.0	37	150	2.1 —	0.8 1.0	0.20	1.90
MC1723G MC1723L		2.0	37	150	2.1 —	0.8 1.0	0.15	3.90
	MFC4060	4.8	32	200	—	1.0	0.20	0.90
NEGATIVE VOLTAGE REGULATORS								
	MC1463G MC1463R	−3.8	−32	200 500	1.8 9.0	0.68 2.4	0.13 0.05	2.75 2.95
MC1563G MC1563R		−3.6	−37	200 500	1.8 9.0	0.68 2.4	0.13 0.05	5.25 5.45
SPECIAL PURPOSE REGULATORS								
	MC1466L	0	(1)	(1)	(1)	(1)	(2)	5.00
MC1566L							(3)	6.50

(1) Limited only by the characteristics of the series pass transistor.
(2) Load Regulation (voltage) 0.03% + 3 mV (current) 0.2% + 1 mA (3) Load Regulation (voltage) 0.01% + 1 mV (current) 0.1% + 1 mA

PREVIEW!

Coming soon . . .
the new State-of-the-Regulator-Art MC1567/1467

MC1567/1467 are ±15 V monolithic voltage regulators offering ±1% output voltage tolerance and burnout proofing through automatic thermal shutdown. They are internally compensated. Preliminary information is available now.

Together, the complete regulator family.

This is the industry's broadest line of monolithic IC voltage regulators, offering the most reasonable prices and the best price vs. performance tradeoffs. General purpose positive voltage types from the MFC4060 to the MC1561 cover the full range of Consumer, Industrial, and Military applications. Industrial and Military designers also find the negative voltage types extremely useful for supplying −15 V to op amps and other linear ICs. Special purpose regulators like the MC1566 are excellent for use as constant current regulators or high voltage regulators and in Lab Power supplies and other laboratory type applications.

Make your choice today. Order from your nearest Motorola distributor or sales office. For a specially compiled data and applications brochure on Motorola voltage regulators, please write Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036 or circle the reader service number below.

MOTOROLA LINEAR
–serving a greater range of analog designs!

INFORMATION RETRIEVAL NUMBER 8

INFORMATION RETRIEVAL NUMBER 9 ▶

Take an idea . . . or do your own thing. Applications for Bourns Cermet Panel Controls turn up everywhere.

Cermet resistance elements offer you a wide advantage in performance over their old-fashioned carbon counterparts. Look for:

- BETTER STABILITY
- HIGHER POWER RATING
- SUPERIOR TEMPCO (±150 ppm/°C)

Bourns Panel Controls **save space,** too. The ¾″ diameter models extend only ¼″ behind the panel — that's not far out.

Take a look at our new brochure on Panel Control Potentiometers — 16 pages of cutaways, photos, specifications and prices. Ask for it anywhere Bourns products are sold, or direct from the factory.

HIGH PERFORMANCE

Series 3852: ¾″ dia.; metal bushing, locking or non-locking; 2 watts at 70°C; res. to 5 meg.; tol. to ±5%. Typical price per piece $2.40; (2M) $0.81.

Series 3862: ½″ dia.; 1 watt at 125°C; res. to 5 meg.; tol. to ±5%. Typical price per piece $4.20; (2M) $1.18.

COMMERCIAL

Series 3859: ¾″dia.; plastic bushing or quickly installed snap-in version; 2 watts at 70°C; res. to 5 meg.; tol. to ±5%. Typical price per piece $1.95; (2M) $0.66.

Now look at the Controls. Stocked in depth by Bourns distributors all over. 24-hour delivery on standards.

BOURNS INC

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INFORMATION RETRIEVAL NUMBER 10

designer's calendar

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

Feb. 9-11
Aerospace & Electronic Systems Winter Convention (WINCON), (Los Angeles). Sponsors: IEEE et al. William H. Herrman, Wincon '71, IEEE Los Angeles Council, 3600 Wilshire Blvd., Los Angeles, Calif. 90005.

CIRCLE NO. 403

Feb. 17-19
International Solid State Circuits Conference (Philadelphia, Pa.) Sponsors: IEEE et al. Lewis Winner, 152 W. 42nd St., New York, N. Y. 10036.

CIRCLE NO. 404

MARCH 1971						
S	M	T	W	T	F	S
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

March 22-25
IEEE International Convention and Exhibition (New York City). Sponsor: IEEE. J. M. Kinn, IEEE, 345 E. 47th St., New York, N. Y. 10017.

CIRCLE NO. 405

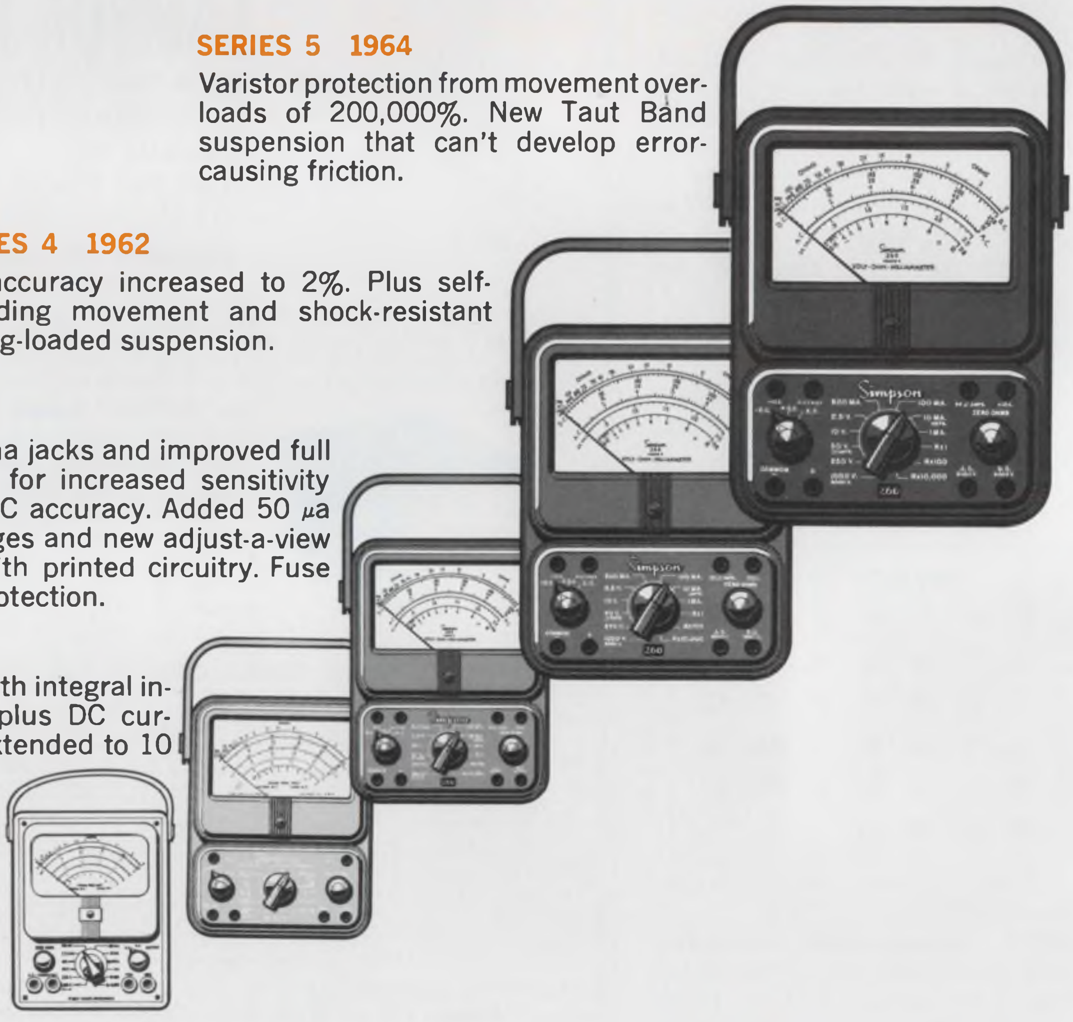
March 31-Apr. 2
Reliability Physics Symposium (Las Vegas). Sponsor: IEEE. O. D. Trapp, Fairchild Semiconductor, 464 Ellis St., Mountain View, Calif. 94040.

CIRCLE NO. 406

THE WORLD FAMOUS

Simpson® 260®

Constant improvement makes it consistently the world's largest selling VOM



SERIES 5 1964

Varistor protection from movement overloads of 200,000%. New Taut Band suspension that can't develop error-causing friction.

SERIES 4 1962

DC accuracy increased to 2%. Plus self-shielding movement and shock-resistant spring-loaded suspension.

SERIES 3 1959

Low resistance banana jacks and improved full wave rectifier circuit for increased sensitivity (5000 Ω/v) and 3% AC accuracy. Added 50 μa and 250 millivolt ranges and new adjust-a-view handle. First VOM with printed circuitry. Fuse added for circuitry protection.

SERIES 2 1947

Molded front panel with integral indicating instrument plus DC current measurement extended to 10 amps.

SERIES 1 1938

Beginning of the revolution in tester design—an instant success. First commercially available VOM with 20,000 Ω/v sensitivity. Complete range coverage for industrial and radio servicing.

Simpson®

INSTRUMENTS THAT STAY ACCURATE

NOW... the new

Simpson®

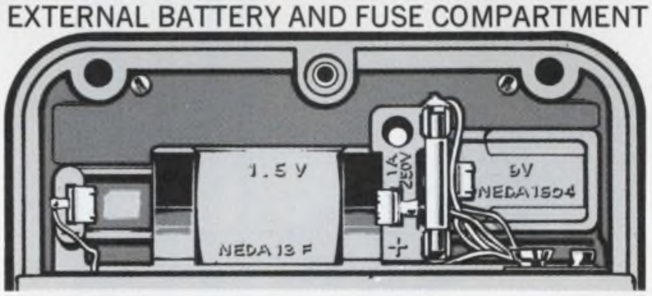
260 SERIES 6 VOM

THE NEW SERIES 6 HAS ALL THESE NEW FEATURES PLUS ALL THE ADVANCEMENTS IN THE SERIES 5:

- External access battery and fuse compartment.
- Clip-type fuse holder.
- 0-1 volt DC range.
- 0-500 volt AC and DC ranges.
- Available 5000 volt adapter-type DC *safety* probe.
- Multi-purpose, screw-on test leads with combination probe and alligator clips.
- Only 2 batteries . . . one 9-volt NEDA 1604 and one 1½-volt "D" cell.
- Rugged taut band movement.
- Varistor overload protection.

260-6 .... $65.00
260-6M (Mirror scale) $67.00

EXTERNAL BATTERY AND FUSE COMPARTMENT



260-6RT (Roll-top protective case) $71.00
260-6MRT (Mirror scale and roll-top case) $73.00
260-6P (Overload protected) $97.00
260-6PRT (Overload protected and roll-top case) $103.00
Safety Probe: 5000 volt DC adapter type #00506 .... $4.50

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IN CANADA: Bach-Simpson Ltd., London, Ontario
IN INDIA: Ruttonsha-Simpson Private, Ltd., International House, Bombay-Agra Road, Vikhroli, Bombay

AGM DIVISION

INFORMATION RETRIEVAL NUMBER 12

System Designers...
Make your move to MOSTEK for

MOS static shift registers

If you're in the market for MOS static shift registers, your best move is to MOSTEK. Our *only* products are MOS. . . engineered to give you outstanding performance and economy. Want proof? Check these features:

MK 1002P. Dual 128-bit static shift register. Full DTL/TTL compatibility. Single-phase, independent clocks (capacitance less than 5 pF) can be driven directly by a single TTL or DTL gate. High speed (DC to 1MHz selectable to 2MHz) clock rates. Recirculate logic built-in. Sixteen-pin ceramic dual in-line package.

MK 1002L. Virtually the same features as the MK 1002P except package is the economical 10-lead TO-5 can. Same full DTL/TTL compatibility; single-phase DTL/TTL compatible clocks.

Check the advantages of MOSTEK static shift registers. Like no need for external components or interface circuitry (not even a resistor!). Like all inputs—data, recirculate and clock (yes, clock too) —driven directly by TTL or DTL gates. Finally, like *nobody* makes MOS as fully compatible with TTL as ours!

'Nuff said? Then contact our home office in Dallas at (214) 242-1494 and ask Gordon Hoffman for information and fast delivery of MOS shift registers. . . plus ROMs and RAMs. Or call your nearest Sprague Electric Company office or representative.

Make a smart move. . . to MOSTEK.

MOSTEK
CORPORATION

An affiliate of Sprague Electric Company.
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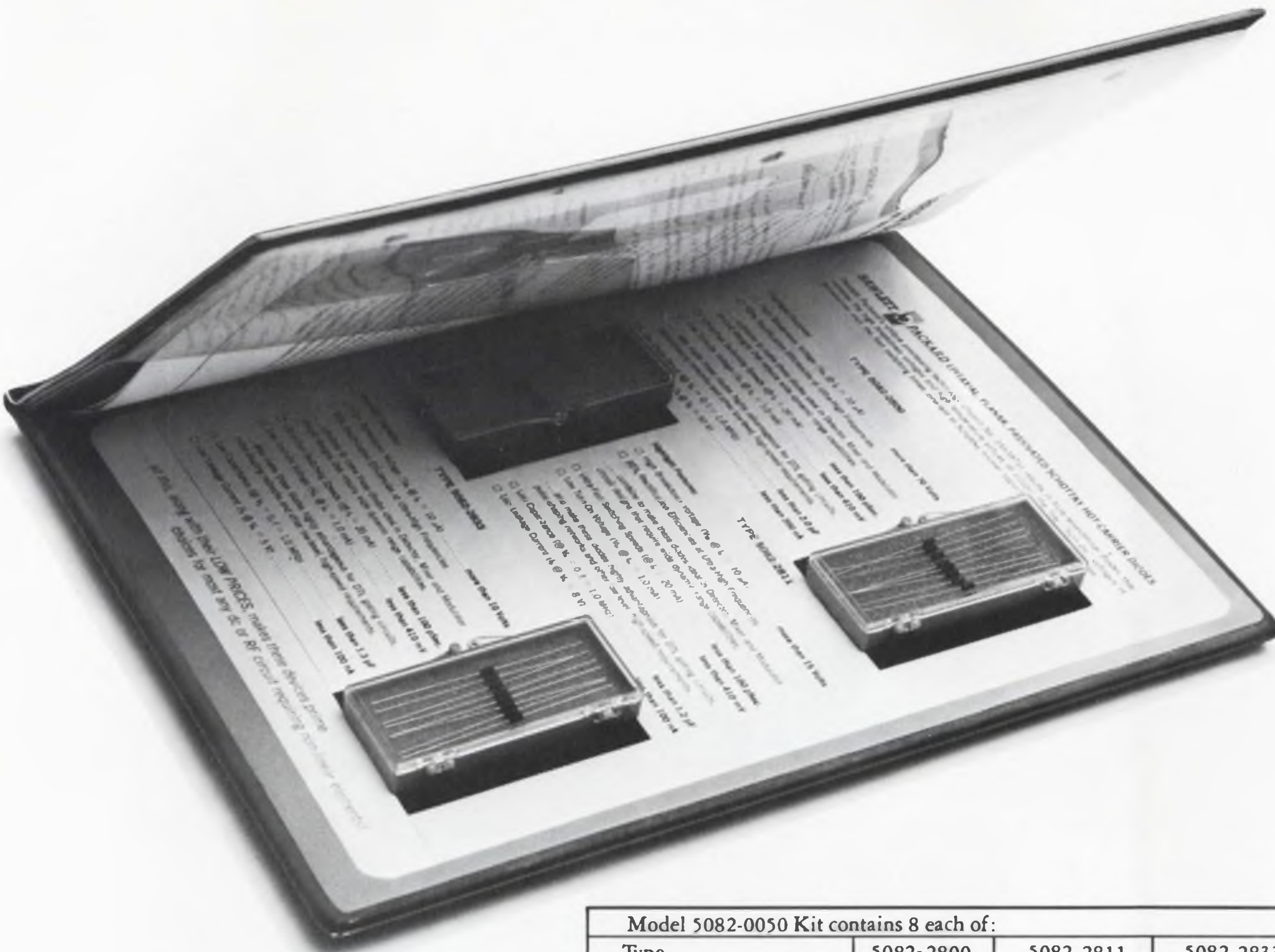
Carrollton, Texas 75006

INFORMATION RETRIEVAL NUMBER 13

To celebrate our 40% price reduction, we're offering this special diode kit.



Model 5082-0050 Kit contains 8 each of:			
Type	5082-2800	5082-2811	5082-2833
Breakdown Voltage	70 v	15 v	10 v
Forward Current at 1v	15 ma	20 ma	100 ma
Capacitance	2 pf	1.2 pf	1.5 pf

If you've never designed around universal Schottky barrier diodes, here's your chance to upgrade circuit performance for pennies. HP will send you \$32 worth of these diodes for only \$8.40. That's right—only \$8.40 for 24 of the best diodes you ever got your hands on (see chart for specs). And they're packed in a handy leatherette folio along with complete data.

The big kit giveaway celebrates HP's across-the-board 35 to 40% price reductions on these great diodes—reductions that bring prices down to 35¢ each in 10K quantities, even less if you order more.

These general-purpose hot carrier diodes deliver better overall performance than P/N junction silicon or germanium diodes. Complementing the 0.4 volt turn-on is low series resistance, 100 picosecond switching speed and 1 mV/°C temperature coefficient. So now you can simplify circuit design and improve performance at the lowest possible cost.

Send for your HP diode bargain and find out for yourself.

\$32.00 value only \$8.40!

(Offer expires May 1, 1971)

Clip this coupon and mail with check, money order, or P.O. to: Hewlett-Packard Associates, 620 Page Mill Road, Palo Alto, California 94304. Your nearby sales office can also handle this offer.

Name__________ Application__________

Company__________

City__________ State__________ Zip__________

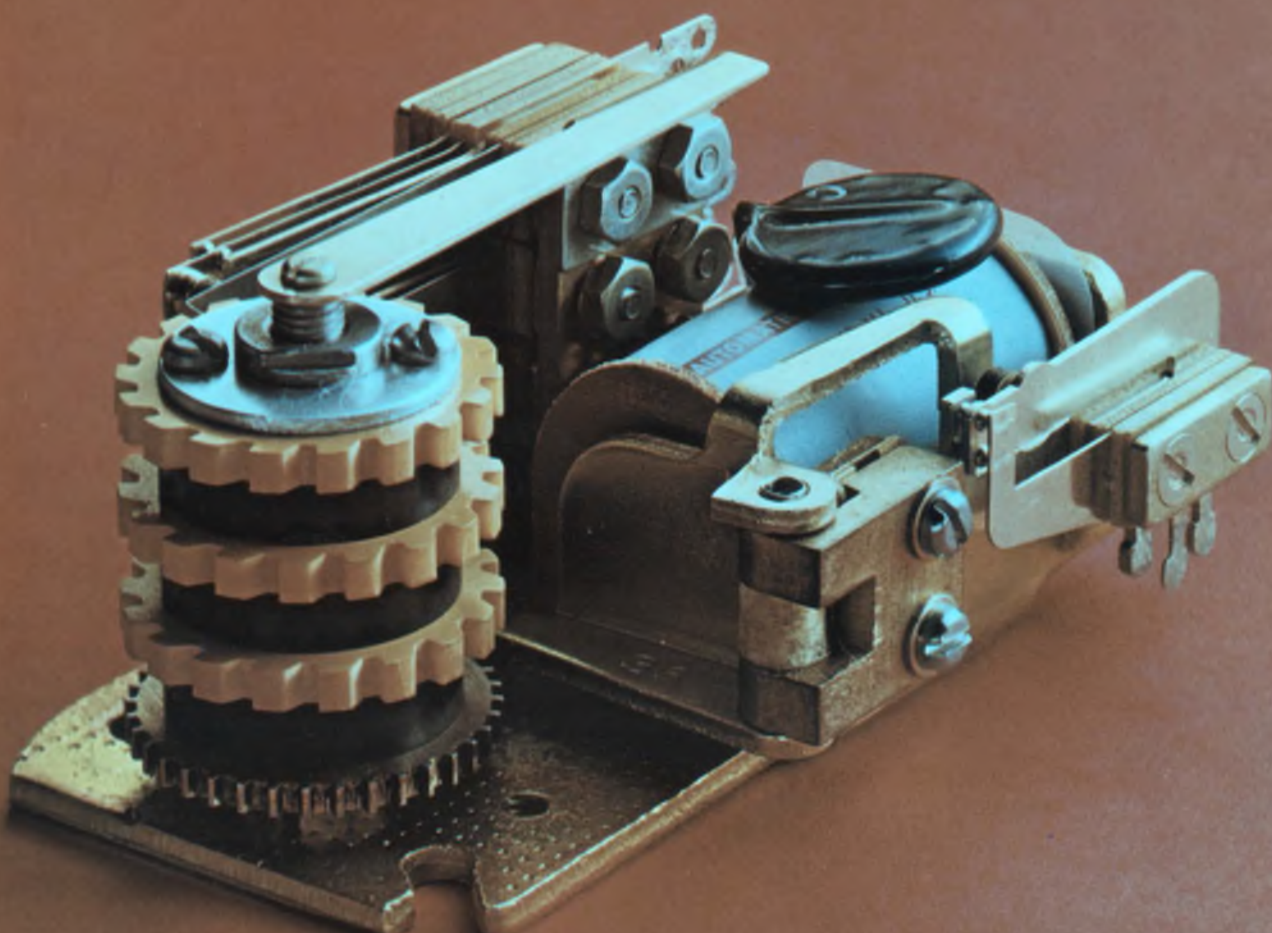
HEWLETT hp PACKARD

COMPONENTS

01102

INFORMATION RETRIEVAL NUMBER 101

Reliability is a notched memory and a double-jointed thumb



We combine the simplicity of a cam-operated relay with a tough, time-proven stepping switch to give you an uncomplicated and sturdy relay. The brains of our OCS relay are precisely notched cams that give it an unforgettable memory. Power blackouts won't change it.

Faithfully redundant

There are no mysteries, no black boxes. First, phenolic cams are notched to your exact needs and every operation is faithfully repeated. The cams control the action. As the finger of the switch traces over the crests and the valleys of the cam, you get simple and precise "ons" and "offs" that you can use to control a variety of equipment. Pulse interval, pulse width—we'll let you make the decisions. Now we anchor the stack of cams and a gear with two long bolts running exactly parallel with the camshaft axis. This keeps everything in line even under extreme vibrations or shock. You can't get this toughness in delicate latching relays.

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14 ways to keep current on computer languages...equipment...terminology

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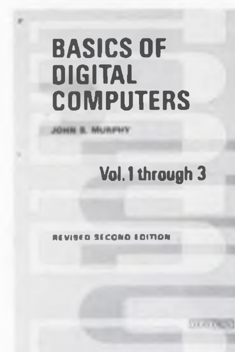

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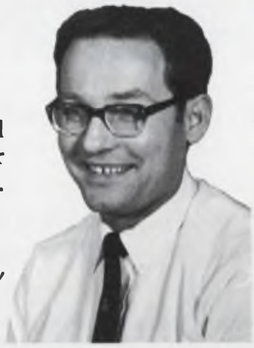
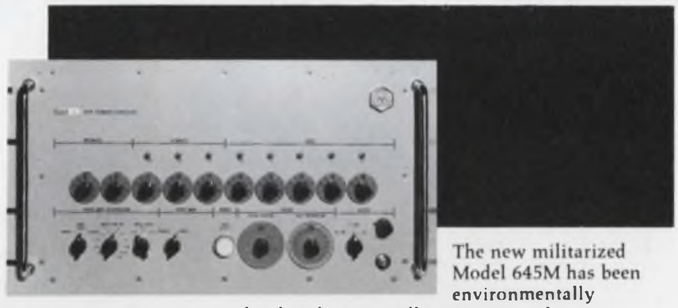


Fluke Product Manager Paul Beihl tells you what to look for in a frequency synthesizer.



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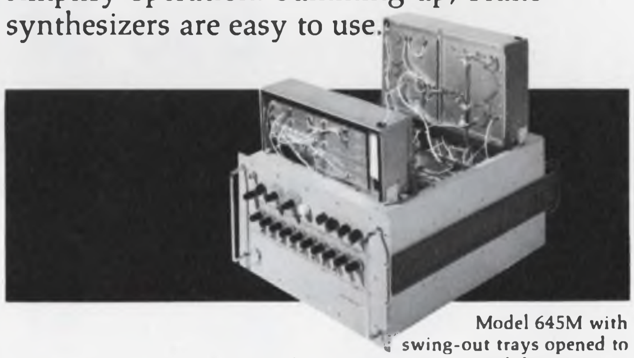

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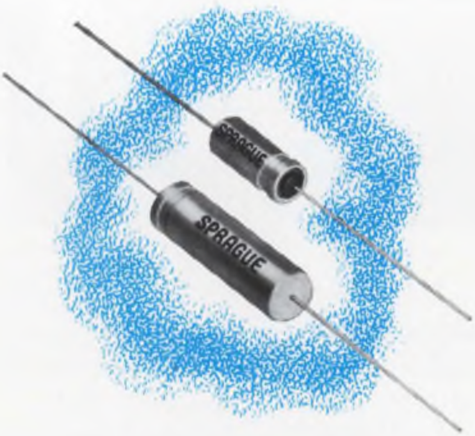

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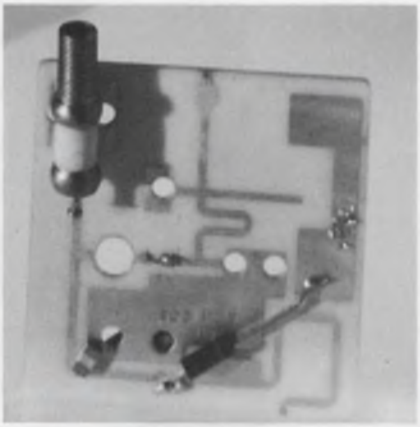


Typically, a solid-state microwave source consists of two basic elements: a transistor oscillator and a varactor multiplier. The design of the oscillator is fairly straightforward, but the multiplier presents some serious challenges. Its design requires nonlinear analysis, and the results are valid only under specific conditions.

When microstrip is used to reduce the size of the multiplier, the problems are compounded. It is difficult to predict the detailed behavior of microstrip circuits because the non-TEM waves that propagate on microstrip lines are not easy to describe analytically.

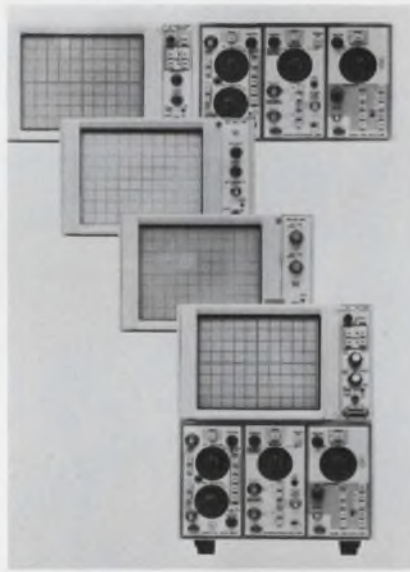
How can the designer overcome these problems and come up with a good, compact microstrip multiplier? The key is to understand clearly the functions of the multiplier circuitry external to the varactor diode itself.

Page 46

Making every telephone line in the country more efficient and more reliable is just one of the promises that digital filters can be expected to fulfill—once large-scale integration arrives. As digital ICs provide more functions on a single chip, digital filters can become more complex and less expensive, and they will take up less space.

When that day comes, digital filters will become a real threat to analog filters. But at present the digital filters that are available are really laboratory instruments offering a good deal of flexibility. With them, you can easily and quickly change filter characteristics by simply programming a different set of numbers that represent the filter you desire.

Page 24



A new low-cost modular oscilloscope system offers the user a wide range of flexibility and the ability to choose economically the proper measurement system compatible with his needs. It also allows single and dual-beam storage and nonstorage displays, high-gain and delayed-sweep measurements, one to four-trace capability, X-Y or Y-T operation and bench-top to rack-mount mobility.

The system consists of four display modules, six amplifier and three time-base plug-ins. Each of the plug-ins and each of the display units is interchangeable for maximum versatility.

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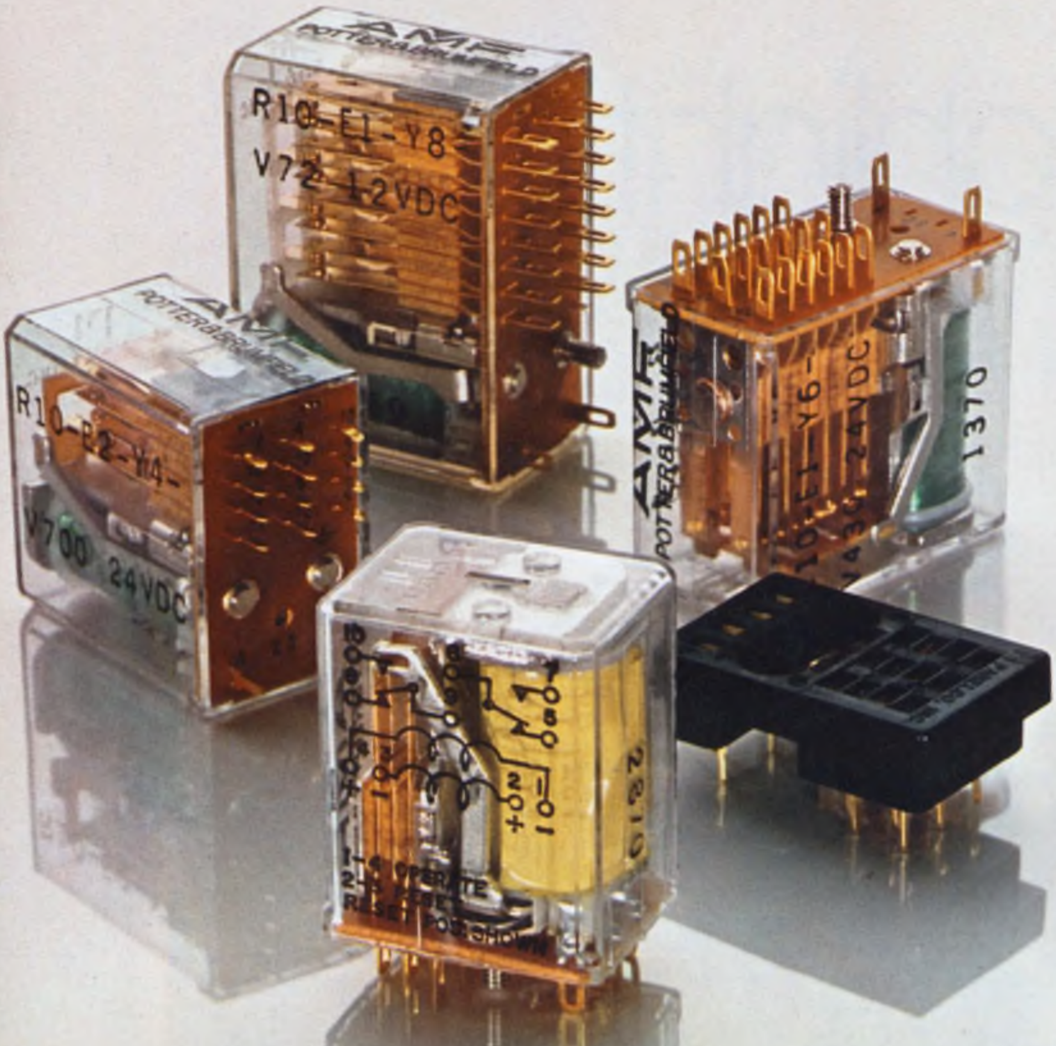

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Soviet submarine expansion spurs rise in ASW market

Soviet submarines, which are now as familiar in the blue-green Mediterranean as dolphins at play and are fast becoming so in the Caribbean, have caused a reversal in at least one area of the generally depressed American military market: antisubmarine warfare.

"By 1974," according to an analysis just published by Frost & Sullivan, Inc., a New York-based defense and space market research organization, "the ASW equipment market will grow 20% from today's $2.3-billion level." The annual figure includes, along with electronics, the cost of platforms—aircraft, ships and submarines.

Big outlays are expected to go for the following:

- Sonar for surface ships. Besides the updating of old ships, 30 destroyers (DD-963) are being built by Litton Industries, Inc., and all will need sonars. One detector already selected is a modified version of General Electric's giant sonar, the AN/SQS-26.
- Sonar for submarines. The new SSN-688 attack submarine calls for a big sonar order. International Business Machines alone has a $50-million contract to develop five sonars for this new submarine class.

One thing for sonar makers to watch for, the report says, is the Navy's increasing interest in developing a common sonar that operates on both surface ships and submarines. This could possibly reduce costs, but it might also reduce the number of companies providing these complicated, expensive systems to the Navy.

