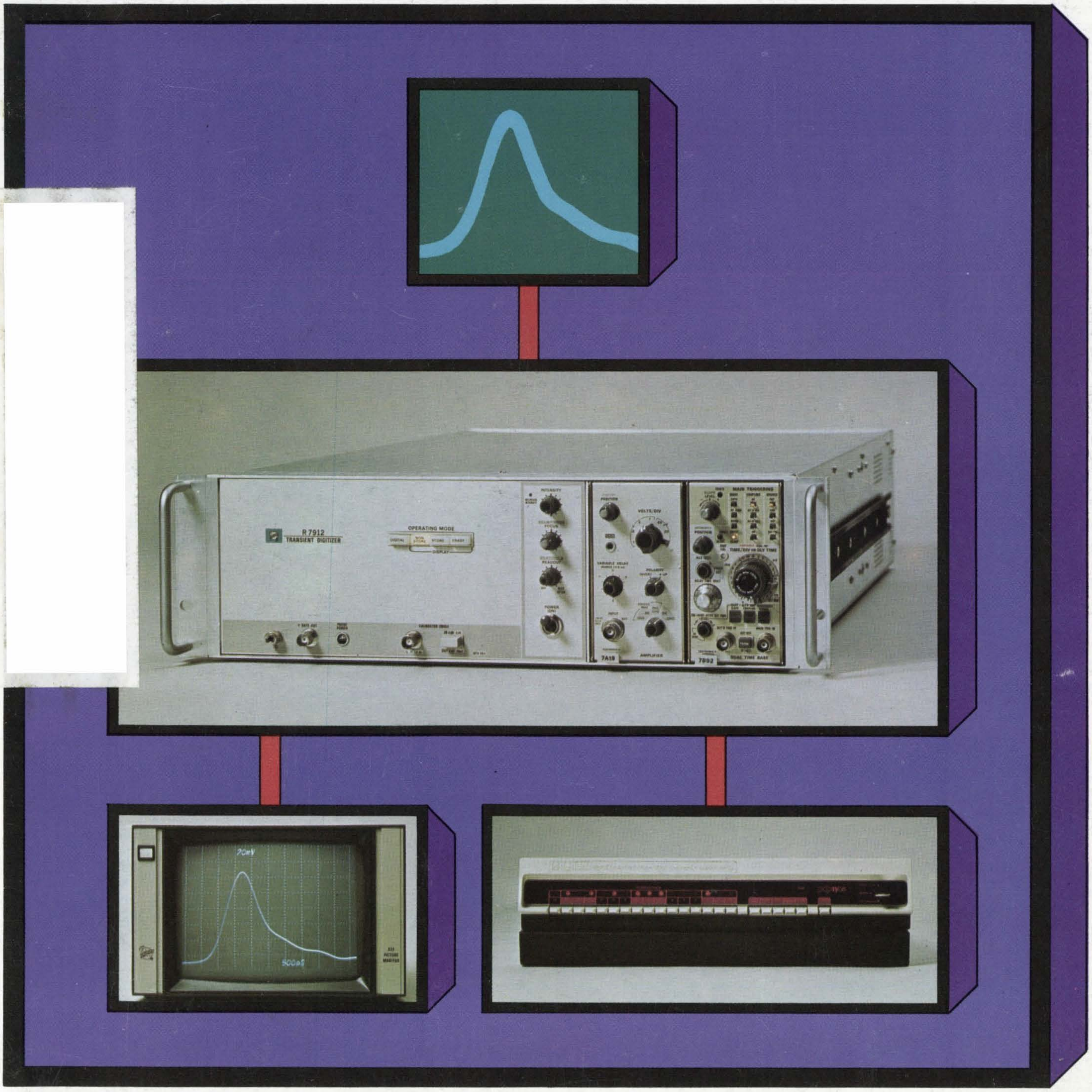
VOL. 21 NO.

Electronic Design 17

FOR ENGINEERS AND ENGINEERING MANAGERS

AUG. 16, 1973

Oops—there it went. It's hard to catch a single pulse. Now, a new instrument will not only catch and display, but digitize transients with widths down to 0.35 ns. Digitizing allows a mini to analyze the stored pulse. Display resolution is 320 by 400 lines; bandwidth is 500 MHz. Learn more on page 91.



Dale Trimmers are good for your system.

Take a moment to consider all the ways Dale Trimmers can help you...and your system:

Short Lead Time—Production quantities of nearly all models can be in your plant in less than 2-3 weeks...at very competitive prices. This includes immersion-proof units sealed for production soldering and cleaning.

Definite Space Savings—Our ¾" low profile models (2700/8700 Series) offer pin spacing and performance identical to many larger competitive models you may be using.

Positive Quality Assurance—Long-term records verify that our customers turn back only 0.93% of all the trimmers we deliver. And this takes in *all* causes—including items not related to quality.

Consider the advantages...then take advantage of them.

IBM uses
Dale Series 2417
in its System 7

NOW AVAILABLE
Complete Trimmer
Interchangeability
Guide. Circle Reply
Number or Phone
402-564-3131.

DALE ELECTRONICS, INC.
1300 28th Ave., Columbus, Nebr. 68601
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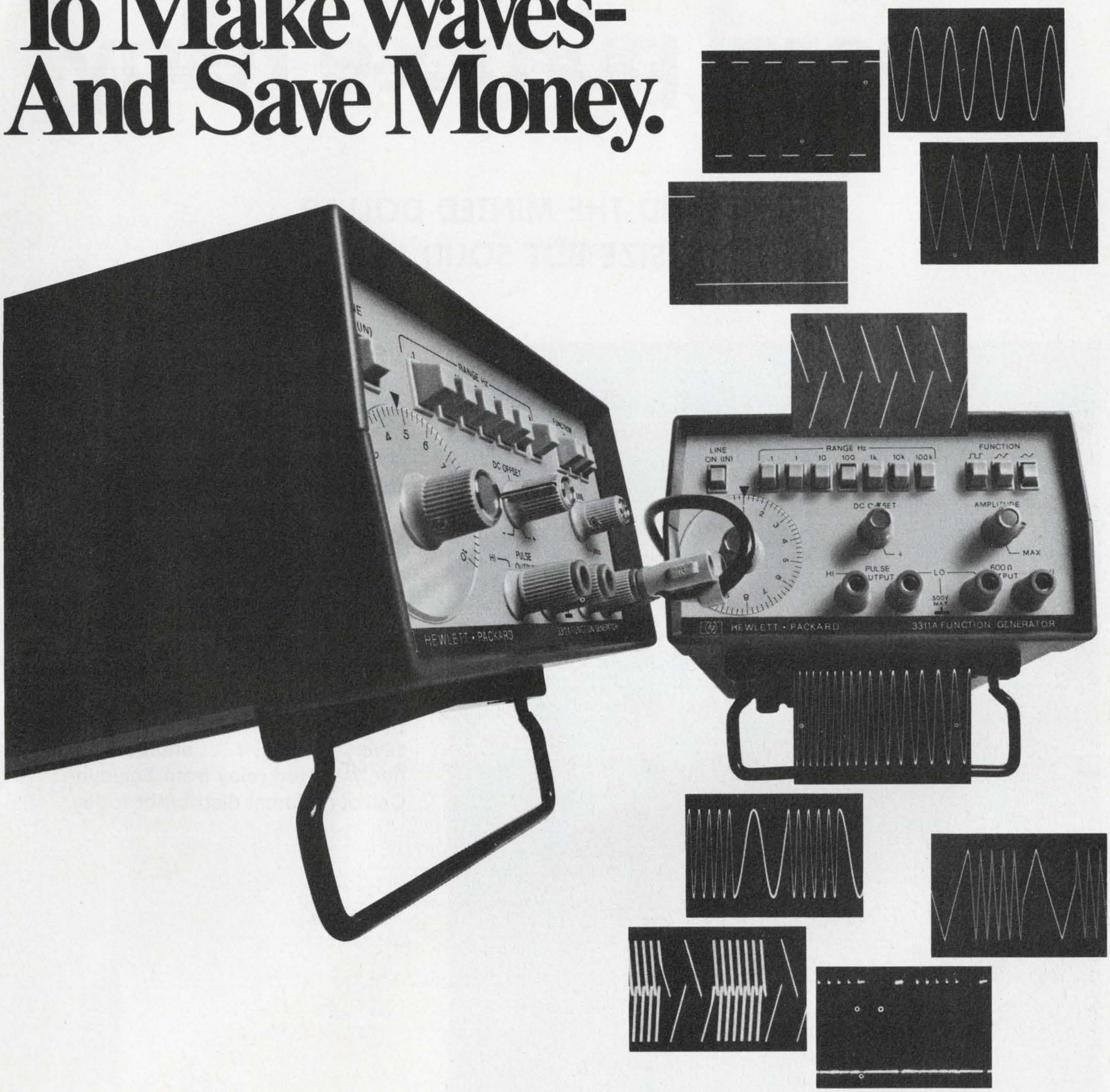
INFORMATION RETRIEVAL NUMBER 242

Here's A Great Way To Make Waves- And Save Money.

With One



With Two

Sine Waves. Square waves. Triangular waves. You get them all – from 0.1Hz to 1MHz – with our new 3311A Function Generator. It gives you both dc offset and external sweep capabilities, and even lets you sum the square- and triangular-wave outputs. But there's another reason why the 3311A is making such a splash – it sells for only $249.*

Use the separate pulse output to provide current sinking for up to 20 TTL loads. It has a 15% duty cycle, and 25nsec rise time. That's a lot of versatility for $249.*

At that price you can afford to put two 3311A's together and do even more...Then you can sweep the outputs. Or frequency shift key the sine- or triangular-wave outputs or even their sum. You'll get full 10V p-p over the 3311A's frequency range. And dc offset is continuously variable from −5 to +5V into 600 ohms. Applying an external 0 to 10V dc will give a 10 to 1 shift in frequency.

*Domestic USA prices only.

For New Standards In Signal Sources, Think HP.

093/50

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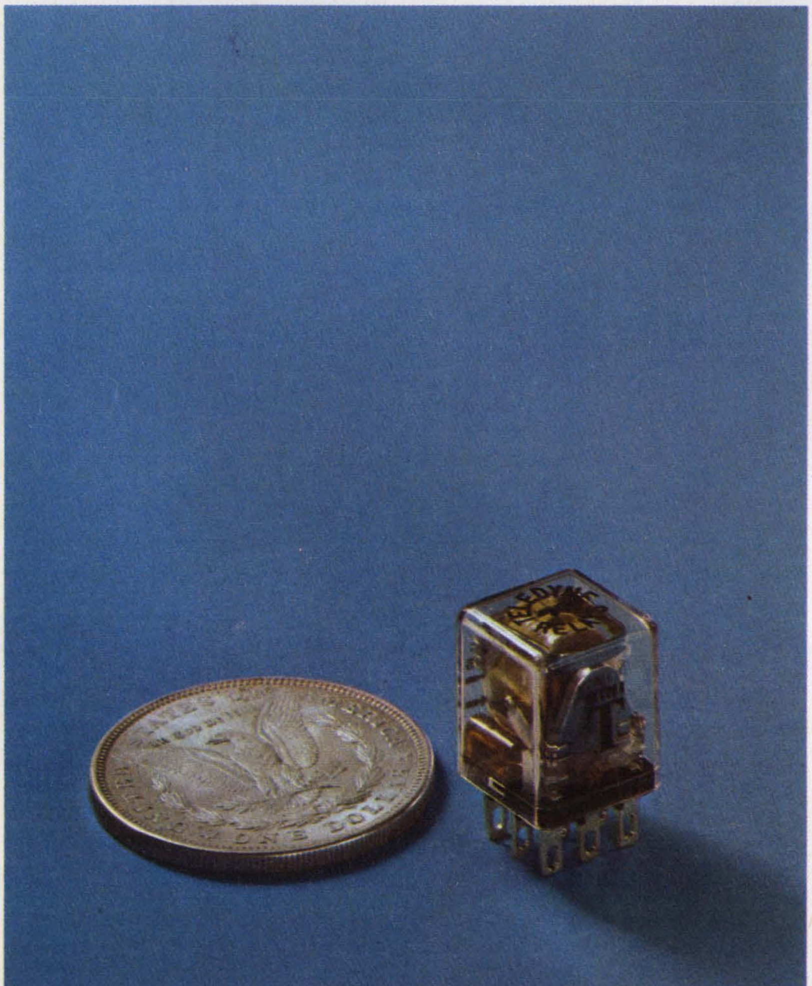
Sales, Service and support in 172 centers in 65 countries.
Palo Alto, California 94303. Offices in principal cities throughout the U.S.

INFORMATION RETRIEVAL NUMBER 2

The smallest 5 amp general purpose relay

MINI-T AND THE MINTED DOLLAR... SMALL IN SIZE BUT SOLID IN VALUE



Teledyne's new, heavy-duty 120 volt 5 amp relay is in stock at your local distributor. The space-saving (.4 cu. in.) 2PDT Mini-T is furnished with sockets and hold down clips for P.C. board or chassis mounting. This Teledyne relay employs an unusual shaded pole design that permits direct AC operation without the need for rectifying diodes. Available with either AC or DC coils and demonstrating cost effectiveness that's hard to beat, the United States-manufactured Mini-T is truly worth its one-half ounce weight in silver. The Mini-T . . . another finely-crafted relay from Teledyne. Call our nearest distributor today.

TELEDYNE RELAYS

3155 West El Segundo Boulevard Hawthorne, California 90250
Telephone (213) 679-2205

INFORMATION RETRIEVAL NUMBER 3

Electronic Design 17

VOL. 21 NO.

FOR ENGINEERS AND ENGINEERING MANAGERS

AUG. 16, 1973

NEWS

TECHNOLOGY

PRODUCTS

Departments

Cover: Design by Art Director Bill Kelly, photos courtesy of Tektronix, Inc.

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Tektronix has taken a new approach to test and measurement instruments. The TM 500 Series is modular, multifunctional, synergistic, cost effective, and more. It includes the features you've been looking for.

Presently, the TM 500 Series includes 24 general purpose plug-in test instruments. All new ways to think of Tektronix. Digital counters to 550 MHz. Signal sources ranging from below 1 mHz to above 1 GHz. Pulse generators to 250 MHz. Digital multimeters with 4½ digit LED readout and temperature measurements from −55° C to +150° C. Plus signal processors, power supplies, and CRT monitors.

All the modules are interchangeable. So you can make combinations of instruments to meet your particular needs. When new instruments are introduced (and many will be soon), you simply plug them into the power unit. You can use a single compartment (TM 501), a triple compartment power unit (TM 503), or two 503's combined for a standard rackmount installation.

Connections between modules and/or external equipment are made through the power unit rear interface board and optional rear panel connectors. Approximately 30 input-output lines are available in each compartment for special set-ups you might want to make. This intracompartment interface feature also permits multifunction applications resulting in a synergistic effect. Instruments working together perform more functions than the same instruments working independently. Many modules include serial BCD so information can be transferred directly to a computer or calculator.

The TM 500 is compact too. A three-compartment power unit is only 6″x8.7″x15.3″. That means the TM 500 is two to six times smaller than comparable instruments. So you save bench space. And it's light weight, easy to carry. A package including a general purpose counter, multimeter, and power supply weighs 14 to 18 pounds!

Cost? All TM 500 plug-in modules are competitively priced with instruments of comparable capabilities. Because TM 500 instruments share the fixed costs of

Modular, compact, synergistic, multifunctional, versatile, cost effective and more.

power supplies, cabinets, etc., they consistently provide the lowest cost per test/measurement function. And, because the instruments are modular, cost of maintenance is lower too.

For complete details, contact your Tektronix Field Engineer. Or write or phone for our new 12 page, full color brochure and 24 data sheets. They show why the TM 500 is the finest test and measurement series available today. Tektronix, Inc. P.O. Box 500, Beaverton, Oregon 97005. In Europe, write Tektronix Ltd., Guernsey, C. I., U.K.

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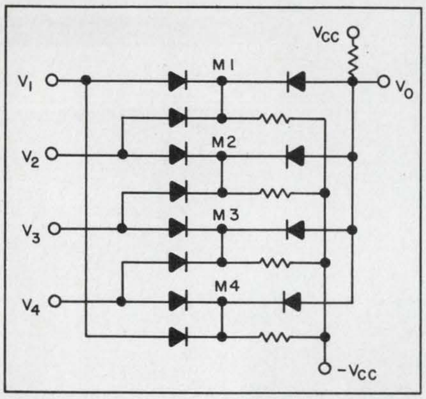
INFORMATION RETRIEVAL NUMBER 4

across the desk

The circuit works on trivial cases

In his Idea for Design "Analog Sorting Network Ranks Inputs by Amplitude and Allows Selection" (ED No. 2 Jan. 18, 1973, pp. 72-74), Dennis R. Morgan presents a schematic that purports to choose the Mth smallest of N input voltages. Indeed it does, for many trivial cases. The first case for which it fails is $N = 4$, $M = 2$. The circuit, employing ideal diodes and reduced to its simplest elements, is as follows:



In this circuit we have $M_1 = \text{Max}(V_1,V_2,)$, $M_2 = \text{Max}(V_2V_3)$, $M_3 = \text{Max}(V_3,V_4)$ and $M_4 = \text{Max}(V_4,V_1)$, as well as $V_0 = M_{in}(M_1, M_2, M_3, M_4)$. If $V_1 < V_2 < V_3 < V_4$, as assumed in the article, then $V_0 = V_2$, the second-smallest value as desired. However, if the levels for V_1 to V_4 are 1, 3, 2 and 4, then M_1 to M_4 are, respectively, 3, 3, 4 and 4, and V_o equals three, which is incorrect.

Actually, for the circuit to work, there would have to be an M-diode-cluster for each subset of M input variables—N!M!/(N-M)! clusters. This could get prohibitive.

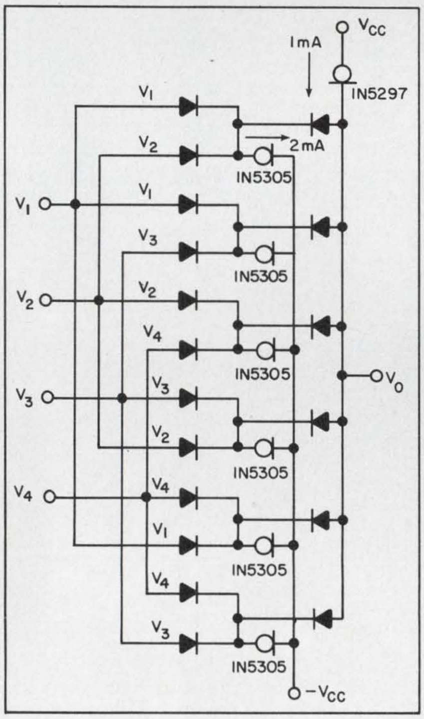
Ronald Silver
President
Taos Computer Associates
Box 111
San Cristobal, N.M. 87564

The author replies:

Mr. Silver correctly points out that the circuit, as originally drawn, gives the correct result only for $M = 1$ or $M = N - 1$. In general, correct operation requires a diode cluster for each combination of the N inputs taken M at a time, or a total of N!/M!(N-M)! clusters not N!M!/(N-M)!.

Even though this may be a relatively large number, the method is still the simplest implementation possible and is readily adaptable to integrated-circuit fabrication.

To exemplify correct circuit configuration, here is a modified version of Mr. Silver's counterexample:



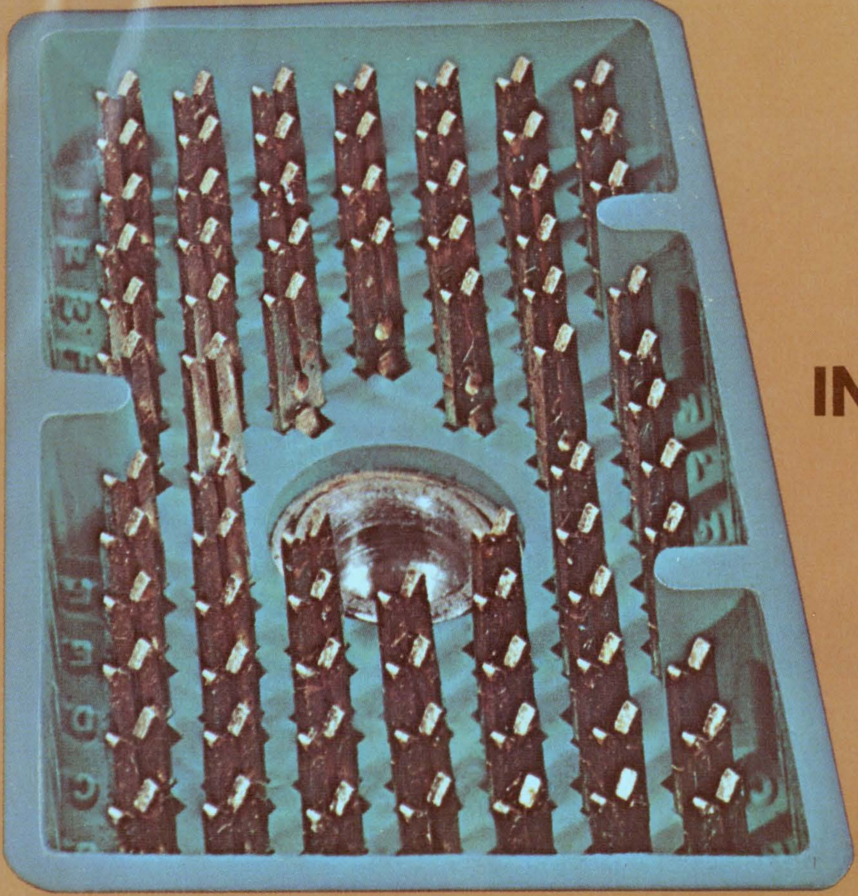
My apologies for the oversight in the original circuit.

Dennis R. Morgan
Electronics Laboratory
General Electric Co.
Syracuse, N.Y. 13201

(continued on page 12)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St. Rochelle Park, N. J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

INFORMATION RETRIEVAL NUMBER 6 ►



PACKS TWICE THE CONTACTS IN THE SAME SPACE AT ABOUT HALF THE COST

Elco's solution to the escalating packaging squeeze and packaging costs in electronic circuitry. A line-up of I/O rack and panel and cable-to-cable connectors with contact spacing on .100″ and .125″ centers.

On a performance/price basis, these high density connectors are your best buy. Quality is equal to or better than, and published prices are much less than those of their pin-and-socket counterparts.

Take the Series 8026 R/P and cable-to-cable connector that's equipped with the Elco high-reliability crimp-and-insert mini Varilok™ contact. Team a Series 8026 117-contact plug with its corresponding receptacle, and you have a 117-contact connector that's in the same envelope as a 56-contact connector on .150″ spacing. But packing more than twice the contacts in the same space.

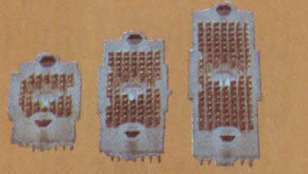
The 75-contact 8026 connector will fit in the same space as a 38-contact connector on .150″ spacing. And the 8026 33-contact connector is one of the smallest 33-contact R/P connectors you've ever seen. For back-up, we offer Series 8026 connector with 55 and 79 contacts on .125″ square grid.

For your I/O back-panel applications, Elco Series 5540 connectors are available in the same sizes as the 8026, but use the field-proven Varicon™ contact with .025″ square wire-wrappable posts. They incorporate—as do the 8026's—a new female turnable jackscrew that eliminates any possibility of damage to plate contacts in difficult or blind mating situations. Both series use standardized polarizing and keying hardware to prevent unmatched plugs and receptacles from being mated.

And by no small coincidence, hardware standardization and using one contact for both sides lets you minimize your in-house and field stocking requirements, and allows you to use the same manufacturing set-up to assemble all sizes.

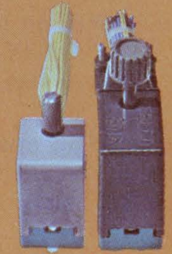
Besides helping you cope with your close-order circuits, these connectors will help you effect other cost economies. Like using your existing 8016 panel punches. Reducing inventory because they can do duty in R/P and cable-to-cable applications as well as be used as an I/O.

There's one more bonus. Immediate availability. Both series. All sizes. Another service in keeping with CONNECTRONICS, Elco's Total Connector Capability.



Series 5540 input-output plate receptacles with or without polarizing hardware. On .100″ grid with 33, 75 and 117 contacts. On .125″ grid with 55 and 79 contacts.

Polarizing hardware provides 36 polarization combinations per connector pair.



Metal covers for 33, 55, 75, 79 and 117-contact connectors have top and side cable entries.

Cable strain relief clamps are adjustable for small and large cable bundles, can be mounted on plug and/or receptacle.

For full details on these new connectors from Elco, contact your local Elco representative or distributor, or: Elco, Willow Grove Division, Willow Grove, Pa. 19090, (215) 659-7000 • Elco, Pacific Division, 2200 Park Place, El Segundo, Calif. 90245, (213) 675-3311.

ELCO™

Operations and sales offices throughout the world.

ACROSS THE DESK

(continued from page 7)

For knob twirlers: a pulse-gen panel

I felt you did a fine job on your recent Focus report on pulse generators (ED No. 11, May 24, 1973, p. 53), with the exception of one fact: The E-H 1501A programmable pulse generator, contrary to your mention of it in the article, does indeed come equipped with a front-panel control option. A pulse generator with this option costs $4500, whereas one without it costs $3500. Many engineers have felt the front-panel control on this instrument to be important enough to be worth the price difference.

Martin Marshall
E-H Research Laboratories, Inc.
515 11th St.
Box 1289
Oakland, Calif. 94604.

And yet another maker of pulse generators

We at Phenix have read your excellent article on pulse and word generators with a great deal of interest. We have been involved in pulse-generator design and manufacturing since 1957, with such companies as Rutherford Electronics, CMS, Advanced Automation, Chronetics and now Phenix Electronics. Our present line of equipment includes both programmable and general-purpose pulse generators, with emphasis on our programmable units.

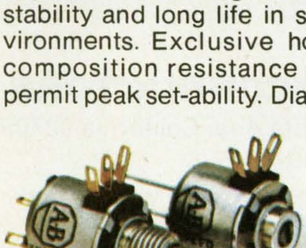
J. M. Hegarty
Sales Manager
Phenix Electronics
13724 Prairie Ave.
Hawthorne, Calif. 90250

Correction

In the tech article "Measure Random-Pulse Frequencies the Analog Way," ED No. 13, June 21, 1973, a gremlin crept into the artwork of Fig. 2. On p. 114 a JFET and a bipolar transistor are both shown with the same type number—2N3904. The JFET should be a 2N4222.

(continued on page 16b)

Type FD trimmer. Type GD pot. Ideal variable resistors for CATV attenuators. Or any Bridged-T or L pad application requiring minimum size, stability and long life in severe environments. Exclusive hot-molded composition resistance elements permit peak set-ability. Diameter 1/2 inch (12,70 mm). Immersion-sealed (can be potted). Standard resistance values from 100 ohms to 5 megs and many popular impedance values. Single turn. For complete technical details request Publication 5231 (FD trimmer), Publication 5213 (GD potentiometer), Publication 5221 (FD/GD attenuators). Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204. Export: Bloomfield, New Jersey 07003. Canada: Allen-Bradley Canada Limited, Cambridge, Ontario. United Kingdom: Jarrow, County Durham NE32 3EN.



Actual Size

INFORMATION RETRIEVAL NUMBER 11

Allen-Bradley
Milwaukee, Wisconsin 53204

Finally
Monolithic True Log IF/RF Amplifiers

Another First from PLESSEY

Specify Plessey's new SL530 series . . . the first monolithic true log IF/RF amplifiers in the world. You may do things you never considered before.

Like designing your own multi-channel radar IF strips in-house. Simply, quickly and economically. Yet your system will have more reliability and accuracy than before . . . at a much lower cost.

Monopulse radar systems or ECM?

Wherever phase information must be retained, the SL530 series is ideal. Throughout the entire strip, input signal phase information is retained. And retained.

Just think of the new SL530 series as building blocks. Cascade them for true logarithmic response at frequencies up to 80 MHz.

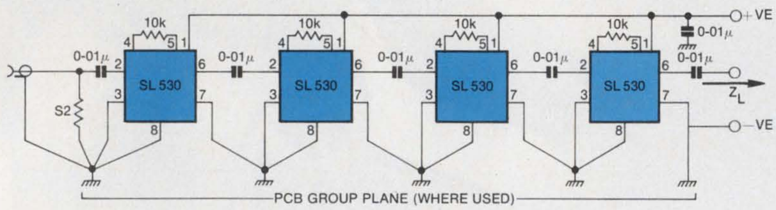
The SL530 may be the first device of its kind in the world. But state-of-the-art is a habit with Plessey.

Successive Detection Log Amplifiers

Another log amp original, the SL521, has been used by designers in successive detection log amplifiers. For over five years Plessey has consistently delivered SL521 devices for critical programs like the TPX-42 and APX-76.

Temperature range is full MIL-spec for both the SL521 and SL530. Screening to MIL STD 883 or 38510 available upon request.

Typical 4-stage strip using SL 530 series

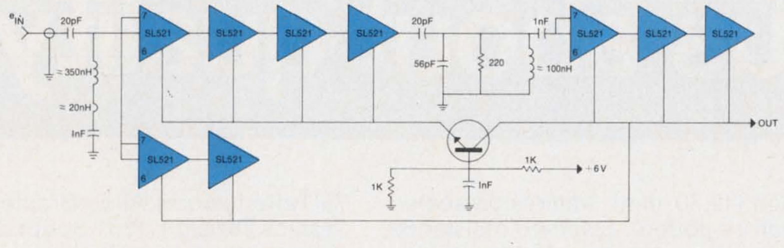


SL530 True Logarithmic Limiting Amplifiers

VOLTAGE GAIN @ 60MHz
14db typical
FREQUENCY RANGE
4-85MHz
MAXIMUM RECTIFIED OUTPUT
1.0V peak
PROPAGATION DELAY
7.0ns typical*
PACKAGE CODE
TO5/F.P.

*Group delay match over input range = 0.6ns

60 MHz wide-range logarithmic amplifier using SL521 series



SL521 Limiting Wideband Amplifiers

VOLTAGE GAIN @ 60MHz
11.3 min.
12.7 max.
FREQUENCY RANGE
7-150MHz
MAXIMUM RECTIFIED OUTPUT
1.0mA min.
1.1mA max.
PROPAGATION DELAY
2.0ns typical
PACKAGE CODE
TO5/F.P.

The next time you require radar IF strips, make things easy for yourself. If you need phase retention, specify Plessey's SL530. Or use the SL521 for successive detection systems.

Now, while you're thinking of it, call or write for more information. **It pays to specify Plessey.**

PLESSEY SEMICONDUCTORS
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170 Finn Court Farmingdale, New York 11735
(516) 694-7377

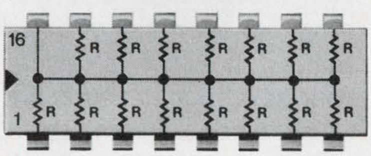
INFORMATION RETRIEVAL NUMBER 12

191 FLAVORS OF BECKMAN DIPS

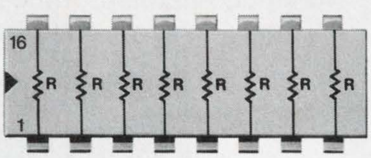
All 191 flavors of RESNET™ DIPs offer system compatibility because we use the same packages you use for I.C.s; plus you get ceramic dependability at plastic prices.

Whether you're inserting resistors automatically or by hand — call your local Beckman/Helipot representative and ask how you can save money using RESNET DIPs. He stocks locally for immediate delivery.

If you need immediate technical literature or the telephone number of your local Beckman/Helipot representative, call H.E.L.P. (Helipot Express Literature Phone) toll-free (800) 437-4677.



898-1 (15 resistors)
Price (1,000-4,999) $.85

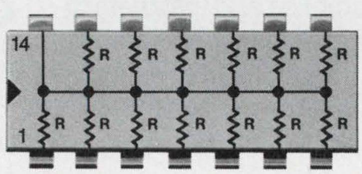


898-3 (8 resistors)
Price (1,000-4,999) $.76

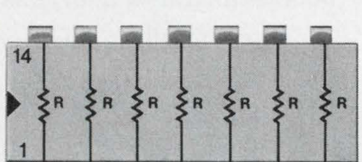
STANDARD RESISTANCE VALUES
(±2% or ±2Ω)

62*	110	330	1.0K	2.2K	6.0K	15.0K
68	150	470	1.5K	3.3K	6.8K	22.0K
100	220	680	2.0K†	4.7K	10.0K	

*Standard in 898-3 only.
†Standard in 898-1 only.



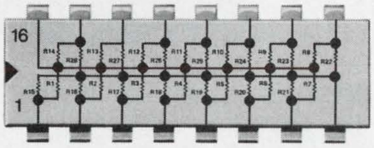
899-1 (13 resistors)
Price (1,000-4,999) $.81



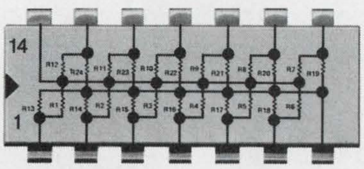
899-3 (7 resistors)
Price (1,000-4,999) $.72

STANDARD RESISTANCE VALUES
(±2% or ±2Ω)

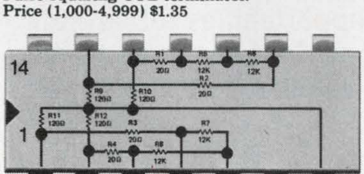
22	62	180	510	1.5K	4.3K	11K
24	68	200	560	1.6K	4.7K	12K
27	75	220	620	1.8K	5.1K	13K
30	82	240	680	2.0K	5.6K	15K
33	91	270	750	2.2K	6.0K	16K
36	100	300	820	2.4K	6.2K	18K
39	110	330	910	2.7K	6.8K	20K
43	120	360	1.0K	3.0K	7.5K	22K
47	130	390	1.1K	3.3K	8.2K	
51	150	430	1.2K	3.6K	9.1K	
56	160	470	1.3K	3.9K	10K	



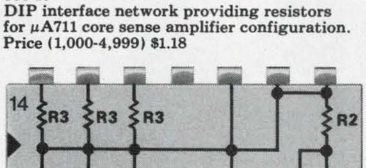
898-5-R220/330
Pulse squaring TTL terminator.
Price (1,000-4,999) $1.45



899-5-R220/330
Pulse squaring TTL terminator.
Price (1,000-4,999) $1.35



899-19
DIP interface network providing resistors for μA711 core sense amplifier configuration.
Price (1,000-4,999) $1.18

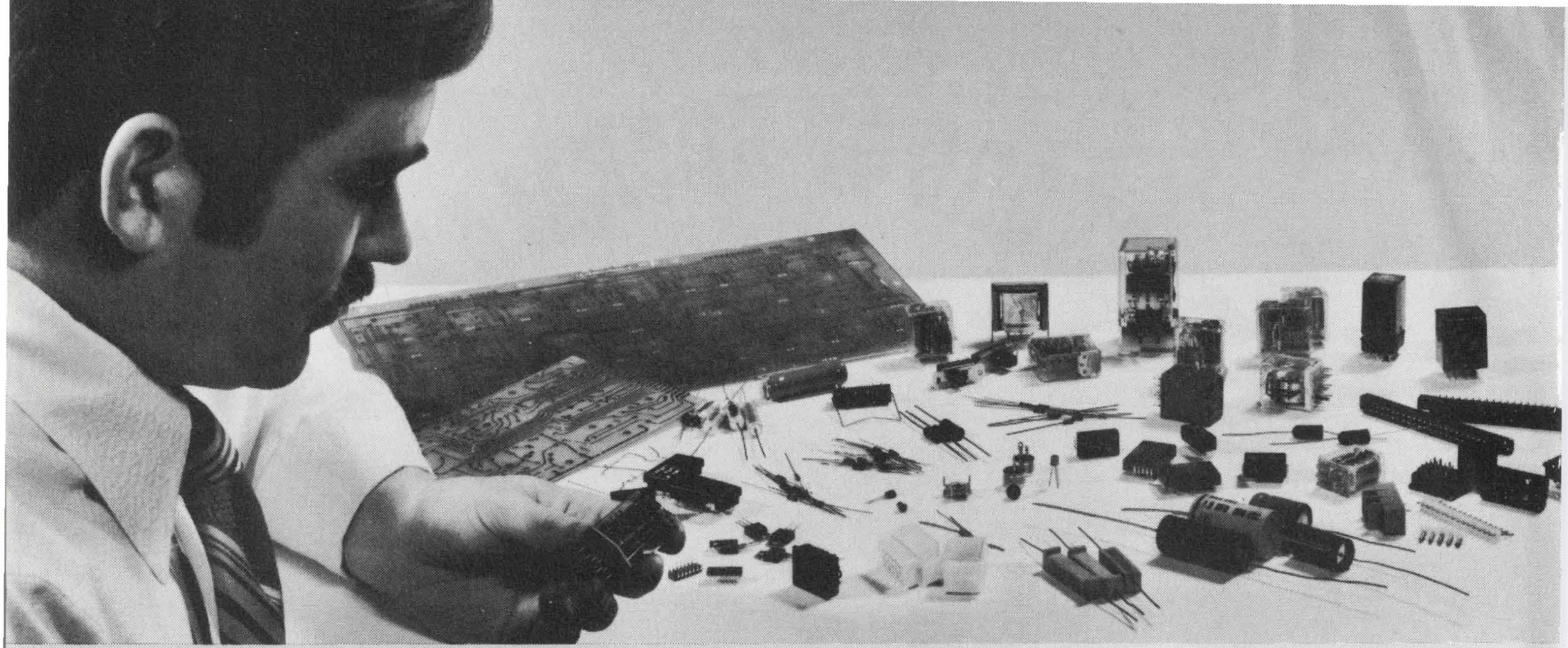


899-40
DIP network provides six line terminators and the threshold setting divider for the Intel 3208A sense amplifier.
Price (1,000-4,999) $1.35

Beckman®

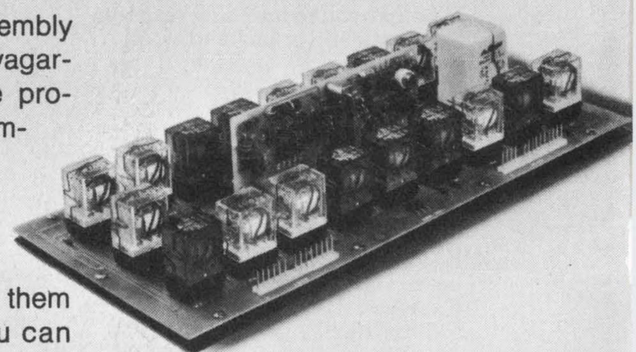
HELIPOT DIVISION

INFORMATION RETRIEVAL NUMBER 13



Sure you can "do·it·yourself" but...

building your own special assemblies can be a very costly decision.