- Sonobuoys, to be ejected from aircraft, and their related cockpit processors and displays. Spending for these will be in the hundreds of millions, the report states. The programs include LAMP (Light Airborne Multi-Purpose system)—a destroyer-based ASW helicopter, of which 200 are to be delivered; the land-based P-3C ASW patrol plane; and the S-3A ship-based ASW patrol plane.
- Fixed underwater arrays to detect submarines. Purchases for the Caesar system of sonars, anchored to the floor of the Atlantic off the East Coast of the U. S., are slowing down after more than a decade, the report says, but hopes are high for initiation of a new moored sonobuoy system. Eleven companies are said to have announced intentions to bid on the latter program.
- Very-low-frequency and extremely-high frequency communications. These will continue to be good markets, the report says, as will magnetic anomaly devices, acoustic counter-countermeasures and explosive echo ranging systems.

The report is less than enthusiastic over the realistic potential of submarine detection by satellite.

Price break predicted for semi memories

Semiconductor memories are encroaching upon the last stronghold of cores—the "extended core" memories above 4 million bits—according to David C. Conrad, vice president of marketing at Computer Microtechnology, Inc., Sunnyvale, Calif. By late 1972 the price of semiconductor memories will be down to 0.3¢ a bit, he says. This compares favorably with core price projections of about 0.8¢ a bit for a 10-million-bit system complete with power supply (see "The Big Memory Battle: Semis Take on Cores," ED 15, July 19, 1970, p. 70).

Primarily responsible for the price break in semiconductors, says Conrad, will be a new 2048-bit dynamic MOS RAM, which CMI expects to ship during the second quarter of the year. The introductory price in prototype quantities will be between 3¢ and 4¢ a bit, but within a year after initial shipments, he predicts, they will be down to 0.3¢ a bit for 50,000 pieces in plastic packages.

Even bigger chunks of memory are coming along in multichip modules. By the third quarter of 1971, Computer Micotechnology will be shipping an 8-k-bit module that contains sixteen 512-bit static MOS storage chips and bipolar sense, drive and decode circuitry. The initial price will be about 5¢ a bit in protoype quantities, but Conrad sees them falling to 1.5¢ a bit by mid-1972.

Microwave ILS proposed for tomorrow's airports

A special committee of the Radio Technical Commission for Aeronautics recommended to the Dept. of Transportation this month that it and other Government agencies develop the microwave scanning beam concept as the standard instrument landing system of the future.

As envisioned by the quasi-official aviation advisory group, the system would use two techniques: C-band guidance to touchdown and Ku-band guidance through flareout. Using this modular approach the system would meet the needs of light aircraft, as well as airline and military equipment. It would be a fully automatic, all-weather system, capable of operating on multiple closely-spaced parallel runways.

RTCA recommended that the next phase of action be a year-long analysis by several Government and industry bodies and then that different manufacturers in different countries test the hardware.

Flying command posts to communicate by satellite

The nation's first operational airborne satellite communications terminals are now being installed. They are going into the Air Force's Worldwide Airborne Command Posts, the electronic-laden EC-135 cargo planes from which the Air Force could direct a war.

The terminals, designated AN/ARA-64, were developed and built by Electronic Communications, Inc., in St. Petersburg, Fla., under contract with the Oklahoma City Air Material Area. They evolved from terminals the company built for the military to experiment with Les-5 and Les-6, experimental communications satellites built by Lincoln Laboratories. (See "'Portable War' Electronics Gets First Pacific Test," ED 10, May 10, 1969, pp. 34 to 45.

The new terminals are solid-state and are lighter than their predecessors. Like the older ones, they operate at 70 MHz, the standard frequency for all Defense Dept. tactical satellite communications.

Each terminal can transmit and receive teleprint, is equipped with a page printer, keyboard, tape reader and tape reperforator. They are being installed by the company's teams at Air Force bases in Hawaii, Europe and the U. S.

Meanwhile, the Joint Service Program for developing tactical communications satellite terminals for all the services—for use in the air, in vehicles and submarines—is still under way. Collins is building the uhf terminals and RCA the terminals that operate in the super-high-frequency range.

Satellites to provide first intrastate TV

A proposed satellite ground station at Lena Point, near Juneau, Alaska, would make possible the first live television between the Juneau area and other parts of the state. The station, to be erected at a cost of $1.5 million, would operate with the Intelsat TV communications satellite, pending the establishment of a domestic satellite system. A petition for the new station was submitted to the FCC at the end of December by RCA Alaska Communications, Inc. (Alascom), a subsidiary of RCA Global Communications, Inc.

Equipped with a 32-foot antenna, the Lena Point station would be connected to the Juneau telephone toll center by an existing microwave route that has a present capacity of 300 voice circuits, according to Howard H. Hawkins, president of RCA Alascom Station design would also permit operation with Intelsat III or other alternative satellite systems.

New heart pump uses advanced electronics

By combining the techniques of modern electronic signal processing with materials and medical technology, a team of engineers, doctors and physicists in Massachusetts has developed an artificial heart pump that has already saved six lives and holds great promise of saving many more. The intra-aortic balloon pump is the result of collaboration between the Massachusetts General Hospital in Boston and the Avco Everett Research Laboratory in Everett, Mass.

The balloon pump, which is inserted into the aorta through a small incision made in the femoral artery in the thigh, has been used to assist failing hearts during the crucial hours following heart attacks.

Naturally, to work properly with the patient's heart, the pump's action must be synchronized with it. In a healthy patient this would present no problem because the component of a normal electrocardiogram waveform that signals the start of each beat is about five times larger than the rest of the signal. In patients with failing hearts, however, the cardiogram can be very distorted, and discrimination is not so easy.

To overcome this problem, the engineers who designed the electronic circuitry for the heart pump had to use a combination of amplitude and frequency discrimination techniques to extract the all-important synchronization signal.

Honeywell joins trend to instrument rentals

When the economy declines (as it did last year) and companies are reluctant to buy new capital equipment, rental of the equipment is often an attractive alternative. Noting this trend, Honeywell's Test Instrument Div. in Denver has joined other electronics manufacturers in setting up a program for the short-term rental and long-term leasing, of testing, measuring and recording instruments.

Called Help (Honeywell Equipment Leasing Plan), the program gives customers outright-purchase options, as do other manufacturers.

According to Allan B. Dallas, Honeywell marketing vice president, customers can rent equipment and patient-monitoring systems for as short as two weeks or as long as five years.

As examples of monthly rental fees, Honeywell cites the following: a two-channel, low-frequency X-Y recorder for $76.50, a 10-channel, medium-frequency oscillograph for $203 and a seven-channel, high-frequency magnetic recorder and playback unit for $260.

Color TV tube exports to 2 areas up 427%

U. S. exports of color TV tubes to West Germany and Britain rose 427% in the first nine months of 1970, according to the Electronic Industries Association.

Compared with the same period in 1969, American color tubes shipped to West Germany increased from 40,000 to 160,000, while tubes shipped to Britain rose from 2800 to 23,000.

Radar weather data being sent by phone

If an airline dispatcher in Dubuque wants to see what the weather looks like in Kansas City, he's only a phone call away from a facsimile representation of that area's weather radar picture.

The facsimile service, offered over voice-grade telephone lines, is now available to the airlines for 15 regions of the country. By 1973, at least 50 regions will be covered.

The radar images are provided by National Weather Service satellites. The radar scope images are combined with geographical overlays and meterological notations.

The service is being offered to the air transport industry by Aeronautical Radio, Inc., the industry's nationwide communications company. ■■

news

Digital filters with LSI promise a new world of applications

Making every telephone line in the country more efficient and more reliable is just one of the promises that digital filters can be expected to fulfill—once large-scale integration becomes practical. As digital ICs provide more functions on a single chip, digital filters can become more complex and less expensive, and they will take up less space.

When that day comes, digital filters will become a real threat to analog filters. Bell Telephone Laboratories, Murray Hill, N. J., actually expects the entire Bell System to go digital, with digital filters replacing the analog filters now used.

But at present the digital filters that are available are really laboratory instruments offering a good deal of flexibility. With them you can easily and quickly change filter characteristics simply by programming a different set of numbers that represent the filter you desire. Only two firms sell them: Rockland Systems Corp. of Blauvelt, N. Y., and Electronic Communications, Inc. of St. Petersburg, Fla.

Applications are numerous

Besides laboratory work, these sophisticated filters can be used in many signal-processing applications —spectrum analysis, line equalization, satellite communications systems, and radar, sonar and audio work.

Spectrum analysis is made possible simply by adding interface circuitry and a display system to the output of the digital filter. Adaptive line equalizers can be implemented with digital filters because of the ease with which filter characteristics can be changed.

Digital filters can also boost signal-to-noise ratios when used as linear, matched or comb filters in radar, sonar, audio and satellite communications systems. Other areas of application include geophysical and vibrational analysis and also medicine, where a digital filter can be used to pre-filter data for an electrocardiogram process.

Digital versus analog

The current cost for a fully versatile digital filter is approximately $20,000. But don't let price scare you. Digital filters offer some major inherent advantages over analog units. Temperature stability is a prime factor, according to Dr. James Kaiser, a member of the technical staff in Systems Theory Research at Bell Telephone Laboratories, Murray Hill, N. J.

"You are using nonlinear switching elements rather than linear passive components that reflect changes in temperature by changes in value," he notes. "The digital filter's characteristic is extremely predictable because it is solely dependent on the coefficients that are programmed into the filter."

Digital filters can also become economically feasible on a per-channel basis when there is a large number of signals to handle. Multiplexing becomes easy because digital signals can be handled with time division, and a bank of digital filters can share the same control system, like clock and power circuitry.

Dr. Leland Jackson, vice president of engineering for Rockland Systems Corp., notes:

"In the digital world, as in the analog world, there is no theoretical limit to the precision that you can achieve. However, when dealing with analog components, you finally come down to a point where the components limit you because of thermal noise or size or impracticability. In the digital world there is only an economic limit to the number of bits that you can add to the filter.

"Usually the complexity of a digital filter varies linearly with its accuracy. If you want to double precision, you simply add another bit. It does not matter if that is the seventh bit or the 27th bit—it is not any harder to add that extra bit. Whereas, with the analog filter, every time you try to double precision, cost is squared or cubed because of the difficulty in building the components.

"Another consideration is the fact that integrated-circuit technology has been making greater strides in the digital world than in the linear. You can buy much more on a digital chip than on a linear one."

There are many ways to implement digital filtering, but there are only two types of digital filters that you can buy today: recursive, made by Rockland Systems, and nonrecursive, manufactured by

Lucinda Mattera
New Products Editor

What are digital filters?

Digital filters can be thought of as special-purpose computers. They implement the filtering function by working with samples of the input signal and samples of the desired filter characteristic. The arithmetic section of a digital filter basically consists of multipliers and adders that operate on corresponding samples of the stored signals.

Electronic Communications, Inc. Both filters use a sampling rate that is at least twice as fast as the highest frequency of the input signal.

A look at a recursive design

Rockland's series 4000 recursive filters are able to simulate both poles and zeros for the filter transfer function. The input analog signal to be filtered is first sampled by an analog-to-digital converter, and these samples are stored in the instrument—as are coefficients that determine the filter characteristics.

The coefficients are the multipliers of the z-transform terms that represent the transfer function of the filter desired.

"The z transform is a special type of Laplace transform," Jackson explains. "It plays the same role in the design of digtal filters that the Laplace transform does for analog filters.

"When you finish taking all your Laplace transforms of the sampled signal, you find that everything has the common term, e^{sT}. You finally get tired of writing that and call it z. And let

$$z = e^{sT},$$

where s is the Laplace transform parameter and T is the sampling period."

The coefficients that determine filter characteristics are the multiplying coefficients of the z-transform terms. They correspond to the passive-component values that you would have in an analog filter.

"You cannot say that this coefficient represents a resistor or another is a capacitor," Jackson says, "but you can say that this ensemble of coefficients used in a certain way gives me a Butterworth filter, and another set will give me an elliptic filter."

From the frequency domain of the z transform, Rockland goes back to the time domain and processes (filters) the input signal with real-time digital circuits. These ICs perform a series of mathematical steps, primarily multiplication and addition, to realize the filtering function.

"Our digital filters are limited to applications where signal frequencies are 1 MHz or less," Jackson says. "Crystal filters are more economical at frequencies above this. However, our applications are still broad. We can handle baseband processing of audio or other low-frequency signals. We can also deal with i-f processing of signals that have been frequency-translated."

Here is a nonrecursive design

The nonrecursive type of digital filter from Electronic Communications is actually a signal-processing instrument that performs the convolution integral in order to effect a filtering function. Dr. William Marquitz, group leader of Digital Communications Technology Div. there, explains:

"We stay away from the z-transform method and work strictly in the time domain. We represent a filter, not by its amplitude and phase characteristics, but by its impulse response. We begin by band-limiting the analog input signal with a low-pass analog prefilter. We must restrict the bandwidth of the incoming signal to something less than half the sampling rate. In our model 999 digital filter, the standard sampling rate is 10 kHz, and the prefilter cutoff is 3.5 kHz."

Electronic Communications' digital filter has two identical shift-register memories. One stores samples of the band-limited input signal, while the other contains samples of the impulse function of the filter that is desired. The sampled impulse response is represented by coefficients that are the various amplitudes of samples spaced equidistant along the time axis.

The coefficients are obtained by using computer software available from the company and programmed into the digital filter via a paper tape. The tapes are set up so that the programs can be put on a time-shared computer system. Up to 200 coefficients can be stored in the sampled-impulse-response memory.

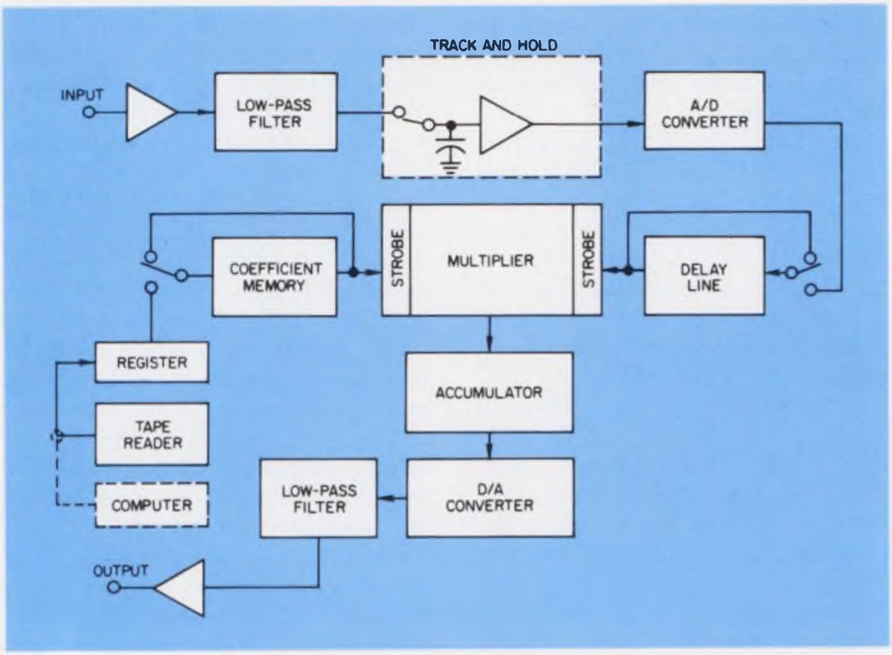
The contents of the two memories are fed into a single multiplier section that forms the product of coresponding samples from each memory. The output of the multiplier goes to an accumulator that puts out the digitized filtered version of the input waveform.

Because this digital filter is a transversal or nonrecursive one, it can simulate only zeros for the filter transfer function.

"However," Marquitz points out, "a nonrecursive filter is not a limited one. The concept of poles and zeros is only a mathematical tool to help analysis. We can represent any filter by its impulse response. There is no recursive filter that you can represent with poles and zeros whose impulse response you cannot find in order to use our nonrecursive model 999."

The need to band-limit the input

There are only two digital filters available to the user at this time. Both are primarily intended for use as flexible laboratory instruments and cost about $20,000 when fully equipped. The Rockland Systems' filter (left) and the Electronic Communications' filter (right) offer fully programmable filter characteristics. A set of numbers, which can be changed easily, completely determines the desired filter function.



The digital filter from Electronic Communications is really a signal-processing instrument that performs the convolution integral. Its major function blocks are two memories, the multiplier, and the accumulator.

signal is not as restrictive as it might seem at first. Marquitz notes:

"We can increase bandwidth by adding multiplier sections. With two multipliers, for example, we can double bandwidth to 7 kHz without sacrificing filter selectivity. The upper frequency limit of our digital filter is really a function of how fast the accumulator can work."

Because it is actually performing the convolution integral, Electronic Communications' instrument is is really a convolutional processor. This means that it can perform the cross-correlation function if the impulse-response samples represent some analog waveform. The autocorrelation function can be implemented if the impulse-response samples represent the input signal itself.

Recursive versus nonrecursive

According to Marquitz, transversal filters offer a major advantage over recursive designs—independent control of amplitude and phase response.

"A customer can specify each one independently, and we can give it to him," Marquitz says. "This cannot be done with a recursive filter."

However, Jackson at Rockland points out that recursive filters produce the sharper cutoffs. "We can approximate linear phase," he says, "so that the input signal comes out with an unaltered shape."

The manufacturers look ahead

Both Rockland and Electronic Communications feel that the future of digital filters is strongly tied to the development of integrated circuit technology. As chip complexity increases, both companies expect the cost and size of digital filters to come down becaus multiplier sections can be greatly simplified. A direct result will also be broader applications.

Marquitz says: "Current prices will be approximately halved when we get the integrated circuits that we need. If we get better IC functional blocks, I think that within five years you will see a digital filter in a housing the size of a cigarette package."

Jackson notes: "There are two things that we will be doing. One is developing digital-filter products, and the other is utilizing digital filters in standard instruments, like wave analyzers, spectrum analyzers and voltmeters. These devices are currently using analog components. Whether we introduce the new instruments ourselves or simply provide the digital-filter subsystems for them remains to be seen. Future applications depend on the technology available to us."

A big user speaks out

The Bell System is expected to be a large user of digital filters because they can reduce costs, according to Dr. Henry McDonald, assistant director of the Communications Principles Research Laboratory of Bell Telephone Labs.

He says, "Parts costs will be reduced by a factor of 10, not to mention our savings on maintenance costs."

Bell is primarily interested in digital filters as tone detectors to implement its plan to convert the entire country to the Touch-Tone system. McDonald foresees useful digital filters coming out of the development stage by 1973 and installed in the Bell System by 1975.

"We install something like half a million channels a year, and most of these in long trunk lines that have tone detectors associated with them," McDonald says. "This is why we have quite an active research program going for the implementation of digital filters.

"We are now waiting for our custom integrated circuits from Western Electric. The commercial MSI that is available today takes 10 times more power and 10 times more silicon area than our custom experimental circuits will require. Instead of the 2-1/4 MSI chips now needed per bit of multiplier, we will get four bits of multiplier on one chip."

Some day all of Bell's needs will be fulfilled digitally with the aid of d/a and a/d converters, McDonald predicts.

"The reason for this," he notes, "is that large-scale integration will greatly reduce the number of wires and the number of parts. The number of wires will decrease because we could use time-division multiplexing to get many digital signals on the same wire. The number of parts will go down because we could get 100 circuits on one piece of silicon. Another factor is reliability. We hope to practically pay for the change because of what we will save on the maintenance costs.

"I see digital filters as very much a part of the Bell System. They are not just a laboratory curiosity." ■■

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INFORMATION RETRIEVAL NUMBER 19

Introducing, the electronic car: antiskid, antipolluting, pro-driver

The British version of the car of the future was recently unveiled by Joseph Lucas Ltd. of Birmingham, England. The car, an experimental British Triumph, was developed as part of a $2.4-million R&D program and is fittted with six newly developed electronic systems. These are:

- Fuel injection.
- Wheel slide protection.
- Vehicle conditioning monitoring.
- Autocruise.
- Ignition.
- Permanent magnet alternator control.

In the fuel-injection system, a small digital computer called a Performance and Demand Analyzer determines the optimum air-fuel combination for engine speed and acceleration. The computer activates solenoid-operated injectors to achieve "perfect fuel control in all conditions," thereby curbing air pollution, according to Lucas.

Wheel slide protection, Lucas says, prevents skidding, wheel-locking, loss of stability and loss of steering control. Each wheel has an electronic module. Wheel speed is checked by an inductive sensor, and the pulse train from the sensor is converted by the module to a dc signal proportional to wheel speed. This signal is differentiated to determine wheel deceleration and then compared with a threshold value (about 1.3 g) to indicate any imminent skid. When the threshold value is exceeded, a power amplifier in the module triggers a solenoid control valve that controls pressure delivered by the brake fluid.

The vehicle condition monitoring system monitors eight vehicles conditions: brake systems, brake fluid level, oil pressure, bulb failure, oil level, radiator coolant level, brake pad wear and window-washer fluid level. These conditions are monitored by both hydraulic and electronic sensors.

The alarms for the system consist of the following:

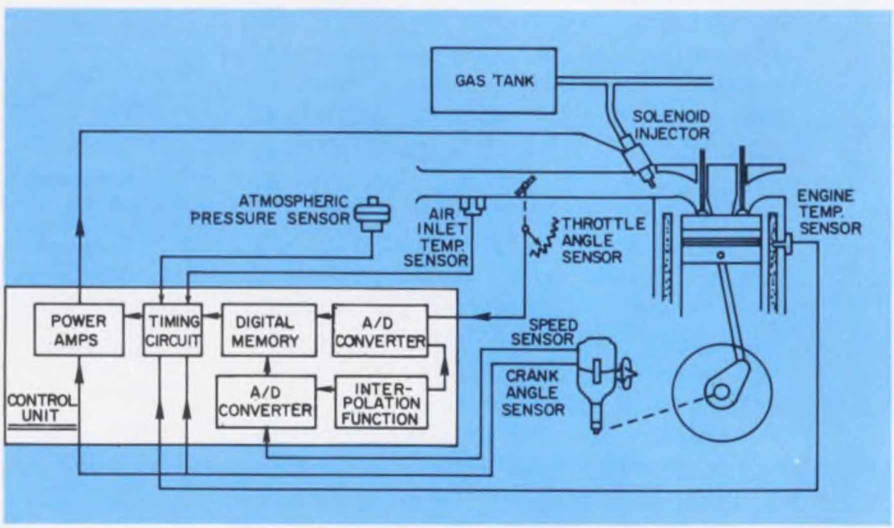
- Simple resistor and transistor circuits that derive an output from a pressure differential.
- Electrodes immersed in a fluid that fail to conduct when the fluid level falls below the probe.
- Series resistors in the supply to each bulb, with the voltage drop in the bulbs monitored by an alarm circuit.
- Heat sensors immersed in oil that get hot when the surrounding medium falls below a level and produces an impedance change.
- Simple contacts inserted below the brake pad that are exposed as the brakes wear.

Autocruise—essentially speed-sensing and correction—is accomplished by conversion of pulsed signals from a prop shaft tachometer (whose frequency is proportional to vehicle speed) to a dc signal and then comparison of this signal with a value set on a potentiometer. Settings are variable from 30 to 80 miles per hour.

Difference signals between actual and desired speed are used to modulate the current of a solenoid control valve. The solenoid current controls a mechanical system that connects the accelerator pedal to the engine manifold via an actuating bellows arrangement.

If the vehicle speed exceeds or drops below the set speed, the bellows expand or contract their link to the throttle and correct the amount of gasoline flowing to the engine. To override the systems, the driver may change gear, step on the brakes or touch a speed-selector switch.

The heart of the Lucas electronic injection system is a thick-film (oscillator) package and an output power transistor connected to a printed-wiring board. This elec-



Electronic fuel-injection system developed by Lucas Ltd., Birmingham, England, uses small digital computer as control unit to regulate air-gas mixture. Engine performance meets air pollution laws.

John N. Kessler
News Editor

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tronic assembly is housed in a little cylinder on the top of a standard distributor. The distributor points are replaced by encapsulated reed-switches, activated by a magnet attached to a high-tension rotor arm.

When the driver turns on the ignition, the power transistor energizes the ignition coil primary. As the engine is cranked, a ferrite coupling rod in the timing rotor passes across the face of the E-core of the pick-up module, and the oscillator breaks into high-frequency oscillation. This oscillating signal is rectified, amplified and used to switch off the output power transistor. Each time a ferrite rod (one for each cylinder) in the timing rotor passes across the face of the E-core, the ignition-coil primary circuit is broken. A high voltage is thus induced into the coil secondary winding, and this creates a spark at the plug.

The permanent magnet alternator designed by Lucas provides its output to the battery through a controlled rectifier bridge. The bridge consists of three diodes and three SCRs, and it is turned on by high-frequency firing pulses applied to the gates of the SCRs. These firing pulses are generated by a voltage-controlled oscillator when the battery voltage falls below a predetermined value.

The rectifier delivers full output of the alternator to the battery when the firing pulses are present. Each SCR conducts one cycle of alternator output. When the battery voltage reaches the predetermined value, the firing pulses stop. Each SCR then completes its phase of conduction and becomes inoperative. Thus the complete rectifier stops conducting after less than one cycle, and it remains inoperative until firing pulses resume.

This form of control means that the alternator's output is supplied in bursts with a duty ratio that adjusts automatically to the required average output for load balancing and battery charging. A warning light tells the driver if there is no output from the alternator. A light also goes on if excessive battery line voltage develops. All rectification and control circuits are housed in the alternator and are fan-cooled.

The price for this electronically controlled car? It cost Lucas more than $132,000 to develop. But then prototypes are always costly. There's no estimate on what the motorist might be expected to pay if these electronic systems go into mass production. ■■

Army developing 30¢ tuning capacitor

An electronically variable ceramic capacitor that has a number of advantages over conventional high-power tuning capacitors is under development at the Army Electronics Command's Electronic Component Laboratory, Fort Monmouth, N. J.

The capacitor will be used in automatic tuners in lightweight radios operating in the 30-MHz-to-70-MHz range.

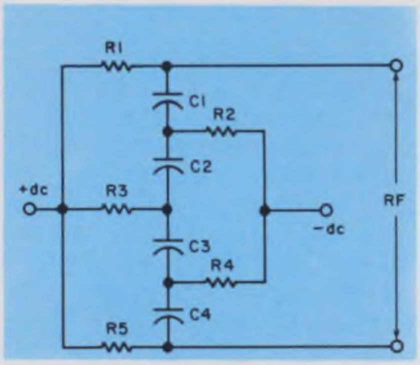
It will be a tenth the size of presently available tuning capacitors, its developers say—equivalent to three quarters stacked one on top of the other. It will retune an antenna automatically, and it will be a hundredth the cost of a conventional capacitor—about 30¢ as opposed to $30, the Army reports.

Though the work has not been completed, it was far enough along last month for the device's two developers to report their progress to a small group of research and development officials of the Army and the Dept. of Defense. The developers are Howard Wichansky, a ceramic engineer, and Francis J. Murdoch, a physicist, both employed by the Army Electronics Command.

The capacitor is a multilayer structure made from a ferro-electric material—barium strontium titanate. It has an rf electrode on each end and a dc electrode going to the inner layer.

When the dc voltage is varied, the material's dielectric constant changes. Thus, the device can be combined with a digital logic network to retune the antenna automatically if any mismatch occurs between it and the transmitter.

"Manpack antennas often need retuning," Wichansky says, "especially when a man is walking up a hill and the transmitted power is reflected back. Using a ceramic variable capacitor, the radio should retune itself automatically in a matter of milliseconds."



In an electronic tuning application a ceramic multi-layer capacitor (C_1 — C_4) is connected with the resistors used to isolate the rf and dc voltages. The dc bias control voltage is set at a high level compared with the peak rf voltage.

Murdoch says of the new capacitor:

"Some people might wonder why varactors weren't used. But to get high power with varactors, you have to use a large number of them. You have to put them in series, and when you do this, you cut down on capacitance. To get more capacitance, you then have to put the groups of series varactors in parallel, ending up with an unwieldy network.

"With a ceramic multilayer approach, you can have a whole stack of these networks in a very small package."

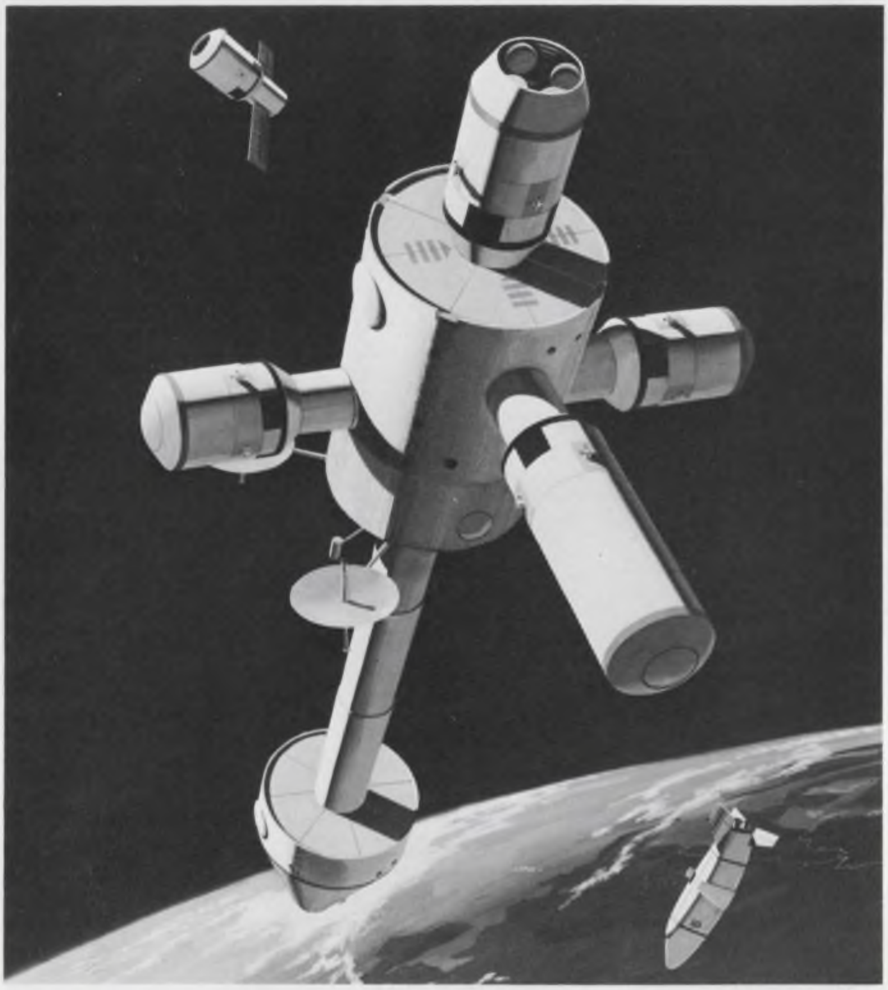
The development work is being done at the Fort Monmouth laboratory, except for the fabrication of a multilayer structure designed by the Army. The latter is being assembled by State of the Art, Inc., State College, Pa., for delivery in March.

Murdoch and Wichansky say they foresee a big future for the tuners in manpack and aircraft radios. ■■

Space-station program needs custom-made sensors

What does the space-station program need most—and before the end of the 70s? Several types of sensors, according to Dr. Carl L. Kober, program scientist at the Manned Spacecraft Operations of the Martin Marietta Corp., Denver, Colo.

"The space-station program will require a quantum step in technology—specifically in sensor performance—similar to what the Apollo program required during the 1960s," Kober says. "In general the trends are: 10 to 1000 times improvement in resolution, time response, accuracy, digital output, and, most important, a greatly increased lifetime of several years."



This 12-man space station proposed by the McDonnell Douglas Astronautics Co., Newport Beach, Calif., has experiment modules attached to its sides. These modules, as well as the free-flying experiment modules, will contain most of the sensors that need to be developed before the end of the decade.

Observing the universe

Most important among the astronomical sensors are electronic imaging systems, high-energy radiation detectors and X-ray jitter removal systems.

Imagers must be developed for use in the ultraviolet and X-ray regions that are as good or better in resolution than photographic film is in the optical region. Photocathode imaging systems that have high quantum efficiency (>10%), large area (>10-cm diameter) and wide spectral range (3000-12,000 Å) are needed. They should also have high resolution (<5 cm at 50% modulation transfer) and wide dynamic range (essentially linear over intensity ratios of 10^2). Photocathode imaging is accomplished by exposing a photocathode plate to the ultraviolet or X-ray source. The photocathode plate (detector) emits photons of visible light in the pattern of the non-visible image. These photons are collected on a screen yielding a visible image.