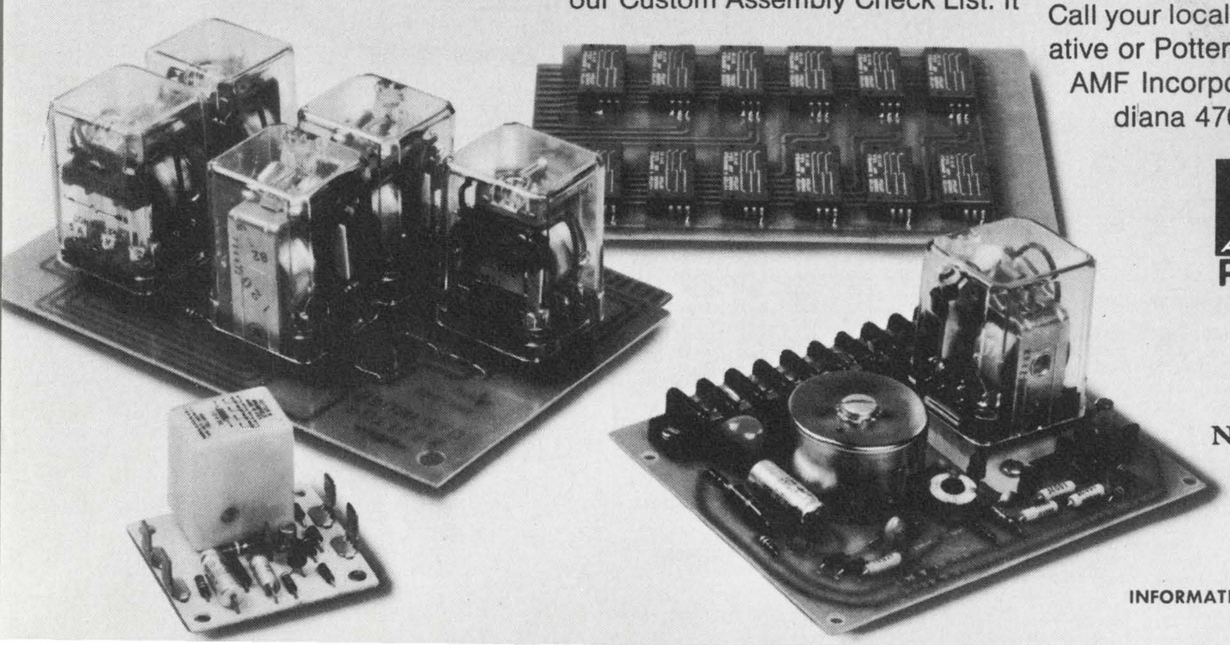


Costly indeed. Especially when you consider the attendant costs of any do-it-yourself production effort. Additional labor, training, supervision, procurement, capital equipment, floor space, production scheduling, inventory, tools, fixture and jigs—all contribute to final costs and make them hard to control.

When you consider the alternative, the opportunities for savings are obvious. Perhaps more to the point, with Potter & Brumfield you know exactly what each assembly will cost. You eliminate all the vagaries associated with in-house production. You see, Potter & Brumfield has all the people and facilities to produce special assemblies and test them to your exacting specifications. And, chances are we'll make them faster and cheaper than you can yourself, and give you a superior product.

If that's what you're after, ask for our Custom Assembly Check List. It simplifies the make or buy decision. Better yet, ask us for a quotation on your next special assembly project. Call your local P&B sales representative or Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47670. 812/385-5251.

AMF
Potter & Brumfield



P&B performance. Nothing else comes close.

No-Problem Memory

Looking for a high-speed memory that won't give you any problems? Look at our Micromemory 3000. It's a reliable 3 Wire, 3 D core memory with a complete cycle time of 650 nsec, and 300 nsec access.

Not only does the Micromemory 3000 give you core reliability and low cost, but the compact convenience of a complete memory system—including all required logic, drive and sense circuitry—on a single printed circuit card. Maximum capacity per card is 8K by 18 bits, or 16K by 9. But you can stack the cards to get any size system you need. Or we'll do it for you.

In fact, the unit shown is our standard Micromemory 3000 chassis. It can accommodate up to four individual memory cards plus power supply, self-test or interface cards and other features. Yet it is only 5¼-inches high, and fits a standard 19-inch rack. Other chassis holding up to 16 cards are also available.

With over two years' field experience, the Micromemory 3000 is so popular we are producing them at the rate of 6000 a year. Combine this proven reliability, high performance and low cost in your next memory system. Write or call Mel Zeramby at (213) 644-9881 for all the details.

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INFORMATION RETRIEVAL NUMBER 101

(continued from page 12)

Watch these pitfalls in designing log amp

Your readers should be informed of some performance limitations of the logarithmic amplifier described in the article "Get Wider Dynamic Range in a Log Amp" (ED No. 4, Feb. 15, 1973, pp. 60-62).

The main limitation is one of accuracy, due to variations of I_{C2} with input signal change. I_{C2} (I_{CQ1B}) is the divisor in the scale factor equation and should therefore be constant. However, I_{C2} varies appreciably with input signal—the mean voltage across R_3, about 0.83 V, is not much greater than the voltage variation with the input signal at S_2 about ±206 mV (58.9 mV/decade).

Detailed calculations show that the transfer function behaves as if the input current were larger by a factor of 1.31 for the lower limit input of 1 mA and smaller by a factor of 1.239 at the full-scale input of 10 mA. Connecting the right end of R_3 to as high a value of stable voltage as possible or providing a stable current source can reduce the error.

Another limitation is that Q_{2A} acts as dead short on the first amplifier when E_{in} is negative. The additional heating of the amplifier degrades accuracy as the input returns to positive values. Connecting Q_{2A} to the right end of R_2, instead of the left, solves the problem. Then conduction of Q_{1A}'s collector-to-base junction protects the amplifier from excessive voltage levels resulting from a negative E_{in}.

Finally R_{10} should be the same value as R_1 to minimize error caused by the first amplifier's bias current.

Nathan O. Sokal
President
Design Automation, Inc.
809 Massachusetts Ave.
Lexington, Mass. 02173.

The author replies:

Mr. Sokal's comments are very valuable and should be considered in the design of this log amp. My replies are as follows:

1. As to error caused by Q_{1B} current variation with input current, the variation of I_{CQ1B} does affect the linearity of the transfer characteristic curve, as indicated in Mr. Sokal's calculations. The calculations are correct, based on R_8 of 100 k, as shown in the schematic (a printing error). In the original design R_8 is 10 k instead of 100 k. Then the mean voltage across R_3 is about 4 V instead of 0.83 V. This reduces the error due to voltage changes at the extremes of the seven-decade range. The error can be further reduced by connecting R_3 to a high stable voltage. However, R_3 must be changed to have the proper input set point. Mr. Sokal did an excellent job in finding the printed error in the schematic.

2. As to protection against negative input voltage, this is a very good suggestion. It is better to connect Q_{2A} to the right end of R_2 instead of the left end.

3. As to other sources of error, the value of R_{10} should be the parallel value of R_1 and the resistance looking into the feedback loop. The resistance looking into the "diode-function" feedback transistor is very low. Therefore $R_{10} = 1$ k is a good choice.

George Niu
Fairchild Systems Technology
3500 Deer Creek Rd.
Palo Alto, Calif. 94304.

Giving credit where it's due

It has come to my attention that in your June 7 issue you reported on the work by a Hughes Aircraft group on a thin-film, transistor-addressed liquid-crystal display ("Liquid-Crystal Panel Overcomes Video-Rate Operating 'Barrier,' " ED No. 12, p. 40). I would like to point out that our work at Westinghouse on exactly the same approach to a video liquid-crystal display has considerable priority in time over that of the Hughes work and is much further advanced.

T. P. Brody, Manager
Thin-Film Devices
Solid-State Research
Westinghouse Electric Corp.
Beulah Road
Pittsburgh, Pa. 15235

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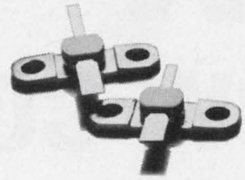

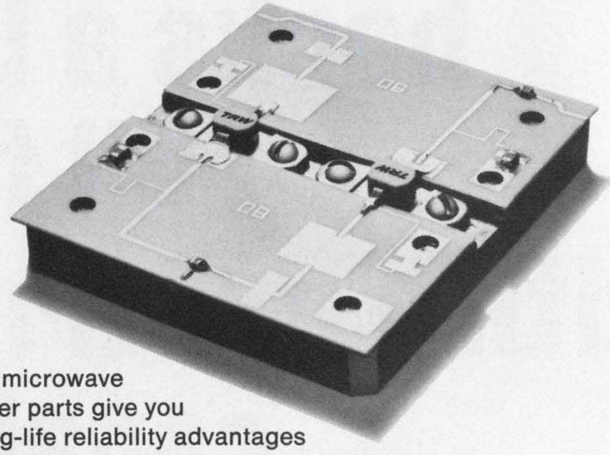

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INFORMATION RETRIEVAL NUMBER 16

Electronics for watches: Packages get smaller

Substantial progress in shrinking the electronics packages of electronic watches has been demonstrated by the Gruen Watch Co. with the announcement of two new models—women's and men's wristwatches. The women's display has hours and minutes and the men's shows hours, minutes, seconds and the date.

The volume of electronics in the women's watch—including a field-effect liquid crystal display—has been cut in half, compared with the electronics package in the men's watch from which it evolved, according to Phil Dunleavy, manager of research for Gruen.

Two new features have been added to the men's watch without an increase in size: the seconds and date displays. The watch has two chips, and by redesigning earlier circuits, Gruen engineers have placed the seconds and the date drivers on the same chip.

Gruen is the only watch manufacturer to use a field-effect liquid-crystal display. The field-effect devices require only one-half the voltage and only a fraction of the power needed for reflective dynamic scattering types, Dunleavy says, and a more readable display is also obtained.

Gruen displayed its new watches at the recent annual Jewelers Trade Show in New York City.

Another major watch company, Bulova, is not yet ready to commit itself to an electronic display, according to Harry Henschel, the company's president. He told the recent annual corporate meeting that the "state of the art of these displays does not yet warrant their introduction into any of Bulova's brands."

A digital dial watch that could meet Bulova's standards, Henschel noted, will not be ready until some time after April, 1974.

Air Force to develop low-accuracy guidance

The Air Force plans to develop a low-accuracy inertial guidance system to complete a family of such systems that will also have a high-accuracy and medium-accuracy units.

The accuracy required is a function of the time the system must operate, explains the project engineer, Capt. Gary Wambold, at the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio. Bomber aircraft with long missions need a high-accuracy system—one with a gyro that doesn't drift very much or very quickly—while a short range air-to-air or air-to-surface missile, in flight for minutes or even seconds, could get to its target with a low-accuracy system before its gyro had time to drift any significant amount.

As for precisely what high accuracy means, the Air Force will only say that it's better than medium accuracy, which it pegs at an error of from one to three nautical miles an hour. Low accuracy is five to 10 nautical miles an hour.

Medium-accuracy systems are suitable for tactical fighters or even remotely controlled vehicles, Wambold says.

The high and medium-accuracy systems, now under development, will have an electrostatic gyro, while the low-accuracy unit will use a laser gyro.

The high-accuracy system, designated AN/ASN-101, is being developed by Honeywell Aerospace in St. Peterburg, Fla. The medium-accuracy system is being built by Rockwell International, Downey, Calif.

The low-accuracy system is still in the components stage, and no company has yet been selected. The choice will depend to a large extent on the kind of laser gyro finally selected.

Besides the lower cost of the low-accuracy system, it has these other advantages: It will be able to withstand more vibration and higher g forces, and it will have quick start up and stabilization time—all important for a short-range missile.

The laser-gyro system will have no moving parts, Wambold says. The electrostatic gyro has only one—the spherical rotor—while the conventional ball-bearing gyroscope has many moving parts.

Skylab crew ready if gyros malfunction

The second crew of Skylab astronauts, launched into orbit July 28, carried a package of electronics equipment that can replace malfunctioning rate-gyro processors should that become necessary.

The Skylab attitude-control system uses nine rate-gyro processors, three in each axis, to sense space-station position. The data are fed into the space-station computer, which signals necessary corrections to the attitude-control system.

The three rate-gyro processors in each axis are redundant. At present only one has been shut down completely because of malfunctioning. However, five others have overheated at different points during this mission, possibly because of a malfunction in the rate-gyro heater circuit.

The switch to new rate-gyro processors would not be made unless all three in one axis are lost, NASA engineers have indicated. Replacement would require extravehicular activity by one astronaut, but engineers say it is a relatively easy operation.

Radio control built into car seat belt

A new automobile seat-belt safety system that prevents the driver from starting the car until he and any passengers have locked their seat belts has independent interlocked "satellite" switches that require no power and are not connected to any control wiring.

This design eliminates the wiring harness now required for present systems of this type, says Daniel Speers, director of research for General Optimation, Inc., Southport, Conn., developers of the system.

The safety system has a master FM transmitter-receiver operating in the 88-to-108-MHz band, Speers explains. The master transmitter sends out digitally coded interrogating signals through a single radiating wire that is looped underneath the seats. The seat-belt interlock switches are connected to small solid-state transponders that pick up the radiated interrogation signal. These devices are adjacent to the radiating wire.

The received energy is fed to a diode that produces a small dc voltage whenever the interlock switch is closed and an input is present. This dc voltage energizes the transponder reply circuit—a small oscillator—which then transmits a reply signal separated from the original interrogation by about 1/10 MHz. The reply is picked up by the master receiver, amplified and compared with the outgoing transmission.

Thus whenever an interrogation is sent and a reply returns at the same time, it indicates that one or more of the seat belt switches—the reel switch, the seat switch, the buckle switch or the belt switch—is closed, and a no-go condition exists. In this case the ignition cannot be turned on.

6-beam laser setup detects intruders

To protect aircraft parked in temporary alert areas or on unsecured airfields, a multibeam laser security system is being developed by the Electronic Systems Div. of the Air Force Systems Command at Bedford, Mass.

At first glance the intrusion detection and identification system looks like a six-light traffic signal, explains James O. Selland, electronic systems project manager. The transmitting unit is a six-foot vertical cylinder with a 5-1/2-inch diameter. Mounted in the cylinder are six transmitting units, each housing a gallium-arsenide laser and its optical projection system. The lowest transmitter is six inches above the ground, the five others are above it, each a foot apart.

An identical type of cylinder houses a vertical row of six receivers with their optical systems.

The system, says Selland, will be used in two-pole transmitter and receiver transfigurations that are a maximum of 500 feet apart and arranged to produce overlapping patterns.

Six invisible three-inch IR laser beams will be transmitted between each pair of poles. The power in these beams is sufficiently low to prevent eye hazard regardless of exposure time.

Power is provided by batteries or ac lines.

False alarms caused by movement of such objects as leaves, birds or small animals are prevented by special circuits. Alarms touched off when people pass through the beam or tamper with a terminal are transmitted by ground wire or radio to a lighted display at a control point.

H-P will market automobile analyzer

A system to provide quick dynamic analyses of automobiles will be offered by Hewlett-Packard later this year.

The system measures the vibrations that appear in a car's major structural components during operation and determines from these measurements the amplitude and frequency of vibration as well as the mode of bending. The information is essential in the design of racing cars.

Hewlett-Packard puts Porsche racing car through dynamic analysis.

While such an analysis has been done before on an automobile, it took so long to reduce the data with analog techniques—several weeks—that it wasn't practical, a company spokesman says.

The key to Hewlett-Packard's system is the company's Model 5451A Fourier Analyzer—a special digital computer system that analyzes frequency distributions by Fourier transformations.

The Fourier Analyzer is an integrated system that includes an a/d converter, digital processor and user-oriented keyboard. Using mathematical techniques such as Fourier transformation and statistical averaging, the system can calculate transfer functions, coherence fuctions, auto power spectra (with double precision preserving a wide dynamic range), cross power spectra, and many other distributions of engineering and scientific interest.

The system operation is entirely digital, to maximize accuracy and flexibility. Its relocatable software feature facilitates the addition of new programs to the system. Programs may be written either in Fortran and in Assembly language.

New TI courses to cover 3 fields

Linear and interface ICs and optoelectronics are the latest subjects to be offered in video-tape courses by the Texas Instruments Learning Center in Dallas.

Classroom presentations of the four courses (two on optoelectronics) will begin Sept. 17 and continue through next April 5 in 22 cities in the United States and Canada.

The linear IC course is devoted to operational amplifiers, comparators and voltage regulators as well as materials and processes used to fabricate linear circuits. Active filters, differential amplifiers and clamping circuits are a few of the application areas to be covered.

Topics for the session on interface ICs include line drivers and receivers as well as sense, video, i-f and power amplifiers.

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INFORMATION RETRIEVAL NUMBER 17

Unusual filter concept promises high-Q, low-frequency IC device

One of the elusive elements for the designer of microcircuits—the IC version of an LC filter with a large equivalent inductance at low frequencies—may be a step nearer realization with the commutative bandpass filter. Although the design concept for this type of filter has been known for a number of years, a working IC version has never been built.

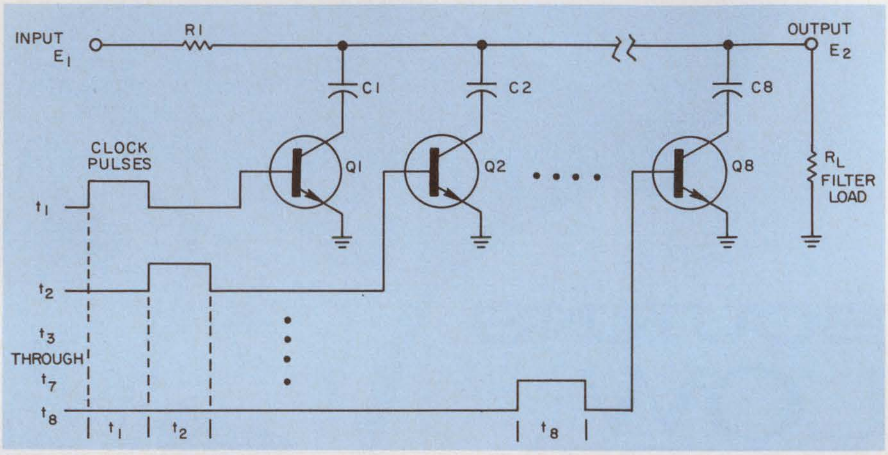
Now, Marvin Ryken Jr., an electronic engineer at the Naval Missile Center, Point Mugu, Calif., has designed and built a laboratory version of a commutative bandpass analog filter which, he says, could be developed into a commercial IC device.

The commutative filter has no amplifiers, Ryken explains. It has an input resistor, a load resistor, and a series of capacitors that are sequentially grounded by transistors driven by a filter clock signal (Fig. 1).