Development of X-ray and gamma-ray detectors is necessary to enable the energy spectra and precise location of the sources to be accurately determined. Also needed are large-area and volume-cooled solid-state detectors for use in spectrometers.

Telescopic sensors include devices for calibration of the telescope itself, as well as detectors, filters and other accessory equipment. Most important of the telescope sensor needs is a method for calibrating the mirror on the telescope in orbit.

Shape control on the mirror surface must be held to within 1/50th of a wavelength. During launch and while in orbit, distortions of the mirror can take place,

David N. Kaye
West Coast Editor

and these must be corrected. A system has been proposed that includes a laser interferometer and a batch of controllers that can introduce precise distortions to counteract unwanted changes in the shape of the mirror.

In order to get precise spectral distribution information about received emissions, it is necessary to develop low-noise increased-sensitivity detectors, preamplifiers and filters. Bolometric and photo-conductive detectors must be developed for the infrared region. And each detector must have a corresponding preamplifier to match particular voltage and impedance characteristics and to avoid capacitive losses while operating in the same environment as the detector.

General development of a parametric amplifier with a cooled (4.2°K) input stage is recommended. Infrared filters across a range of from 20 to 500μ with narrow bandwidths ($\Delta\lambda/\lambda \sim 1/10$) are needed in order to break the spectrum into well defined regions.

Bioanalytical studies made

Most important among the biological and physiological sensors that must be developed are those for mass determination and bioanalytical instrumentation.

For physiological studies on animals and plants it is important that mass should be determined to an accuracy of ± 0.1 mg. A device has been developed for use on the Skylab that will determine mass at zero-g to an accuracy of several grams. This is not nearly good enough for the proposed space-station experiments.

Although a great deal of bioanalytical instrumentation exists on the earth, several of these instruments must be adapted to work in a zero-g environment. In addition, the equipment must be reduced from normal laboratory size, and it must be made computer-compatible.

Measuring the earth

Advances required in earth-resources sensors include precision altimetry, broadband ultraviolet to infrared detection, and broadband microwave radiometry.

Dynamic mapping of the surface of the earth requires an X-band precision altimeter with a ±10-cm altitude accuracy from orbit. Present equipment is more like ±10 meters.

Earth-resources detection requires scanning over several important regions of the frequency spectrum. Among the most important is the region that goes from the infrared through the optical and into the ultraviolet. At present several discrete sensors are necessary to scan that region. A large-aperture, broadband, tunable detector is needed so that the job can be done with a single compact instrument. Another important frequency range is the microwave range from 1 to 30 GHz. A single tunable radiometer that would cover the whole range could replace several discrete radiometers needed to do the job.

Understand the ionosphere

Vlf studies must be made to better understand the ionosphere. Most significant of the advances in space-physics sensors is the need for a vlf antenna that would be stable in the space station's thermal and acceleration environment. If vlf crossed dipole antennas were used for wave-particle interaction experiments they would have to be perhaps as long as 45,000 feet from tip to tip. An antenna that long could never be kept sufficiently straight to make accurate measurements. A simple old-fashioned crossed-loop (magnetic-coil) antenna might do the job better. Studies are necessary to come up with the optimum antenna configuration.

Stop the yaw

Present techniques provide knowledge of yaw attitude to an accuracy of approximately ±2°. But for synthetic aperture radar and photographic experiments, without smear problems, vehicle yaw attitude will have to be controlled to an accuracy of 0.1° to 0.01°. Doppler radar with extremely accurate, narrow-band filtering may give the solution to this problem. This is the most significant of the pointing and control sensor problems that the space station faces. ■■

Ultrasonics takes the needle out of sewing

A new ultrasonic machine "sews" without either needle or thread, using a new technique that welds together synthetic materials with ultrasonic (high-frequency) vibrations. And it makes good strong seams, straight or zig-zag, as required.

But don't throw your needles away—yet. The new machine, developed by Branson Sonic Power Co. of Danbury, Conn., is still too high-priced, because of development costs, for home use. Its initial application will probably be in the apparel, drapery, upholstery, bagging and packaging and related industrial fields.

The machine's ultrasonic vibrations generate localized heat by causing one piece of material to vibrate against the other, creating a molecular change that joins—or "sews"—the pieces together. The machine can operate at rates up to 50 feet per minute, in a variety of patterns. ■■

Needle and thread are eliminated by welding together synthetic materials with high-frequency vibrations. The new "sewing" machine is made by Branson Sonic Power Co., Danbury, Conn.

technology abroad

An experimental satellite receiving station is to be constructed by AEG-Telefunken, the German electrical giant at Leeheim (Hesse). It will be used in conjunction with an Italian synchronous satellite slated to be launched in 1972, as a means of studying ways of using the 10-to-20-GHz band for telecommunications purposes. The present Intelsat network operates on the 4 and 6-GHz bands. The 3.5-million Deutschmark contract will be funded by the German Ministry of Posts and Telecommunications.

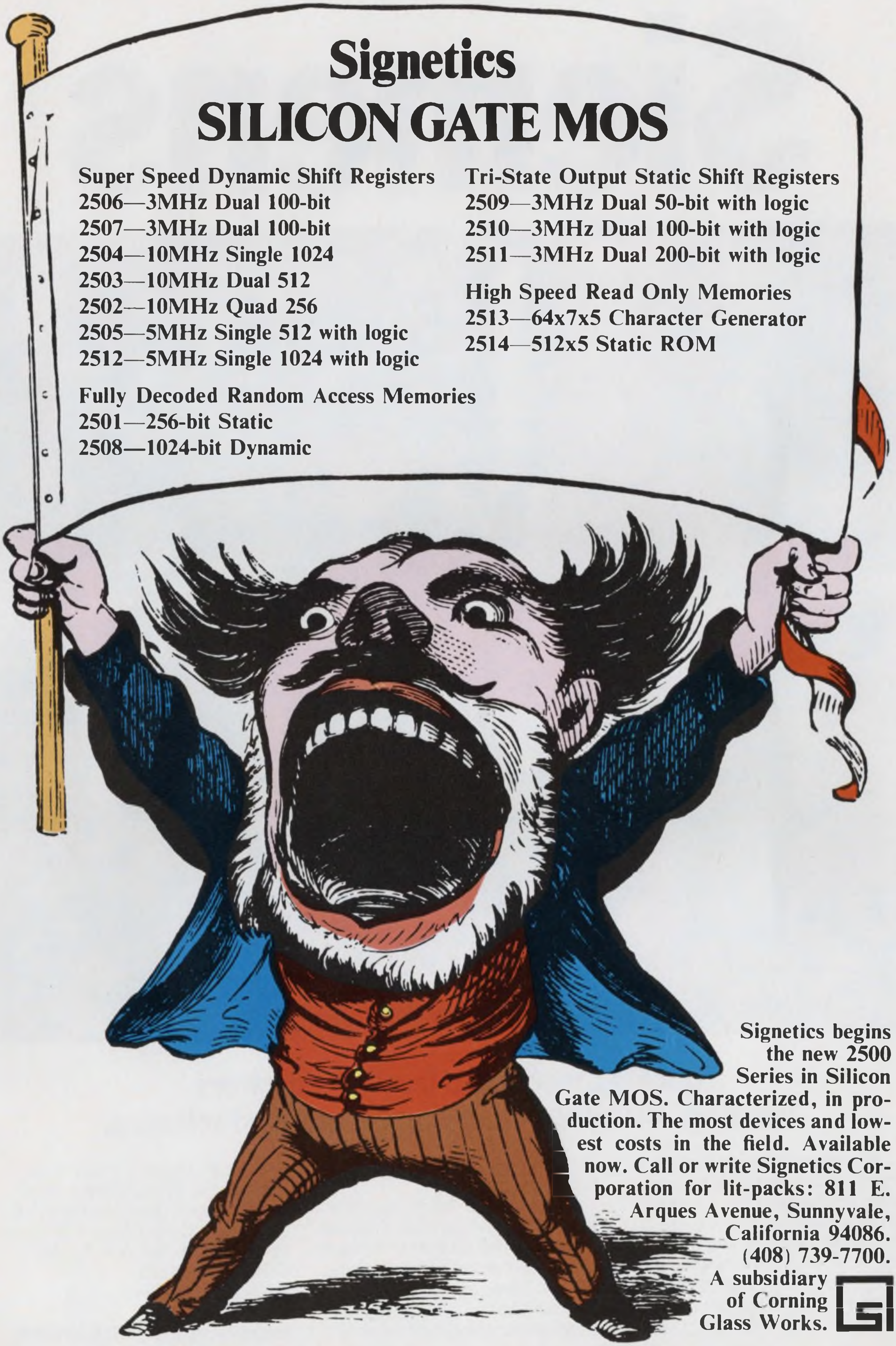
IC masks to a 0.5-micron line width have been fabricated by engineers at Cambridge (England) Scientific Instruments by coupling their Stereoscan microscope to a flying-spot scanner. This is reported to be four to five times better than can be obtained by conventional optical masking methods. Cambridge engineers first coat the mask with a special electron resist. Then the microscope's main electron beam raster scans across the mask material, painting in circuit details. After exposure, the mask is etched by conventional chemical techniques.

A much-needed portable unsoldering tool could soon be used in computer maintenance and service. The tool was developed by the Cheltenham (England)-based Marconi research laboratories. Previously, unsoldering equipment was not portable since an air line was generally required to remove newly melted solder. In the new unit a metal piston drives electrically-heated molten solder. A vertical hole through the piston is fitted with one of a number of nozzles, shaped to accommodate different packages. The component to be removed is held in a spring-loaded remover. Thus, when the piston is depressed, molten solder wells up through the holes and contacts the underside of the board. This melts the joint and permits removal of the component.

The job of producing a commercially viable vidicon with a solid-state target has been assigned to the research laboratories of semiconductor manufacturer Sescosem of Corbeville, France. So far they've produced a device with a solid-state target composed of 750,000 photodiodes. The target diameter is 2.1 mm; useful target area is 1.4 cm^2. Sescosem says the tube has an extremely wide spectral response.

A new dielectric material has been developed by scientists at Mullard's Central Materials Laboratories at Mitcham, London. The material is a doped form of titanium dioxide that can be deposited on silcon chips to provide integrated circuits with a built-in high capacitance. The materal has a wide range of properties, depending on subsequent treatment. One process produces a semiconductor material with a relative dielectric constant, ϵ_r of about one million. Another has an ϵ_r of only 100 but with much lower losses and much greater stability than comparable materials.

Failure of the European Launcher Development Organization (ELDO) satellite to be placed in orbit last June has been traced to a prematurely loosened connector. As a result, the launch-vehicle heat shield failed to detach itself and the payload was more than doubled. This meant that the satellite was unable to attain the 7893 ms injection velocity. Main objectives of the launch are considered to have been met, however, and plans are going ahead for orbiting a 125-kg geostationary satellite with the Europa I launcher.



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washington report

DON BYRNE, WASHINGTON BUREAU

Commerce Dept. offers to help companies push exports

Electronics firms with 500 or less employees that want to explore the possibilities of overseas sales may be helped by a new Commerce Dept. plan aimed at helping small U. S. businesses penetrate foreign markets. The Bureau of International Commerce of the Commerce Dept. has launched a plan called the MBA (Master's of Business Administration) Export Expansion Program, which will seek applications from companies interested in overseas sales. A graduate student from one of 21 universities across the country will be assigned to the company to examine its capacity to begin export operations or to expand them. After sizing up the company, the student will examine international business data compiled by the Commerce Dept. and relating to the company's products and then draw up a set of recommendations for action. Data on users, competition, market size, expected gross profit margins and how to enter the market will be studied, and the names of customers, agents, distributors and needed licenses will be supplied. Any company interested should get in touch with a Commerce Dept. field office or with the Bureau of International Commerce in Washington.

Conference on DOD Lockheed proposal coming up

Deputy Defense Secretary David Packard is expected to meet with House and Senate Armed Services Committees within the next two weeks to iron out kinks in a DOD proposal to help Lockheed head off bankruptcy. DOD has not spelled out a final figure needed in addition to existing contracts with Lockheed, but House sources indicated it would be in excess of $1-billion. A bitter fight is expected when the issue comes to the floor with this year's appropriation bills.

New trade-bill battle looms in Congress

Key figures in the Senate and House expect another round of hearings on import quotas in this session of Congress. Sen. Russell Long, chairman of Senate Finance Committee, and Rep. Wilbur Mills, chairman of the House Ways and Means Committee, both say they want early hearings to see what changes should be made in legislation that passed the House but died in the Senate in the last Congress. As expected, foes of the restrictive measure added so many amendments in the Senate that the bill became unacceptable to just about everyone. As it left the House, it contained import quotas for shoes and textiles but left the door open for protective measures to be extended to virtually any other industry—including, of course, electronics.

Hughes and GT&E enter domestic satellite race

Hughes Aircraft and General Telephone and Electronics, filing separate applications for a joint system, have entered the competition for a domestic communications satellite system. Western Union and AT&T, with Comsat, have already filed, and Microwave Communications, Inc., is expected to file before the March 1 cutoff date set by the FCC. Hughes, the major shareholder in Teleprompter, the nation's largest cable television entity, said it planned to use the system for a nationwide CATV network and to lease eight of the 12 channels on one satellite to GT&E for long-distance telephone service. Hughes proposes to build two send-and-receive earth stations and at least 100 receive-only stations for its CATV net at a cost of between $50-million and $80-million. GT&E would build four earth stations at a gross investment of $27-million. The two satellites, which would be built by Hughes, would weigh 1120 pounds and would be placed in synchronous orbit over the equator by Thor-Delta vehicles. Each would have 12 microwave radio channels and could transmit a wide variety of signals.

The eight channels to be leased by GT&E would have 10,560 voice grade circuits or eight TV circuits. The two Hughes transmitting antennas would be placed near New York and Los Angeles and employ 98-foot tracking antennas. The receive-only sites would be equipped with a 35-foot nontracking antenna. The four GT&E earth stations would be located in California, Florida, Indiana and Pennsylvania.

Little change expected in House Armed Services Committee

Rep. F. Edward Hebert (D-LA.), the new chairman of the House Armed Services Committee, is expected to follow pretty closely in the footsteps of his predecessor, the late Rep. L. Mendel Rivers. Hebert, who has been in Congress since 1940, is described as a tough but fair chairman who made his reputation on the committee by hard-hitting investigations. A former newsman, the 69-year-old Hebert is expected to take a harder look at military budgets than Rivers did. He is regarded as a friend of the military but has led tough investigations into military waste, sole-source procurement and the practice of retired officers finding high salaried jobs in the defense industry. He is expected to be a little more conservative in seeking military funding than Rivers, who was wont sometimes to introduce money bills knowing they would not pass. Hebert, like Rivers, is a strong advocate of modernizing the Navy with a massive shipbuilding program and increased R&D funds over the next decade.

Capital Capsules:

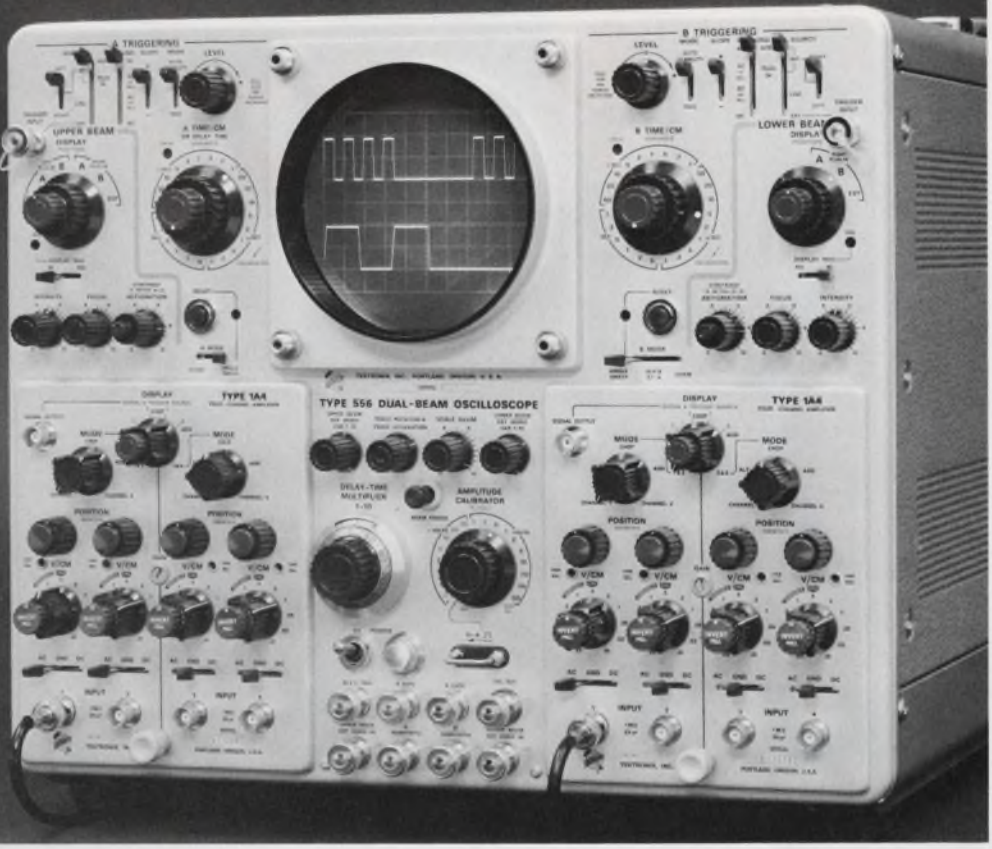
About 145 scientists from around the world are meeting at **NASA's Houston Center to report findings from the analysis of lunar samples and to consider data from scientific experiment packages left on the moon.** NASA has dubbed the meeting a "rock festival." . . . The House Committee on Foreign Affairs has issued **a report that says excellence in technology may be establishing a new set of standards that will determine a nation's worldwide leadership.** The new standards, says the report, may eclipse military power. The report also cites the effect of technology on U. S. foreign policy and diplomacy. Copies can be obtained from the committee at Room 2170, Rayburn Office Building, Washington, D. C. 20515. . . . **NASA has named George W. Cherry to head its Aeronautical Operating System Div.** in the Office of Advanced Research and Technology. He will direct R&D programs in navigation, aircraft control and the impact of aircraft on the environment. He was formerly with the Charles Stark Draper Laboratory of the Massachusetts Institute of Technology. . . . The Commerce Dept.'s National Bureau of Standards reports that **failure by the U. S. to go along with developing metric system product standards could deal a crippling blow to U. S. overseas trade.** An interim report of the U. S. metric study, run by the bureau, notes that European countries are moving toward an international system of Engineering standards for a variety of products, including electronics, and that failure to meet these standards could bar U. S. products from those countries.

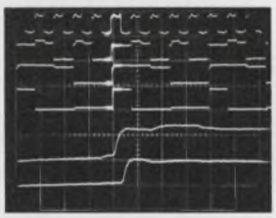
50-MHz dual-beam oscilloscope

556

delayed sweep

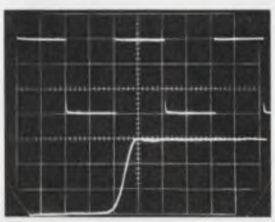
7-ns risetime





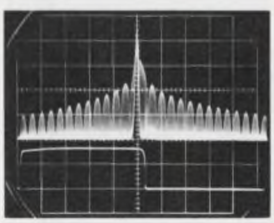
Multi-Trace

The six waveforms are time related digital pulses. The upper four displays are A Sweep (2 μs/cm) with the Type 1A4 Four-Channel Plug-In. The lower two displays are B Sweep Delayed (100 ns/cm) with the Type 1A2 Dual-Trace Plug-In.



Sampling and Real-Time

The upper beam shows a square wave at 2 μs/cm as applied to a Type 1A2 Dual-Trace Plug-In. The lower beam shows the risetime of the same pulse with the Type 1S1 Sampling Plug-In at 1 ns/cm.



Frequency and Time

The upper beam shows the spectral output of a 200 MHz gated oscillator applied to the Type 1L20 Spectrum Analyzer; calibrated dispersion is 1 MHz/cm. The lower beam shows a real-time display of the 2.5 μs gating pulse.

The Tektronix 556 Dual-Beam Oscilloscope features 50-MHz bandwidth, calibrated sweep delay, 6 x 10 cm scan per beam and dual plug-in flexibility. Using two plug-ins at a time, the 556 offers many display combinations, including: **dual-beam single-shot;** multiple-trace; sampling and real-time; frequency and time; delaying and delayed sweep.

The two independent horizontal deflection systems provide full bandwidth triggering and calibrated sweep speeds from 5 s/cm to 100 ns/cm, extending to 10 ns/cm with the X10 magnifier. The calibrated sweep delay range is from 100 ns to 50 seconds.

The CRT shows two simultaneous single-shot pulse sequences displayed at two different sweep speeds, a measurement that is possible only with a truly dual-beam oscilloscope. The two 1A4 Four-Channel Plug-Ins provide eight channels, each with 7-ns risetime and DC to 50 MHz bandwidth. You can also select from differential plug-ins with bandwidths to 50 MHz, TDR and sampling plug-ins with 90-ps risetime, and spectrum analyzer plug-ins that cover the spectrum from 50 Hz to 40 GHz. The 556 is also available in a rackmount model.

For a demonstration, contact your nearby Tektronix field engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.

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editorial

Do we want free trade – or fair play?

In our editorial of December 20, 1970, we stated that we are against the provisions of the recent import quota bill. We're against blind protectionism, because it invites retaliation and stifles trade for everyone. But we are also concerned about blind adherence to free-trade policies toward countries that don't reciprocate. We don't interpret free trade as a free ride for foreign companies in our markets.

Electronics companies throughout the U. S. are complaining about foreign restrictions on their exports to other countries, preferential treatment, through tariffs and quotas, of one country for the products of another, foreign import licensing procedures that slow or stop U. S. exports to the countries involved and pitifully low declared values on foreign imports to the U. S. None of these are in the spirit of free trade.

The Japanese, for instance, are accused of restricting or refusing our exports to Japan. Japanese companies that want to buy our goods must often obtain specific permission from their Ministry of International Trade and Industry. If the permission isn't denied outright, it can take months to get.

And executives at Wang Laboratories, Inc. complain of extremely low declared value on Japanese calculators imported to the U. S. Edward Lesnick, Director of Product Planning, says that the Japanese products are typically declared at 20% of their U. S. market value, rather than the customary 60%.

The Japanese pay only 7% tariff on this 20% declared value. Lesnick says that what annoys his Tewksbury, Mass., company most is that identical imports to Japan must be declared at full market value, and the Japanese tariff is 15%. Is our policy of free trade, he asks, being interpreted as "something for nothing?"

The U. S. electronics manufacturers interviewed by ELECTRONIC DESIGN don't want protection, they want fair play. They aren't afraid of foreign competition, and they want free trade, but not at the expense of our own industry. They want countries that take advantage of our free trade policies and our low tariffs to recriprocate with like policies of their own.

Our government is willing to listen to our industry's problems, and to act on our behalf. If you are aware of unfair trade practices involving electronic imports or exports, write Mr. Harold B. Scott, Director of the Bureau of International Commerce, U. S. Dept. of Commerce, Washington, D. C., 20230, (202) 967-5261.

RAYMOND D. SPEER

Microstrip can reduce multiplier size

but it can also enlarge the design problem. Understanding the circuit functions is the key to success.

First of two articles

Typically, a solid-state microwave source consists of two basic elements: a transistor oscillator and a varactor multiplier. The design of the oscillator is fairly straightforward,[1] but the multiplier presents some serious challenges. Its design requires nonlinear analysis, and the results are valid only under specific conditions.

When microstrip is used to reduce the size of the multiplier, the problems are compounded. It is difficult to predict the detailed behavior of microstrip circuits because the non-TEM waves that propagate on microstrip lines are not easy to describe analytically.

How can the designer overcome these problems and come up with a good, compact microstrip multiplier? The key is to understand clearly the functions of the multiplier circuitry external to the varactor diode itself. The functions are threefold:

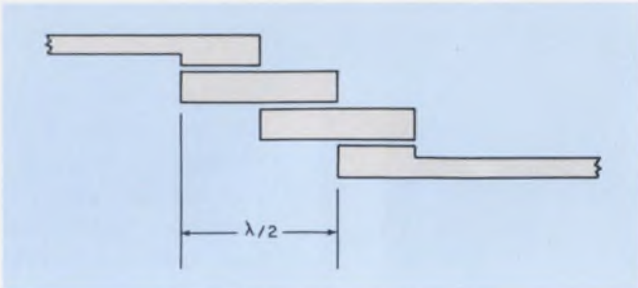
- Separating the input and output frequencies.
- Matching the input and output impedances.
- Biasing the diode.

Although these functions are interrelated, it is helpful to keep them conceptually separated to avoid losing sight of the ultimate purpose of the circuitry.

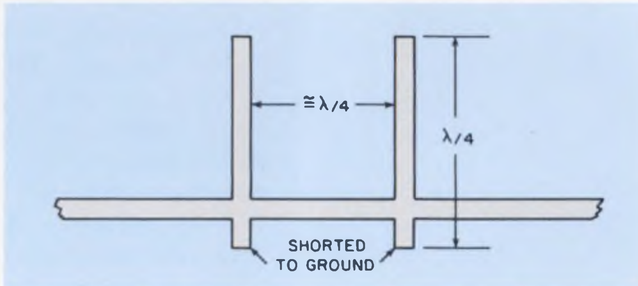
Frequency separation: Pick a filter

Bandpass filtering is usually the most effective method of frequency separation for multipliers. Ideally, the output filter (as seen by the diode) should pass the output frequency with low loss while presenting an open circuit to the fundamental and the unwanted harmonics. Similarly, the input filter should pass the fundamental and block all of the harmonics.

The complexity of the filters will be determined by the design requirements. Thus, for example, a multiplier with a requirement for a wide instantaneous bandwidth and a low level of spurious outputs will need filters with a large number of poles to reject adjacent harmonics.



1. **This filter looks like an open circuit** at all frequencies below its passband—a property that makes it a popular design despite its several drawbacks.



2. **Compactness is this filter's strong point,** but it suffers from poor selectivity at low frequencies and fabrication problems at the high end of the frequency band.

A popular filter for microstrip multipliers is made from an array of closely spaced half-wave resonators (Fig. 1). The great attraction of this type of filter is that it acts as a high capacitive reactance at all frequencies below its passband. Its disadvantages are threefold: Its use of half-wave instead of quarter-wave resonators increases its size over competitive types; it has a very narrow gap between its resonators, requiring great care in its fabrication; and its operation is such that the calculation of its even-mode and odd-mode impedances is difficult.

A more compact type of filter is made of a string of direct-coupled quarter-wave resonators (Fig. 2). Calculating the resonant frequency and loaded Q of this type is easy, but the filter suffers from poor selectivity at the low microwave frequencies and from very tight spacing between

Bob Weirather, Microwave Engineer, Motorola, Government Electronics Div., 8201 E. McDowell Rd., Scottsdale, Ariz. 85252.

A solid-state perspective

Where does the varactor-diode frequency multiplier fit in this day of Gunn, Impatt and LSA devices? The newer types of diodes have some definite advantages over oscillator-multiplier combinations in certain applications. But often, particularly at the lower microwave frequencies, the older approach comes out ahead.

For example, some direct-conversion devices require high power-supply voltages (90 V), have only pulse capabilities at low duty cycles, have poor efficiencies (2% to 5%), have narrow bandwidths and are quite noisy.

By contrast, the transistor-oscillator/varactor-multiplier combination needs only low voltages, can operate either continuous wave or pulsed, has higher efficiency (10% to 20%) and has wideband capabilities. Furthermore, its size disadvantage is not as great as one might at first imagine. This is because high-dielectric-constant substrate materials can shrink the size of the oscillator-multiplier considerably, while the cavity or other resonant structure used with a direct-conversion device makes it a lot bigger than just a semiconductor chip.

The noise properties of the oscillator-multiplier may well be its strongest advantage. The multiplier adds no noise of its own to that of the oscillator. A well designed crystal-controlled transistor oscillator can be combined with a multiplier to provide very clean signals at very high frequencies.

Even in cases where the direct-conversion devices are clearly superior to the oscillator-multiplier for a variety of other reasons, noise considerations may make it necessary to combine the two approaches. One rather successful combination has been made by using a low-power crystal-controlled oscillator-multiplier source to injection-lock a high-power but noisy silicon Impatt oscillator.

the transmission line and the shorts at higher frequencies.

Another method of frequency separation is the use of a resonant-line filter. This approach, which will be described in detail in the second part of this article, uses a quarter-wave resonator spaced a quarter-wave from the diode. The resonant-line filter is a narrowband device, but it is quite satisfactory for many designs.

Simplicity is its major advantage while lack of suppression of out-of-band harmonics is its major disadvantage. This can be overcome, in a doubler, by adding additional stubs to the line to reject the third and higher harmonics.

In considering the bandwidth of the filters used in a frequency multiplier, one should not lose sight of the fundamental limitation on the bandwidth of any multiplier, even one using ideal (square-response) filters on the input and output. The theoretical maximum bandwidth, as a percentage of the center frequency, is $(100/n)\%$ where n is the multiplication number. But in practice a good rule of thumb for maximum percentage bandwidth is $(100/2n)\%$.

Impedance matching: First define it

The first problem in impedance matching to a diode is to decide what is meant by the diode's "impedance." Strictly speaking, impedance is defined only for linear circuits being driven by a single frequency in the sinusoidal steady state. The term, however, is used—and misused—in a much wider sense. In this article, we will define a diode's input or output impedance as that impedance which maximizes the multiplier efficiency under specified conditions of drive and bias.

Since the diode impedance levels, as defined above, will not necessarily correspond to the desired levels (usually 50 ohms), some matching techniques will have to be employed. And a good way to accomplish this matching is to include it in the design of the input and output filters.

Since filters of more than one section have an axis of symmetry, two separate filters with identical responses and different impedance levels can be designed and joined to form a composite filter. One filter would be designed to operate with the specified multiplier load, say 50 ohms, and the other filter would be designed to operate with terminations equal to the diode impedance. These two filters can be divided and then rejoined at their axis of symmetry and equal internal impedance, and still retain the original bandpass characteristic.

An alternate approach to impedance matching is to add lumped elements—or their microstrip equivalents—to the diode to transform its impedance to the required level. The first approach has the important advantage of compactness. Matching is done by the filter and, therefore, adds nothing to the size of the multiplier.

Biasing: How it's applied is important

There are two ways to obtain the required dc bias across the diode: it can be supplied by an external dc source, or it can be internally generated by slightly overdriving the varactor and using the rectified forward current to develop a self-bias voltage across a parallel resistance.

Of more importance than the type of bias to be used is the method of applying it to the diode. Often, this aspect of multiplier design is treated too casually, with the result that the bias circuit interacts in unforeseen ways with the other circuits or causes breakup of the output signal by acting as a low-frequency idler. (An idler is a circuit that maximizes current flow in the diode at a particular frequency. Since the idler can modulate the output, it robs it of power and can break up the output signal.)

Two things can be done to minimize these problems: First, the bias can be applied through either the input or output filter, rather than across the diode terminals. Second, the bias can be applied through a resistance.

Keeping a filter between the diode and the bias source minimizes the chance that an idler frequency can exist. It should be recalled in this connection, however, that some types of filters are better than others at rejecting signals far removed from the passband.

Using resistive coupling simply ensures that any idler circuit that does exist will have a very low Q and so will not pose much threat of breakup, although it may cause some loss of output power and efficiency. ■■

(references continued on pg. 50)

The how and why

A microstrip transmission line (see illustration) is a structure consisting of a strip transmission line separated from a ground plane by a dielectric material.[3] The development of good dielectric materials with high dielectric constants and uniform characteristics has made possible the construction of compact microwave integrated circuits (MICs).

Microstrip MICs have three big advantages over other transmission structures:

- Excellent repeatability in manufacture because photolithographic batch processing can be used.
- Easy access to circuitry because all the circuitry is on one side of a dielectric substrate.
- Small circuit size because materials with high dielectric constants can be used as the substrate.

The two most common substrate materials in use today are alumina (Al_2O_3) and sapphire (the same material but in crystal form).

To design a circuit in microstrip (or in any other transmission structure, for that matter) three primary parameters should be determined: the characteristic impedance, Z_0; the guide wavelength, λ_g; and the attenuation per unit length, α.

Two of these parameters, Z_0 and λ_g, have been theoretically computed and experimentally checked. Sobol[4] has fitted curves to Wheeler's analysis[5], and the results compare well with the experimental data. These design equations are summarized below. Other equations in the tabulation are for the calculation of losses and unloaded Q.

$$Z_0 = \frac{377h}{\sqrt{\epsilon_r}\, W \left[1 + 1.735\, \epsilon_r^{-0.0724}\, (W/h)^{-0.836}\right]} \text{ (ohms)}$$

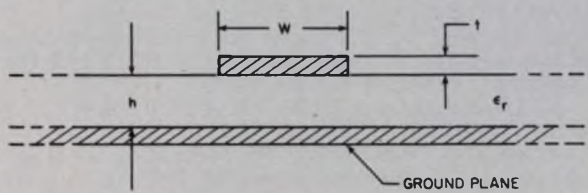
$$\lambda_g/\lambda_0 = \begin{cases} \left[\dfrac{1}{1 + 0.63\,(\epsilon_r - 1)\,(W/h)^{0.1255}}\right]^{1/2} & \text{for } W/h \geqq 0.6 \\ \left[\dfrac{1}{1 + 0.6\,(\epsilon_r - 1)\,(W/h)^{0.0297}}\right]^{1/2} & \text{for } W/h \leqq 0.6 \end{cases}$$

$$\alpha_c = \frac{1}{2Z_0 W}\,(R_{s1} + R_{s2}) \text{ (nepers/meter)}$$

$$\alpha_d = \frac{\pi}{\lambda_g}\,\frac{\epsilon''}{\epsilon'} \text{ (nepers/meter)} \qquad Q_c = \frac{\pi f}{V_g\,\alpha_c}$$

$$Q_d = \frac{1}{\tan\delta} \qquad \frac{1}{Q_t} = \frac{1}{Q_d} + \frac{1}{Q_c}$$

of microstrip microwave circuits

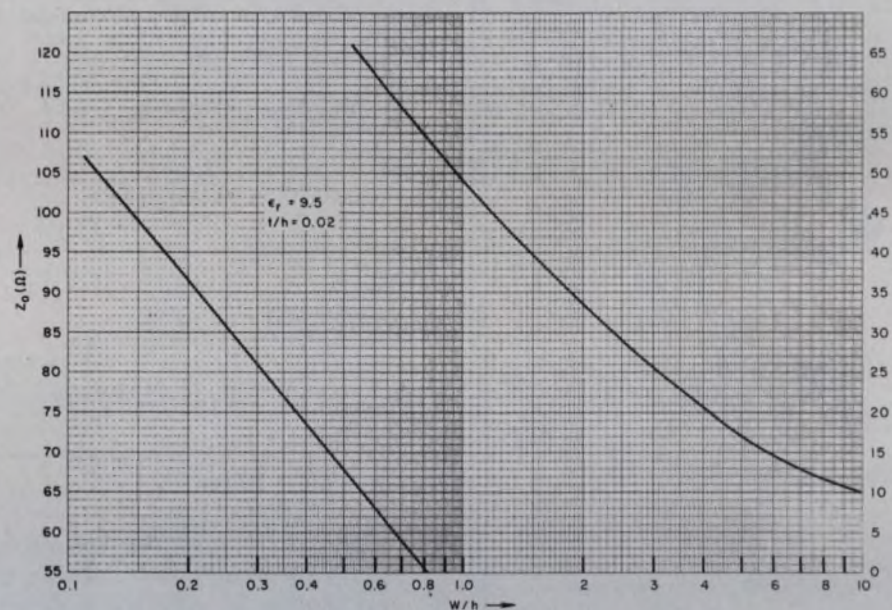


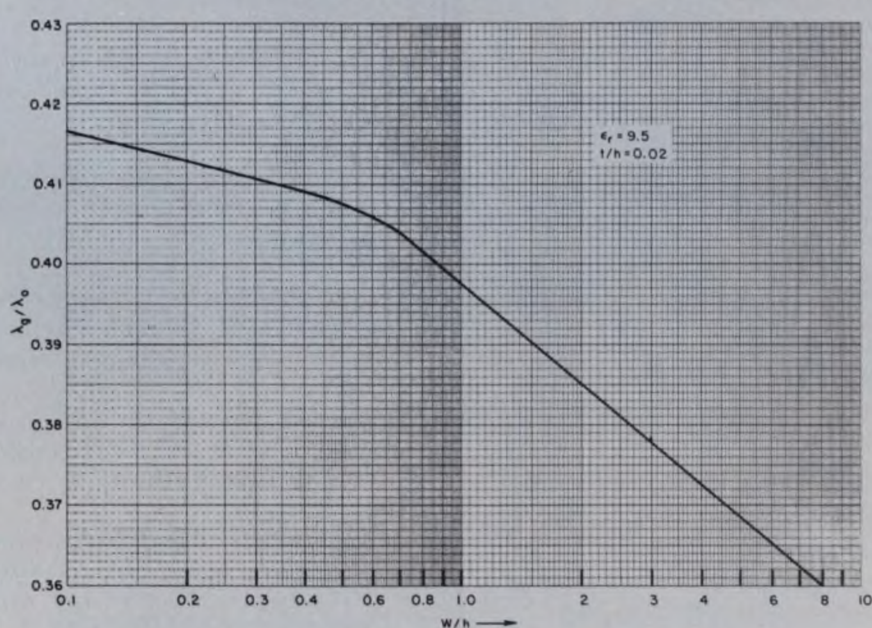
In the equations, the quantity ϵ_r is the relative dielectric constant of the substrate material (permittivity of the material divided by the permittivity of free space) and is dimensionless. The quantity λ_g/λ_o is the ratio of the wavelength in microstrip to the wavelength of a signal of the same frequency, propagating through a vacuum. The dimensions W and h are explained in the illustration.

The quantities α_c and α_d are the attenuation factors of the conductors and the dielectric substrate, respectively. R_{s1} is the sheet resistivity (in ohms per square) of the top circuit metallization and R_{s2} is the sheet resistivity of the ground-plane metallization. The quantites ϵ' and ϵ'' are the real and imaginary parts of the permittivity of the dielectric material ($\epsilon = \epsilon' + j\epsilon''$).

Q_c and Q_d are the Qs of the conductors and dielectric, respectively. V_g is the velocity of propagation in the microstrip line ($V_g = f\lambda_g$). Tan δ is the loss tangent of the dielectric. And, Q_t is the total Q of the circuit.

Plots of Z_o and λ_g/λ_o are shown below for the frequently used substrate material, alumina, with $\epsilon_r = 9.5$.





References

1. Klein, Carl F., "Designing with microstrip is easy," *Electronic Design*, Jan. 4, 1970, pp. 100-104.
2. Westman, H. P., editor, *Reference Data for Radio Engineers*, fourth edition, International Telephone and Telegraph Corp., New York, 1956.
3. Assodourian and Rimai, "Simplified Theory of Microstrip Transmission Systems," *Proc. IRE*, December, 1962.
4. Sobol, H., "Extending IC Technology to Microwave Equipment," *Electronics*, March 20, 1967, pp. 112-124.
5. Wheeler, "Transmission Line Properties of Parallel Strips Separated by Dielectric Sheet," *IEEE Trans. Microwave Theory Tech.*, March, 1965, pp. 172-185.

Bibliography

Burckhardt, C. B., "Analysis of Varactor Frequency Multipliers for Arbitrary Capacitance Variation and Drive Level," *Bell System Technical Journal*, April, 1965, pp. 675-692.

Matthaei, Young and Jones, *Microwave Filters, Impedance Matching Networks, and Coupling Structures*, McGraw-Hill Book Co., New York, N. Y.

Penfield and Rafuse, *Varactor Application*, MIT Press, Cambridge, Mass., 1962.

Ragan, George L., editor, *Microwave Transmission Circuits*, Radiation Laboratory Series, McGraw-Hill Book Co., New York, 1948.

Richardi, "The Insertion Loss of Transmission Line Used in Matching Networks," *IEEE Trans. Microwave Theory Tech.*, March, 1968.

Schaffner, G., *Motorola Application Notes AN-147, AN-151, AN-159 and AN-213*, Motorola, Semiconductor Products Div., Phoenix, Ariz.

Storer and King, "Radiation Resistance of a Two Wire Line," *Proc. IRE*, November, 1951, pp. 1408-1412.

Weirather, R., "Microwave Integrated Circuit Medium Powered Varactor Multipliers," June, 1969, *MS Thesis*, Arizona State University.

Wells, R., "Microwave Band Pass Filter Design," *Microwave Journal*, November and December, 1962.

Wu, T. T., "Theory of Microstrip," *Journal of Applied Physics*, Vol. 23, No. 3, March, 1957, pp. 299-302.

Test Your Retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. What are the three major functions of the external circuitry in a varactor multiplier?

2. How can a symmetrical filter be modified to perform impedance matching, as well as filtering?

3. Why is it important to apply the dc bias voltage through the input or output, rather than to apply it directly across the diode?

4. What is the maximum theoretical percentage bandwidth of a $\times n$ multiplier?

5. Why is the parallel-coupled half-wave resonator filter (Fig. 1) often preferred in MIC designs despite the difficulties in its analysis and fabrication?

microtopics

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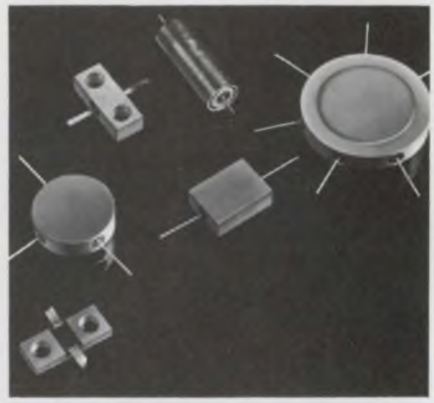

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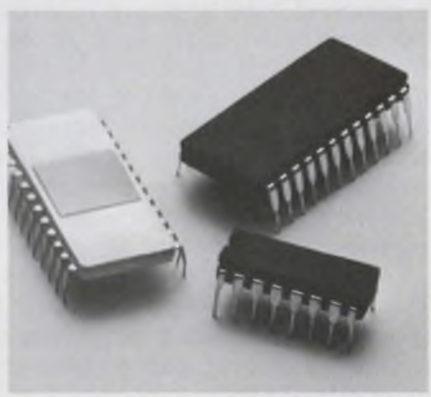

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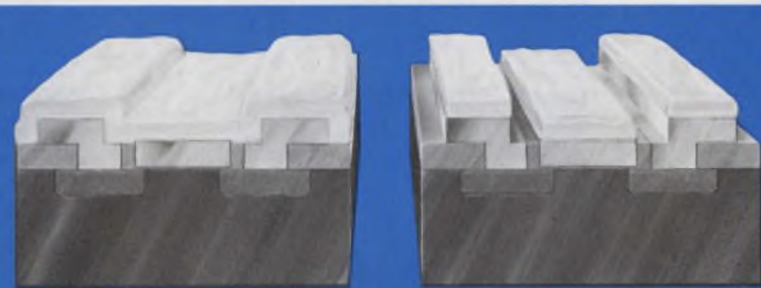

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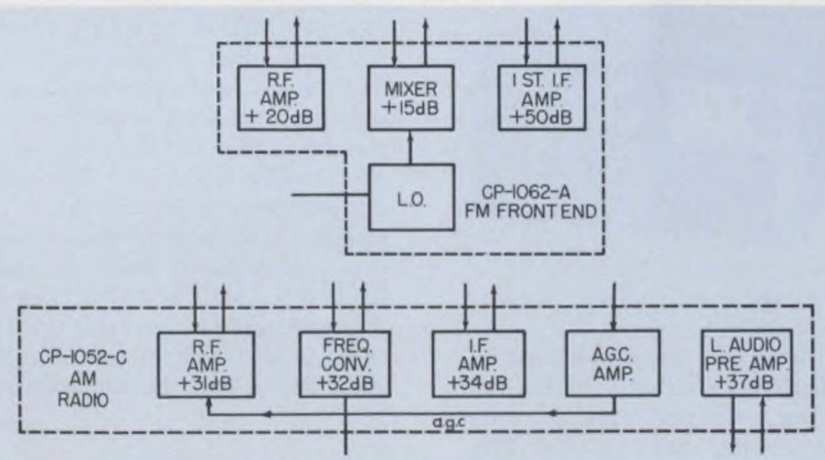
Linear MSI...the new approach to AM, FM and stereo receiver design.

All active semiconductor circuitry for a complete AM-FM stereo receiver is contained on six MSI linear IC chips. Of special interest are the AM and FM front-end chips.

The AM chip contains the RF amplifier, frequency converter, IF amplifier and automatic gain control amplifier stages. Add an audio amplifier, and you have a complete AM radio.



The FM chip is particularly significant, because it combines high frequency, high performance front end characteristics with the complexity of linear MSI circuitry. It contains the RF amplifier, mixer, first IF amplifier and local oscillator.

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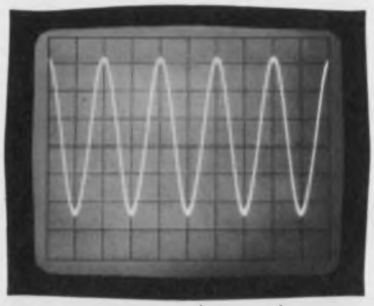
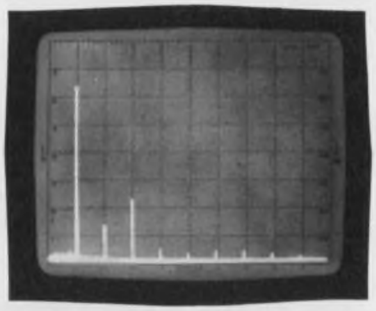
INFORMATION RETRIEVAL NUMBER 165

If you only see this

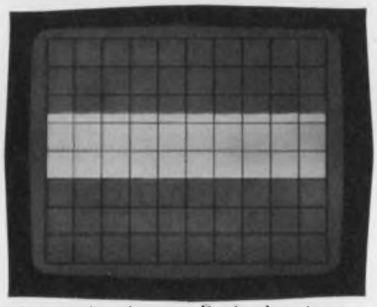
look what you're missing.



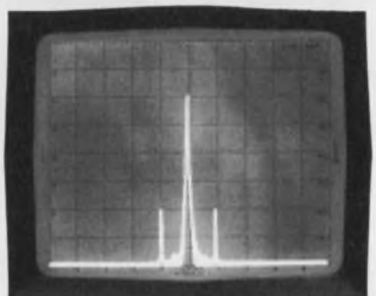
Conventional scope display of 5 MHz signal appears undistorted ⟶



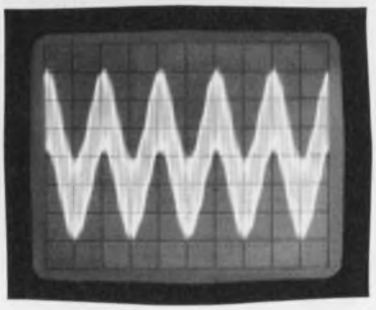
but spectrum analyzer display shows 2nd harmonic 50dB down and 3rd at −40 dB.



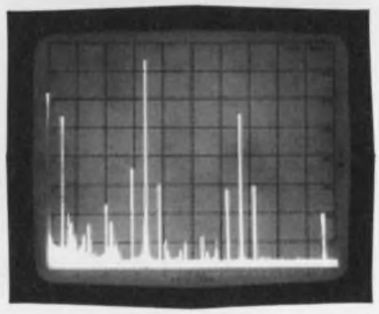
Conventional scope display barely shows 10 kHz AM of 30 MHz carrier ⟶



but spectrum analyzer shows sidebands 40 dB down; i.e., 2% AM.



Conventional scope display merely shows "fuzzy" sine wave ⟶



but spectrum analyzer identifies parasitic oscillations.

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SIGNAL ANALYZERS

INFORMATION RETRIEVAL NUMBER 33

Speed up synchronous counters

by eliminating logic-gate delays in the front end and restricting gates to slowly changing signals.

The maximum speed of a synchronous counter is frequently less than the toggle frequency of the flip-flops that are used to make it. This reduction in speed is caused by the propagation delay in external gates that are required to implement the design of the counter.

There are several ways in which this propagation delay can be minimized. One is to restrict all external logic to a single level, thus reducing the delay to that of a single gate, but in this approach gate count cannot be minimized.

A better method is simply to eliminate gating of the signals that are changing most rapidly, while permitting the slower signals to be gated. More reliable synchronous counters of higher speed can be built by carefully integrating gate design with clock frequency. The final speed limitation, the propagation delay of the flip-flops, is one restraint that cannot be overcome.

Binary counter is basic

An n-stage synchronous binary counter, because of its familiarity, is a good circuit on which to illustrate the use of the suggested gating technique. The condition for switching the nth stage of this counter, if J-K flip-flops are used, is

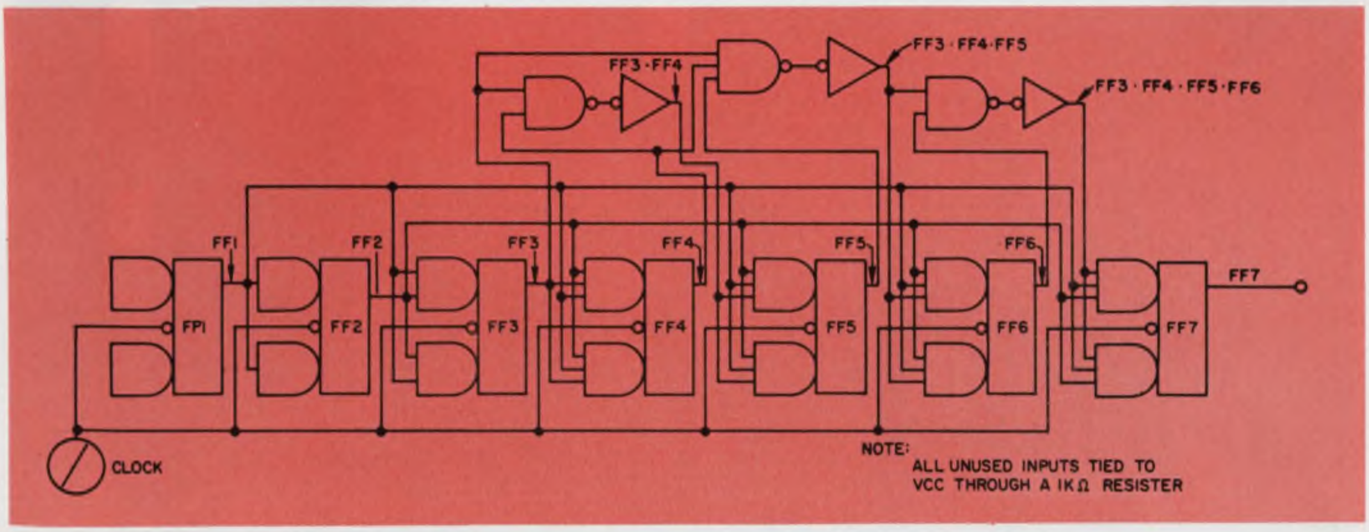
$$\text{Switch } FF_n = (FF_{n-1})(FF_{n-2})\ldots(FF_1)(\text{Clock}). \quad (1)$$

An implication of this equation is that the AND gate at the input to the nth flip-flop either must have n-1 inputs or it must have a logic tree to reduce the number of inputs. The second alternative is the usual solution, even though it introduces an additional delay for each level in the logic tree.

Consider, for example, a J-K flip-flop with AND inputs. (SUHL II/SF200 has three J, three K and one clock input.) The data to be entered must be present at the J and K terminals before the clock goes high. If the clock frequency is a 25-MHz square wave, its period is 40 ns. Thus the clock is low for only 20 ns. The worst-case propagation delay of the SF200 flip-flop is 15 ns, which leaves 5 ns for the gating operation.

Since the worst-case delay for a SUHL II gate is 11 ns, 6 ns more than is available, it is obvious that the logic tree approach cannot be used or the clock must be slowed. Neither alternative is particularly attractive.

Edward G. Linde, Engineer, Harris Semiconductor, Div. of Harris-Intertype Corp., Melbourne, Fla. 32901.



1. **This seven-stage binary counter has logic gating** only at the inputs to the third and subsequent flip-flops. Elimination of gating at the least significant stages raises speed by removing gate delays.

Resolve the impasse

As a first step in clearing this impasse, regroup Eq. 1 as follows:

Switch $FF_n =$

$$[FF_{n-1} \cdot FF_{n-2} \cdot\cdot\cdot FF_3] [FF_2 \cdot FF_1 \cdot \text{Clock}]$$

Now form the AND of FF_2, FF_1 and the clock at the inputs of FF_3 through FF_n as shown in Fig. 1. The effective clock rate to these stages of more significant bits is the clock frequency divided by 2^2 or, in this case, 6.25 MHz.

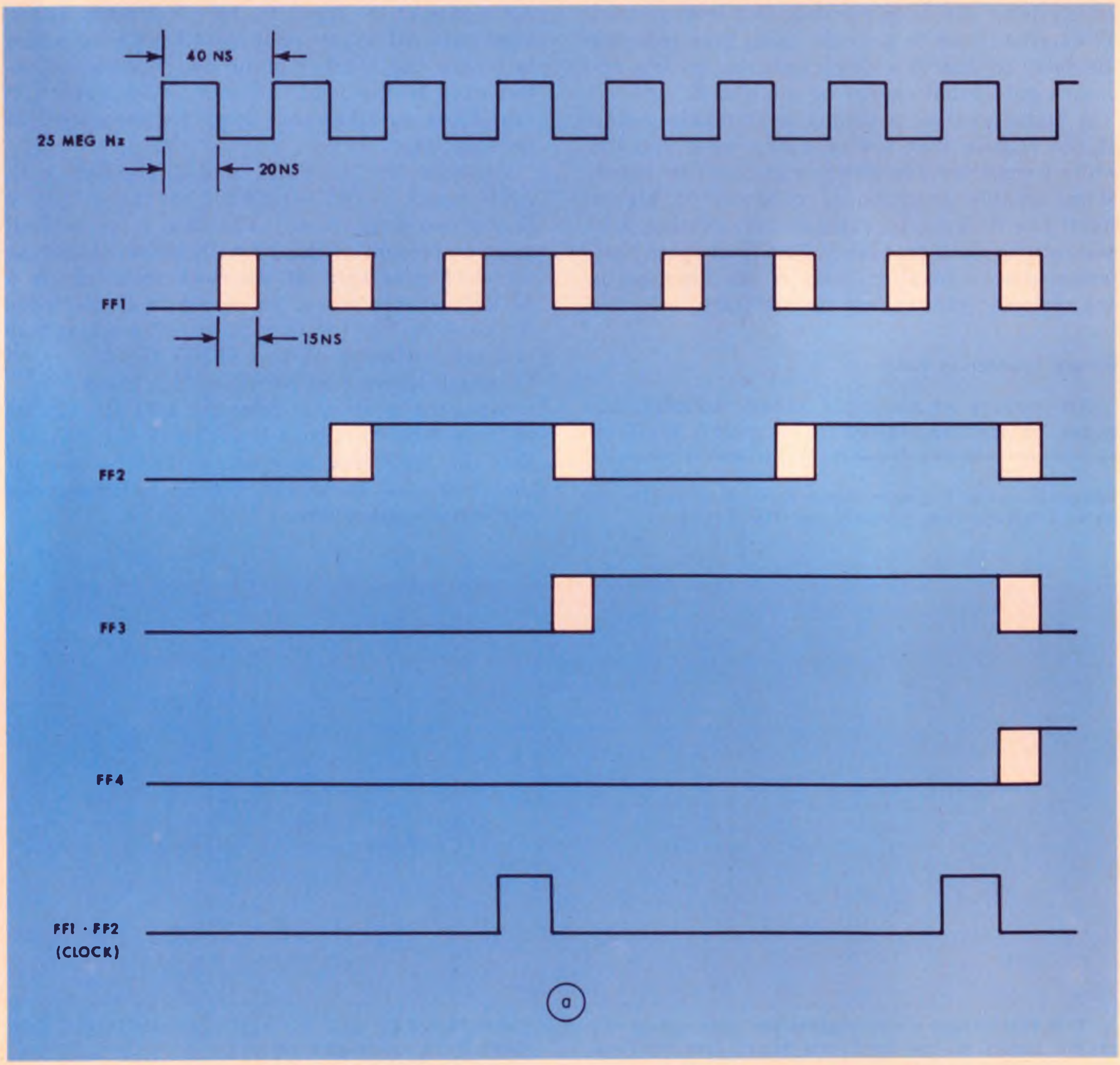
The effective clock, which is the logic product of clock FF_2 and FF_1, is not a square wave (see Fig. 2). Rather, it is high for one half of the clock period (20 ns) and low for the remainder of 2^2 clock periods, which is $(4 \times 40) - 20$ or 140 ns.

Since the worst-case propagation delay is 15 ns, 140−15 or 125 ns are available for delay in the gates. Assuming an 11-ns gate delay, as many as 11 levels of logic can be used and 4 ns are still left over. The timing diagram in Fig. 2 graphically illustrates this process.

The seven-stage synchronous binary counter of Fig. 1 has been built and tested. An input clock frequency as high as 33.3 MHz was divided by 2^7 (128), and satisfactory operation was then obtained.

Divide by 100

A second application of selective gating is a divide-by-100 counter that consists of two cascaded synchronous decade counters (Fig. 3). Each decade counted has a divide-by-five and a divide-by-two stage.



The progression of the count in each decade counter is listed in the decade-counter sequence table. The least significant bit (LSB) is generated in FF_1 while the most significant bit (MSB) is generated in FF_4.

The accompanying box describes the derivation of the flip-flop equations of the divide-by-five stage. These equations,

$$J_{FF1} = FF_2' \cdot FF_3'; K_{FF1} = FF_2,$$

$$J_{FF2} = FF_1; K_{FF2} = FF_1',$$

and

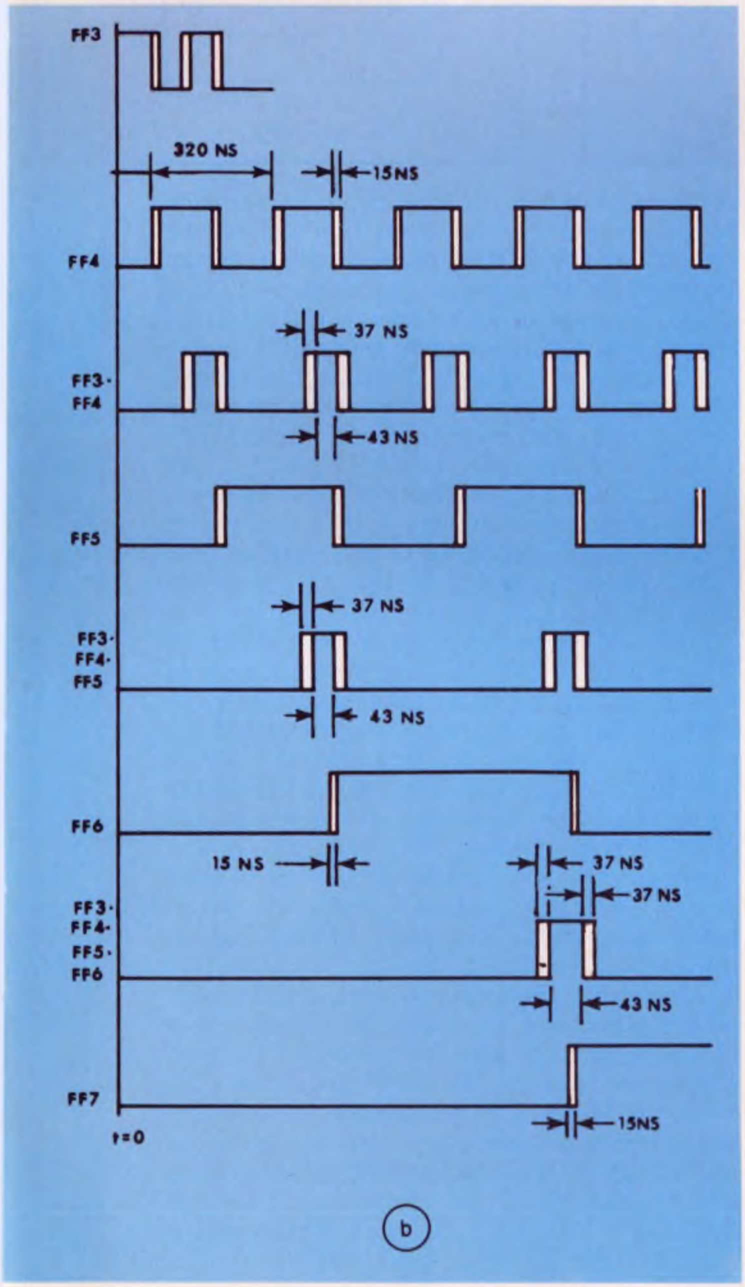
$$J_{FF3} = FF_1' \cdot FF_2; K_{FF3} = FF_2'$$

are implemented in the first three stages of the divide-by-100 counter of Fig. 3.

The output of FF_3 is fed directly to the inputs of FF_4 along with the clock. This is the equiva-

Decade counter sequence table

CNT	FF1	FF2	FF3	FF4
0	0	0	0	0
1	1	0	0	0
2	1	1	0	0
3	0	1	0	0
4	0	0	1	0
5	0	0	0	1
6	1	0	0	1
7	1	1	0	1
8	0	1	0	1
9	0	0	1	1



2. **A worst-case timing diagram for the binary counter of Fig. 1** shows the relationship between areas of uncertainty (shaded) and the actual pulse width. The uncertainty arises from worst-case propagation delay of the flip-flops. Because it is operating with the shortest period, FF_1 has least time available for gating after the propagation delays has been subtracted from its pulse. Since all gating must be accomplished during this interval, it is obviously advantageous to relieve FF_1 of as much gating as possible if a high-speed counter is to be built.

Divide-by-five derivation

Truth table

Count	FF1	FF2	FF3
0	0	0	0
1	1	0	0
2	1	1	0
3	0	1	0
4	0	0	1
0	0	0	0

Map symbols

Transition	Enter Map	Read Map J	Read Map K
0 to 0	0	0	X
0 to 1	1	1	X
1 to 0	0	X	1
1 to 1	1	X	0
Optional	X	X	X

Karnaugh maps

FF3 \ FF1, FF2	00	01	11	10
0	1	0	0	1
1	0	X	X	X

FF1 : J = FF2′·FF3′, K = FF2

FF3 \ FF1, FF2	00	01	11	10
0	0	0	1	1
1	0	X	X	X

FF2 : J = FF1, K = FF1′

FF3 \ FF1, FF2	00	01	11	10
0	0	1	0	0
1	0	X	X	X

FF3 : J = FF1′·FF2, K = FF2′

In order to divide by a given integer, n, a counter must provide n unique states. If n=5 as in this case, at least three flip-flops (scale of eight) must be used. A truth table, such as the one in this box, then defines each state or count in terms of the outputs of each flip-flop. For example, at count 0 each of the flip-flops, FF_1, FF_2 and FF_3, are set to ZERO. This can be abbreviated as 0, 0, 0 and is the equivalent of count 0.

At count 1, FF_1 goes to 1 while FF_2 and FF_3 remain unchanged. Count 1 thus corresponds to 1, 0, 0. In the transition from count 0 to count 1, only FF_1 changed its state from 0 to 1. As can be seen in the transition from count 1 to count 2 in the accompanying truth table, FF_1 remains at 1, FF_2 changes from 0 to 1 and FF_3 remains at 0. The remaining counts entail similar changes of state of the flip-flop outputs.

The truth table can be translated into a set of Karnaugh maps in which each flip-flop has its own unique map. The coordinates of the entries in a given map are all of the possible flip-flop states. In this case there are eight entries. The coordinates across the top of each map are the states of FF_1 and FF_2, respectively, and on the left side are the states of FF_3. Each entry thus corresponds to one of the eight possible states. However, since only five counts are being considered, three of the possible states have no relation to the truth table.

A set of rules is given in the table of map symbols for making entries in the Karnaugh maps. As an example, consider the top left entry in the FF_1 map for which the coordinates are 0, 0, 0. The entry to be made is the symbol for the transition undergone by FF_1 as the 0, 0, 0 state (corresponding to count 0) advances to the next or 1, 0, 0 state (corresponding to count 1). This transition, 0 to 1, requires the entry of 1.

As a second example, look at the transition undergone by FF_2 as the count advances from 2 to 3. The coordinates of count 2 are 1, 1, 0 and the coordinates of count 3 are 0, 1, 0. Since FF_2 is under study, the transition of interest is from 1 to 1 for which 1 is the entry according to the map symbol table. Thus, the entry in the FF_2 map for 1, 1, 0 is 1.

After all three maps have been filled in, Xs are used in the maps for states which do not appear in the truth table, and the maps are read in order to determine the minimum expressions for each flip-flop. This is done by first reading each map for the J or K inputs according to the reading rules given in the table of map symbols. For example, if a J input is to be determined, a 0 entry is read as 0, a 1 entry is read as 1, and so on. Minimum expressions are then determined in conventional fashion.