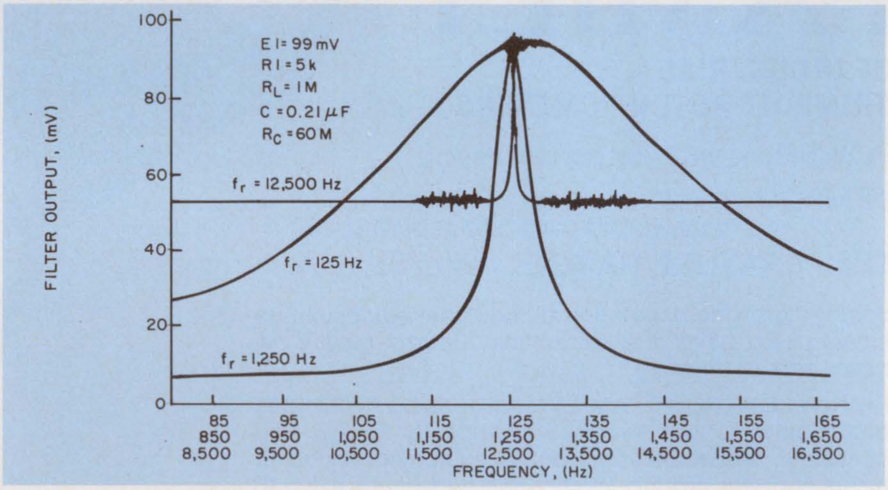
This type filter, Ryken says, has a number of advantages:

- It can be electronically tuned by changing the clock frequency.
- It has a wide, variable range —0 to 2 MHz in the configuration described here.
- The bandwidth is independent of frequency and is easily adjusted.
- The filter has an unusually high Q at very low frequencies. The Q, which is also adjustable, increases as a function of frequency.
- The filter Q is substantially less sensitive to changes in filter-element values, in contrast to relatively large variations in the Q of standard twin-T active filters for small changes in amplifier gain.
- It has a comb-filter response that is useful in increasing the signal-to-noise ratio.

Jim McDermott
Eastern Editor



1. **The commutative filter is simple.** The prime elements are R_1 and the capacitors. R_L is the load on the output. It is an analog filter.



2. **For a given commutative-filter configuration, the bandwidth is constant** over a range of frequencies. Here the range is 1:100.

According to Ryken, this device is expected to find low-frequency applications in equipment such as transponders, radar, underwater sound gear and low-frequency spectrum analyzers.

Because of the filter's unique operation, Ryken notes, it is possible to tune the commutative filter by changing the clock frequency. With this type of filter (Fig. 1), Ryken explains, the input signal is applied to the network consisting of an input resistor R_1 and several commutating capacitors—C_1, C_2, etc.

The commutator clock frequency, f_c, is some multiple of the

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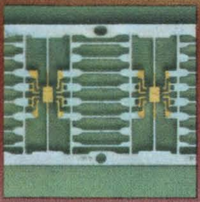

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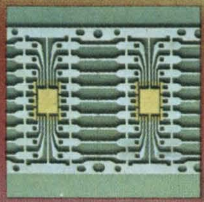
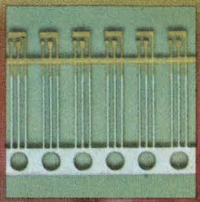


Signal transistor/ lead frames TO-92.



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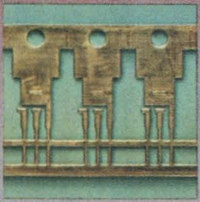
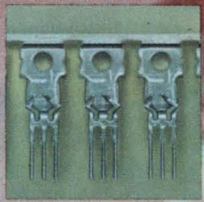


TO-66 power transistor/ lead frames.



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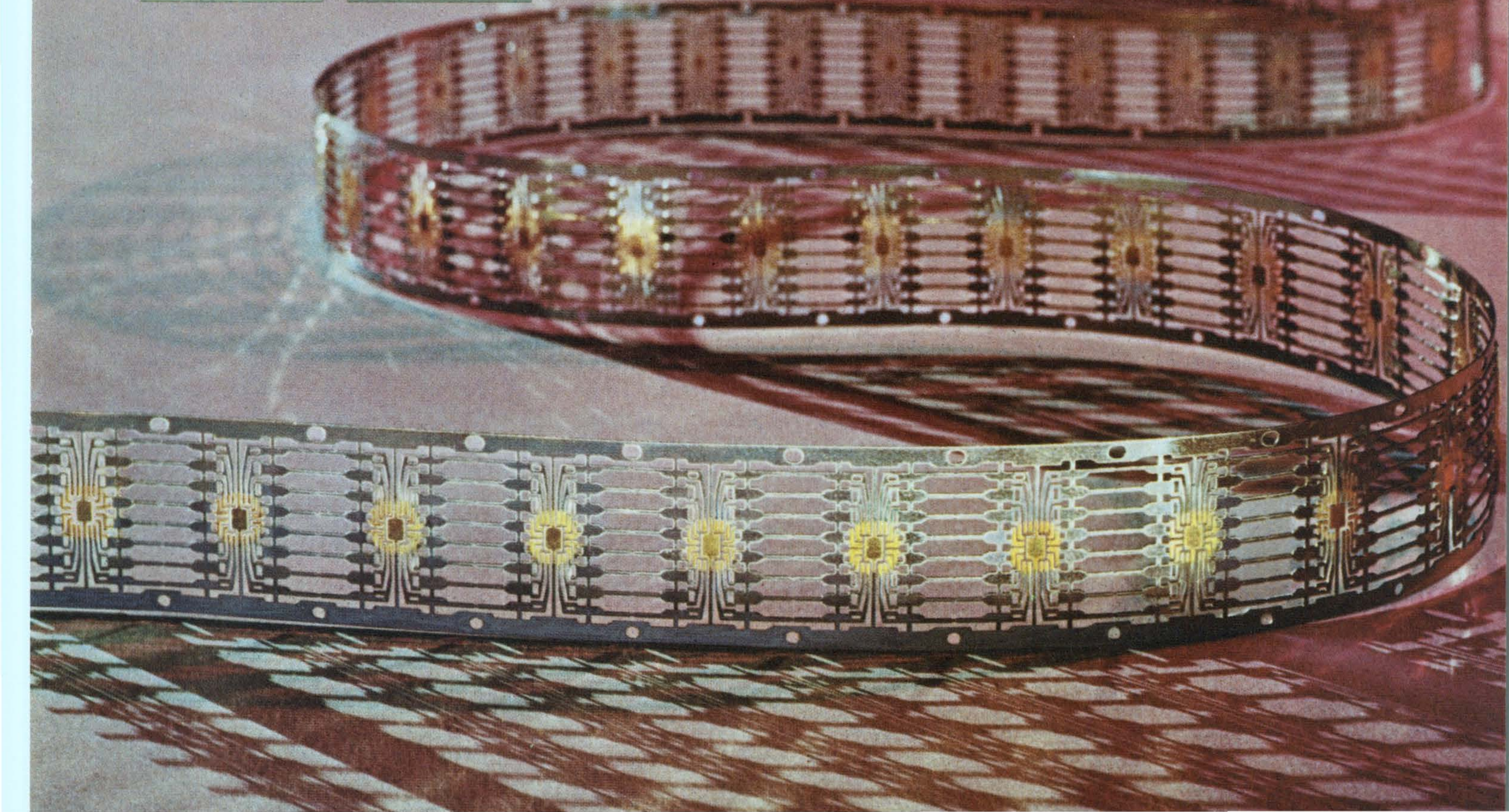


fundamental resonant frequency of the filter, f_r, depending upon the number, N, of capacitors being commutated ($f_c = Nf_r$).

During commutation, Ryken points out, each capacitor is successively exposed to a portion of the input signal. The charging rate of each capacitor is governed by R_1C time constant which is several times larger than the clock "on" periods, t_1, t_2, etc. Several clock cycles are required to charge the capacitors to the average value of a segment of the input voltage.

Therefore, if the input frequency, f_r, is some submultiple of the clock frequency, the average value of the sampled segments of input voltage will ultimately appear on the capacitors. In this case, the fundamental frequency and its harmonics will be passed by the filter.

However, if the input frequency is not an exact submultiple, the average value of the sampled voltage will be different for each clock cycle and the capacitor bank will charge to some small voltage near zero. As a result, the frequency is rejected by the filter.

Hence, by changing the clock frequency, the frequency at which the filter will pass a signal is also changed.

The upper frequency limit is about 2 MHz which, Ryken says, is a tradeoff between the high-speed clocking logic and commutation noise which increases with frequency.

The biggest problem with the filter to day, Ryken admits, is that the filter itself adds noise components: switching noise caused by unequal saturation voltages of the bipolar transistor switches, unequal stored charge on the capacitors, and feedthrough spikes from the commutating signal.

Reducing the noise level

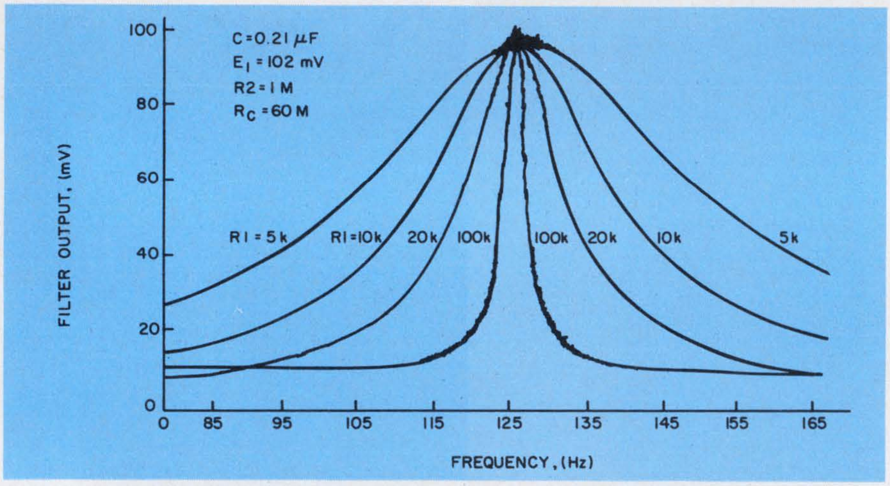
The bipolar transistors in the original version were a prime offender, Ryken points out. In his latest version using FETs instead of bipolars, the noise level at 12,500 Hz (Fig. 2) has been reduced from about 55 mV to 8 mV.

The noise shown on top of the response curves in Figs. 2 and 3 is due to the clock frequency beating with the input. This gives a difference frequency that appears as small perturbations. These can be removed with post-filtering, Ryken says.

For a sine-wave input, the output is a sampled sine wave, and post-filtering is needed here for smooth reconstruction. The commutative filter is useful, Ryken says, for filtering pulse trains, such as in radar returns. These pulse trains have their energies concentrated at the fundamental pulse frequencies and in small-number harmonics.

To preserve the pulse train the 3-dB frequency should be at least 4 f_r, he explains, in which case N equals eight, the number of stages used in the experimental model.

The capacitors for the test filter (Fig. 1) were 0.22 µF Mylar, matched within 0.86% at 0.21 µF. The clock pulses for the filter were generated and sequenced by standard IC logic circuits.



3. **The bandwidth of the commutative filter is adjusted** by simply changing the value of input resistor R_1. In practice, this may be a potentiometer.

The bandwidth of this type filter, neglecting the loading, is dependent on the relation:

$$BW = 1/(\pi NR_1C)$$

It is independent of frequency.

The bandwidth is easily adjustable, by substituting a potentiometer for R_1 (Fig. 1). Variation of R_1 changes the bandwidth as shown in Fig. 3.

The Q of the commutative filter, neglecting leaky capacitors and the load resistance is equal to: $\pi f_r NR_1C$. As a result, the Q is frequency dependent, increasing directly with frequency.

The Q for this filter is unusually high, particularly at the very low frequencies. For example, for the response shown in Fig. 4, at 125 Hz, for a filter with R_1 = 100 k, Q is about 60. The effective inductance of this filter is about 7.7 H at 125 Hz.

The sensitivity of bandwidth and Q of the commutative filter to changes in the values of the filter elements, R_1, load, R_L, and the capacitors is very low.

For a given change in R_1, sensitivity factors range from −1.3 for the change in bandwidth to 1.3 for the change in Q. This is substantially less than that of a typical RC active filter with a twin-T feedback network. In this circuit the sensitivity of Q to amplifier-gain changes is equal to 2Q.

The comb-filter frequency response can be used to good advantage in increasing the signal-to-noise (S/N) when the signal energy is concentrated at harmonics of the commutator frequency. This can be done by filtering the noise energy out of the frequency spectrum between the harmonics of the signal.

If only the fundamental response is desired, Ryken points out, a low-Q, low-pass active filter can be used to remove the harmonics while the commutative filter provides the high Q and narrow bandwidth which further minimizes noise.

Representative figures for signal-to-noise improvement between the input and output is from 25 to 30 dB. Insertion loss of the filter is low (see Figs. 2, 3). ■■

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TV cameras employing charge-coupled devices being readied for market

Charge-coupled device television cameras, a laboratory development only a year ago, are headed for the commercial marketplace, with at least two companies—General Electric and RCA—readying cameras to be announced before the end of this year.

The camera being developed by RCA at its laboratories in Princeton, N.J., is, according to Roy Minet, marketing manager for imaging devices, aimed at proving the feasibility of building an all solid-state CCD image sensor—one that will have the same performance as currently available 2/3-inch silicon target vidicon tubes. The CCD camera will be cheaper, more reliable, smaller and consume less power than the vidicon types now being used.

RCA's new camera will be announced before the end of this year, notes Minet. Other sources indicate that the announcement could come as soon as next month.

The RCA camera, for black and white television, will be fully compatible with today's broadcast receivers. This is in contrast to the low resolution CCD cameras that have been developed to date by Bell Laboratories, Fairchild Semiconductor and RCA.

Using what they claim is the largest chip so far—about 300 by 400 mils in size—the CCD imaging chip will contain an array of 256 by 320 bits. According to

TV resolution explained

The resolution of the standard television receiver is not as good as is generally thought, notes RCA's Minet.

Of the 525 horizontal TV lines, 35 are lost due to blanking and synchronization. This leaves 490 active horizontal lines on the screen. Of this, it is generally accepted that about 30% of the scene detail will be lost due to the line sampling. This leaves the vertical resolution of the home TV receiver at about 343 horizontal lines.

The horizontal resolution of a TV receiver is usually defined as the amount of detail visible in the picture expressed in TV lines. Of the 6 MHz available in the standard TV channel assignment, only about 4.2 MHz can be used for video information. If, as in the 525 line system, 30 complete picture frames are transmitted each second, then the total number of picture elements per frame turns out to be 280,000.

About 15% of this number of elements is lost due to horizontal blanking, resulting in 214,000 elements. Since the active number of scan lines has been determined as 490, dividing this into the number of horizontal elements yields 437 elements as the maximum horizontal resolution available from the standard TV signal.

This number is further reduced due to the fact that there is an aspect ratio in which the width of the picture is 33% greater than the height. Thus the horizontal resolution of the home TV receiver is only about 328 elements, or approximately 80 elements/MHz.

Minet, this is sufficient to give a high-quality television picture as good as that obtained from a vidicon. The reason, he explains, is that the 256 vertical lines can be interlaced, or read out in two progressively scanned fields. This, he continues, makes it look like there are 512 lines, compared to 525 in the home TV set.

Interlacing is used now in standard television sets, but not to increase resolution. Instead it is used to increase the number of pictures per second that the eye sees, thus reducing the amount of flicker.

GE looks at low resolution camera

While RCA is placing its bets on a high resolution TV camera, General Electric, Syracuse, N.Y., is looking at the low resolution market for its first commercial entry.

According to Richard Stuart, manager of engineering for GE's Image Device Dept., complete systems based on a CCD chip are currently in the design stage.

Industry sources indicate that the chip GE is using is a 100 by 100 array using charge injection. This device differs in many respects from the CCD used by RCA. Instead of using one photodiode per picture element, the GE device uses two photocapacitors per element. Elements are chosen by an xy addressing scheme.

During the horizontal scanning of the array each line is turned off as it is addressed, resulting in one capacitor in each element on that line being turned off. When the capacitor is turned off, the charge that was on it is transferred to the other capacitor of the pair.

During the vertical scan a pulse is applied to each element in the horizontal line. As it addresses each element in that line the second capacitor is turned off and the charge is dumped into the substrate. This substrate current comprises the video signal.

As Stuart sees it, the big markets for low resolution TV cameras of the type GE is building consist of surveillance and closed circuit television applications. In these areas, he goes on, the smaller number of elements—as compared with the high resolution devices—isn't going to prevent or really limit the usefulness of these cameras. This is particularly true, says Stuart, where small size and low power are significant factors.

In addition to the low resolution CCD camera which GE is expected to announce before the end of the year, the company is looking at higher resolution devices, such as the RCA one.

Applications for a high resolution camera, notes Stuart, include the possibility of electronic movie cameras to replace present photographic ones. In this application movies could be recorded on a tape cassette. The key advantage of such a situation would be no need for photographic processing and the possibility of instant replay.

Fairchild Semiconductor, Mountain View, Calif., the first company to produce a commercially available CCD imaging device—a 500 by 1 line sensor—is also working on TV compatible CCD camera.

As a result of winning the second phase of a Navy contract in which RCA and Texas Instruments were also involved, Fairchild is required to deliver a 500 by 500 image sensing array to the Navy by April, 1974.

According to Gilbert Amelio, director of the company's CCD group, the requirement is not really for a 500 by 500 array, rather it is for a TV compatible device.

Amelio notes that compatibility can be accomplished with a somewhat smaller device, something in the neighborhood of 390 by 490 elements.

Amelio says that their main customer for such a device would be the military, although it seems clear that the broadcast TV industry would also be interested.

Fairchild has also developed a low resolution 100 by 100 element CCD camera. Although no plans have been formulated yet, notes Amelio, Fairchild does have the capability of making it a commercial product by the end of the year.

"If we did decide to market the low resolution camera," he goes on, "we'd also supply modified monitors to use with them, since these cameras require different sweep frequencies."

While the need for special monitors might seem to be a problem, Amelio says that it's not. The extra cost to modify a TV monitor is not significant, he notes. ■■

Air Force continues push toward laser communication satellite net

Later this month the Air Force will select one of two competing lasers for continued development of the military's first laser communications satellite system.

The Air Force's goal is to get a small, lightweight laser package into orbit that will have a bandwidth capability of better than one gigabit per second, says Maj. Paul Freedman who manages the program at the Avionics Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio.

Known as 405B, Wright-Patterson's program, which will last for two more years, is expected to provide the Air Force with the technology it needs to build a high-data-rate laser communications network that will consist of both synchronous and low-orbiting earth satellites, and even aircraft.

By using synchronous satellites as relay stations, low earth-orbiting satellites could transmit at any time, regardless of where they might be, to a ground station in the United States.