A complete description of this Karnaugh map method can be found in "Single Map Method Speeds Design," by Mitchell Marcus, *Electronic Design*, ED 26, December 20, 1969, pp. 66-68. The techniques for extracting minimum expressions can be found in any standard text on Boolean algebra, such as *"Introduction to Switching Circuit Theory,"* by Donald D. Givone, McGraw-Hill Book Co., New York, N. Y., 1970.

lent of forming the AND of FF_4 with the clock frequency. Since FF_4 sees the clock only once in each five clock cycles, it toggles at one-tenth of the clock rate.

Two of the three available inputs of each stage of the second decade counter are used to synthesize the effective clock, and this leaves only one input to implement the design equations. However, since the effective clock is one-tenth of the input clock, the time to propagate signals has increased from 20 ns, if a 25-MHz square-wave clock is used, to $(10)(40) - 20 - 15 = 365$ ns. The effective clock is high for 20 ns, and the worst-case propagation delay of the flip-flop is 15 ns. With this large increase in allowable gate propagation delay, many levels of external gating can be used to implement the second decade counter.

Approach suitable for high bit rates

This design approach, feeding the most rapidly changing signals directly to the flip-flops while the slower signals are gated, has proved to be a highly satisfactory way of implementing Boolean logic at high bit rates. Rates approaching those limited only by the propagation delay of the logic device are attainable. ■■

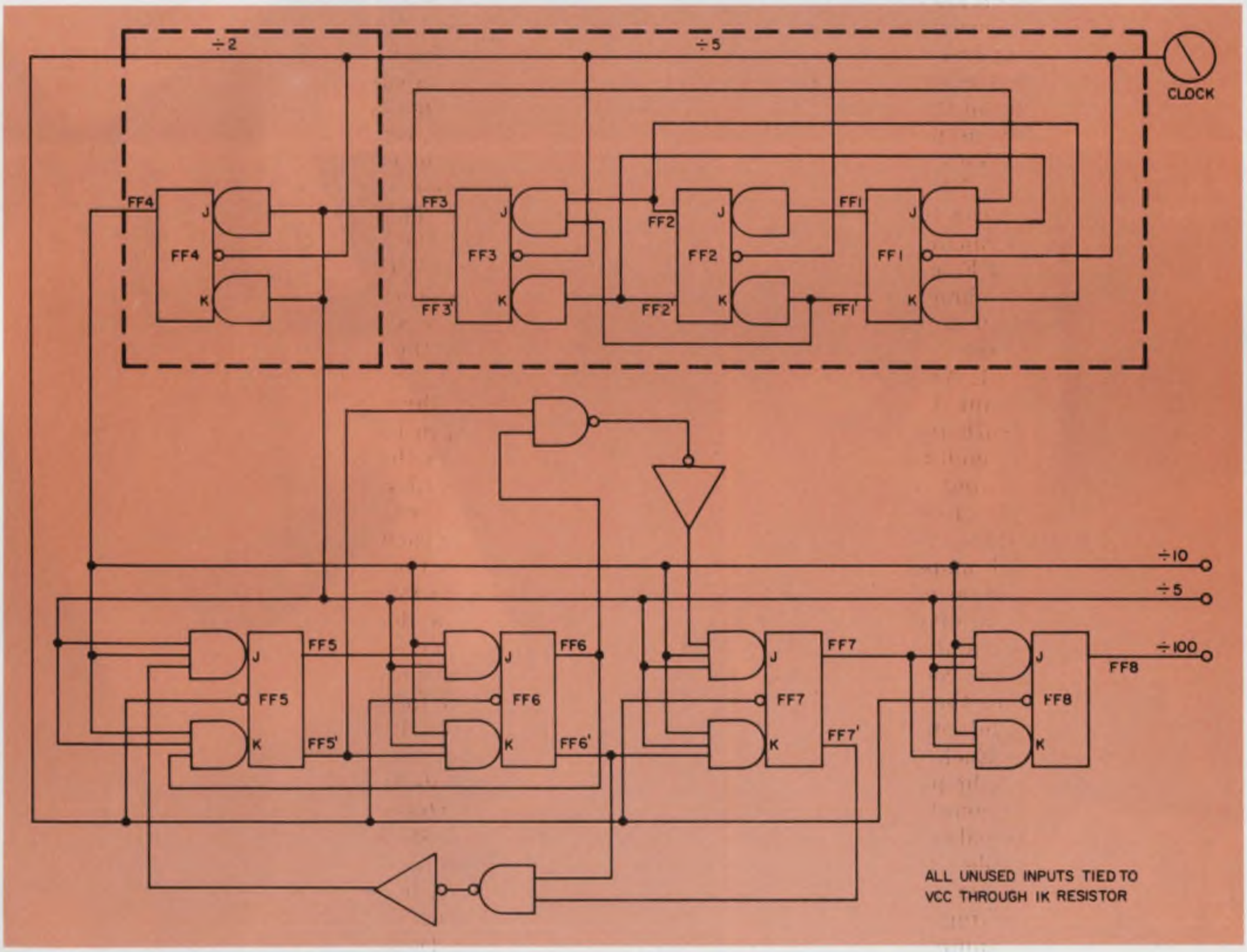
Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. How many inputs are needed for the Nth stage of a binary counter?

2. Is the most significant bit generated in the slowest or fastest stage of a counter?

3. What is the relationship between clock frequency and propagation delay in flip-flops? In logic gates?



3. **Division by 100 is accomplished by this cascade of decade counters.** Logic gating is restricted to the second decade to speed operation. Each decade contains a divide-by-five and divide-by-two stage.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Don't minimize noise figure to optimize the noise performance of your operational amplifier. Concentrate instead on maximizing the output S/N ratio.

While noise figure is excellent for comparing amplifiers, it is not necessarily the appropriate indicator for optimizing the noise performance of an amplifier circuit.

In designing op-amp circuits, for example, best noise performance—that is, highest output S/N ratio—is not usually obtained under the same circuit conditions that minimize the noise figure.

The problem comes about because noise figure (NF) is defined as the ratio of an amplifier's input S/N to its output S/N (Eq. a in the box). The NF can therefore be reduced by increasing the amount of noise at the input—hardly the way to improve the amplifier's noise performance.

The mistaken idea that minimum noise figure equals best noise performance comes from the days when noise figure was almost exclusively used in the design of transformer-coupled rf amplifiers. In that application, adjusting the source resistance by varying the transformer turns ratio yields the best noise performance when the noise figure is minimized. This result applies only to transformer-coupled circuits because a transformer scales the source resistance proportional to the square of its turns ratio while scaling the input signal voltage proportional to the turns ratio itself.

Total amplifier noise is a better idea

A better indicator of amplifier noise performance is the total equivalent amplifier input noise voltage, e_{nit} (see box). Both this quantity and the noise voltage of the source, e_{ng}, are functions of the source resistance. They should, therefore, both be studied as functions of this variable.

To see how e_{nit} varies with source resistance, consider the standard inverting op-amp configuration of Fig. 1. In this circuit, it is assumed that the two input noise current sources are essentially equal (in a statistical sense).

Generally, to minimize thermal drifts, the source resistances presented to the two amplifier inputs are made equal. Since both the feedback and summing resistors in Fig. 1 are returned to low-impedance points, the resistance seen by the inverting input is essentially the parallel combination of R_1 and R_2. Thus, standard practice would be to choose $R_g = R_1 \| R_2$.

Under these conditions, the expression for total amplifier input noise voltage (Eq. d in the box) simplifies to

$$e_{nit} = \sqrt{\overline{e_{ni}^2} + 2R_g^2\overline{i_{ni}^2}} \ . \qquad (1)$$

In this form, the noise produced by the op amp can be compared directly with input signal levels to evaluate the S/N ratio regardless of the function to be performed by the op amp.

The noise voltage of the source, e_{ng}, is generally accounted for by the thermal noise of the source resistance. The thermal noise of the combined source resistance, $2R_g$, is given by

$$e_{ng} = \sqrt{8KT\,\Delta f\,R_g} \qquad (2)$$

where K is Boltzmann's constant (1.38×10^{-23} joules/°K),
T is the absolute temperature and
Δf is the bandwidth in hertz.

Plugging Eqs. 1 and 2 into Eq. f (in the box) yields an expression for noise figure as a function of source resistance:

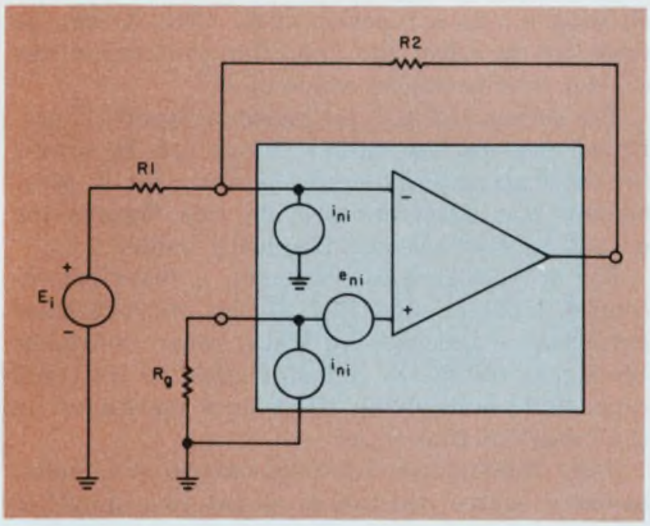
$$NF = 10 \log_{10} \left[1 + \frac{\overline{e_{ni}^2} + 2R_g^2\overline{i_{ni}^2}}{8KT\Delta fR_g} \right] . \qquad (3)$$

Eqs. 1, 2 and 3 are plotted in Fig. 2 to show how misleading noise-figure measurements can be, especially for low values of R_g.

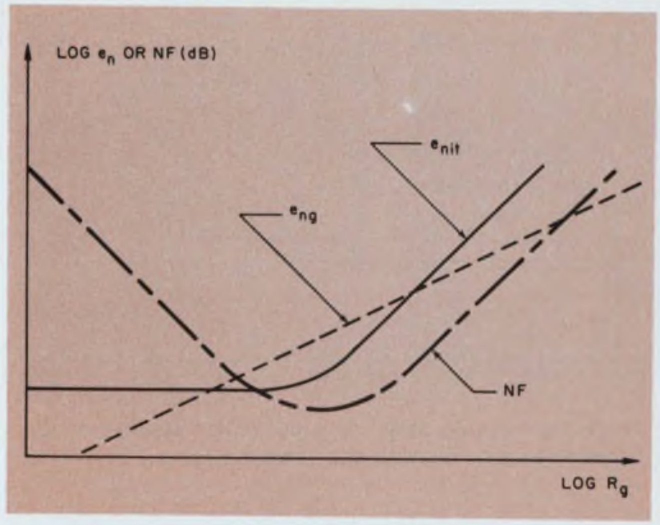
The noise contributed by the op amp is essentially constant for low R_g where the effects of current noise are small compared with those due to voltage noise. The thermal noise of the source resistance is a linear function of R_g and can exceed the total amplifier noise over some range of resistance.

The noise figure hits a minimum when the ratio of amplifier noise to source noise is smallest, leading to the common recommendation that R_g be adjusted to minimize NF. Unfortunately, this does not lead to optimum noise performance.

Jerald Graeme, Manager, Monolithic Engineering, Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706.



1. **Amplifier noise increases as the resistances go up** because of the increased contributions from the noise-current sources. The voltage contribution is constant.



2. **Noise figure is minimized** when the ratio of amplifier noise to source noise is smallest. This does not correspond to optimum noise performance.

What is the noise figure of an op amp?

Noise figure is defined as the power S/N ratio at the input of an amplifier divided by the same quantity measured at the amplifier's output. In decibels, it is given by

$$NF\ (dB) = 10 \log_{10} [(S/N)_i/(S/N)_o]. \quad (a)$$

To see how the noise figure and the output S/N ratio are affected by external circuitry, it is convenient to rewrite Eq. a in terms of noise voltages and currents. The resulting expression is

$$NF = 10 \log_{10} \left[\frac{(E_i^2/R_i)/(\overline{e_{ng}^2}/R_i)}{(E_o^2/R_L)/(\overline{e_{no}^2}/R_L)} \right] \quad (b)$$

where E_i is the input signal voltage,
E_o is the output signal voltage,
$\overline{e_{ng}^2}$ is the mean-square noise voltage of the source,
$\overline{e_{no}^2}$ is the mean-square noise voltage at the output,
R_i is the input resistance and
R_L is the load resistance.

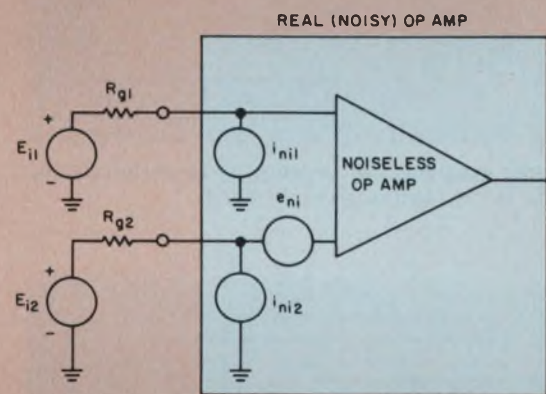
For a gain, $A = E_o/E_i$, Eq. b can be simplified to

$$NF = 10 \log_{10} [\overline{e_{no}^2}/A^2\overline{e_{ng}^2}]. \quad (c)$$

This relationship makes clear the fact that increasing the level of input noise can reduce an amplifier's noise figure while worsening its noise performance.

To relate the standard definition of noise figure to an operational amplifier, it is useful to represent the op amp as an ideal noiseless amplifier preceded by equivalent input noise voltage and current sources (see diagram).

The equivalent noise sources are uncorrelated and without polarity. They therefore add in a mean-square sense, and the total mean-square amplifier noise voltage presented to the noiseless amplifier is



$$\overline{e_{nit}^2} = \overline{e_{ni}^2} + \overline{i_{ni1}^2}\, R_{g1}^2 + \overline{i_{ni2}^2}\, R_g^2 \quad (d)$$

where it is assumed that the input resistance of the amplifier is much larger than R_{g1} and R_{g2}.

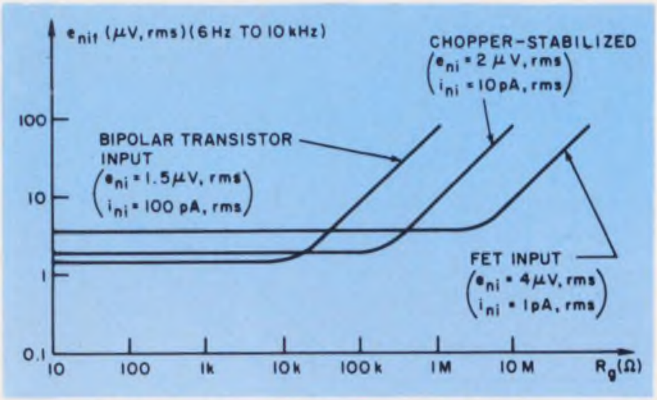
If we make the assumption that the noise from the signal sources is not correlated with the amplifier noise, then it will add in a mean-square sense yielding a total mean-square output noise

$$\overline{e_{no}^2} = A^2 (\overline{e_{ng}^2} + \overline{e_{nit}^2}). \quad (e)$$

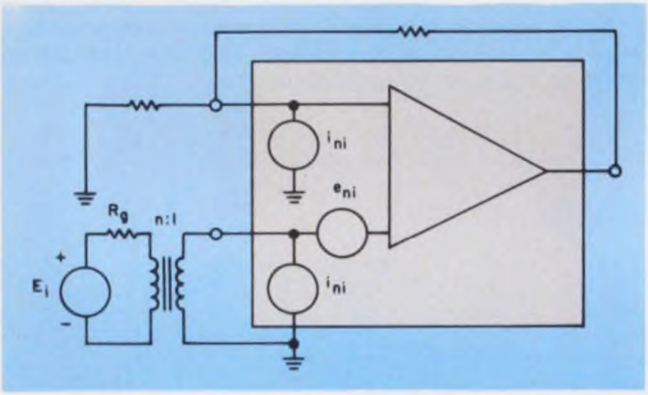
Plugging this expression into Eq. c yields an expression for noise figure in terms of the op-amp noise parameters:

$$NF = 10 \log_{10} [1 + \overline{e_{nit}^2}/\overline{e_{ng}^2}]. \quad (f)$$

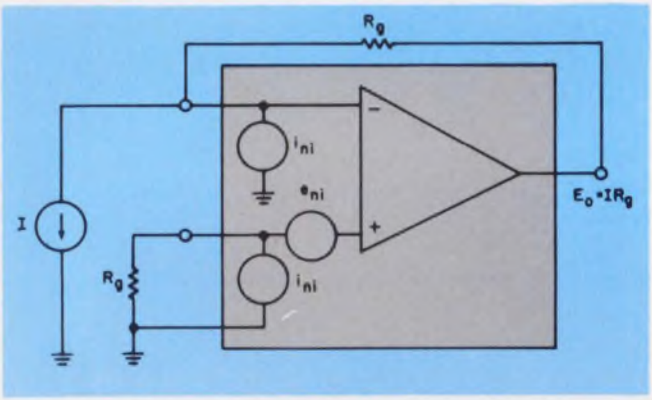
In this form, the noise figure is related to the ratio of noise generated by the amplifier to that generated by the source. Since the comparison reference is arbitrarily set by the source, the noise figure serves only as a common, arbitrary reference from which a comparison can be made between amplifiers under fixed conditions.



3. **Pick the best op amp** for a particular application by by selecting the unit with the lowest e_{nit}.



4. **Transformer coupling can improve noise performance.** The optimum turns ratio is given in Eq. 5.



5. **The S/N ratio of this current measuring circuit is** maximized for very large R_g. $(S/N)_{max} = 1/2i_{ni}$.

In fact, the best S/N ratio is obtained when $R_g = 0$—a condition for which the noise figure becomes infinite, demonstrating that high NF does not, in itself, indicate poor noise performance.

Match the amplifier to the circuit

It is clear that noise performance is optimized when e_{nit} is minimized. How can this be done?

For the very common case of dc voltage amplifiers, Eq. 1 indicates that R_g should be made as small as possible. Once R_g is specified, a graph showing e_{nit} as a function of R_g (Fig. 3) can be consulted to select the amplifier that minimizes e_{nit} for that particular value of R_g.

The curves of Fig. 3 are based on specific Burr-Brown models, but similar curves can be drawn for other op amps by simply plotting Eq. 1. Most op-amp manufacturers provide rms figures for e_{ni} and i_{ni} over selected frequency bands.

For ac voltage measurements, a transformer-coupled input circuit (Fig. 4) can improve noise performance because the transformer multiplies the signal voltage by a factor equal to its turns ratio while multiplying the source resistance by the square of that ratio.

Since transformers are used only in ac circuits, balanced source resistances at the two amplifier inputs are not needed to ensure the cancellation of the dc voltages caused by input bias currents. Instead, the feedback and summing resistances are minimized to make the noise contribution of the noise-current source at the inverting input small enough to be considered negligible.

As a result, the current i_{ni1} and the resistance R_{g1} (see box illustration) are assumed to be zero, and the S/N ratio of the circuit is given by

$$S/N = \frac{E_i/n}{\sqrt{\overline{e_{ni}^2} + R_g^2\overline{i_{ni}^2}/n^4 + 4KT\Delta fR_g/n^2}} \quad (4)$$

where n is the turns ratio of the transformer.

To find the turns ratio resulting in maximum S/N ratio, the derivative of S/N with respect to n is equated to zero, yielding

$$n_{opt} = \sqrt{i_{ni}R_g/e_{ni}} \,. \quad (5)$$

If the input signal is a current, rather than a voltage, an analysis of the standard current-measuring circuit (Fig. 5) will show that the S/N ratio increases as R_g is increased. ■■

Test your retention

Here are questions based on the main points of this article. Their purpose is to help you make sure you have not overlooked any important ideas. You'll find the answers in the article.

1. Under which condition is a noise figure measurement likely to be most misleading: low source resistance or high source resistance?

2. For dc voltage measurements, what condition will maximize the S/N ratio? What is the noise figure under this condition?

3. How can a transformer be used to maximize the S/N ratio of an ac amplifier?

Major advances in IC performance are obtained by combining advanced processing techniques with complete mastery of advanced circuit design. One manufacturer does that: Analog Devices . . . *Circuit Specialists.*

A perfect example: the AD503, an FET-input op amp with 5 pA bias current, and a slewing rate of 6V/μsec. To put it bluntly, the AD503 outperforms every other FET/IC design, in every significant parameter, by wide margins.

The spec summary we've shown stacks the AD503 against the best conventional FET/IC op amp. You'll see why we made the AD503 pin-interchangeable with the μA740 (and 741). We expect to cure a lot of your nagging design headaches — simply by saying: *"Retrofit with the AD503!"*

Here's how we do it: the AD503 is a dual-chip IC, combining a monolithic dual FET chip with a specially designed monolithic amplifier chip. This permits independent optimization of both chips, since they are processed independently, each with the most favorable starting materials and doping profiles for its function. Consequently, the yield is high, the cost is low, and the performance is superb. The AD503, in other words, is not limited by the processing constraints inherent in single-chip FET op-amp designs.

Coming soon: specially optimized versions of the AD503 . . . one with 1 pA bias current . . . an externally compensated version with 40V/μsec slew rate . . . and one in which we use laser trimming to internally reduce the offset voltage to less than 1 mV.

The AD503, like all of our new fourth-generation devices, was created by the most experienced team of linear circuit and processing engineers ever assembled. And it is manufactured in one of the few microcircuit facilities that is currently capable of large-volume fourth-generation processing.

The "C" in IC's stands for Circuits

—therefore the AD503 ...a 5pA FET Op Amp in a TO-99 Can

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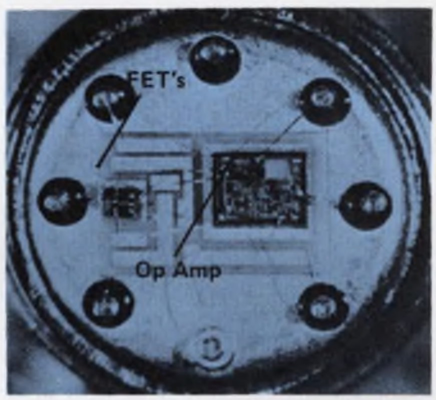


Parameter	AD503J	μA 740C	AD503K	μA 740
Max V_{OS} (mV)	50	no max spec*	20	20
Max I_b (pA)	25	2000	10	200
Max ΔV/ΔT (μV/°C)	75	no max spec*	25	no max spec*
Min Gain	20K	no min spec*	50K	50K
Min CMRR (dB)	70	no min spec*	70	64
Min Slew Rate (V/μsec)	4	no min spec*	4	no min spec*

*Manufacturer gives this parameter as typical value only. (Note that only the AD503 is completely min and max specified; the μA 740C is almost completely unspecified.)

ANALOG DEVICES
Circuit Specialists

INFORMATION RETRIEVAL NUMBER 35

High energy silicon for the 70's

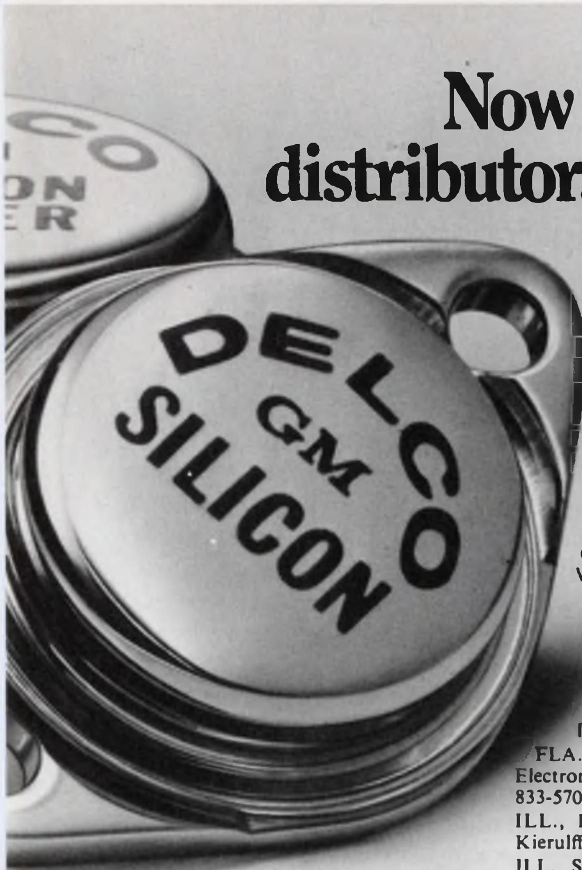
The new tough breed from the Kokomoans

Circle No.	Transistor	V_{CEX} Voltage	Continuous I_C	V_{CEO} (sus)	Maximum Power Dissipation	Typical Applications
121	DTS 103	80V	15A	60V	125W	Voltage regulators, power amplifiers, high efficiency switching circuits.
122	DTS 104	80V	15A	60V	125W	
123	DTS 105	100V	15A	75V	125W	
124	DTS 106	110V	15A	80V	125W	
125	DTS 107	120V	15A	85V	125W	
126	DTS 401	400V	2A*	300V		*I_C Peak = 5A Vertical magnetic CRT deflection, has good gain linearity.
127	DTS 402	700V	3.5A*	325V		*I_C Peak = 10A Horizontal magnetic CRT deflection, features fast switching time, high reliability under horizontal sweep fault condition.
128	DTS 410	200V	3.5A	200V	80W	
129	DTS 411	300V	3.5A	300V	100W	Voltage regulator, switching regulator, DC to DC converter, class A audio amplifiers.
130	DTS 413	400V	2.0A	325V	75W	
131	DTS 423	400V	3.5A*	325V	100W	*I_C Peak = 10A High V_{CBO} and V_{CEO} ratings make it practical to operate directly from rectifier 117V or 220V AC line.
132	DTS 424	700V	3.5A*	350V	100W	
133	DTS 425	700V	3.5A	400V	100W	*I_C Peak = 10A High V_{CBO}, V_{CEO} (sus) ratings make them ideal for use in deflection circuits, switching regulators and line operating amplifiers.
134	DTS 430	400V	5A	300V	125W	
135	DTS 431	400V	5A	325V	125W	Voltage regulators, power amplifiers, high voltage switching.
136	DTS 701	800V	1A	600V	50W	Vertical magnetic CRT deflection circuits.
137	DTS 702	1200V	3A	750V	50W	Horizontal magnetic CRT deflection circuits operating off-line.
138	DTS 704	1400V	3A	800V	50W	
139	DTS 721	1000V	3A	800V	50W	High voltage DC regulators.
140	DTS 723	1200V	3A	750V	50W	Very high voltage industrial and commercial switching.
141	DTS 801	1000V	2A	700V	100W	Color vertical magnetic CRT deflection circuits.
142	DTS 802	1200V	5A	750V	100W	Color horizontal magnetic CRT deflection circuits.
143	DTS 804	1400V	5A	800V	100W	
144	2N3902†	700V	3.5A*	325V	100W	*I_C Peak = 10A Ideal for switching applications. Can be operated from rectified 117 or 220 volt AC line.
145	2N5157	700V	3.5A*	400V	100W	
146	2N5241	400V	5A	325V	125W	
147	2N2580	400V	10A	325V	150W	For general use in electrical and electronic circuits such as converters, inverters, regulators, etc.
148	2N2581	400V	10A	325V	150W	
149	2N2582	500V	10A	325V	150W	
150	2N2583	500V	10A	325V	150W	
151	2N3079	200V	10A	200V		
152	2N3080	300V	10A	300V		

†Mil. qualified units available.

Transistors are NPN triple diffused.

Now available from these distributors in production quantities.



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Firm name games are serious business.

Companies spend more time and money than necessary for a name; examples show need for flexibility to avoid duplications.

Have you ever wondered how a company gets its name, and what it signifies? If you're an engineer or a manager, thinking about starting your own company one day, chances are you'll find what follows informative and entertaining. Included are the legal steps required for selecting a corporate name, and a few of the more interesting stories behind the selection of some of the more unique names in the electronics industry.

Getting a company name is a lot more work than meets the eye. Because of the growing number of new businesses each year, the choice of a company name is often determined by what's available, rather than what's wanted. Gene Rogers, one of the founders of the Intellex Corp., a California-based venture capital and management firm, advises:

"A simple guideline for choosing a name is this: don't choose a name that's likely to be confused with a firm already in the same business. The name probably won't get approved and, even more important, will tend to confuse your customers and do more harm than good."

Another important point to remember in the game of naming is how the company name will fit a logo, which is the graphic symbol of the company name. In this age of mass media, the logo is an important tool of recognition for a firm. So a logo should be chosen carefully. Many companies are chagrined when they discover that, after using their logo successfully in their home state, they run into a conflict when making their first out-of-state shipment. If they want interstate business they must re-do all their literature and art work. This kind of mistake can be very costly, and anyone forming a new company should do the necessary research to avoid it.

Company names come in three flavors

A company is named in one of three different ways: after its founder (namesake); to tell the world what it does and/or what its market is (descriptive); or simply to attract attention (invented).

Frank J. Burge, Vice President Marketing, Data Technology Corp., Palo Alto, Calif. 94303.

For many firms, the selection of a company name seemed an easy job. Sherman Fairchild called one of his companies *Fairchild Camera*, Dr. Arnold Beckman tagged his enterprise *Beckman Instruments*, Seymour Schweber, *Schweber Electronics*, Howard Hughes, *Hughes Aircraft*. Then there's *McDonnell Douglas, Hewlett-Packard, Varian Associates, Philbrick, Julie Research, John Fluke* and on and on.

In today's "down" market, many companies have found that their markets have dried up, or in some cases leveled off. Two of today's industry leaders found themselves with an even more ominous future at the end of World War II when the switch was made to a peacetime economy. A few days after AMPEX took a day off to celebrate the end of the war, it had all of its contracts canceled, and Haloid (later Xerox) found its

Steps required for selecting a corporate name

A corporate name is required in order to complete incorporation procedures. The requirements for incorporation are generally the same in most states, and the secretary of each state can usually provide a corporation check list that details the requirements of that particular state.

In general, to be as certain as possible that another electronics company hasn't taken your name, check all electronic indexes, i.e., trade press; EEM; Thomas Register; Buyer's Guide; Instrument Databook, etc., and, of course, check with the Patent Office in Washington, D.C. Also check on registered company names in those states or countries that represent your major markets. Your attorney will arrange for a trade name and corporate name check. The fee ranges from $50 to over $400, depending on how extensive you want the search to be.

A corporate name must be submitted and approved before incorporation can be completed. The rules (Corporation Check List State of California) applying to corporate names in California, for example, are as follows:

1. Check with the office of the Secretary of

markets were shrinking rapidly. Something drastic had to happen, and it did.

Dr. John H. Dessauer and Joseph C. Wilson of Xerox visited Batelle Memorial Institute and started negotiations on what was later to be known as xerography, and made Xerox a household word. The generic word, xerography was coined from the Greek words "xeros" (dry) and "graphein" to write.

On the other hand, Alexander M. Poniatoff and Harold Lindsay of AMPEX decided to take a chance and develop a high-fidelity tape recorder for broadcast applications. This was the beginning of an entire new industry and one of the biggest success stories in American industry.

Four-Phase Systems, a new LSI minicomputer company, derived its name from the use of four-phase logic design throughout its general-purpose computer.

Intel founders Dr. Robert Noyce and Dr. Gordon Moore (also founders of Fairchild Semiconductor) started their company with an interim name, NM Electronics, until they were able to get a name cleared and registered. They tried to register 12 names before they came up with Intel, which is an abbreviated form of Integrated Electronics. As it turned out, there's an Intel in Ohio that's in the hotel business.

Sid Klein, executive vice president of *QED Systems*, explains his company's name this way:

State as to the availability of your proposed name before drafting your Articles of Incorporation. In requesting a name check, explain what the principal business will be and where it will be conducted.

2. Obtain two or three alternate names, but do not submit more than four names at one time. Due to the great number of corporations on file, the similarity of names is becoming a problem.

3. Since names cannot be checked out properly during the telephone call, make your request for a name availability check by telegram, letter or postcard. There is no fee for a name check.

4. If you desire to reserve a name prior to the incorporation, you can do so by requesting a reservation by letter and by enclosing the reservation fee of $4. This reserves the company name for 60 days. Name reservations cannot be made for consecutive reservation periods to the same applicant or for that party's benefit.

5. A name is not acceptable if it is likely to mislead the public or if it is the same as, or resembles another so closely as to tend to deceive (like the name of a domestic corporation, such as a computer company called IBN); or if it is the name of a foreign corporation that is qualified in California; or if it is a name under reservation for another corporation.

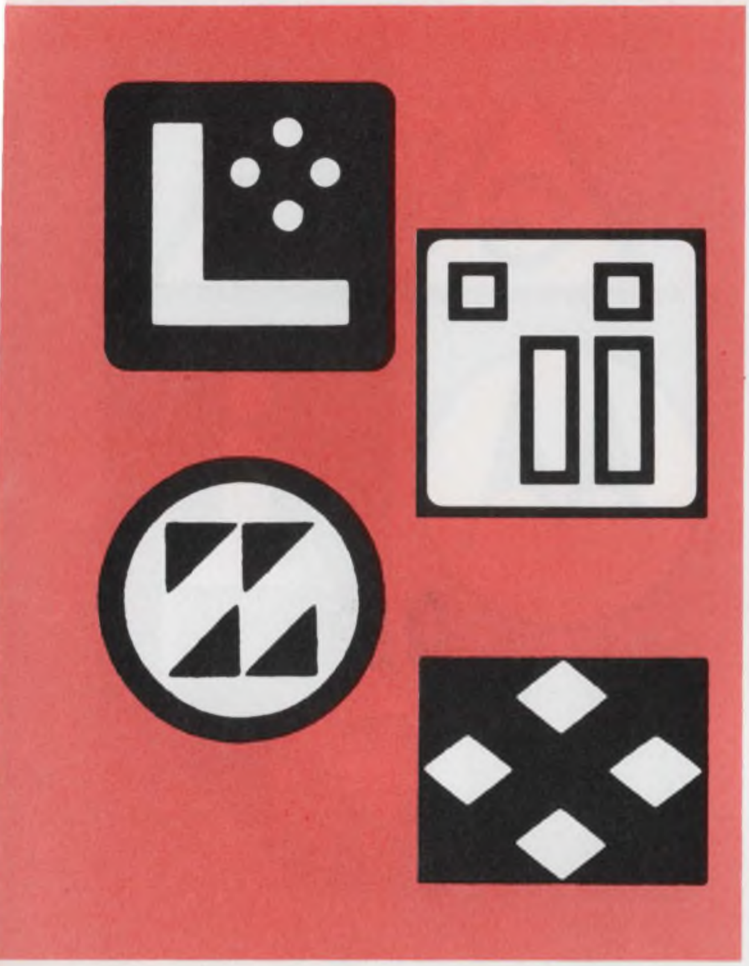
6. The words "bank," "trust," "trustee," or related words, may not be a part of the corporate name unless the certificate of approval of the Superintendent of Banks is attached to the Articles of Incorporation.

7. Generally speaking, the word "co-operative," or any abbreviation thereof or word similar thereto *may not* be a part of a corporate name.

8. The words "Olympic" or "Olympiad" should not be a part of the corporate name.

9. The name of a person may not be used as a corporate name without the addition thereto of a corporate ending or some other word or words which show that the name is not that of the individual alone.

The Small Business Administration has published a number of aids, (including "Steps to Incorporating a Business") for the small businessmen. Although small firms are sometimes incorporated without the help of an attorney, the information offered is not intended as a substitute for professional advice. Professional legal help will usually result in a better corporate charter and in the long run will save the company time and money.



"QED is a familiar expression in engineering text books and is derived from the Latin 'quod erat demonstrandum,' which means 'that which can be demonstrated.' All of us have had a great deal of experience in the systems business and can therefore demonstrate performance."

Genesys Systems started out as General Systems, but because of conflicts with that choice, settled on Genesys (*Gene*ral *Sys*tems) and then tacked on Systems to describe the business.

Intersil is a shortened form of International Silicon and was so named because the founder, Dr. Jean Hoerni, had an eye on the international microcircuit market. Dr. Hoerni was also one of the founders of several other northern California semiconductor firms, including Fairchild Semiconductor.

Burton R. Cohn, president of *XYNETICS* relates, "The name is a precise description of the business in which we are engaged, the manufacture of X Y positioning devices. X and Y represent the Cartesian coordinates and 'netics' is from the Greek 'kinetikos' which has the dual meaning of both 'to move' and 'to command'. Our only difficulties to date have been a series of misspellings and inevitable mispronunciations. Our consolation is that a few years ago 'Xerox 914' was thought to be an incomplete telephone number."

The word *Kodak* was first registered as a trademark in 1888, having been adopted the year before as the name of a camera that was to make photography everybody's hobby. This first Kodak camera sold for $25 already loaded with film; and after 100 exposures, it was returned to the factory for the developing and printing of the pictures and the insertion of another roll of film.

There has been some fanciful speculation on how the name was originated. But the plain truth is: George Eastman invented it out of thin air!

"I devised the name myself . . . the letter 'K' had been a favorite of mine—it seems a strong, incisive sort of letter . . . It became a question of trying out a great number of combinations of letters that made words starting and ending with 'K.' The word 'Kodak' is the result."

'Lectrion, one of the few companies headquartered on an island (Whidbey Island, near Seattle), coined its name from the word "electronics" but with a twist that is decidedly different.

Frederick Van Veen, *Teradyne* Publicity Manager, explains that the company name has no particular meaning other than to suggest a highly dynamic company. He claims some people refer to them as the Japanese branch of Teledyne, but they just shrug that off.

"The Teradyne subsidiary that owns all of the buildings we occupy," he says, "is called Terrafirma Inc.—so you see we have had our own fun with our name."

Then there's the story behind *Zehntel* as told by Bill Martin, president and founder.

"We had decided to form a company, and were asked by a friend to bid with him on a job involving a digital system. We asked that he give us a day or two to get incorporated. We called our attorney and gave him six space-age type of names we thought fitted our type of activity. He called back and said that he hadn't been able to incorporate us because three of the names were too similar to other companies' names, one was on reserve, and the other two were already taken.

"We couldn't bid this new job without being incorporated, and we couldn't incorporate without a name. The name we wanted was something related to digital or small systems. After hours of searching we came across the German word '*zehn*tel,' which, according to the German dictionary, stood for 'decimal.' The next day we were incorporated under the name 'Zehn*tel*,' using the anglicized pronunciation.

"The postcript to the story is that later we discovered that the preferred meaning of 'zehntel' is 'one-tenth.' It took us a few weeks to make a psychological adjustment to the new meaning, but to my knowledge it hasn't been a problem."

In 1946, there was a small Northwest company called Tekrad, that stood for Technical/Radio, but a few months after incorporation, the firm ran into troubles because a small receiver-tube manufacturer on the East Coast had copyrighted the name Tekrad. The name was then changed to *Tektronix*, a phonetic spelling of a coined word for technical and electronics.

AMPEX is coined from the initials of the Company's founder; *A*lexander *M*. *P*oniatoff—AMP—plus EX, which stands for excellence.

D. G. C. Hare sold his DGC Hare company to Sangamo in 1956 and in 1958 moved to Grass Valley, Calif. to set up an R&D Lab for Sangamo. In 1959 he started another company on a shoestring, and on the day of incorporation decided to call his company *The Grass Valley Group*, for no good reason at all.

"About the only problem has been that some people think we are a medical or insurance group . . . but in the Television Industry, we are pretty well known as 'The Group.' "

F. Douglas Van Sicklen, president of *XYZ Corp.*, Newton, Mass., tells us why this unusual name was chosen.

"For years people have referred to the 'XYZ Company,' so we decided to capitalize on this mythical company's notoriety. We're a rather unusual organization of engineers and entrepreneurs. Our business is putting other companies in business. We have 25 to 30 products already developed that we use to start new companies. We provide the seed capital, get the people and management team, and get additional financing when needed. Next time a would-be entrepreneur thinks of starting an XYZ company, we hope he'll think of us and let us help him get started."

Intech founders selected their name since it sounded like a technology-based company. The name cleared registration—so they stuck with it.

Itron, like Intech, is a name that doesn't mean anything in particular. Itron was picked because it gave the impression that the company was in electronics, and yet was not restrictive to any specific area, since product line diversification was planned.

Harold E. Eden, president of *IOMEC*, manufacturer of computer peripherals, explains, "IOMEC actually had a logotype before we had a name. We had settled on 'Informec Inc.,' but the name was not available because another company had a similar name. We didn't want to lose the logotype, so we had to come up with another name beginning with 'I.' We merely dropped the 'nf' from the 'Infomec' to get 'Iomec.' Now we're delighted with both the name and the logotype."

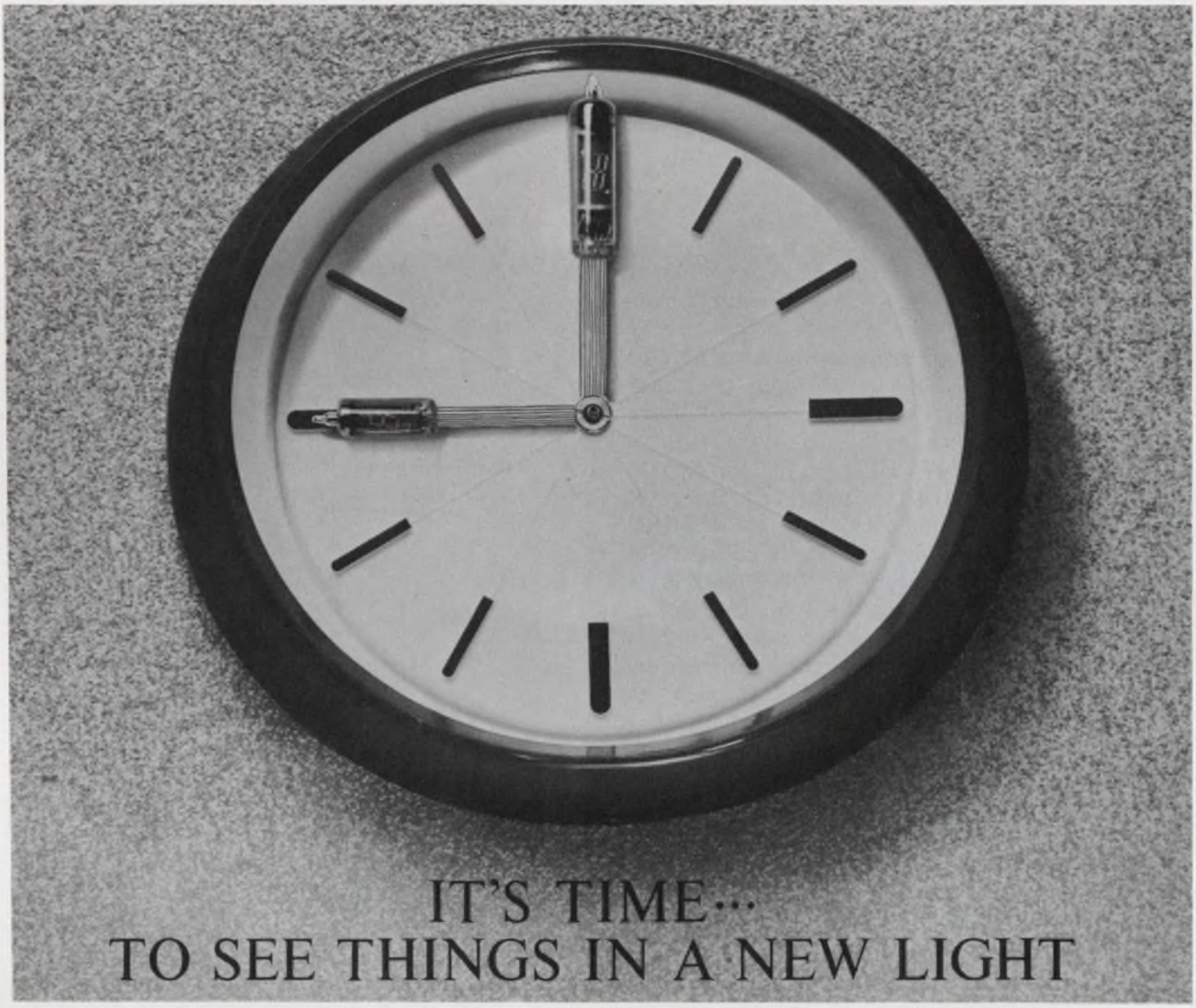
As you can see, selecting a name is not as easy as it first appears. There is almost no foolproof way to insure that your company name or logo is not in conflict with another previously registered corporate name or trade mark. The best you can do is check to see if your proposed name is in conflict with an existing corporation—then register the name in your state and keep your fingers crossed.

"Motorola" became a trademark of the Galvin Manufacturing Corp. in 1930 to identify a line of radios for motor cars. In 1947 it became the corporate name, and the present logotype (bottom) was introduced in 1955.

What's in a name tag?

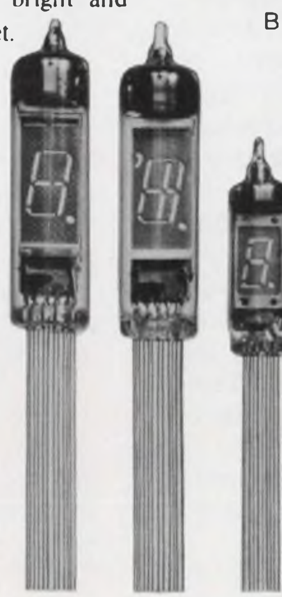
Corporate names, of course, are neither good nor bad in themselves. If the corporation is successful, the name will be good. If it flops, the name will be lousy. "Xerox" is a beautiful example. Who would ever have thought of choosing a funny Greek word that most people couldn't spell or pronounce? Except for its brevity, it's a bad choice by all the usual criteria. Yet the success of the company has made it one of the great corporate names. ■■

The logos represent the following companies: Intersil; 'Lectrion; Iomec; Motorola; Four Phase Systems; Grass Valley Group; Zehntel; and Xynetics.



When multi-faceted display problems dictate 9 to 9 work days, it's high time you saw things in a new light, on a single plane with no "dancing" digits and with no eye strain.

Legi DG 12C numerical indicator tube segments are an eye-easy phosphor green for a readout as bright and clear as day, legible at distances over 35 feet. These tubes offer low-voltage, low current drain, and high stability advantages so definitive and pack a performance punch so large, you can't afford not to afford to examine full particulars. They fit to the "T" perfectly portable and circuit-board mounting applications and are available at mass production prices. Look at these important particulars, then write for comprehensive data that show display tube performance in an entirely new light:



DG 12H

DG 10A

LEGI DG 12C

Filament voltage at 95 mA .... 0.85 volts ±10%

Phosphor segments & control grid .... 20 Vdc

Brightness .... 80 foot-lamberts

Operating temperature ...... −10° to +70° C

∗ Dynamic life expectancy ..... 200,000 hrs.

U.S. PATENT 3508101

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INFORMATION RETRIEVAL NUMBER 39

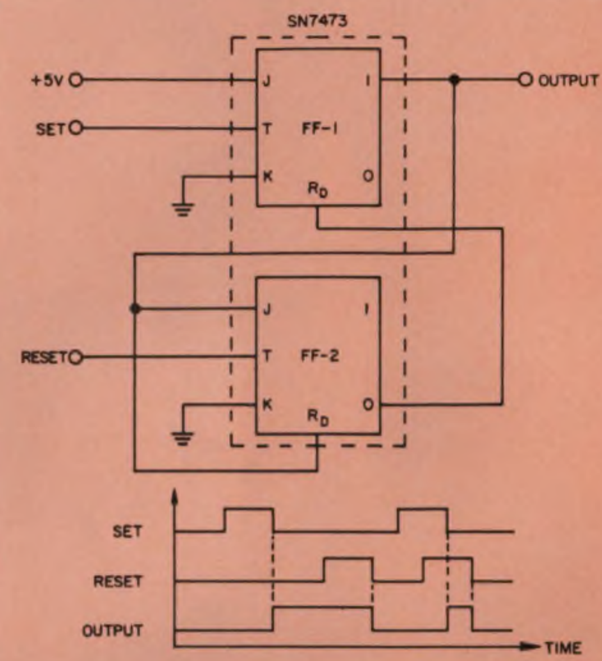
ideas for design

Set and reset flip-flops with separate pulses

In computer interfacing and control timing, it is often necessary to set and reset a flip-flop on the trailing edges of two separate pulses, where the pulses may be asynchronous and each may be at either ONE or ZERO level when the other occurs. This action can be accomplished by using a dual J-K flip-flop IC.

In the circuit shown, FF-1 is the flip-flop to be set and reset by the two pulses. In the reset condition both FF-1 and FF-2 are in the ZERO state. On the trailing edge of a set pulse, FF-1 toggles to the ONE state. The ONE output of FF-1 is then high, enabling the J input of FF-2. On the trailing edge of a reset pulse FF-2 is then set to the ONE state, and the resulting low ZERO output of FF-2 resets FF-1 through its direct reset input. The low ONE output of FF-1 resets FF-2 through its direct input, and the circuit is now ready for the next cycle.

In the case of a series of set pulses between reset pulses or vice versa, the circuit responds to only the first pulse of the series. The circuit is compatible with almost any line of logic commercially available The width of the set and reset pulses can vary from 50 ns to several seconds.



The output of FF-1 is controlled by the trailing edges of two different pulses. The width of the pulses can be varied from 50 ns to several seconds.

Edward S. Peltzman, Engineering Specialist, Tridea Electronics, 11581 Federal Drive, El Monte, Calif. 91731.

VOTE FOR 311

Digital hysteresis amplifier cleans up noisy signals

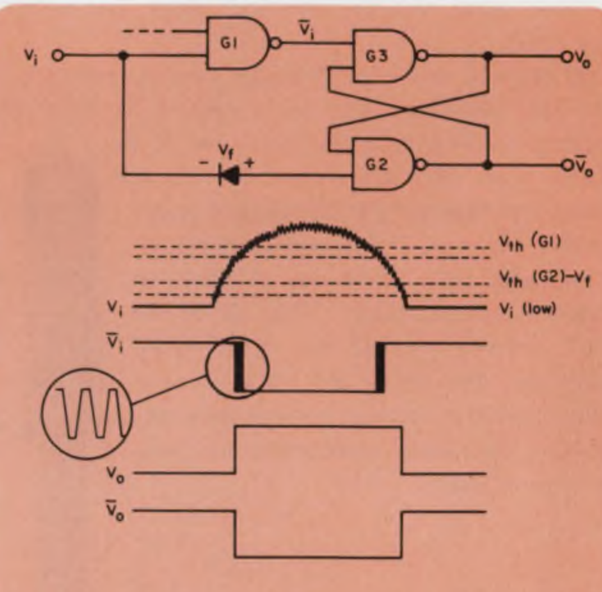
Noisy or slowly varying input signals can create unwanted oscillations at the outputs of digital logic elements. The digital hysteresis amplifier shown eliminates the oscillations by using the forward voltage drop across a diode to increase the hysteresis of a switching circuit.

In addition to the diode, the circuit uses only one quad or triple-gate IC. Unlike comparators and op amps used in a hysteresis configuration, this circuit needs only a single 5-V dc source.

There is no loss in the input low-level margin as might be expected (see waveforms); however, precautions must be taken to ensure that the sum of the diode forward voltage drop, V_f, and the low-voltage value of the input signal, $V_{i(low)}$, is below the switching threshold of gate G_2. The diode will tend to compensate for changes of this threshold with temperature.

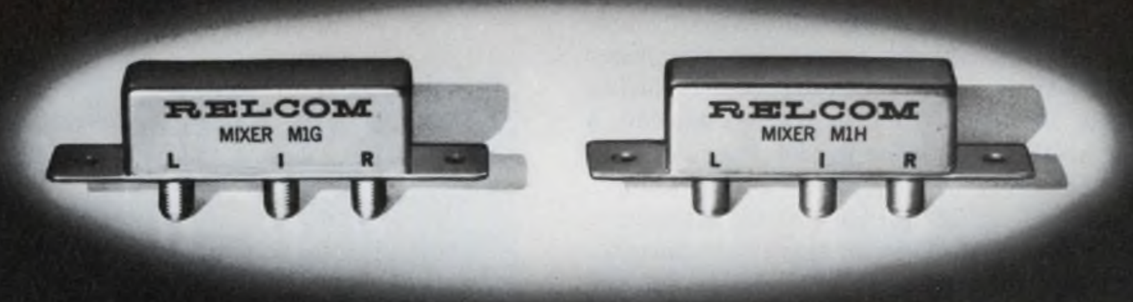
R. C. Nybo, Principal Engineer, Standards Engineering, Univac, Federal Systems Div., 322 N. 21 St. West, Salt Lake City, Utah 84116.

VOTE FOR 312



Clean output signals are obtained from slowly varying or noisy inputs with this digital hysteresis amplifier. Noise margin is not sacrificed.

MICROWAVE DOUBLE-BALANCED MIXERS



Model M1G
Inputs (L&R): 1–4.2 GHz
Output (I): DC–1 GHz

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INFORMATION RETRIEVAL NUMBER 40

Adding three components cuts regulator ripple

Simple regulator circuits provide two paths through which ripple and input variations can reach the error amplifier—and thus the output. One is through R_1 to the base of Q_2; the other is through R_2 to the collector of Q_1 (dashed portion of the illustration)

The first path can be easily eliminated by providing a constant-current source for the zener diode. The second path is removed by replacing the dashed circuitry with two resistors and a transistor as shown in color in the diagram.

To see how this arrangement works, assume that an error signal at the base of Q_1 has caused a change in I_{c1} of ΔI. This, in turn, will cause I_{c2} to change by ΔI, resulting in a change in the voltage drop across R_7 and, hence, a change in the bias of Q_4. This in turn, will change the current through R_8 by an amount $\Delta I(R_7/R_8)$.

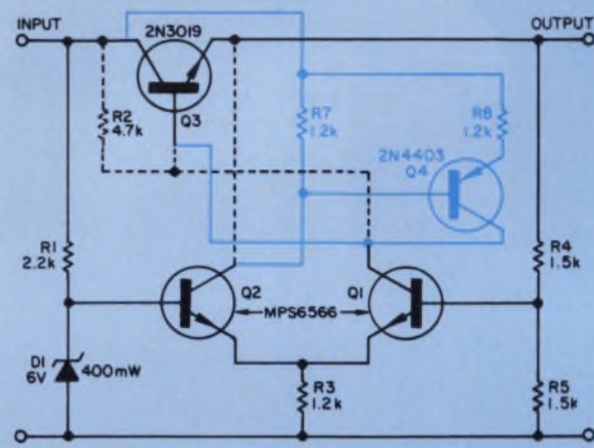
The change in current through the base of Q_3 will thus be equal to $\Delta I(1+R_7/R_8)$. If $R_7 = R_8$, the change will be $2\Delta I$. If R_3 is chosen equal to R_7 and R_8, current will be equally shared between Q_1 and Q_2. Changes in the input signal will appear across both R_7 and R_8 and not across the output.

Because of the very high gain of the circuit, it may be necessary to connect a small capacitor—about 1.0 nF—between the collectors of Q_1 and Q_2 to eliminate high-frequency oscillations.

The components shown in the diagram will provide a 12-V output at up to 100 mA for inputs of 18 to 30 V. The 2N3019 should be fitted to a suitable heat sink.

A. Johnstone, Chief Engineer, Electronic Consultants, P.O. Box 27, Stoke-on-Trent, England.

VOTE FOR 313

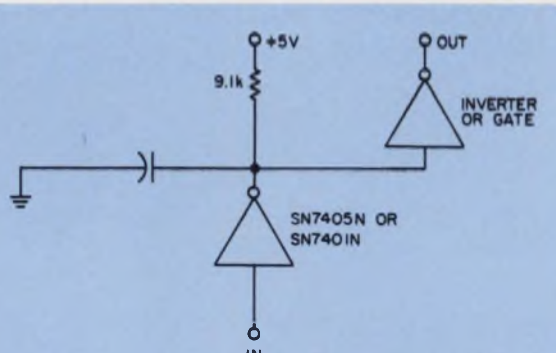


Output ripple is reduced when the dashed circuitry is replaced by that shown in color. This effectively eliminates the signal path from the input to the collector of transistor Q_1.

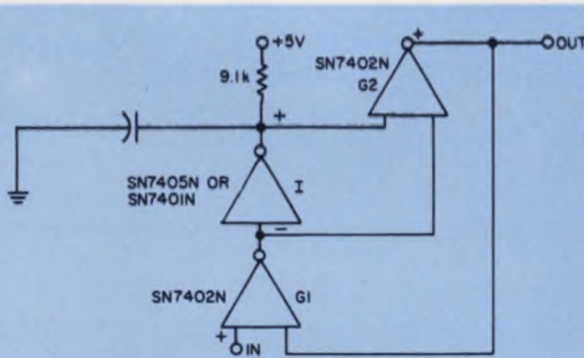
Get longer time delays with TTL ICs

Some pulse detector or limiter applications require time delays longer than is normally possible with TTL ICs. Delays of 1.5 ms/μF can be obtained by using the open collector versions shown in Fig. 1. The output is delayed by a specified time after the input is applied.

A further application of this delay method is shown in Fig. 2. With this configuration, an out-



1. **An adjustable time delay is obtained** by varying capacitor C. After an input signal is applied the output changes after a delay of 1.5 ms/μF.



2. **An output of specific time duration** is achieved in response to a pulse of unspecified length. This circuit is useful for pulse limiter applications.

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INFORMATION RETRIEVAL NUMBER 41

put of specific time duration is achieved in response to an input pulse of unspecified length.

Gate G_1 produces a ZERO output when a positive pulse is applied. This causes the outputs of gate G_2 to switch to the ONE state. The output of G_2 also latches G_1. At the same time the inverter switches to the ONE state, but not fast enough to affect the other input to G_2.

After the delay period, this second input to G_2 becomes positive, switching G_2 back to its normal ZERO state. The output of G_1 then becomes positive when both inputs are ZERO. The ZERO output of G_1 holds G_2 in the ZERO state.

W. M. Muehter, Engineering Consultant, American District Telegraph Co., 155 Sixth Ave., New York, N. Y. 10013.

VOTE FOR 314

Switch improves accuracy of op-amp comparator

The usual op-amp comparator with hysteresis (Fig. 1a), has input switching points that are functions of the output voltage, E_o. Since the two stable-point voltages of E_o are typically specified rather loosely, the switching-point accuracy is low.

The equation for the switching points is given by

$$E_i = \frac{E_o R_2/R_f}{1+(R_2/R_f)+(R_2/R_1)} + \frac{E_b R_2/R_1}{1+(R_2/R_f)+(R_2/R_1)}$$

where E_i is the input switching-point voltage and E_b is the bias voltage. Since the output voltage can assume two values, depending upon the state of the comparator, the equation gives two values for E_i.

To build a comparator with a higher degree of accuracy, a designer can use a controlled switch in the op-amp circuit (Fig. 1b). The switch, which is controlled by the output voltage, E_o, can be a saturating transistor or a FET. Since E_o is not fed back to the op amp's input, it does not affect the switching-point accuracy. Instead, the switching points are determined by the bias voltages E_{b1} and E_{b2} and by the quality of the switch. If the bias voltages are chosen so that

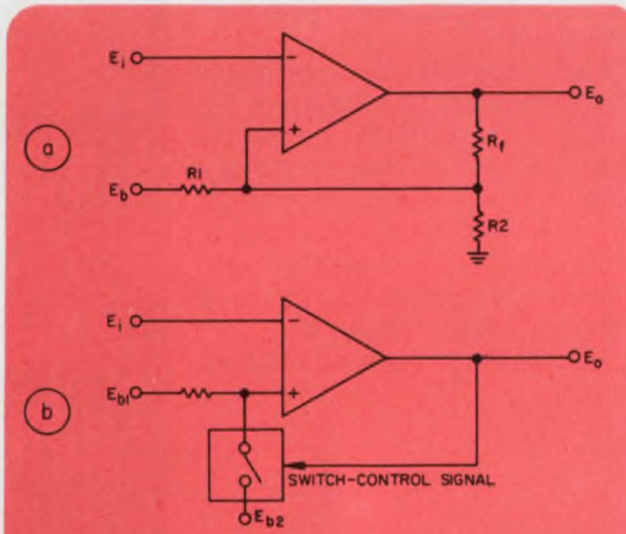
$$|E_{b1}| > |E_{b2}|,$$

then the comparator will exhibit hysteresis. If, however,

$$|E_{b1}| < |E_{b2}|,$$

the circuit will oscillate at a rate determined by the circuit's time constants.

A whole new world of application possibilities opens up if one or both of the bias voltages are allowed to vary and if a time delay is introduced between the comparator output and the switch. For example, the complex feedback networks used in some a/d converters and delta modulators consist of comparators, feedback step or ramp generators and timed or delayed switches. Simpler configurations can be used to make single-pulse generators and gated oscillators.



1. **Ordinary op-amp comparators (a) are not very accurate** because their switching points are functions of E_o, which is not tightly controlled. By using E_o to control a switch (b) a much more accurate and versatile circuit can be made.

To consider just one simple application of the circuit of Fig. 1b, it can be used to generate a square wave of period 2T if three conditions are met:

1. $|E_{b2}| > |E_i|_{max}$
2. sgn E_{b2} = sgn E_i
3. A delay of duration T is placed in the path of the switch-control signal.

The oscillations will be present as long as $|E_i| > |E_{b1}|$.

Acknowledgment: This research was performed at the Ordnance Research Laboratory under contract with the Naval Ordnance Systems Command.

Ralph M. Seeley, Ordnance Research Laboratory, Pennsylvania State University, P. O. Box 30, State College, Pa. 16801.

VOTE FOR 315

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INFORMATION RETRIEVAL NUMBER 42

Semiconductor trip circuit protects delicate circuitry

A semiconductor trip circuit eliminates the conventional-fuse problems of slow triggering and high resistance, thus effectively protecting semiconductor circuitry or sensitive instrumentation. Figure 1 shows a transistorized version of such a circuit.

The transistor Q_1 is saturated and provides a low and practically constant impedance path to ground for the network requiring protection. Transistor Q_2 is biased OFF through diode D_1. Saturation base current is supplied to Q_1 by the trip-adjust resistors R_2 through R_4. Resistor R_3 provides selection of the desired trip current.

When a short occurs, the collector of Q_1 rises above its saturation voltage because of the demand of unavailable current, and R_1 instantly saturates Q_2. Transistor Q_2 further limits current to Q_1, thus providing network protection.

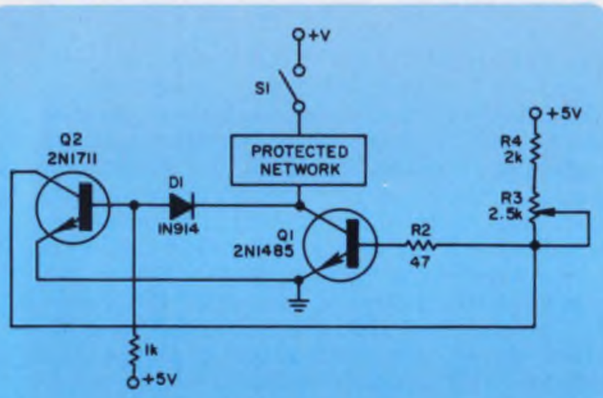
The trip circuit can be restored by pressing the normally closed reset switch S_1, which allows the slight bias on the base of Q_1 to turn it ON. D_1 is then forward-biased and Q_2 turns OFF. Note that the protected network can be powered by any positive voltage that is compatible with Q_1.

Figure 2 shows another way of implementing the trip circuit using an integrated circuit NAND gate. Switch S_1 activates the circuit by causing a logic 0 to be temporarily applied to G_1 via capacitor C_1. This causes the output of G_1 to go high. G_1 turns Q_1 ON to saturation through trip-point current-limiting resistors R_4 and R_5.

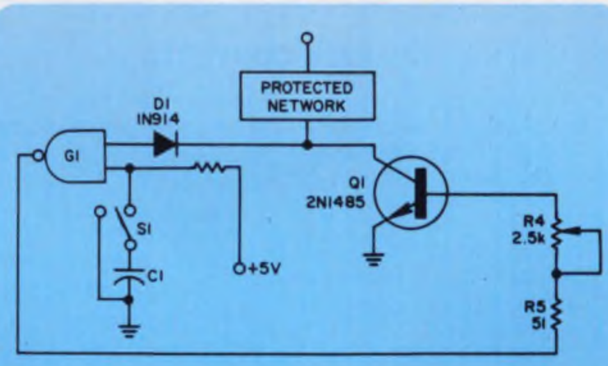
Diode D_1 is now forward biased, forcing the second input to G_1 to go low and sustaining the base bias to Q_1. If Q_1 is pulled out of saturation by excessive current demand, both inputs to G_1 are high, causing the low output from G_1 to bias Q_1 OFF and terminating the output current.

Alphonse H. Marsh, Jr., Senior Engineer, Raytheon Company, 111 Horse Pond Rd., Sudbury, Mass. 01776.

VOTE FOR 316



1. **Transistorized trip circuit protects semiconductor networks** without the speed and impedance drawbacks of conventional-fuse techniques.



2. **An integrated circuit NAND gate can also be used** to implement the high-speed trip circuit. The trip-point control resistors are R_4 and R_5.