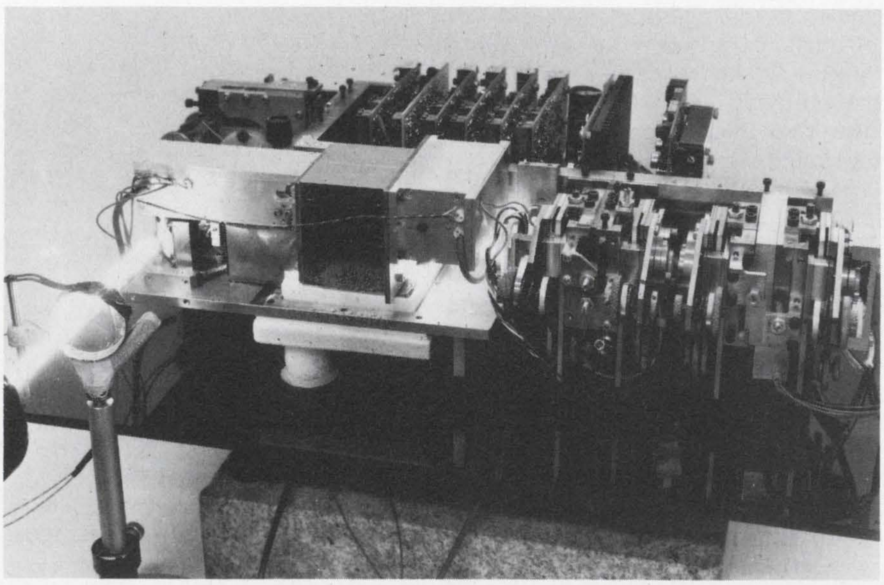
The actual space system will be built under the supervision of the Air Force's Space and Missile Systems Organization in Los Angeles.

John F. Mason
Associate Editor

Vying for the big job

The two competing brassboard laser systems—which means that all the components used are qualified for space flight—have been at Wright-Patterson since mid-July. They were built by Lockheed Missiles and Space, Sunnyvale, Calif., and McDonnell Douglas Astronautics, Huntington Beach, Calif.

The Lockheed candidate is a single-frequency laser that operates continuously in a single longitudinal and transverse mode. McDonnell Douglas offers a mode-locked pulse laser.



Lockheed's candidate for the Air Force's laser communications satellite system is a single-frequency system that operates continuously in a single longitudinal and transverse mode (TEM_{oo}). The competing system by McDonnell Douglas is a mode-locked pulse device. Both systems use lithium tantalate modulators.

Each airborne or spaceborne unit will function as a relay station. It will be equipped with a transmitter and receiver and a means for acquiring and tracking the next satellite that's within line of sight.

With such a system, a ground station in Australia, for example, could communicate with a low-flying satellite, or even aircraft, which would in turn relay the signals to a synchronous satellite over the Indian Ocean, from there the signals are relayed to another satellite over the Atlantic Ocean and to a ground station in the United States.

The communications portions of both systems use a frequency-doubled neodymium-doped yttrium aluminum garnet (ND:YAG) laser providing a .53 μm visible output.

Achieving an adequate power output—250 milliwatts—is still a problem. Lockheed has been able to meet the Air Force power requirement level only at low efficiency using a krypton pump lamp.

The beams in both systems are modulated electro-optically by a lithium tantalate crystal by means of quadriphase shift keying (QPSK).

The receiver package utilizes very high speed static and dynamic crossed-field photomultiplier tubes. Gains are on the order of 10^4, 10^5 and 10^6, "depending on how you want to build the tubes," Freedman says,. The quantum efficiency of the tubes depends on the type of photocathode surface used. These tubes have response speeds of some avalanche photodiodes. Explaining further: "As for photomultiplier bandwidths the tubes will actually pass two gigabit-per-second pulses."

Lockheed uses a polarization analyzer in the receiver to convert the polarization modulation into intensity modulation that can be sensed by a photodetector. Digital

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data are regenerated by performing the inverse of the QPSK modulation function. The photomultiplier was built by Varian Associates, Palo Alto, Calif.

The lasers will operate with 7-in. antennas which put out a beam 5 μrad wide. "This means that after traveling a distance of 60,000 km, the beam will spread to a diameter of about 1000 feet—a fact that makes pointing accuracy important," Freedman says. The 7-in. antenna has a gain of 112 dB.

Finding the target

For acquisition and tracking "both systems are able to point the beam with an accuracy of less than half a μrad," Freedman says. The transmitter and receiver lock on to each other by dual laser beams. Not only does the transmitter package send out a laser beam, but it can also receive a beam transmitter by the receiver package. "It's a closed-loop system with a laser beam going in each direction."

For pointing accuracy the synchronous satellite is able to determine its attitude within ±0.2 degree. The lower-orbit bird knows its attitude to within ±0.5 degree. "The whole acquisition and tracking sequence only takes between three to five seconds," Freedman says.

The lock-up sequence begins when the beacon acquisition laser signals the tracking satellite with a train of high-power pulses emitted at a rate of 10 per second. With attitude and ephemeris information for each satellite known, the location of the satellite can easily be determined. The searching beam can, therefore, have a beam angle of only one degree and still quickly locate the target.

A quadrant photomultiplier on the tracking portion of each satellite serves as a coarse acquisition detector whose output signal moves a gimbaled mirror so that the pointing laser points toward the beacon with an accuracy of better than 50 μrad (10.3 arc seconds). The pointing laser is then turned on, transmitting a beam of approximately 200 μrad back to the receiver satellite. In the brassboard model now at Wright-Patterson a helium-cadmium laser is used. In space, a frequency-doubled ND:YAG would be used.

The fine acquisition and pointing stage begins when the tracking laser's light beam enters the limited scan field of the image dissector tracker. The image dissector then takes over the job of pointing and tracking. The beamwidth of the tracker laser is 75 μrad (15.5 arc seconds).

In Lockheed's laser, frequency doubling is performed internally by a barium sodium niobate crystal. The laser is pumped by a potassium-rubidium lamp, or a krypton lamp, and the laser rod is conduction-cooled.

Traditionally, neodymium-doped lasers have been cooled by gas or liquid. "But we didn't want gas or liquid in a satellite," Freedman explains. "We did, however, want potassium rubidium for its high efficiency.

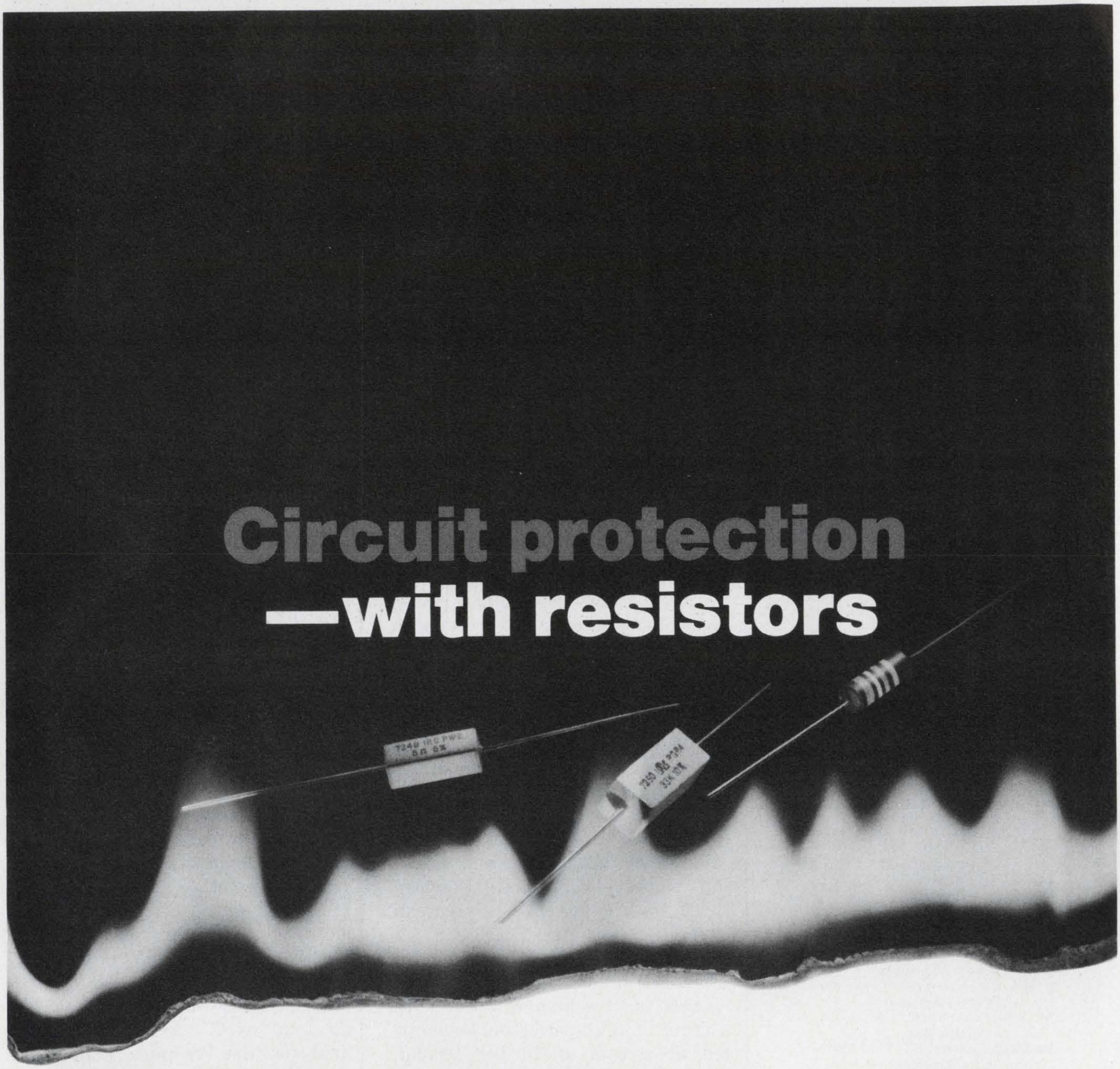
"The laser operates with only 250 W of power. In the past, such lasers have required up to a kilowatt. Both lasers operate in the green," Freedman explains. "We've got a banana crystal inside the cavity which generates second harmonics on a wavelength of 1.06 μs, which is what a YAG runs on. It generates green power at 0.53 μ."

In explaining the design philosophy, Freedman says: "It's a system tradeoff whether you operate in the green or at infrared frequencies—1.6 μ. Green is easier to modulate than red, it is more sensitive to detectors, but its light generation is less efficient. So which do you use?" After a systems analysis, the Avionics Laboratory chose green.

Splitting the beam

The McDonnell Douglas mode-locked laser puts out pulses at a rate of 500 million times a second. The pulses are 2 ns apart.

"The pulses come into the modulator system and enter a beam combiner which splits the beam. Half the beam goes through one modulator and the other half through another. Each modulator puts 500 million bits of information per second on its portion of the data stream, which is then combined again into a single stream. A 1 ns delay is created in one of the lanes so that they are optically multiplexed to a gigabit per second. ■■



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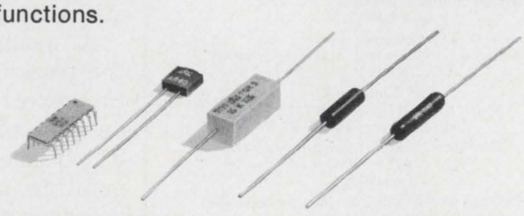

For technical data, flameproof specifications or specific application needs, contact your local TRW sales representative. Or write TRW/IRC Resistors, an Electronic Components Division of TRW, Inc., Greenway Rd., Boone, N.C. 28607. (704) 264-8861.

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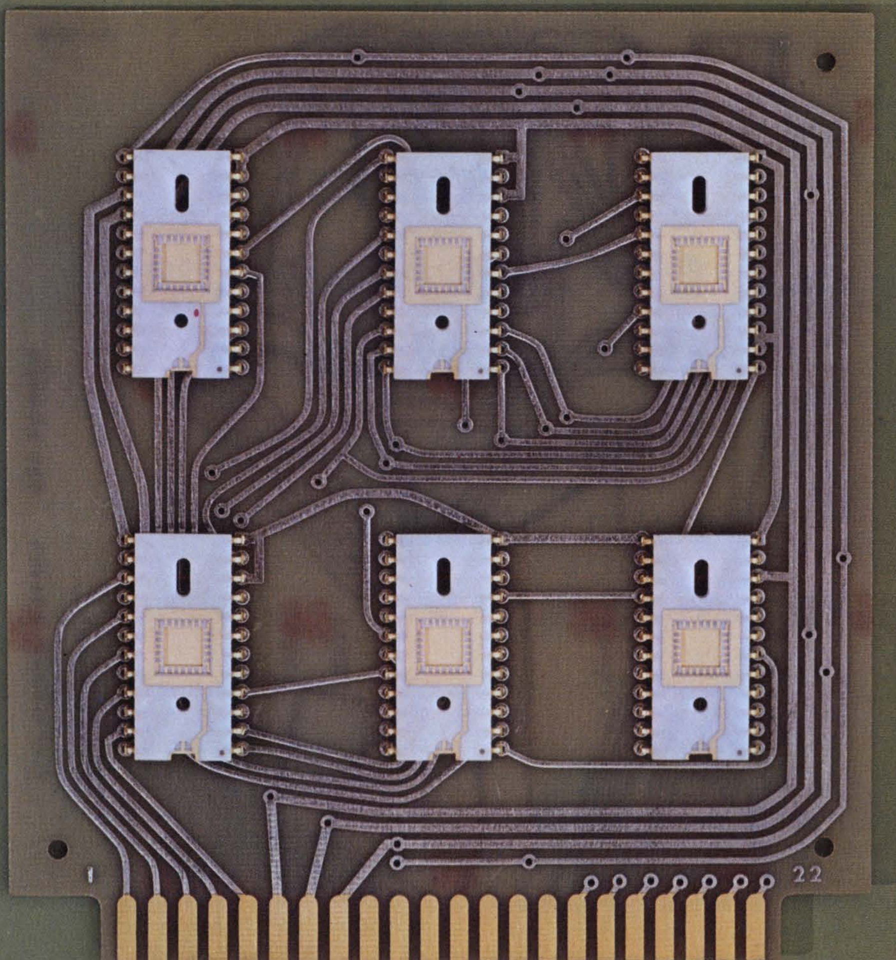

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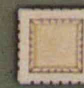

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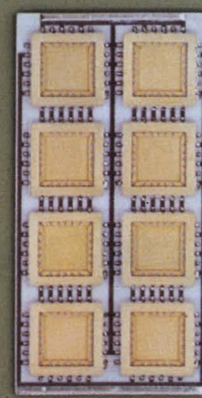

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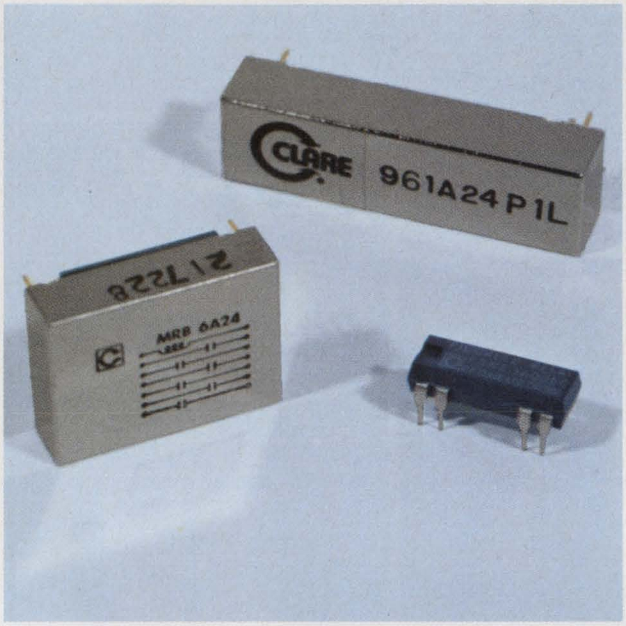

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INFORMATION RETRIEVAL NUMBER 27

washington report

Heather M. David
Washington Bureau

More stalemate for the long suffering F-14

The Navy's F-14 aircraft program has been thrown into limbo destined to last at least until Congress comes back from its summer adjournment Sept. 5. The situation is a result of contradictory actions of the House and Senate Armed Services Committees. The Senate unit voted to cut F-14 funds from $703.1-million to only $197.6-million while the House committee voted to permit the Navy to go ahead with a 50-aircraft procurement from Grumman Aerospace as the Navy requested. Both committees vetoed a Defense Department proposal to have the Navy conduct a "fly-off" competition between prototypes of a stripped-down, and hopefully less expensive, F-14, and a modified version of the Air Force F-15 fighter, built by McDonnell Douglas. The committees' refusal to permit the prototypes to be built was based in large part upon testimony by aeronautics expert George Spangenberg, who said the prototyping program and any subsequent choice of a new design would cost even more than it would to proceed with the current F-14 program. Deputy Defense Secretary William Clements, however, indicated he will continue to press for the prototype design competition and fly-off, which, according to some estimates, would cost between $150-million and $500-million.

White House fights proposal for a procurement office

The Administration is opposing a proposal for a new Office of Federal Procurement Policy which has been endorsed by the Electronic Industries Association, the Aerospace Industries Association and a large number of independent companies. The House Committee on Government Operations has been informed that the White House would rather let the Office of Management and Budget handle the job after making certain internal changes in the office that would enable it to serve as a focal point for uniform procurement policies. However, defense and electronics industry executives have argued the need for an independent office, with a professional and nonpolitical staff to act as arbiter between buyer and seller.

Air Force slips B-1 avionics; axes SCAD

The Air Force is postponing the award of a contract for the B-1 bomber's electronics suite as a result of the Defense Dept.'s decision to stretch out the bomber airframe program at Rockwell International. The Air Force was to make a choice in August between competing electronics suite designs by Cutler-Hammer's AIL Division and Raytheon. The first flight of the B-1 prototype carrying a full load of new electronics will be delayed from January, 1975, to the fall of that year, and a decision to go into production of the B-1 will not now be made until May, 1976, 10 months later than planned.

The service also recently killed off a program once associated with the B-1, the Subsonic Cruise Armed Decoy (SCAD), which was under development at Boeing. The countermeasures electronics for SCAD, which were being developed by Philco-Ford, will be kept alive by moving them over to the Navy's subsonic cruise missile program office.

Trade bill: relief for multinationals

Prospects for Congressional passage of a comprehensive trade bill before the September international trade negotiations begin in Japan seem almost nil. This means the Administration will enter the talks without a clear picture of what Congress may eventually permit in the way of tariffs and suspensions.

The House Ways and Means Committee has, however, tentatively agreed to vote in a bill that will be welcome to electronics firms with offshore manufacturing plants. The bill would require the President to order additional hearings by the Tariff Commission and other Federal bodies on the possible impact of suspension of Tariff Items 806.3 and 807. These items now exempt U.S. components sent abroad for assembly from tariffs upon reentry into the U.S. Both WEMA and the Electronic Industries Association testified against suspension of these items.