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Output	See table. Output is floating; either positive or negative output terminal may be grounded. Zero to full load current ratings as shown in table.
Regulation	0.1% +5 mV NL-FL, ±0.1% ±5mV for 10% Input change.
Ripple	2mV RMS max., 20 mV P-P max.
Stability	Typically 10mV for eight hour period after initial warmup.
Temp. Coeff.	0.02%/°C max.
Output Impedance	DC-1KHz: 0.001 R_L or 0.005 ohm max. 1KHz-100KHz: 0.005R_L or 0.03 ohm max. (R_L is the rated load)
Transient Response	Output voltage returns to within regulation limits within 50 μsec in response to a 50% load step.
Remote Sensing	Terminals are provided to maintain regulation at the load, compensating for the DC voltage drop in the load cable.
Remote Voltage Adjustment	Output voltage may be remotely adjusted over a limited range by insertion of a variable resistor in the positive sensing line.
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Overvoltage Protection (Optional)	Any model can be furnished with overvoltage protection which crowbars the output in the event of a rise in the output voltage of between 1 to 2 Volts or 10-20% (whichever is larger). This protection circuit is completely independent of the supply and is adjustable. The addition of overvoltage protection does not add to the outline dimensions of the supply.
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Dimensions	See Table Below.

DIMENSIONS				
Case Size	H	W	L	Weight Approx. (Lbs.)
R1	3 3/16	4 15/16	6 1/4	4 1/2
R2	3 3/16	4 15/16	10	7 1/2
R3	4 15/16	4 15/16	10	12
Obtain ACDC outline drawing for design and mounting details.				

① NOMINAL OUTPUT VOLTAGE	ADJ. RANGE ±V	MAXIMUM CURRENT RATING (AMPS) 40°C	55°C	71°C	CASE SIZE	MODEL NUMBER (add -1 for OVP)	PRICE③ 10-24 PIECES (Add $10 for OVP)
4	.25	6.0	5.1	3.9	R1	OEM4N6	59.00
		11	9.3	7.1	R2	OEM4N11	84.00
		18	15.3	11.7	R3	OEM4N18	128.00
②5	**.25**	**5.7**	**4.8**	**3.7**	**R1**	**OEM5N5.7**	**59.00**
		10	**8.5**	**6.5**	**R2**	**OEM5N10**	**84.00**
		17	**14.5**	**11.0**	**R3**	**OEM5N17**	**128.00**
6	.25	5.2	4.4	3.4	R1	OEM6N5.2	59.00
		9.5	8.1	6.2	R2	OEM6N9.5	84.00
		15	12.7	9.7	R3	OEM6N15	128.00
8	.25	4.2	3.6	2.7	R1	OEM8N4.2	59.00
		7.5	6.4	4.9	R2	OEM8N7.5	84.00
		12	10.2	7.8	R3	OEM8N12	128.00
10	.5	3.5	3.0	2.3	R1	OEM10N3.5	59.00
		6.5	5.5	4.2	R2	OEM10N6.5	84.00
		10.2	8.6	6.6	R3	OEM10N10.2	128.00
②12	**.5**	**3.2**	**2.7**	**2.1**	**R1**	**OEM12N3.2**	**57.00**
		5.8	**4.9**	**3.8**	**R2**	**OEM12N5.8**	**76.00**
		9.5	**8.1**	**6.2**	**R3**	**OEM12N9.5**	**119.00**
14	.5	2.8	2.4	1.8	R1	OEM14N2.8	57.00
		5.2	4.4	3.4	R2	OEM14N5.2	76.00
		8.7	7.4	5.6	R3	OEM14N8.7	119.00
②15	**.5**	**2.7**	**2.3**	**1.7**	**R1**	**OEM15N2.7**	**57.00**
		5.0	**4.2**	**3.2**	**R2**	**OEM15N5**	**76.00**
		8.2	**7.0**	**5.3**	**R3**	**OEM15N8.2**	**119.00**
16	.5	2.6	2.2	1.7	R1	OEM16N2.6	57.00
		4.7	4.0	3.0	R2	OEM16N4.7	76.00
		7.7	6.5	5.0	R3	OEM16N7.7	119.00
18	.5	2.3	1.9	1.5	R1	OEM18N2.3	57.00
		4.2	3.6	2.7	R2	OEM18N4.2	76.00
		6.9	5.9	4.5	R3	OEM18N6.9	119.00
20	1	2.1	1.8	1.4	R1	OEM20N2.1	57.00
		3.8	3.2	2.5	R2	OEM20N3.8	76.00
		6.2	5.3	4.0	R3	OEM20N6.2	119.00
22	1	1.9	1.6	1.2	R1	OEM22N1.9	57.00
		3.6	3.1	2.3	R2	OEM22N3.6	76.00
		5.9	5.0	3.8	R3	OEM22N5.9	119.00
②24	**1**	**1.8**	**1.5**	**1.2**	**R1**	**OEM24N1.8**	**57.00**
		3.3	**2.8**	**2.1**	**R2**	**OEM24N3.3**	**76.00**
		5.4	**4.6**	**3.5**	**R3**	**OEM24N5.4**	**115.00**
26	1	1.7	1.4	1.1	R1	OEM26N1.7	57.00
		3.1	2.6	2.0	R2	OEM26N3.1	76.00
		5.0	4.2	3.2	R3	OEM26N5.0	115.00
②28	**1**	**1.6**	**1.4**	**1.0**	**R1**	**OEM28N1.6**	**57.00**
		2.9	**2.5**	**1.9**	**R2**	**OEM28N2.9**	**76.00**
		4.7	**4.0**	**3.1**	**R3**	**OEM28N4.7**	**115.00**
30	1	1.5	1.3	1.0	R1	OEM30N1.5	57.00
		2.7	2.3	1.8	R2	OEM30N2.7	76.00
		4.5	3.8	2.9	R3	OEM30N4.5	115.00
32	1	1.4	1.2	0.9	R1	OEM32N1.4	57.00
		2.5	2.1	1.6	R2	OEM32N2.5	76.00
		4.3	3.6	2.8	R3	OEM32N4.3	115.00

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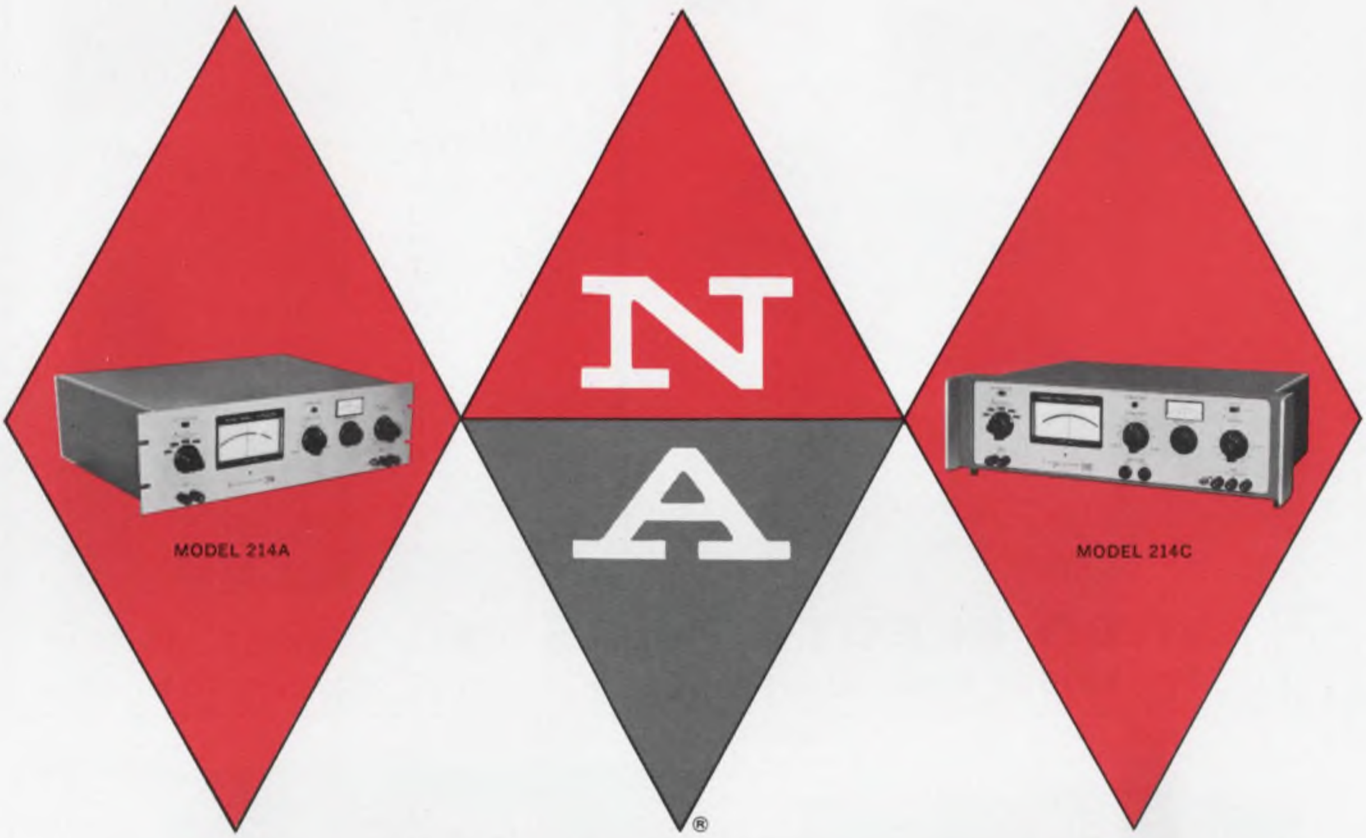

CAN YOU THINK OF A BETTER ANGLE TO AVOID OBSOLESCENCE?

North Atlantic's 214 FOUR-FREQUENCY PHASE ANGLE VOLTMETER introduces a new flexibility in AC voltage measurements. It enables direct reading of null balance, total voltage, fundamental voltage, in-phase voltage, quadrature voltage, and phase angle.

It's also pre-wired to handle four operating frequencies from 30Hz to 20kHz, which means extended longevity and broader application. Even if you only need one frequency, there are three extra spots to add other frequencies later. Frequency changes can be made rapidly and conveniently in the field with plug-in modules. The 214 can be completely recalibrated at the installation site by a single rear-panel adjustment.

Harmonic rejection and high signal overload design of the unit screens out conventional distortion and errors in measurement and calibration. The all solid-state Model 214 offers full accuracy over $\pm 5\%$ bandwidth, 1° phase measurement, adjustable meter scaling for go/no-go testing, and 300 μV full-scale sensitivity. Priced from $1215.00.

Options? Other models offer 0.25° phase accuracy, lower-cost single frequency operation, broadband phase-sensitive performance from 10Hz to 100kHz.

Whether your AC measurements are large or small, contact your North Atlantic sales engineering representative today. He'll show you a new angle to your AC voltage measurements.

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INFORMATION RETRIEVAL NUMBER 43

INFORMATION RETRIEVAL NUMBER 44

INFORMATION RETRIEVAL NUMBER 45

INFORMATION RETRIEVAL NUMBER 46

Flexible scope system with 9 plug-ins allows economical measurements

Tektronix, Inc., P. O. Box 500, Beaverton, Ore. Phone: (503) 644-0161. P&A: see text; stock to 2 months.

Offering the user flexibility and the ability to economically choose a professional measurement system compatible with his needs, a new dc-to-2-MHz low-cost modular oscilloscope system includes four interchangeable displays for single and dual-beam storage and non-storage applications, six amplifier and three time-base plug-ins for high-gain and delayed-sweep measurements, one to four-trace capability, X-Y or Y-T operation and the mobility of changing from a bench-top to a rack-mount system.

The new system includes the $220 5103N mainframe which contains a power supply/amplifier module with three plug-in compartments; the single-beam $320 D10 and dual-beam $650 D12 non-storage display modules, each with a 6-1/2-in. CRT; the single-beam $800 D11 and dual-beam $1150 D13 storage units, each also with a 6-1/2-in. CRT.

The $115 5A15N and $265 5A18N are single and dual-trace 2-MHz 1-mV/division amplifier plug-ins; The $165 5A20N is a 1-MHz 50-$\mu$V/division single-trace differential plug-in and the $185 5A21N is a 1-MHz 50-$\mu$V/division and 0.5-mA/division single-trace differential plug-in for voltage and current measurements. The $65 5A23N is a 10-mV/division single-trace 1-MHz plug-in and the $25 5A24N is a 50-mV/division single-trace plug-in.

Rounding out the system are the single sweep $175 5B10N and the single and dual-sweep $550 5B12N time-base units with normal and delayed-sweep features, respectively. The former operates over a sweep-rate range of 1 μs/divsion to 5 s/division and the latter over a sweep rate of 100 ns/division to 5 s/division. The $85 5B13N single-sweep unit operates over 5 μs/division to 0.5 s/division.

The 5103N mainframe module contains the low-voltage power supplies, the vertical and horizontal amplifiers and the electronic switching and logic circuitry for dual-trace or dual-beam operation. Chopped and alternate modes are selected from the time-base plug-ins. The mainframe also contains all the interconnections for interchanging the display modules.

The four display modules feature CRTs with 8 $\times$ 10 divisions at 1/2 in./division. All have internal graticules. P31 phosphor is standard for the non-storage units and a phosphor similar to P1 phosphor is standard for the storage units.

New oscilloscope system shows bench-top version with two amplifier and one time-base plug-in.

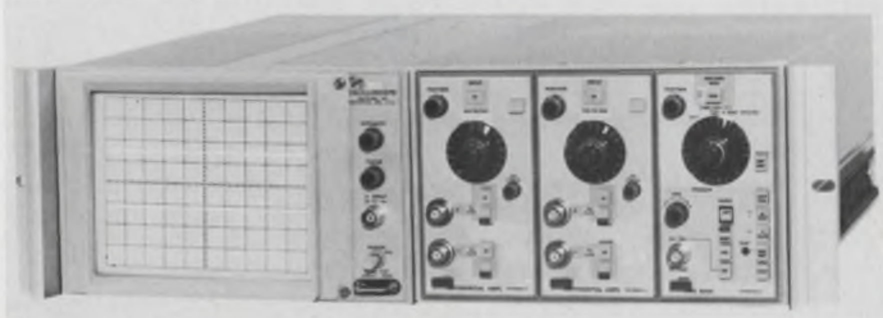
The display modules include the power switch, a voltage-current time calibrator, a beam finder, related CRT display controls and a dc-coupled Z-axis input.

The D11 single-beam storage display unit has a bi-stable split-screen storage CRT with increased light output, particularly in the stored mode. A brightness control allows the user to vary the stored brightness level. By adjusting this level, the CRT retains the information for as long as several hours. The stored brightness control in conjunction with other storage controls also increases the effective CRT writing rate.

The D13 storage display has all the storage features of the D11 storage display and differs only in that it is a dual-beam unit. The D12 dual-beam non-storage display is the same as the D10 single-beam non-storage display except that it's CRT has two writing guns and two pairs of vertical deflection plates.

A new improved scale-factor readout is provided by backlighted skirted knobs which automatically switch to the correct reading when using the recommended 10X

(Continued on page 84)



Versatile oscilloscope system converts easily into a rack-mount version with the display unit alongside two amplifier and one time-base plug-in.

(Continued from page 83)
probes and X10 magnifier. The readout goes off when a plug-in is not used and remains off until a plug-in or a channel is placed into operation.

Up to four simultaneous traces can be selected with the amplifier plug-ins, while a chopped or alternate display mode is selected on the time base. Pressing the display pushbutton on the amplifiers places the left, center or both plug-ins into use.

The ability to simultaneously use different types of amplifier plug-ins such as high-gain-differential and dual-trace plug-ins expands performance by removing the limitation imposed by only switching between channels on a dual-trace amplifier.

By using the amplifier input of the time base or inserting a vertical amplifier plug-in into the horizontal plug-in compartment, the system converts into an X-Y oscilloscope. A time-base plug-in into the left amplifier compartment solves applications requiring a vertically oriented sweep. Channel switching between left and center plug-ins is accomplished in the mainframe with logic commands generated in the plug-ins.

The 5B10N single-sweep time-base plug-in includes full-frequency triggering, 10-times magnification and a calibrated compensated amplifier with inputs of 50 and 500 mV/division for X-Y operation. The 5B12N has dual delaying sweeps with independent sweeps for simultaneous time measurements at different sweep rates. The dual sweep operates in an alternate or chopped mode.

When two vertical amplifiers are used with the 5B12N in the dual-sweep mode, the A and B sweeps are slaved to the left and center plug-ins, respectively. The 5B12N also operates as a high-performance delaying sweep plug-in.

All plug-ins in the 5103N system stress simplicity of design and operating ease. Logical grouping of controls and the use of color-coded panel markings by function is used throughout. For conversion from bench-top to rack-mount systems, a kit is available.

CIRCLE NO. 250

Battery-powered scope responds to 35 MHz

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000. P&A: $1850 (plus $200 for battery pack); January, 1971.

The new model 1701A dual-trace oscilloscope with delayed sweep, a 6 by 10-cm display and a frequency range of dc to 35 MHz operates from a rechargeable battery pack which draws only 18 W of power for up to 6 h of operation on a single charge. The new scope weighs only 35 lbs and also operates from 115/230 V ac.

CIRCLE NO. 251

Table-top analyzer diagnoses digital ICs

Signetics Corp. Measurement Data, 341 Moffet Blvd., Mountain View, Calif. Phone: (415) 961-9384. P&A: $450; 60 days.

Complete analysis of failure causes in digital ICs can be made with the new table-top Function Analyzer. The instrument diagnoses specific digital IC malfunctions by operating as an accessory to the model 1110 digital IC tester. Indicators on the Function Analyzer's front panel show the type, mode and state of IC failure.

CIRCLE NO. 252

Programmable sources enhance interfacing

John Fluke Mfg. Co., Inc., P. O. Box 7428, Seattle, Wash. Phone: (206) 774-2211. Price: $895, $1195, $895, $1195.

Four new programmable sources interface digital and analog circuits. The 4210A and 4250A have 0 to ±10-V outputs in 1-mV increments at 100 mA and 1 A, respectively. The latter also has a 0 to ±50-V 10-mV-increment output. The 4216A and 4265A have 0 to ±16.383-V outputs in 1-mV increments at 100 mA and 1A, respectively. The latter also have a 0 to ±65.532-V 4-mV-increment output.

CIRCLE NO. 253

500-MHz counter has a $1445 price

Atec, Inc., 1125 Lumpkin St., Houston, Tex. Phone: (713) 468-7971. P&A: $1445; stock.

Spanning the frequency range of 10 Hz to 500 MHz, the 4058 seven-digit low-cost frequency counter with an input sensitivity of 100 mV rms and an input impedance of 50 Ω at 500 MHz and 1 MΩ shunted by 50 pF at 5 MHz features a price of only $1445.

Its solid-state construction insures instant-on operation and it uses a highly stable 1-MHz crystal oscillator with a stability of ±4 parts per 10^7 per month for all combinations of aging, temperature variations of ±10°C at room temperature and power-supply voltage variations of ±10% at 115 V ac.

Another important feature of the 4058 counter is a maximum input voltage of 5 V rms. In the event that the 5-V amplitude is inadvertently exceeded, a lamp indication is given on the front panel of the counter.

Three selectable readout resolutions of 1, 10 and 100 Hz are provided for the high-frequency channel and 0.1, 1 and 10 Hz for the low-frequency channel. Accuracy for either channel is ±1 count ±the time-base accuracy.

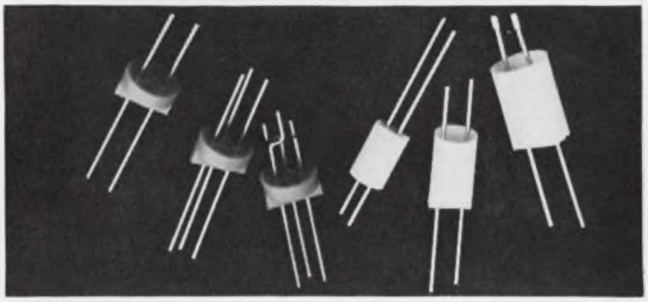
Display time is continuously adjustable from 0.2 to approximately 5 s. A hold provision allows infinite display time until the counter is manually reset.

The 4058 counter is available in a half-rack configuration and measures 3-1/2 by 8-1/2 by 12 in. Its total weight including its instrument stand and a carrying strap is only 6 lbs.

For an additional price of $35, optional BCD output is available in 1-2-4-8 formats.

CIRCLE NO. 254

Plastic Cheaper Than Gold?



Lots cheaper. That's why you can encapsulate LEDs and photo cells on GE plastic headers for up to 25% less than gold plated, solder sealed cans. Reliable enough to replace many hermetically sealed devices in non-critical applications, standard headers are available off-the-shelf for $10 per M and lower. Design and production capability for your own special types too. Plug-in or solder to circuit boards. Bipin bases shown on right ideal for photo cells. Headers (left) come with several options on twist, form, and number of lead wires. Write today or call today for more information.

General Electric Company, Lamp Metals and Components Department, 21800 Tungsten Road, Cleveland, Ohio 44117
Telephone: (216) 266-3942

GENERAL ELECTRIC

INFORMATION RETRIEVAL NUMBER 47

ALCO LITE OFFERS MORE

PANEL INDICATORS

Miniature incandescent lamp assemblies have 5V 60 ma. rating, and 100,000-hr. life. Its sealed plastic assembly contains a T-1 #680 lamp. Mounting ring is included. Choice of 5 colors, pins or leads.

ALCO ELECTRONIC PRODUCTS, LAWRENCE, MASS.

INFORMATION RETRIEVAL NUMBER 48

THINK DIGITAL

NEON READOUT DRIVER MODULE

USES ELFIN* 7-SEGMENT DISPLAY TUBE

Factory assembled Elfin readout modules with built-in decoder-drivers are ready to plug into your systems. Choice of decoder-drivers or with memory, counter. Model DM-17G-721

13.62 IN 500 LOTS

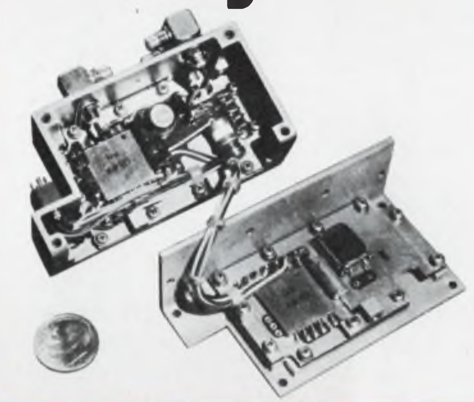
ALCO LAWRENCE, MASS.

* Manufactured Under a License By Burroughs Corp.

INFORMATION RETRIEVAL NUMBER 49

Good News: Your "Make or Buy" Problems are solved!

Custom Miniaturized Sub-Systems



Give CTI your Black Box Function and QC Requirements. Then relax!

CTI will do the whole job for you. Completely. Right from the beginning. Right the first time.

With the complete sub-system designed, miniaturized, packaged, tested, ready to go to work. And delivered, as promised, on time.

Is it expensive to go this route? Not at all. You'll be amazed how inexpensive it is compared to making it in-house. In fact, it is the only way to go these days if you're going to remain competitive!

How does CTI do it? By using a unique combination of talents. • Top circuit engineering • Established-quality micro-circuit production (to MIL Std 883) • Innovative packaging capability, with the optimum combination of thick-film, monolithic and discrete components for maximum economy and performance • Quick turn-around.

CustomHybrid + Hybrid + Hybrid + Hybrid = SubSystems

See how great it is to do business with the Leader!

On the East Coast, call: Mel Spitz (516) 293-8686.

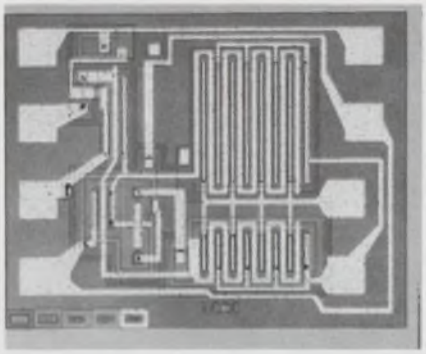
In the Mid-West, call: Bryan Geyer (502) 425-5434.

On the Pacific Coast, call: Syl Cole (213) 372-8419.

CIRCUIT TECHNOLOGY INCORPORATED
160 Smith St., Farmingdale, N.Y. 11735

INFORMATION RETRIEVAL NUMBER 50

Fast complementary switch handles ±10-V analog signals



Siliconix, Inc., 2201 Laurelwood Rd., Santa Clara, Calif. Phone: (408) 246-8000. P&A: $5.10, $3.50 (for 100-unit quantities); stock.

Featuring a switching time of 50 to 80 ns, a complementary metal oxide silicon (CMOS) switch can handle an analog signal range of ±10 V equal to the supply voltage range and exhibits only 60 Ω of ON resistance at a signal modulation of 20%.

The G150 switch, which has low feedthrough capacitance and microwatt power dissipation, incorporates both n and p-channel MOS transistors on the same substrate.

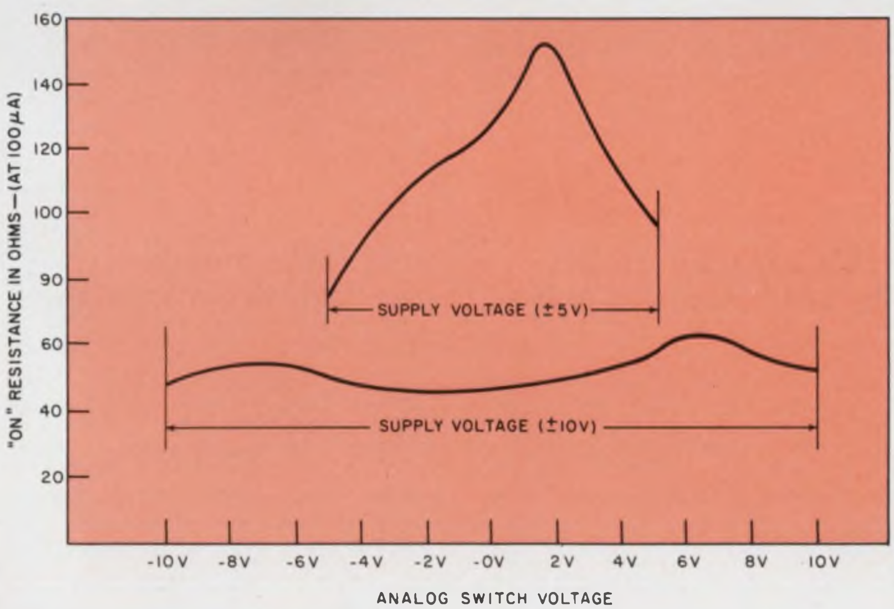
The n and p-channel transistors are used in a parallel combination. Since they turn ON with opposite-polarity signals, varying the analog voltage increases the drive to one transistor while decreasing it to the other. Thus one of the paralleled transistors is always ON, even though the analog voltage reaches the supply voltage level.

The use of n and p-channel transistors also reduces the modulation of ON resistance as the analog signal is varied. This reduction occurs because the ON resistance of one transistor increases while the ON resistance of the other transistor decreases, leaving the parallel combination nearly constant.

The switch includes a built-in inverter to provide opposite-polarity signals to the n and p-channel devices which are used in such a way that only one of the two devices is conducting in either quiescent state.

Two models are available: the G150AA for the temperature range of −55 to +125°C and the G150DA for the temperature range of −55 to +85°C. Future models are expected to have the capability of handling ±15 V analog signals.

CIRCLE NO. 255



Typical switch ON resistance as a function of the applied analog voltage for the ±10-V range (lower curve) and the ±5-V range (upper curve).

14-lead flatpacks have three 741 op amps

Mini-Systems, Inc., Washington Park, N. Attleboro, Mass. Phone: (617) 695-0206.

Providing circuit designers with multiple-amplification functions out of a tiny package, a new 1/4-in. hermetic flatpack comes complete with three μA741 operational amplifiers in the same case. The case is a TO-86 14-lead flatpack.

CIRCLE NO. 256

Field-effect transistors cost just one dollar

General Instrument Corp., 600 W John St., Hicksville, N. Y. Phone: (516) 733-3333. Price: $1, $1.10.

Two new low-cost FETs, the NEM655 and the NEM614, retail in 100-unit quantities at $1 and $1.10 each, respectively. The former is designed for use in TV and FM tuners and i-f, SSB and wideband amplifiers. The latter is also for use in wideband amplifiers.

CIRCLE NO. 257

Compensated op amp comes on a film-strip

General Electric, Integrated Circuit Products Dept., Electronics Park, Syracuse, N. Y. Phone: (315) 456-0123. P&A: $2.25 (100 to 999); stock.

The GEL 1741 is an internally compensated operational amplifier that is available in the new mini-Mod film-strip package. The package is formed by attaching a silicon IC pellet to a film-strip lead frame.

CIRCLE NO. 258

JAN varactor diodes have Q values of 350

Teledyne Crystalonics, 147 Sherman St., Cambridge, Mass. Phone: (617) 491-1670. P&A: $5.60 (1 to 99), $3.75 (100 to 999); stock.

A new line of JAN-approved voltage-variable capacitance diodes features Q values (at −4 V) as high as 350. Designated as the Varactron series JAN IN5139A to IN5148A, they also feature ratings of 60 V dc and low leakage.

CIRCLE NO. 259

256-bit bipolar PROM has 25-ns delay time

Harris Semiconductor, Melbourne, Fla. Phone: (305) 727-5412. P&A: $30.75; $23.50; stock.

A new 256-bit bipolar programmable read-only memory features a worst-case address-to-output propagation delay of 50 ns, and 25 ns when using the chip enable. The HROM-1256 is fully decoded on the chip.

CIRCLE NO. 260

Power transistors handle 50 amperes

Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. Phone: (305) 848-4311. Availability: 2 to 4 wks.

The SDT2205 (MT23 case) and SDT2305 (TO-68 case) germanium transistors feature typical collector-to-emitter voltages (sat.) as low as 0.075 V and collector currents up to 50 A. Typical common-emitter forward current gain is 120.

CIRCLE NO. 261

IC Schmitt trigger drives 50-mA loads

Amperex Electronic Corp., Integrated Circuits Div., Cranston, R. I. Phone: (401) 737-3200. Price: 40¢ (25,000-unit quantities).

A new silicon monolithic IC Schmitt trigger provides up to 50 mA of output current to drive large loads without further amplification. TAA560 consists of a Darlington input that operates as a low-current Schmitt trigger.

CIRCLE NO. 262

TTL/MSI counters are fully programmable

Texas Instruments, Inc., 13500 N. Central Expressway, Dallas, Tex. Phone: (214) 238-2011. P&A: from $3.24; stock.

Two new TTL/MSI asynchronous counters are the dc-coupled SN54/74196 decade counter and SN54/74197 binary counter which are fully programmable. Both are guaranteed to count input frequencies of 0 to 50 MHz.

CIRCLE NO. 263

Tape cassette transport operates at 30 in./s

Redactron Corp., 100 Parkway Dr. S., Hauppauge, N. Y. Phone (516) 543-8700.

A new magnetic-tape cassette transport for data capture operates at 30-in./s when reading, writing, rewinding and searching. It is a read-after-write unit with a write gap that is 10% greater than the full width of the tape. The instantaneous transfer rate is 1800 characters/s and the average transfer rate with 110-character blocks is 1000 charcters/s.

CIRCLE NO. 264

16-bit data coupler converts BCD to ASCII

Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. Phone: (714) 871-4848.

The Auto-Pro 3109 Intercoupler converts 16-bit digital BCD inputs into ASCII formats. It is suitable for operation with ASR Teletypewriters and provides an output in a direct-entry format for most data processors. Two types of controls are available: front-panel pushbuttons and remote-control through external contact closures to ground.

CIRCLE NO. 265

Read/write memory interchanges ROM

Unicom, Inc., 1275 Bloomfield Ave., Fairfield, N. J. Phone: (201) 228-1696.

The UI-1011 is a read/write memory that is interchangeable with a read-only memory. This interchangeability allows the user to write and debug his program using the UI-1011 read/write memory. When satisfied that his program is correct, he can have a read-only memory made with the correct memory contents.

CIRCLE NO. 266

Solid-state displays mount on PC boards

Bowmar/Canada Ltd., div. of Bowmar Instrument Corp., 1257 Algoma Rd., Ottawa, Ontario, Canada. Phone: (613) 746-3100.

Either 0.11 or 0.19 in. in height, two new solid-state displays come in flatpack configurations, making them ideally suited for printed circuit mounting. Models R7M-111 and R7M-191 are totally monolithic seven-segment semiconductor readouts with decimal point included. They light with an output illumination of 100 ft-L per segment at 10 mA.