Capital Capsules:

The Air Force's Avionics Laboratory, Wright-Patterson AFB, Ohio, has awarded **study contracts to Texas Instruments and General Dynamics to define the all-new Digital Integrated Avionics System (DIAS).** . . . **A breakthrough in the program to develop nuclear fusion as a source of power has been achieved** by the AEC, which announced that a new tokamak plasma heating technique—a toroidal magnetic confinement approach—was successfully demonstrated at the Princeton University Plasma Physics Laboratory, N.J. It is hoped that the method can be used to achieve the 100 million degree temperature required for a fusion reactor. . . . The House Science and Astronautics Committee has embarked on a **three-phase inquiry into Federal policy, plans and organization for the support and utilization of science and technology.** Among other things, the committee is looking into how well the President's reorganization plan is working out that calls for abolishing the White House Office of Science and Technology and Science Advisor. . . . The Department of Transportation System Center, Cambridge, Mass., is **looking for contractors to develop a short-range, high definition radar for surveillance of airport surface traffic** that will operate at microwave or millimeter wave frequencies. . . . **The Air Force's Rome Air Development Center is investigating a recently observed phenomenon called the "Bulk Stain Effect"** which can reduce wafer yields. The Air Force will contract to identify and investigate the causes and the effect of the phenomenon on performance and reliability of silicon discrete devices and integrated circuits. . . . Philco-Ford and General Dynamics have each received **contracts in the $900,000 range from the Air Force to define the Defense Navigation Satellite system.** . . . After a delay of some nine months, the Naval Training Center, Orlando, Fla., says it will issue **requests for proposals in September for a low power, eye-safe laser to be used by the Army in training to simulate rifles, machine guns and missiles.**

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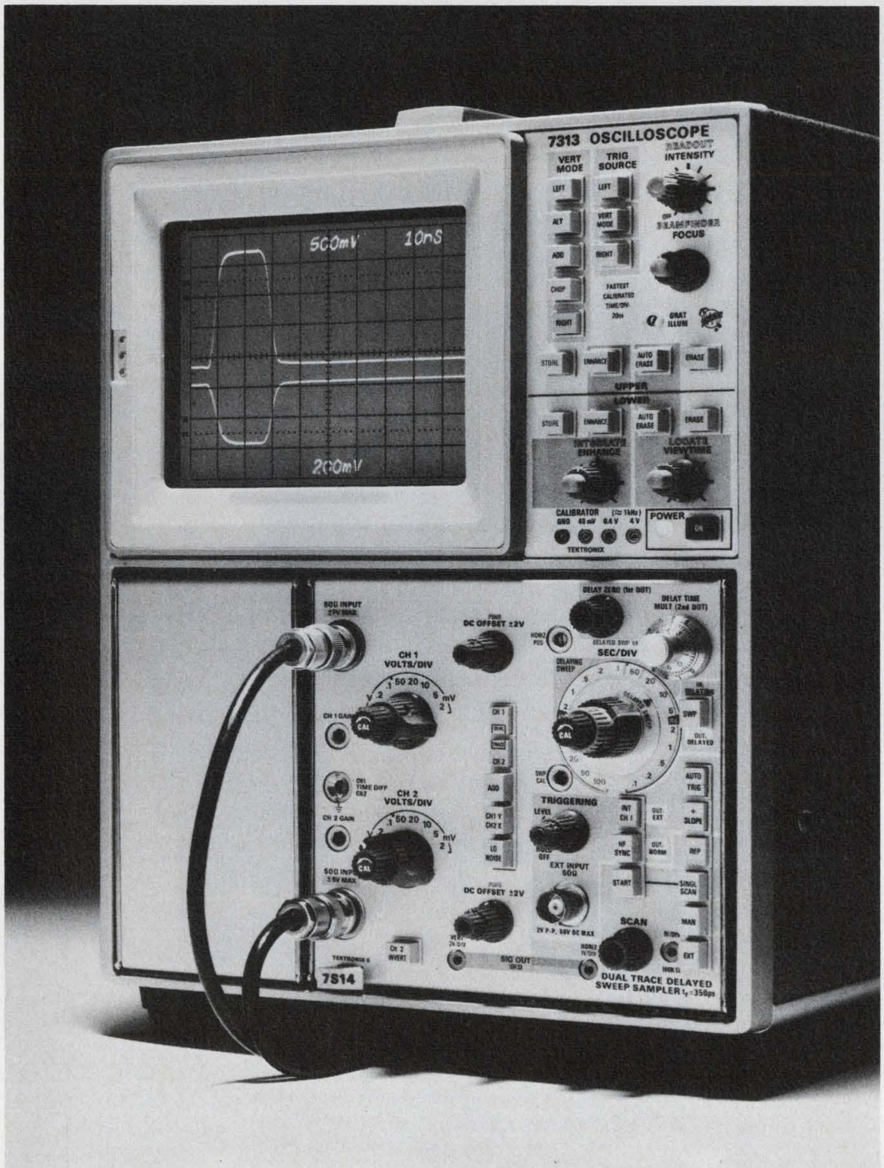

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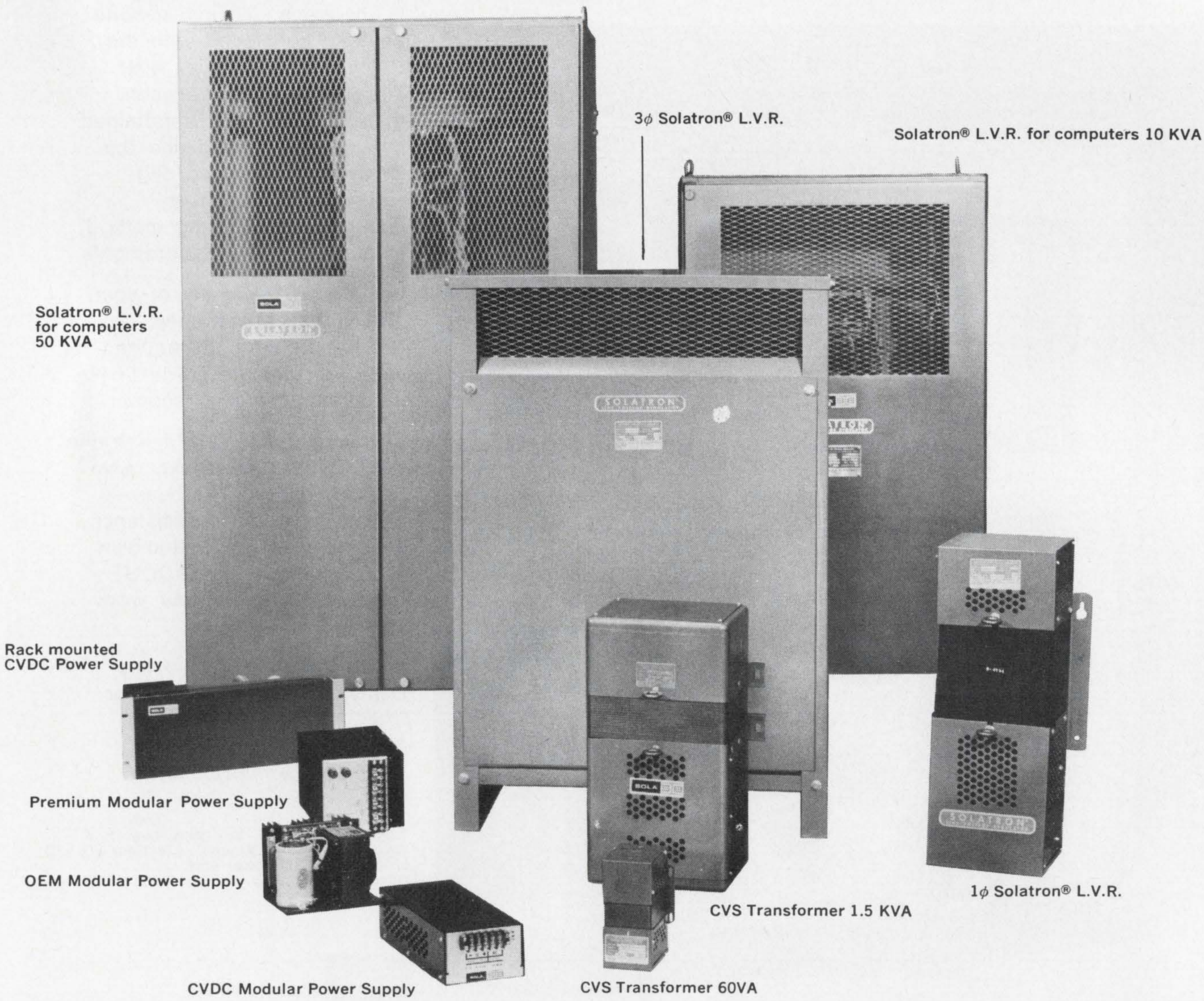

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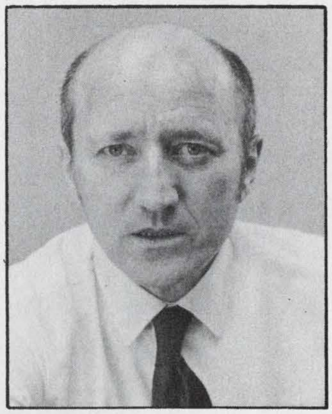
INFORMATION RETRIEVAL NUMBER 92

editorial

Women



"If you insist upon publishing pornographic advertisements," a reader wrote me recently, "please cancel my subscription to ELECTRONIC DESIGN. It's a shame, because I think ED is the best EE periodical around." Understandably, I was pleased with the second half of his note and quite upset with the first. I was concerned because, in the last few months, we received several notes from readers complaining about "pornography," "bad taste" or the "exploitation" of women in electronics advertising.

Now I hardly want to take up the banner for pornography, bad taste or exploitation. But what can I do about them? I don't even know what's pornographic, and I don't think the Supreme Court does either.

Is an ad pornographic or does it exploit women if it includes a scantily clad girl? Or just a pretty girl? Or just a girl? Would we be safe from charges of pornography if advertisers were to use ugly girls as models? Or men? It's certainly true that in a magazine with a predominantly male audience, a pretty girl has some attention-getting qualities. But this is a situation created by nature—not by advertisers. If we are to reject the use of women in advertising because they appeal to men, aren't we declaring that nature has been naughty or careless?

What about bad taste? As I read through any publication, I occasionally find ads that I feel are in terrible taste. Some of these ads show girls. Some don't. So what's bad taste? Who can be the judge of bad taste? Whom can we safely nominate as our censor? The Supreme Court? Richard Nixon? Me? Should I be arrogant enough to assume that others should not see an ad because I don't like it?

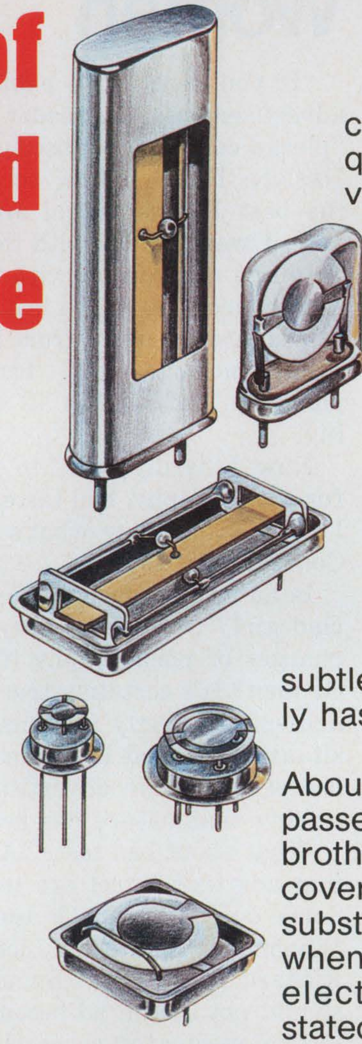
The specter of censorship is a far more dreadful danger than "bad taste." Unless engineers are so frail that they will be corrupted by bad-taste or sexploitation advertisements, the bad ads will be self-defeating. Readers will tire of them, and manufacturers will stop using them because they're not effective. The bad ads will die of their own weakness.

I have enough confidence in engineers to feel that bad-taste ads will annoy them. But they don't need censors to protect them.

George Rostky

GEORGE ROSTKY
Editor-in-Chief

apollo 11 dispelled forever the myth of the moon and green cheese



. . . . but we know for a fact there's a little bit of ham on the moon. We put it there.

Once upon a time ours was a very straightforward business. We processed nice, simple crystals and "HAM" filters. What a far cry from those uncomplicated days to that chilling instant when Neil Armstrong proclaimed his arrival on the lunar surface. McCoy crystals were imbedded in his space suit, and we at McCoy were as proud as we were disbelieving.

The quartz crystal is a truly remarkable substance. People become emotional about the diamond, yet it displays none of the versatility - the vitality - the virility - of quartz. Our quartz is crystalline in structure. Its atoms - its smallest bits and pieces - are exquisitely arranged in a preordained manner. The arrangement is about three mutually perpendicular axes. Quartz is very dense. Whereas a cubic foot of water weighs about 62 pounds, a like volume of quartz weighs a backbreaking 165 pounds.

Our survival as a nation depends upon a continuing supply of quartz. That's why we devised a method to produce it synthetically. Today, what mother nature takes eons to produce in the earth, we serve up from pressure cookers in a couple of months. In certain respects we have even improved on nature - in other very subtle respects, she apparently has much yet to teach us.

About a hundred years have passed since two scientist brothers named Curie discovered that a certain few substances, including quartz, when squeezed would squirt electricity. That's crudely stated, yes, but accurately stated no less. The brothers elected to call this behavior the Piezoelectric Effect (*piezo* from the Greek meaning *pressure*). Squirt for squeeze one of the better piezoelectric substances is Rochelle salt; however, it unfortunately is hygroscopic - it absorbs moisture from the air and crumbles. Quartz, which is not so piezoelectric as Rochelle salt, is lots less difficult to deal with. So over the years, we have thrown our lot in with quartz.

Those three mutually perpendicular axes we mentioned can best be understood if we were to visualize a six-sided prism.

FOCUS on Piezoelectric crystals and devices

Piezoelectric oscillator crystals and filter elements have simple basic shapes, such as bars, plates, or discs. When leads are attached to the element and it is mounted in any of the variety of MIL-standard or commercial crystal packages, it is a simple device that appears deceptively easy to specify.

But the reverse is true. Specifications for these devices are extensive and detailed. Frequently they are confusing and difficult to understand.

There are several reasons for the current confusion in crystal specs, some historical. But a main factor is that the quartz vibrating element is not simple electrically. It is a complex electromechanical system with several modes of resonance. Its operation is derived from the piezoelectric phenomena in which the mechanical strain or distortion of certain crystals that occur in nature, like quartz, produces an electric charge on their surfaces. Synthetic materials, including the barium-titanate and lead-zirconate-titanate crystalline ceramics, also exhibit this piezoelectric behavior.

The inverse effect—distortion of the crystal when a voltage is applied—is inherent in these piezoelectric devices. Use of this mechanical response to applied voltages is made in piezoelectric elements that perform as active, frequency-control devices in oscillators and provide passive, frequency-selective elements in bandpass or band-reject filters.

Device specifications have been developed by many independent authorities and agencies over the last 30 or 40 years. As a result, there is confusion today in terminology, in crystal manufacturers' specifications and in industry specifications like the MIL standards and the EIA and IEEE specifications. Nonstandardization of names and symbols is a problem. Frequently the same quantity is represented by different symbols.

Jim McDermott
Eastern Editor

No manufacturers' literature provides an exact, detailed analysis of the equivalent circuit of the quartz crystal operating in the resonant and anti-resonant modes. Instead approximations are given, and frequently they differ from manufacturer to manufacturer.

Specifications like aging rates are often given in terms that will make the device look better. Important specifications, like "pullability" are omitted by most manufacturers.

Other less obvious specs—like spurious response, which is particularly important in crystals used for filters—are generally omitted.

Specs don't agree

Some specs are not in agreement with themselves. For example, it's not unusual to find the L, R and Q of a crystal specified for a filter application, with a Q value that differs considerably from the X_L/R ratio. And in some cases L, C and the operating frequency may not be compatible for the same device.

Dependence on MIL standards for specifying commercial devices—a common practice—can be misleading and costly. Crystal users frequently refer to the MIL specs and select a unit from that listing, giving the manufacturer a CR number. But the CR number is associated with a comprehensive specification that includes a requirement for withstanding salt-spray corrosion. Also, CR types tend to have close tolerances over a temperature range of −55 to 105 C. For a commercial application in a controlled environment, the designer is paying a high cost for salt-spray resistance and operation over a temperature range that he doesn't need.

Temperature-stability specifications vary widely from manufacturer to manufacturer for the same type crystal and the same type cut.

A comparison of manufacturers' specifications, and in particular the curves that illustrate crystal characteristics and performance—like the plots of frequency drift vs temperature change—show wide variations in performance. Which data can you believe?

John Holmbeck, president of Northern Engineering Laboratories, points out that the industry suffers from excessive use of ideal curves that have been picked up years ago and passed on without revision from catalog to catalog. In evaluating a group of different vendors' specs, he suggests that the tightest tolerances are probably theoretical, while the loosest, or apparently the poorest performance, are substantially closer to what can be realistically expected.

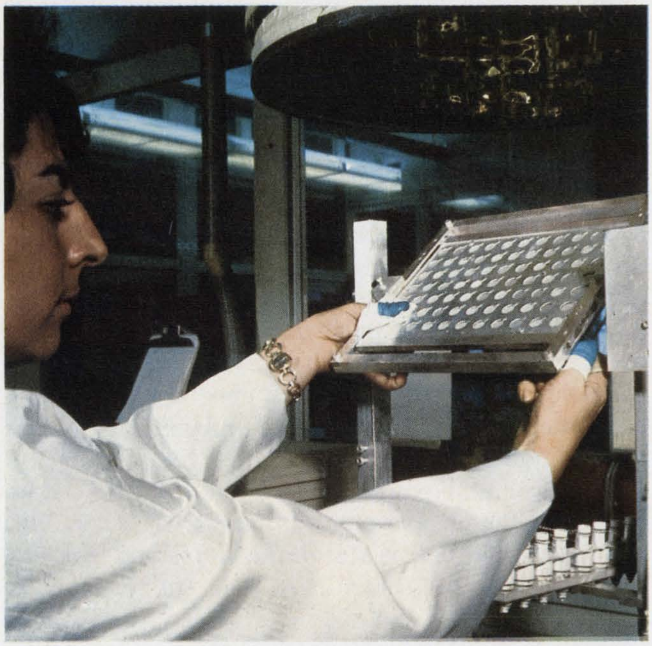
This brings up the question of just how much can you believe in the specifications? Can you expect to buy crystals and get the specified characteristics and performance?

According to Don Montgomery, vice president of engineering for Monitor Products Co., when you buy crystals, there's a good chance you won't even come close to getting the specified performance if you test the crystals in your own circuit.

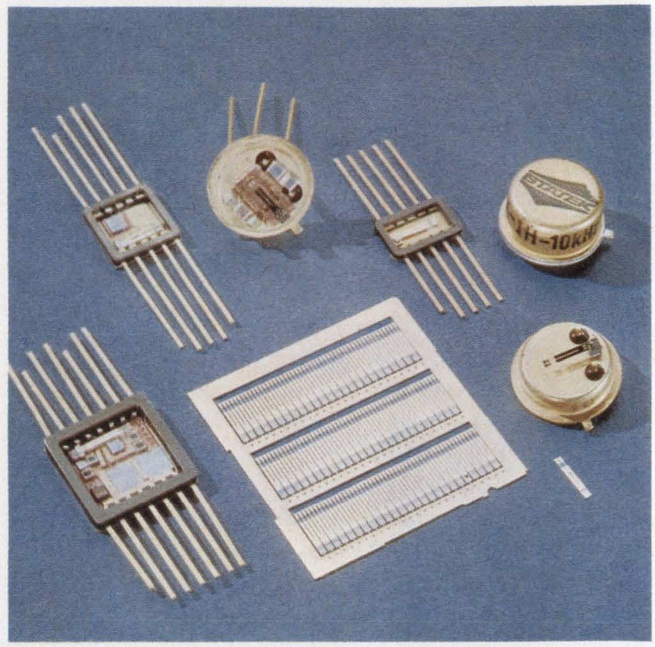
Why? Let Montgomery explain.

Today, he says, most crystal manufacturers are using test sets that the Government requires for contractors suppling MIL-spec crystals. They continue to use the basic numbers that MIL specs have established over the years, such as drive level and equivalent resistance. But these test sets, which are a minimum of 20 years old, are vacuum-tube crystal impedance meters that are series oscillators, in which the crystal is

Quartz crystal wafers, sawed from synthetically grown quartz boules, are polished and mounted in a variety of packages, including glass. Electrodes are plated or deposited on the quartz blank and connections are made to them through the mounting structure. These crystals, by Electronic Research Co., show wide variety available.



Seventy masked quartz crystals are being inserted, at Bulova Watch Co., into a fixture for vacuum deposition of electrodes. These crystals are fabricated for a TCXO.



A wafer of 75 tuning-fork crystals, by Statek, is flanked by typical packages and hybrid circuits in which they are mounted. The TO-5 header shows mounting.

actually operating as the oscillator frequency-control element.

This has created a major problem in the industry, Montgomery insists. For a direct comparison of performance, crystals must be compared on the basis of exactly the same kind of measurements. For example, he says, the industry specifies and ships crystals on the basis of its tests with the Government equipment that has high drive levels. But customers today use the designs with transistorized or IC circuits, where the drive levels are very low. This alone is sufficient to cause a frequency difference of as much as 1 to 5 ppm.

"Now the customer, upon receiving the crystal, may turn around and measure it with a Hewlett-Packard vector-impedance meter," Montgomery says. "This is an extremely good and accurate method. But it's measuring the characteristics different than we are, and the results will not agree."

Whereas in the test oscillator the crystal is actually a part of the oscillating circuit, in the vector-impedance meter the crystal is being driven by a signal generator. As a result, there will be a phase-angle difference and an equivalent resistance difference.

Montgomery cites a 2-MHz crystal. Assuming you measure it with a 10-mW drive on the Government test equipment, the crystal may measure 180 Ω. In the vector impedance meter this may drop to 100 Ω. And the frequency will also change slightly.

If the customer wants a crystal within a 0.005% tolerance, his vector-impedance measurements will indicate the crystal is out, although the manufacturer calibrated it to that tolerance on his own equipment.

What's the answer to this problem? Montgomery recommends that where the required calibration tolerance is closer than 0.002%, the crystal circuit designer provide the manufacturer with a test oscillator configuration exactly like that in which the crystal is to be used.

As the first step in specifying a crystal properly, the equivalent circuit of that device must be analyzed, according to John Gliever, crystal circuit designer at Hewlett-Packard's Santa Clara Div. in California. For the best insight, he suggests taking the equivalent circuit (Fig. 1) and analyzing it mathematically.

In the electromechanical system represented by the equivalent circuit of Fig. 1, the crystal blank itself has a vibrating mass that appears to the circuit to be a motional inductance (L_1).

The mechanical losses of the vibrating element —which include the molecular friction and acoustic loading of the blank by the ambient air or inert gas in the case in which it is sealed—appear as an equivalent resistance, R_1.

The elasticity of the quartz crystal appears to the circuit to be a small motional capacitance, C_1.

Capacitance C_0 is the static capacitance between the electrodes plated on the quartz blank together with the stray lead and holder capacitances. A crystal can operate in the series-resonant mode or in the parallel anti-resonant mode, or at some frequency between these points.

At frequency f_s, at which the reactance of L_1 and capacitance C_1 are equal ($f_s = \frac{1}{2\pi\sqrt{L_1 C_1}}$), the net reactance is zero and the series-resonant circuit becomes an equivalent of R_1 connected in parallel with C_o. The R_1 is very small compared with the reactance of C_o, and series resonance will occur at minimum impedance and at zero degrees phase shift.

As the frequency is slightly increased above f_s, the inductive reactance increases and the capacitive reactance decreases. This produces a rapid increase in the net inductive reactance. Capacity C_o is now a portion of the frequency-determining network. When $X_{L1} - X_{C1} = X_{Co}$, parallel anti-resonance occurs. In this case the impedance is a maximum and parallel anti-resonance occurs at the frequency f_p.

The frequency separation between the series and parallel resonance points of the crystal is a function of the ratio

$$C_1/C_o, \text{ or } f_p - f_s = 1/2\, f_s\, (C_1/C_o).$$

At anti-resonance, f_p, the crystal has a very high impedance and is also highly inductive. Because a voltage applied across it would also be inductive, this fact should be considered when measurements are made of the drive level at which the crystal is operating.

In the anti-resonance mode any capacity added to the crystal, such as a load capacitor C_L, becomes a portion of the frequency-determining network. The effective operating frequency of the crystal changes. As shown in Fig. 1, the frequency is slightly reduced by the added capacitance.

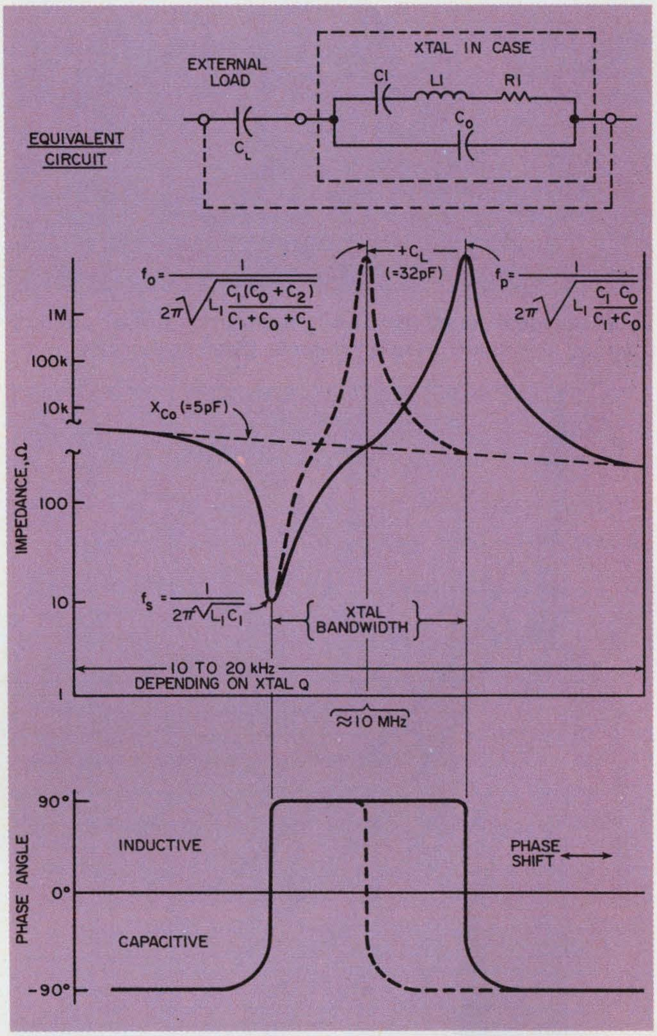
Check for crystal capacitive load

The only difference between a crystal that is designed for series-resonant operation and one for parallel anti-resonant operation is the capacitive load for which the crystal is calibrated. Where closer adjustment of the crystal frequency is required than that which can be provided by manufacturing tolerance, operation in the anti-resonant mode is usually used.

The preferred value for C_L below 1-MHz operation is 20 pF, Holmbeck points out, while 30 pF is preferred above 1 MHz. While 32 pF has been specified in the U.S. for over 23 years, 30 pF is the international standard.

Holmbeck cautions that extremely small values of C_L are generally avoided. He points out, however, that a tradeoff may be made here that normally would be unacceptable. As an example, he points to the fact that to obtain the low-power drain of CMOS circuits such capacitances must be kept very low.

A disadvantage of very large values of C_L is inconvenience in getting a large enough capacitance to obtain a desired frequency variation.



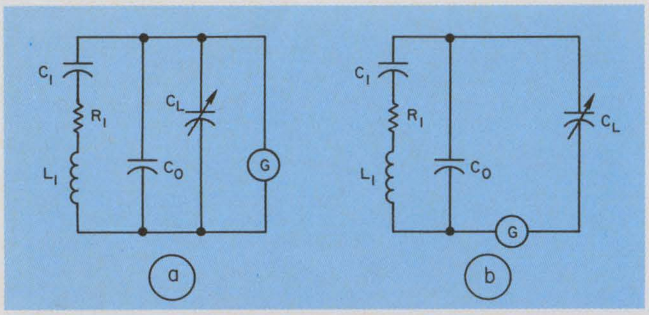
1. **Characteristics of the equivalent circuit of a quartz crystal** are such that when operating at series resonance f_s the reactive components of C_1 and L_1 are equal and the load is resistive. At the antiresonant frequency f_p the crystal presents a high inductive reactance.

Typical crystal parameter values

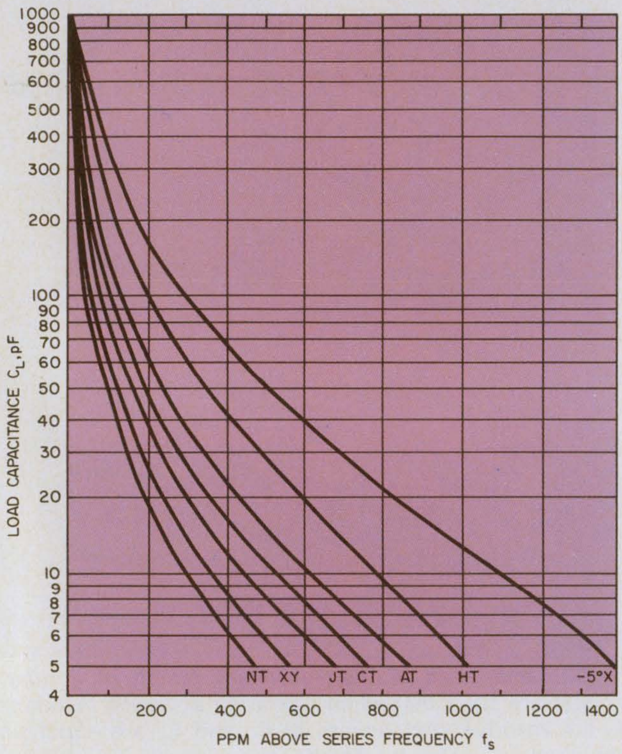
Parameter	200 kHz	2 MHz	30 MHz
R_1 (Ω)	2k	100	20
L_1 (mH)	27 k	520	11
C_1 (pF)	0.024	0.012	0.0026
C_o (pF)	9	4	6
Q	18 k	54 k	100 k

The pullability—or ability to shift the operating frequency of a crystal over a given range by means of a change in the capacitive load, C_L—is important for such applications as voltage-controlled crystal oscillators, temperature-controlled crystal oscillators and the design of crystal filters.

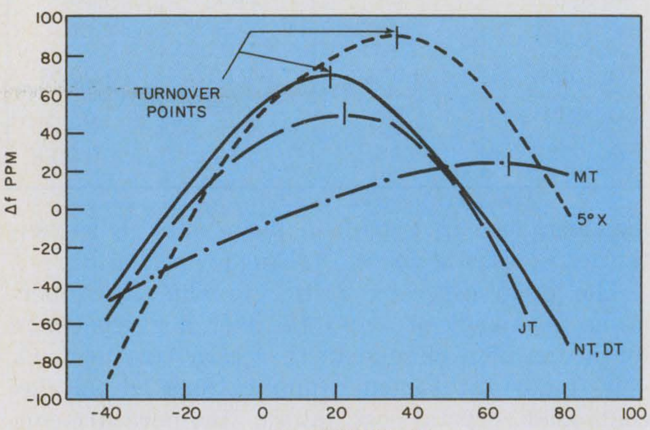
The bandwidth over which the frequency may be pulled is limited at the low end by series-resonant operation and at the high end by



2. **With ideal crystals and generators,** these circuits produce the same frequency for a given value of C_L.



3. **The degree to which a crystal can be varied in frequency** depends upon the ratio of the motional capacitance C_1 and stray capacitance C_0 as well as the Q of the device. Variations of bandwidth are shown.



4. **Frequency variations vs temperature change** for several kinds of low-frequency crystal cuts have same general shape. These curves can be shifted along the temperature axis to a limited degree by crystal fabricating methods.

parallel anti-resonant operation (Fig. 1). This bandwidth is a prime function of the ratio of motional and static crystal capacitances (C_1/C_0) and also of the Q of the crystal.

This C_1/C_0 ratio varies from about 1/900 for an NT cut to about 1/130 for the 5-degree X cut. (This ratio is conventionally stated in inverse form—C_0/C_1). Consequently, the NT cut has a narrow bandpass characteristic and the 5° X cut is a wide bandpass crystal. This bandwidth can be varied in manufacturing by control of the equivalent R_1, L_1 and C_1 parameters. For a given crystal, the operating frequency can be changed by a change of load capacitance (Fig. 3). The shift in frequency can be determined by the approximate formula

$$\Delta f = 1/2\, f_s \left(\frac{C_1}{C_0 + C_L}\right).$$

By special attention to control of crystal parameters and by the addition of capacity or inductance external to the crystal and within the total resonant circuit, it is possible to double normal pullability and bandwidths in voltage-controlled crystal oscillator applications.

The atomic structure of a quartz crystal has a unique orientation about three principal axes: the Z, or optical axis, which is nonpiezoelectric; the X, or electrical axis, which shows greatest piezoactivity, and the Y, or mechanical axis. A Y-cut plate—one with a major face normal to the Y axis—is also piezoelectric, and it has a positive temperature coefficient of about 100 ppm/°C. The X plate has a negative tempco of −10 to −25 ppm/°C.

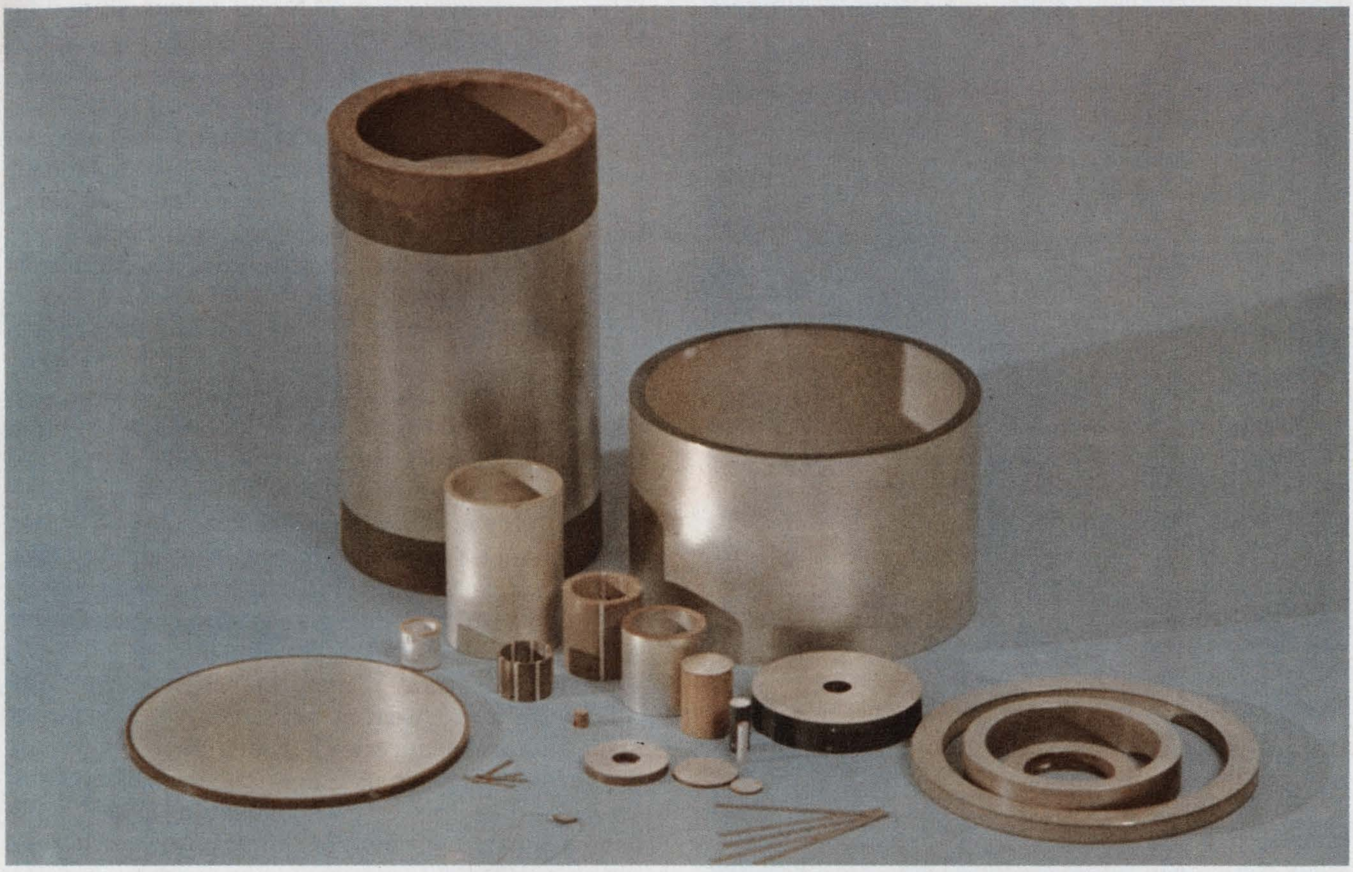
By slicing, from a quartz crystal, a plate that is rotated with respect to one or two of the axes, the manufacturer can combine the positive tempco of the Y plate and the negative tempco of the X plate, so that at one or more temperatures the coefficients tend to cancel each other. This can create a point at which there is no frequency shift with small temperature changes. This is called a turning point.

For the low-frequency types of crystal cuts shown in Fig. 4, which range in frequency from about 1 kHz to 700 kHz, the frequency-temperature curves are parabolas that can, by crystal design, be varied over a wide range.

For example, the curve shown for the NT, DT crystals may be shifted left or right, with the turning point falling between −50 C and over 100 C.

The range within which the turnover temperature may be shifted back and forth along the temperature axis is found in most detailed specifications of low-frequency crystals. If the range is missing, the manufacturer can provide it.