CIRCLE NO. 267

Power op amps put forth 300 W

Analog Devices, Inc., 221 Fifth St., Cambridge, Mass. Phone: (617) 492-6000. P&A: $176, $122; stock.

Two new power operational amplifiers, designated models 408 and 409, develop 110 and 300 W of output power, respectively, and can internally dissipate 50 and 400 W, respectively. Both amplifiers measure 4.7 by 2.8 by 0.75 in. and feature electrically insulated integral heat sinks. Model 408 develops an output of ±22 V at 5 A while model 409 produces ±20 V at 15 A.

CIRCLE NO. 268

15-bit a/d converter has 0.01% accuracy

Analogic Corp., Audubon Rd., Wakefield, Mass. Phone: (617) 246-0300. P&A: $2000; 4 to 8 wks.

Measuring 48 in.^{3}, the AN2715M 15-bit a/d converter offers 0.01% absolute accuracy and linearity to 0.002%. Conversion speed is user-adjustable from 0.5 to 1.1 μs/bit. The AN2715M is available with inputs of +10 V or ±10 V.

CIRCLE NO. 269

Programmable supply provides 3 HV outputs

Bertran Assoc., Inc., 15 Newton Rd., Plainview, N. Y. Phone: (516) 293-3340. P&A: $685; stock.

The model 620 is a triple-output precision programmable high-voltage power supply that provides an anode supply of up to 20 kV dc, a focus supply which is remotely programmable to 5 kV dc and a grid supply of up to 500 V dc. All three supplies are highly regulated for line and load conditions and feature stability and low ripple. Programming is accomplished at low-voltage levels.

CIRCLE NO. 270

Sample/hold module is ±0.025% accurate

Varadyne Systems, 1020 Turnpike St., Canton, Mass. Phone: (617) 828-6395. P&A: $110; stock.

Model SHM-1 sample-and-hold module is a 1 by 2 by 0.4-in. device capable of tracking a full-scale ±10-V analog input in less than 5 μs to within an accuracy of ±0.025% of the full-scale output. Other features include frequency response of 200 kHz, aperture uncertainty of less than 50 ns and hold-delay time of 1 ms for 1 mV. Input impedance is 100 MΩ and temperature coefficient is ±20 ppm/°C.

CIRCLE NO. 271

Fast 60-W op amp slews at 25 V/μs

Torque Systems, Inc., 225 Crescent St., Waltham, Mass. Phone: (617) 891-0230. P&A: $85; stock.

A new high-speed 60-W class-B operational amplifier for driving CRT sweeps features a slew rate of 25 V/μs. The model PA-131 includes output currents to ±3 A at voltages to ±20 V, built-in current limiting and short-circuit protection. It also features high open-loop gain of up to 20,000 permitting full-load compensation capability. The new operational amplifier is packaged in a sealed 1.8 by 3.5 by 0.47-in. case.

CIRCLE NO. 272

Unitized switches form 150 stations

International Electro Exchange Corp., 6851 Oxford St., Minneapolis, Minn. Phone: (612) 929-7875.

A new unitized switch design permits construction of versatile pushbutton switches with up to 150 stations. The switches are totally enclosed contact modules with up to 8pdt contacts. Any combination of individual switch functions is available. Shorting or non-shorting 2-A bifurcated contacts are included. A printed-circuit connector is available for rear wiring.

CIRCLE NO. 273

60-V/μs FET op-amp settles in 1 μs

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. Phone: (602) 294-1431. P&A: $37; stock.

Model 3402 fast-settling FET operational amplifier settles in 1 μs to final value ±0.01% and slews at a minimum rate of 60 V/μs. The 3402 is packaged in a 1.12 by 1.12 by 0.4-in. case and has a 20-mA output current rating. Open-loop response rolls off at 6 dB/octave and open-loop gain is 100 dB. Unity-gain bandwidth is 10 MHz.

CIRCLE NO. 274

Three hybrid op amps cut bias to 2 x 10^{-15} A

Bell & Howell Control Products Div., 706 Bostwick Ave., Bridgeport, Conn. Phone: (203) 368-6751. Price: $25, $50, $13.

Three new hybrid operational amplifiers are the F-318 with an input bias current of 200 femtoamps, the C-238 with a slew rate of 80 V/μs and settling time to 0.01% of 1 μs, and the low-cost C-118 with 5 pA of bias current.

CIRCLE NO. 275

Flatpack connectors ignore soldering/drilling

Teledyne Kinetics, 410 S. Cedras Ave., Solana Beach, Calif. Phone: (714) 755-1181.

Flatpacks can now be installed on PC boards without soldering or hole drilling by using the new Becon Carrier connectors. They can mount and connect seven 10-lead or five 14-lead flatpacks (or a mixture of both) to PC boards of any thickness. Individual flatpacks can be changed without de-soldering, or the entire connector removed to a new board at any time.

CIRCLE NO. 276

Cassette wiring unit displays instructions

Monitron, Inc., Concord Airport, Concord, N. H. Phone: (603) 225-6625. P&A: $1000; 30 days.

The MI105 instruction display unit provides a cassette-tape-to-alphanumeric presentation of a sequence of instruction to aid assembly and wiring. Wiring data is digitally recorded on magnetic tape in cassette form and displayed in sequence as required by the operator. Each wire instruction is independently presented and the operator output is counted and displayed.

CIRCLE NO. 277

Fast wafer sectioner has 10^{-6}-in. tolerance

PhilTec Instrument Co., 620 Carpenter Lane, Philadelphia, Pa. Phone: (215) VE-6-5133. P&A: $1275; 2 wks.

The model 2015 Gaugematic wafer sectioning system provides all necessary functions for measurement of deposited layers at any stage of wafer processing within 2 minutes of operator time and down to a repeatable tolerance of $\pm 10^{-6}$ in. The system features an instant-loading chuck, uses no vacuum or bonding agents, has mechanical clamping and sections wafers from 5/16 to 2 in.

CIRCLE NO. 278

6-GHz oscillator diode pulses out 100 W

Microwave Diode Corp., 467 Merrimac St., Newburyport, Mass. Phone: (617) 462-7462. P&A: $67.50; stock.

The MD632 is a self-pulsing oscillator diode using the trapatt mode of oscillation with a dc current bias of 1 to 2 ma applied in the reverse direction for outputs of 50 to 100 W of pulsed power. Due to its low input power requirement, no special heat sinking is required. PIV is 250 V and the range of oscillations is from 200 MHz to 6 GHz. Capacitance at no reverse voltage is 8 pF.

CIRCLE NO. 279

Tiny 75-Ω T pad works 0 to 300 MHz

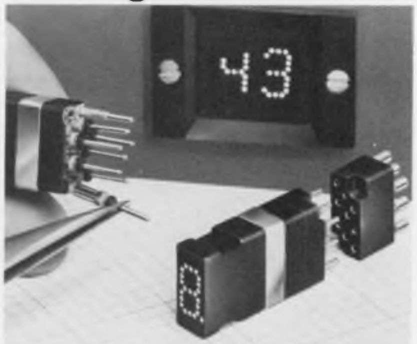
Aerovox Corp., 740 Belleville Ave., New Bedford, Mass. Phone: (617) 994-9661.

Distortion-free ac signals over 0 to 300 MHz for CATV or audio-distribution systems are now provided by a new 75-Ω plug-in T pad only 0.375-in. in dia and 0.473-in. high. Incorporating a thick-film cermet resistive element, it provides minimum inductance with improved stability. It is available in a range of 11 values from 0 to 15 dB. Tolerances are ±0.05 to ±1 dB.

CIRCLE NO. 280

COMPONENTS

Fiber-optic readout has large characters



Master Specialties Co., 1640 Monrovia, Costa Mesa, Calif. Phone: (714) 642-2427. P&A: approx. $20; 3 wks.

A new miniature plug-in 7-segment readout utilizes 30-mil-dia optical fibers to transmit light to a 0.32-in.-high by 0.19-in.-wide character pattern. The 903 readout has a low power requirement of 5 V at 20 mA per segment and produces sharp and bright character patterns at more than 100 foot lamberts. Push-pin connector blocks are available for pre-wiring ease.

CIRCLE NO. 281

Wire-wound resistor dissipates 1000 W

Dale Electronics, Inc., Box 609, Columbus, Neb. Phone: (402) 364-3131.

The SPR-574 wire-wound resistor can be internally water cooled to dissipate up to 1000 W. Without water cooling it will dissipate up to 500 watts at 25°C ambient. It is designed for use as a shunt or dummy load and ranges in tolerance from ±0.05% to +5%. Available resistances cover 0.1 Ω to 500 kΩ. Temperature coefficient is ±20 ppm for standard units and +5 ppm for special units.

CIRCLE NO. 282

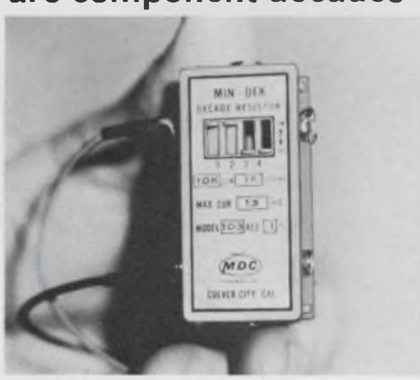
GaAsP panel lights snap-in with clips

Monsanto Electronic Special Products, 10131 Bubb Rd., Cupertino, Calif. Phone: (408) 257-2140. P&A: $1.65; stock.

The MV5020 series of low-cost GaAsP panel lights with an operational lifetime of 10^6 h easily mount in 1/16 to 1/8-in. thick panels with only plastic snap-in clips and require no extra mounting hardware. Four models are distinguished by their lenses: clear, diffused, clear red and diffused red. Output is 750 foot-lamberts at 2 V and 20 mA.

CIRCLE NO. 283

Match-box-size units are component decades



MDC Instruments, Inc., 11822 W. Jefferson Blvd., Culver City, Calif. Phone: (213) 391-8308. Price: $9.50 to $18.

Called Min-Deks, a new line of match-box-size decade components include switch-selectable resistors, capacitors, potentiometers, attenuators, four-terminal shunts and transistor substitution units. Measuring 2 by 1 by 1/2 in., Min-Deks may be connected in series, in parallel or in branching networks by simply snapping them together.

CIRCLE NO. 284

evaluation samples

PC-card handles

A series of three attractive plastic printed-circuit card handles are available in a variety of colors to suit the requirements of most equipment. Two of the handles, models 10035 and 10037 have a specially designed clip-on feature which enables them to be assembled into a PC board without any mounting hardware since they snap into pre-drilled holes on the PC board. The former is used with PC boards mounted at a minimum pitch of 0.25 in. while the latter is used with boards at a minimum pitch of 0.4 in. The third series is the model 10035 which attaches to PC boards by means of two screws or bolts. It is used with PC boards mounted at a minimum pitch of 0.35 in. All three handles have card-identification provisions. Free samples are available. Vero Electronics, Inc.

CIRCLE NO. 285

Harness mount

The new SCMS-P swivel clip-on mount fits on a harness band by attaching clips to lightening holes and on edges of sheet metal to hold the harness away from sharp edges. The mount is used with any miniature, intermediate or standard cross-section cable ties. The mount may be swiveled in any direction. Panduit Corp.

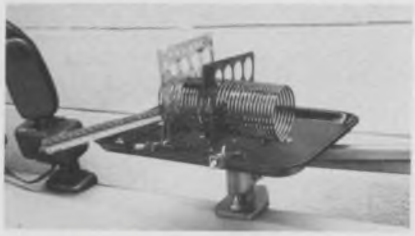
CIRCLE NO. 286

Magnetic materials

A new Alnico permanent-magnet material with a higher energy product than any currently available Alnico 8 is available in evaluation samples. New high-energy Alnico 8HE offers a typical energy product of 6 million, which results in a flux 10% greater than Alnico 8 materials. It is particularly suitable for applications requiring the magnet material to operate at or above the knee of the magnitizing curve. Indiana General.

CIRCLE NO. 287

design aids



Drafting aid

A new caddy permits art or drafting tools to be always within easy reach of a draftsman without covering or being covered by work on the drafting table. The Caddy consists of a tray on a folding arm which permits organizing of drafting implements and positioning them within a 30-in. radius of the caddy's mounting position. The device fits any table from −1 to +15 degrees. The caddy's tray measures 10 by 13 in. and supports up to 10 pounds of equipment. It sells for $28. McElroy Mfg., Inc.

CIRCLE NO. 288

Core design chart

A comprehensive tape-wound core design chart provides, at a glance, all the pertinent data an engineer needs to design with cores. Presented is information on gross core area, mean path length, core size, gross core weight, case size (for both plastic and metal) as well as turns/V at 10,000 gausses (60 and 400 Hz). Also given is data on μH/turn, core saturation, and the product of window area times the core area. Also provided is a complete wire table. Magnetic Metals Co.

CIRCLE NO. 289

Microwave ICs

A new wall chart for microwave integrated circuits and discrete devices is available. Measuring 17 by 22 in., the chart covers transistors, diodes, beam-lead diodes and capacitors, and microwave integrated circuits. Applications, product specifications, and package types for each device are listed. Texas Instruments Inc.

CIRCLE NO. 290

application notes

D/a converters

Written expressly to improve user understanding of d/a converters so that one may better anticipate device performance, the "Designer's Guide: D/A Converters" goes into considerable detail to define critical d/a converter specifications and operating mechanics and to explain their influence upon over-all system performance. Analogic.

CIRCLE NO. 293

Snap-action switches

A new pamphlet provides a simple step-by-step approach in showing what design factors should be considered when selecting the proper snap-action switch for an application. It points out that the designer need only prepare a composite switch sketch and then take into consideration four key switch parameters: lever movement, lever force, space and load. Diagrams and sketches are also given. Cherry Electrical Products Corp.

CIRCLE NO. 294

Photon equipment

A four-page illustrated catalog describes a wide range of digital synchronous computers, amplifier discriminators, data converter consoles, power supply consoles and photomultiplier tube housings. SSR Instruments Co.

CIRCLE NO. 295

Maintenance concepts

Three technical papers on maintenance philosophies and concepts discuss the problem of growing module failure and the increasing need for effective repair of electronic assemblies. Included in the papers are suggestions for setting up a repair program and realistic decision criteria for throwing away vs repairing of modules. Pace, Inc.

CIRCLE NO. 296

new literature

TV equipment

An extensive catalog features 144 pages of a large selection of new and used TV cameras and associated equipment. Denson Electronic Corp.

CIRCLE NO. 297

SCRs

A new eight-page brochure covers the features, applications and performance characteristics of two series of SCRs. Westinghouse.

CIRCLE NO. 298

Reed relays

A new series of economy reed relays are described in a data sheet. Guardian Electric Manufacturing Co. of California.

CIRCLE NO. 299

Pollution instruments

Direct-reading colorimeters for water and pollution testing are the subject of a new brochure. Hach Chemical Co.

CIRCLE NO. 300

Insulating compounds

Three new electrical insulating compounds are described in a new technical bulletin. Richardson Co.

CIRCLE NO. 301

PC card guides

A catalog covers PC card guides, brackets and card racks. Calabro Plastics, Inc., Unitrack Div.

CIRCLE NO. 302

Vises

An eight-page brochure has detailed illustrations of high-precision vises. Karl A. Neise, Inc.

CIRCLE NO. 303

Driving and perception

A summary of research on the importance of visual perception in driving has been published in a pamphlet by the Highway Users Federation for Safety and Mobility. Highway Users Federation for Safety and Mobility.

CIRCLE NO. 304

New tools

A new 40-page tool catalog illustrates in full color screw drivers, nut drivers, pliers, wrenches, crimping tools, riveters, steel tapes and other specialty tools. Vaco Products Co.

CIRCLE NO. 305

Function modules

A comprehensive 28-page catalog contains detailed electrical and mechanical information on a line of miniature a/d and d/a converters, sample-and-hold modules, multiplexers and miniature PC power supplies. Varadyne Systems.

CIRCLE NO. 306

Interconnection systems

An eight-page brochure describes a complete line of self-locking electrical connector systems, modular card edge plates, quick-connect receptacles, solderless terminals, flat cable connectors, PC card guides, rack-and-panel connectors and other interconnection systems. Malco Manufacturing Co., Inc.

CIRCLE NO. 307

Power supplies

A new 64-page power supply handbook and catalog contains power supplies and power modules for systems, laboratory and OEM applications. Trygon Electronics, Inc.

CIRCLE NO. 308

Memory products

An eight-page illustrated brochure covers digital memory modules, delay lines, analog video delay line modules and analog delay lines. Corning Glass Works.

CIRCLE NO. 309

Lacing tapes

Introduction to a complete line of braided lacing tapes, cords, and twines for electronic and electrical harnessing is contained in a buyers guide. Western Filament, Inc.

CIRCLE NO. 321

IC dynamic testing

A new eight-page brochure describes a computer-operated dynamic test system for integrated circuits. Teradyne

CIRCLE NO. 322

Digital displays

A full-color 12-page catalog contains photographs and specifications of a line of digital displays. Wagner Electric Corp.

CIRCLE NO. 323

Standby power

A comprehensive 12-page folder describes standby electric power systems for emergency electric power applications. Onan Corp.

CIRCLE NO. 324

Miniature lamps

A new four-page catalog describes a complete line of subminiature lamps. Inter-Market Inc.

CIRCLE NO. 325

Scientific instruments

More than 3000 laboratory and scientific products are presented in a 400-page general catalog of selected equipment, instruments and appliances for industrial research, the health sciences, chemistry, agriculture and biology. Cole-Parmer Instrument Co.

CIRCLE NO. 326

Noise control services

A four-page brochure describes consulting acoustical engineering services that include noise control, environmental noise, architectural, psychological and physical acoustics and project management. Donley, Miller & Nowikas

CIRCLE NO. 327

INFORMATION RETRIEVAL NUMBER 65

INFORMATION RETRIEVAL NUMBER 66

INFORMATION RETRIEVAL NUMBER 67

INFORMATION RETRIEVAL NUMBER 68

bulletin board

of product news and developments

General Electric's Integrated Circuit Products Dept. of Syracuse, N. Y. has announced a new **packaging process for ICs that uses a plastic film strip.** The process known as the Multibond lead attachment process uses a film strip made of polymide plastic which comes in continuous lengths and is perforated with indexing holes for mechanized testing and processing. Holes in the film strip accept silicon pellets and provide access to the IC substrate's copper leads.

CIRCLE NO. 328

Five new CMOS ICs have been introduced by Hughes Aircraft Co., Los Angeles, Calif. They are a 16-bit memory, a four-bit adder, two hexidecimal buffers and a shift register.

CIRCLE NO. 329

Electronic Graphics, Inc., Garland, Tex., has a **new computerized design analysis service** for use by logic circuit designers. Designated Logic Network System, it performs a wide range of load analysis, simulation, packaging, timing and miscellaneous error checks on logic network descriptions at any desired level of complexity. It reveals any unused inputs and outputs, automatically completes all power and ground connections, and determines that allowable loading is not exceeded on any circuit. The program is written in FORTRAN.

CIRCLE NO. 330

advertiser's index

Design Data from Manufacturers

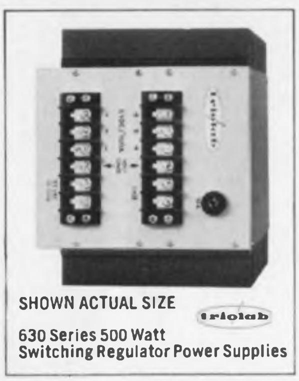
Advertisements of booklets, brochures, catalogs and data sheets. To order use Reader-Service Card.
(Advertisement)

Mini-Computer Mated with Real-Time Analyzer for Automatic Testing

Complete Spectrum Processing System SP-6-1 automatically scales, equalizes, processes underwater acoustic data and noise/vibration signatures for production testing. Monitors on-line signals (nuclear reactor noise, heart sounds, machine tool vibration), recognizes aberrations, gives alarm. Setup conditions are entered via teletype unit as requested by computer. System prints out **all** spectral data or only frequency amplitude above preset levels. Data also pre-recordable on tape, played back often faster than real time. Analysis over frequency bands as wide as 40 kHz are possible. Many options. CIRCLE NO. 171

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

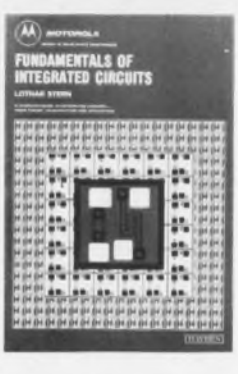
WORLD'S SMALLEST 5VDC/100 AMP POWER SUPPLY



Now you can squeeze your power supply down to fit your microcircuitry with our complete line of off-the-shelf 100 watt to 500 watt supplies. All offer small size, lightweight, high efficiency, cool operation, low cost.
630 Series 5V/100 Amp supply has volume under 500 cubic inches! (8½" x 6¾" x 8¾"); weighs under 20 lbs; 65% efficiency even with light load conditions; no forced air or external cooling for full rated output to 55°C; priced lower than large conventional supplies.
The 100 watt series come in single, dual, triple outputs; 5VDC to 30VDC; commercial, Military, and export models available. CIRCLE NO. 172

Trio Laboratories, Inc.
80 Dupont Street
Plainview, Long Island, N. Y. 11803

FUNDAMENTALS OF INTEGRATED CIRCUITS



A practical guide to integrated circuits, their theory, manufacture, and applications. This new guide by Lothar Stern offers compete, highly readable coverage of the various techniques of circuit fabrication, and their effect on circuit design and performance. As to marketing considerations, it compares the characteristics of the numerous IC structures devised to date in terms of economics and logistics. A volume in the **Motorola Series in Solid-State Electronics.** 198 pages, 7 x 10, illustrated. $8.95, clothbound. Circle the reader-service number below for 15-day examination copies. CIRCLE NO. 173

Hayden Book Company, Inc.
116 West 14th Street
New York, N.Y. 10011

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.
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BPEA BPA

AMERICAN BUSINESS PRESS, INC.

product index

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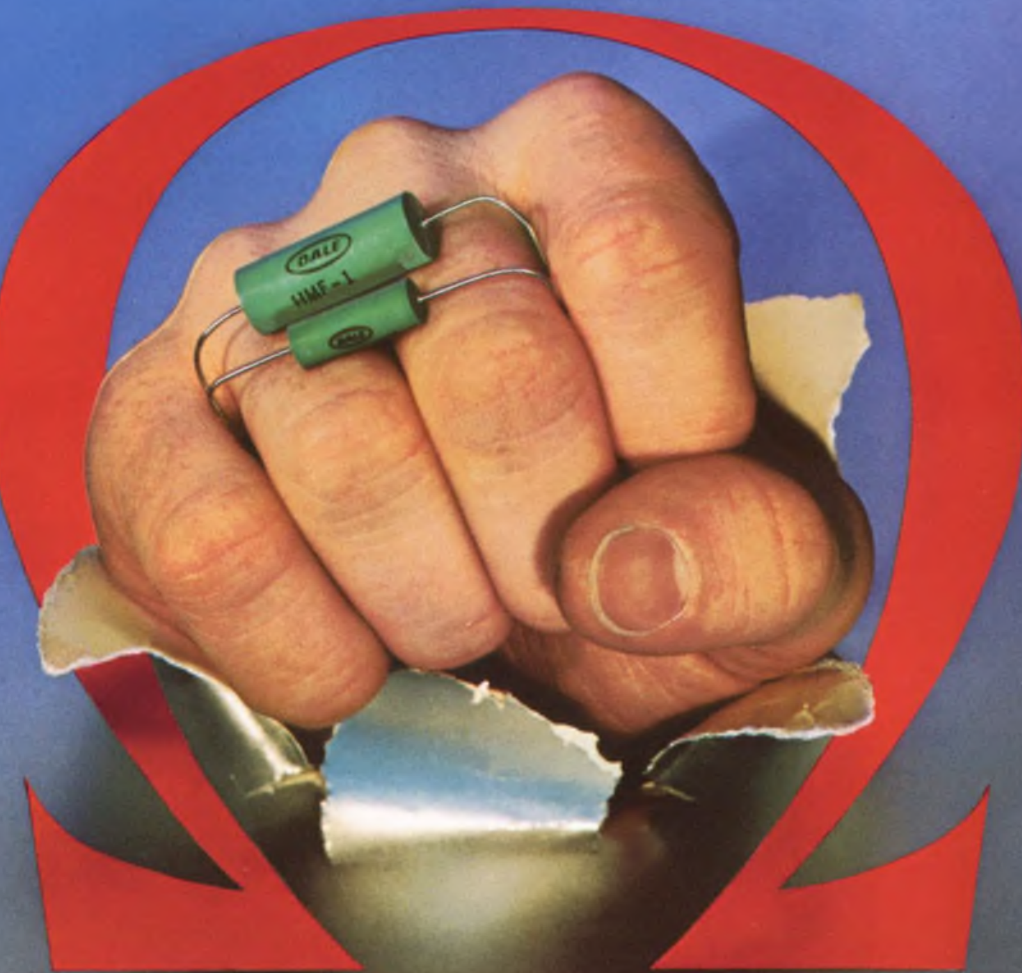
new literature

application notes

design aids

evaluation samples



Dale breaks metal film value barriers

Exclusive new LMF/HMF Resistors go as low as 1 Ohm... and as high as 50 Megohms!

Now you can use low-priced Dale Metal Film Resistors in more applications than ever. New LMF and HMF Series let you extend the use of high stability metal film parts to your lowest and highest resistance requirements. This Dale breakthrough gives you design and performance uniformity you've never had before. T.C.'s are no longer a problem —packaging is easier, too. The price: Competitive with the non-precision carbon film parts you previously had to use in low and high value situations. Check the specifications at right, then ask Dale for details on the industry's broadest and most useful line of metal film resistors.

Phone 402-564-3131 today
or write:
DALE ELECTRONICS, INC.
1300 28th Avenue
Columbus, Nebraska 68601
In Canada: Dale Electronics Canada, Ltd.
A subsidiary of The Lionel Corporation

DALE

SPECIFICATIONS

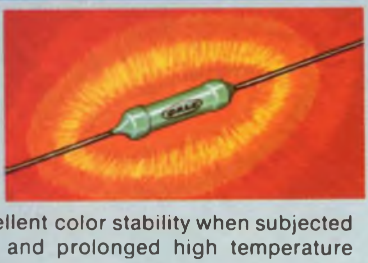
RESISTANCE				T.C.
LMF	1-9.9 ohms	**HMF**	100K-50M	150 PPM
	5-30 ohms		100K-50M	100 PPM
	10-30 ohms		100K-30M	50 PPM
	15-30 ohms		100K-5M	25 PPM

Tolerance: 1% standard. Special tolerances and T.C.'s available.

Applicable Mil Specifications: MIL-R-10509 (Char. C, D, E), MIL-R-22684 (RL-07, RL-20).

Power Rating:
LMF—1/10, 1/8, 1/4, 1/2 watt.
HMF—1/20, 1/10, 1/8, 1/4, 1/2, 3/4, 1 watt.
Per Char. C & E 125° C rating, MIL-R-10509.

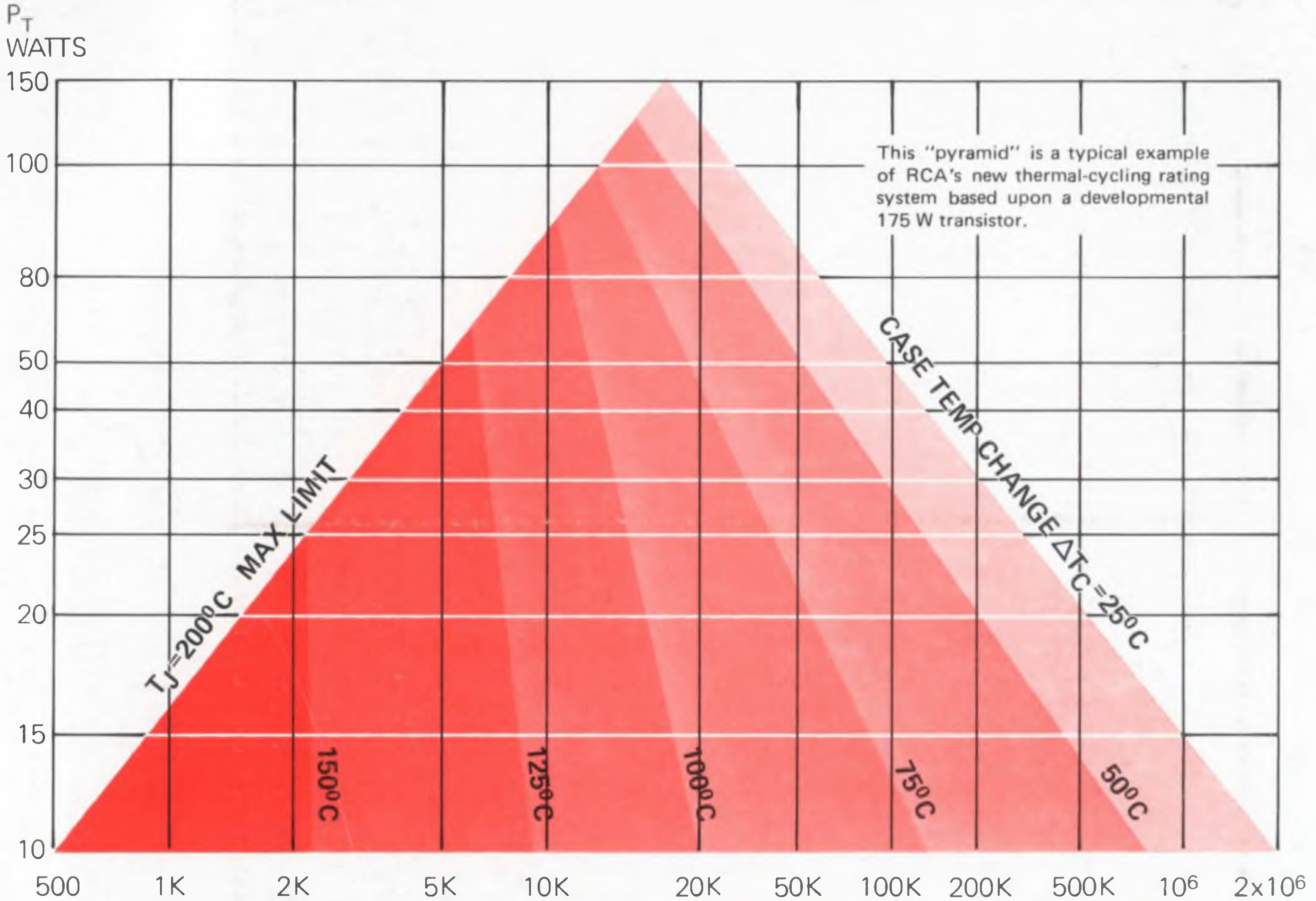
FLAME RETARDANT COATINGS are standard on all Dale 1/10 thru 1/2 watt conformally-coated metal film resistors.



These resistors have excellent color stability when subjected to short time overloads and prolonged high temperature operation. They have withstood 100 times rated power for as long as 10 minutes without exhibiting flame.

INFORMATION RETRIEVAL NUMBER 243

RCA Announces the Industry's First Power Transistor Thermal-Cycling Ratings.



The Rating "Pyramid"–built with the help of RCA's Controlled Solder Process.

RCA, the industry leader in over-all silicon resources, introduces a totally new concept in thermal-cycling ratings to help you establish and extend equipment life.

Using these new thermal-cycling ratings, you can tell at a glance the life expectancy of any given RCA power transistor in terms of number of cycles, power dissipation, and case temperature change. A rating chart is being developed for each family of RCA power transistors, and will be included in data sheets as they are completed. RCA's Controlled Solder Process (CSP) has made possible these ratings — the only such ratings in the industry.

Controlled Solder Process is an RCA development. With it, RCA can control the effects of thermal stress between the pellet and mounting base, and thereby extend the number of times a transistor can be cycled thermally. CSP increases the device thermal-cycling capability from five to 20 times. The RCA "pyramid" is the only rating chart yet devised to help you avoid thermal-fatigue failure in the field.

This announcement of thermal-cycling ratings on power transistors is made in the same spirit as RCA's pioneering disclosure in 1964 on Second Breakdown capability. The philosophy, simply, is to continue to provide power transistor users with the best possible tools to achieve the optimum interface between the capabilities of RCA devices and the needs of their applications.

For more information on RCA's new thermal-cycling ratings, consult your local RCA Representative or your RCA Distributor or write:
RCA, Commercial Engineering, Section 57A-21/UT16, Harrison, N.J. 07029.
International: RCA, 2-4 rue du Lièvre, 1227 Geneva, Switzerland, or P.O. Box 112, Hong Kong.

RCA

INFORMATION RETRIEVAL NUMBER 244