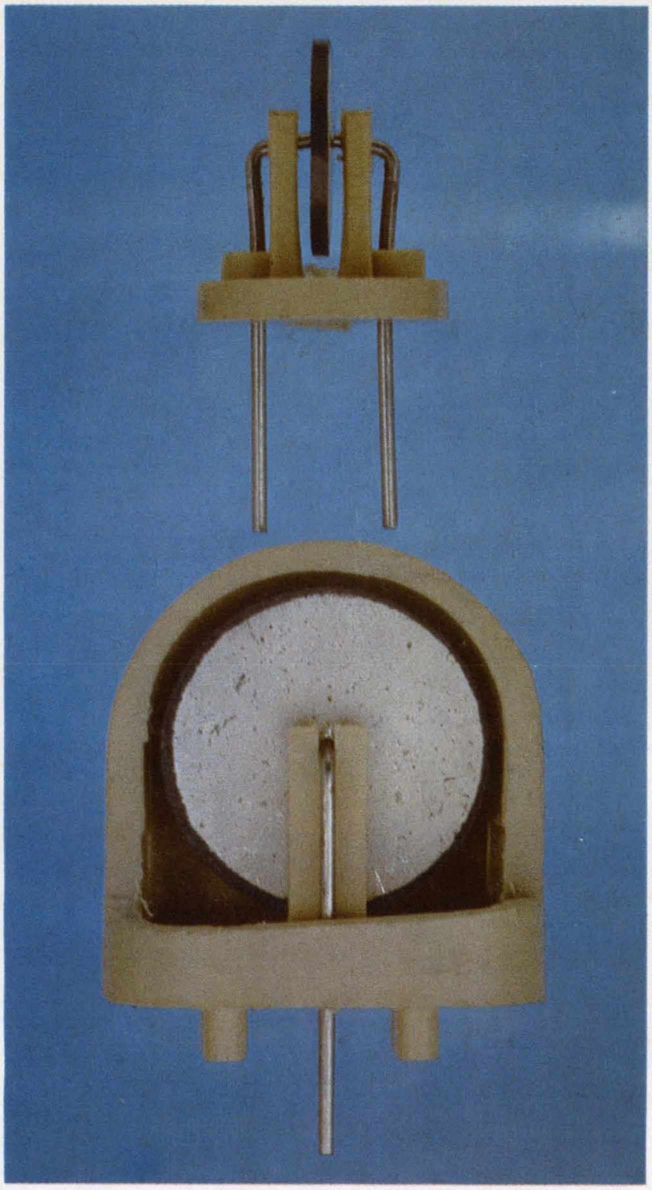
The AT-cut crystal, which covers more than 75% of today's requirements, is unique in that it has a cubic tempco of frequency that makes



Piezoelectric ceramic elements, like these from Vernitron, can be fabricated in a wide range of sizes and shapes impossible to produce in single-crystal materials. These elements are electrically poled during fabrication to produce their piezoelectric activity. This poling is applied to give a preferred electrical output or motion.

Piezoelectric transducer material characteristics

Material	Designation	Mode	k	ϵ/ϵ_o	d (10^{-12} m/V)	c (C/m²)	$V^2\rho$ 10^{10} N/m²	Curie Point (°C)	ρ (g/cm³)
Lead Zirconate Titanate	Navy I Vernitron PZT-4 Channel 5400 Edo West EC-64 Gulton HDT-31	TE TS LE_D LE_t PE_t	0.51 0.71 0.70 −0.33 −0.58	635 730 1300 1300 1300	— — 289 −123 −246	15.1 12.7 — — —	15.9 5.2 12.7 8.1 9.1	328	7.5
	Navy II Vernitron PZT-5A Channel 5500 Edo West EC-65 Gulton G-1500	LE_D LE_t PE_t	0.705 −0.34 −0.60	1700 1700 1700	374 −171 −342	— — —	10.6 6.1 6.9	365	7.75
	Vernitron PZT-5H Channel 5550 Edo West EC-70 Gulton G-1278	LE_D LE_t PE_t	0.75 −0.39 −0.65	3400 3400 3400	593 −274 −548	— — —	11.1 6.05 6.9	193	7.5
	Navy III Vernitron PZT-8 Channel 5800 Edo West EC-69 Gulton G-1408	LE_D LE_t PE_t	0.64 −0.30 −0.51	1000 1000 1000	218 −93 −186	— — —	12.5 8.7 9.9	300	7.6
Lead Metaniobate	Keamos, Inc. — Linden Labs —	TE LE_D	0.37 0.38	190 225	— 85	— —	— 3.7	.570	6.0
Barium Titanate	(Widely available under chemical name)	PE_t	−0.36	1700	—	—	11.7	115	5.7



Piezoelectric resonators, like this one from Radio Materials Co., can be used as active frequency-determining elements in oscillators or as filters.

it possible to maintain the tightest frequency tolerance over the widest range of any readily producible resonator. Fundamental operating frequencies range from about 0.5 to 30 MHz, while operation on third and fifth overtones produce frequencies from 10 to 150 MHz.

AT crystal has families of curves

Curves showing deviations of frequency with temperature for the AT crystal are invariably displayed in families of three or more (Fig. 5). These curves are produced by slightly different orientations of the crystal plate with reference to the crystallographic axis.

The curves in Fig. 5, from Northern Engineering Laboratories, are bounded at the −50 and 50 ppm scales by a 0.005% tolerance. The minimum coefficient over a wide temperature range falls well within a 0.0025% frequency tolerance between −55 and 105 C, while the minimum room temperature coefficient is within 0.0025% at −35 and 85 C. These values are typical.

Where precise temperature stabilities are required for AT crystals, ovens are recommended. For a frequency stability on the order of 10 ppm, the crystal temperature must be maintained within ±5 C. For 1-ppm stability, the temperature must be controlled to within ±1 C.

Excessive crystal drive levels can cause catastrophic failure of the quartz for the low-frequency cuts and destruction of the thin, deposited electrodes for the high-frequency cuts, at worst. At best, high drive levels force the frequency upward for AT cuts at high frequencies and down at low frequencies.

Permanent frequency shift can occur at drive levels that are substantially below catastrophic. High drive can also degrade aging characteristics and increase the crystal resistance.

Generally speaking, maximum drive levels for AT crystals range from 1 to 10 mW, depending upon the frequency, with the higher levels for the lower-frequency AT crystals. Low-frequency crystals—like the CT, DT, E-plate (+5° X)—have a maximum drive of 2 mW, while others—like the HT, NT and XY—are held to but 0.1 mW. When used in ovens, the 2-mW low-frequency AT crystals should be reduced to a drive of only 0.1 mW.

Aging is a complex phenomena

Aging of a quartz crystal is caused by many factors, such as leakage of the seals, contamination, wire and solder-mounting fatigue, outgassing of materials within the sealed holder, and overdriving.

Aging exhibits an asymptotic type of behavior, with most of the aging occurring during the first several weeks of dynamic operation. The aging rate then decreases to what is an essentially constant value for the life of the unit. A reasonable level for aging of room-temperature AT-cut crystals is about 5 ppm per year and double that for the low-frequency crystals, according to Holmbeck of Northern Engineering Laboratories.

Many suppliers specify the room-temperature crystals with a daily aging rate. This, according to Marvin Willrodt, applications engineer at Hewlett-Packard, Palo Alto, Calif., may make the crystals look better in some cases. But in any event, he points out, it is a meaningless specification because it simply can't be measured in a room environment. Daily temperature perturbations caused by drafts, air-conditioning or heating, completely obscure the aging rate.

"I prefer to use a monthly aging rate," Willrodt says, "because the same temperature variations in a plant environment tend to occur about the same time every day. And a different, but consistent, temperature variation occurs on the weekends. After a month's observation of these temperature cycles, the trend becomes obvious, and an averaging line drawn through the perturbations provides the true aging rate."

If aging rates of a crystal must be low, the crystal can be pre-aged by operation in a circuit for an extended period, by temperature-cycling or by giving it a high-temperature bake.

"In our high-reliability programs," Frank Wolf, manager of the high-reliability testing group at McCoy Electronics, says: "We find a high-temperature bake is sufficient. We age the crystals from two or three weeks to 1000 hours or more at elevated temperatures."

Best seal gives lowest aging rate

Crystal aging is strongly dependent on the seal of the crystal housing, Wolf points out. The glass-enclosed unit is the most permanent seal and provides the lowest aging rate, with the cold-weld seal next best. Solder seals give higher aging rates than either of the two.

The spurious response characteristics of crystals are like unwanted children. They're there, but nobody ever talks about them.

"You need to know spurious response," says HP's Gliever, "because such a response at an unwanted resonance close to an oscillator operating frequency can cause some circuits to lock onto a false frequency at start-up."

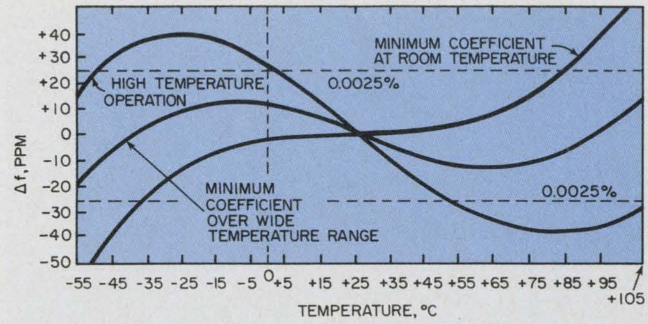
All crystals have spurious modes of operation, Gliever points out, and some manufacturer's products have worse parasitics than others.

Since spurious response is notable for its absence in manufacturers' specs, Gliever checks his crystals with an RX meter and a sweeping oscillator, used in combination. The relative separation and heights of the responses can be seen on the scope.

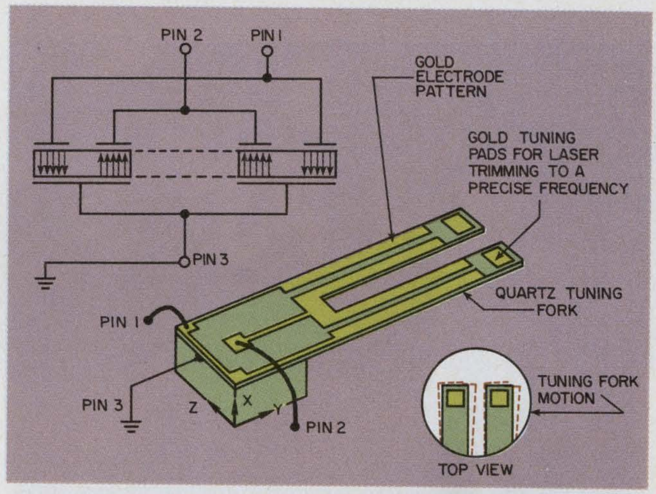
Gliever notes that when he makes spurious response a part of his purchasing spec, suppliers insist on an additional charge.

Today the AT-cut crystal, because of its superior temperature and frequency-stability characteristics, as well as range from about 1 to 200 MHz, is used in over three-quarters of all applications. The various cuts of low-frequency crystals—developed for World War II military applications in radar, sonar and low-frequency navigation and communication systems—make up the remainder of the market.

However, within the last two years a new mass market for low-frequency crystals has emerged: electronic watches and clocks. Initially a tiny 32.768-kHz XY bar was the industry's first watch standard and even today these crystals are being produced in the U.S. by Bulova, Motorola, CTS Knights, Reeves Hoffman and other firms. But in a drive to reduce further the size of these crystals, newer miniature elements, using conventional low-frequency crystal cuts, have emerged. They have frequencies of higher binary multiples like 131.071, 262.144, 245.760, 327.68 and 409.60 kHz. Miniature AT-cut crystals in the 1 and 4-MHz ranges are also under development.



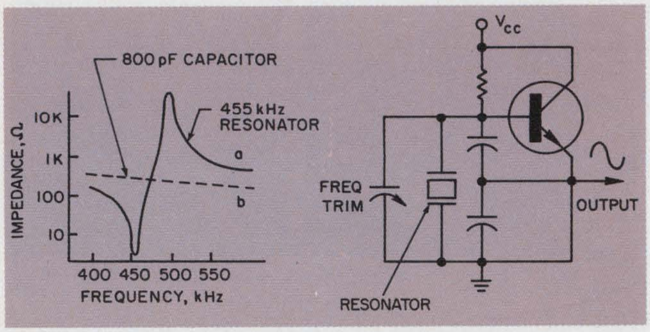
5. **The temperature curves of the AT-cut crystal** have unique shapes that can, by proper fabrication, be rotated about the turning point. For the example shown the crystal was designed for room-temperature operation.



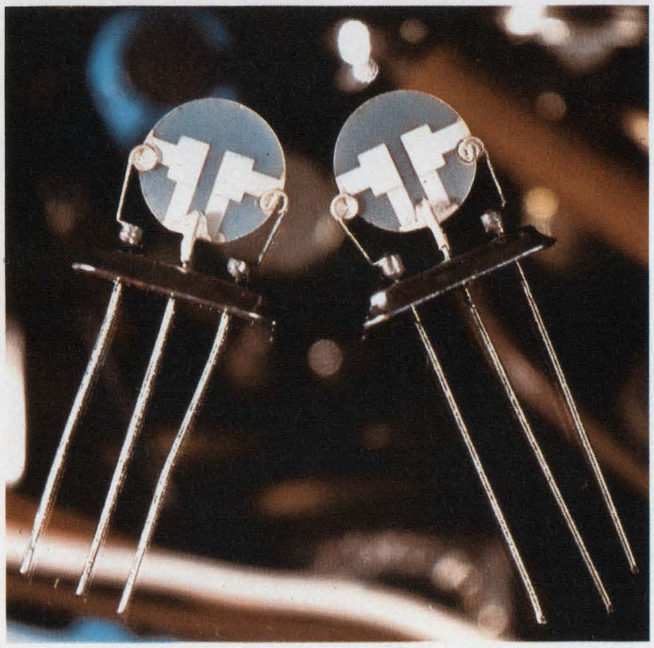
6. **The tuning-fork crystal has gold-plated electrodes** on both top and bottom. The varying electric field bends the tines towards and away from each other. The frequency of this configuration is about four times lower than that of a standard crystal of the same dimensions.

For low-frequency applications in watches and also for frequency-selective applications, such as in beep-tone pocket pagers and telephone data-transmission systems, a new type of low-frequency quartz crystal has emerged—the first major development in quartz-crystal production technology in many years. This is the tuning-fork crystal, produced by Statek Corp. (Fig. 6).

Tuning-fork crystals, which operate in the fundamental mode from 10 to 100 kHz and in the sixth overtone mode from 100 to 600 kHz, are tiny quartz tuning forks 160 to 250 mils long,



7. **The curves of a ceramic resonator are similar to those of a quartz crystal.** Here, the impedance of a 455 kHz resonator, by Radio Materials, is compared to the reactance of an 800 pF capacitor. The device is used in the oscillator circuit to produce a sine-wave output.



These two-pole, 21.4-MHz monolithic filters by Piezo Technology are ultraminiature. Four, six and eight-pole filters are made using multiple two-pole units.

25 to 40 mils wide and 1 mil thick. Fork-tine lengths range from 40 to 150 mils, and tine widths are 10 to 15 mils.

These forks are formed in multiples of 75 on a 1-inch-square polished quartz blank that is 1-mil thick. On this is deposited a thin film of gold. With standard photolithic techniques of IC technology, the gold electrode patterns for 75 resonators are etched on the blank. Unwanted quartz areas are then chemically milled out of the wafer, leaving 75 tiny tuning forks.

The crystal forks are then probed for activity. For the good ones, the gold pads on the ends of the tines are laser-trimmed to frequency. The standard tuning tolerance is within 0.01% at room temperature, although 0.002% can be obtained at additional cost. Statek watch crystals are currently being specified at 0.001%.

While quartz has been the sole piezoelectric crystalline material for years in frequency control and communications, a new synthetic material—lithium tantalate—has appeared. Developed by Bell Laboratories, it promises to be substantially cheaper and to provide filters with bandwidths that are 10 times larger than for quartz. Bell is using the lithium tantalate as a 1.5-MHz resonator, replacing quartz in telephone systems.

Other new synthetic crystals have been produced in recent years, such as lithium niobate. It is well-suited for surface-wave applications because of its high coupling coefficient and low acoustic velocity of 3.47×10^5 cm/s. Bob Carlson, marketing manager of Crystal Technology, Inc., pioneer producers of this material, says that until recently it was used in surface-wave delay lines only in military applications. But recent cost reductions have made it of possible use as a surface-wave broadband i-f filter in color TV receivers.

Piezoceramics are like quartz

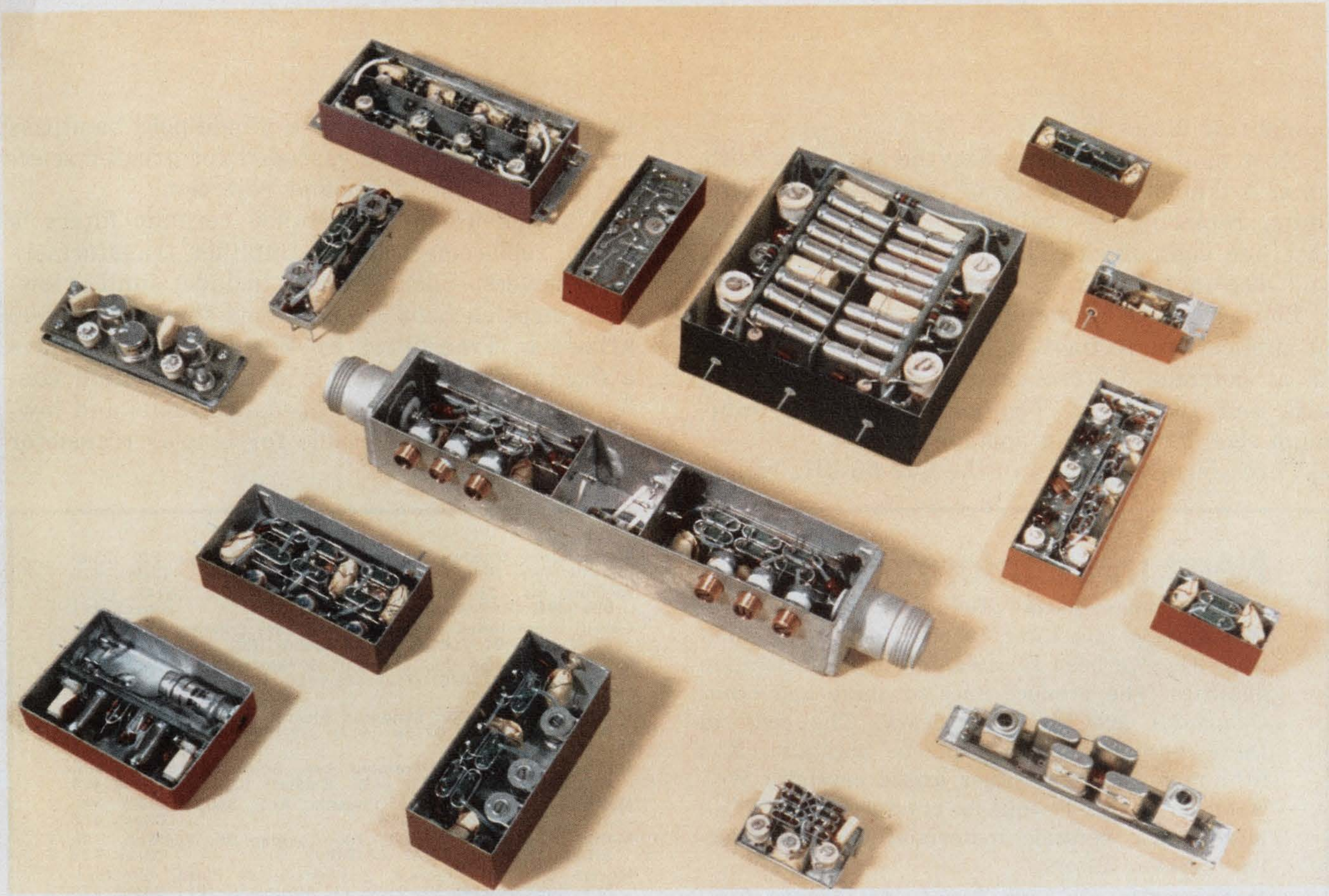
Piezoelectric ceramic materials are available that have the same basic piezoactivity as quartz and other crystalline materials. These ceramics —the lead zirconate titanates, the barium titanates and lead metaniobate—are nonpiezoelectric until a high voltage "poling" field is applied during high-temperature fabrication of the various shapes in which they are made.

Many of the larger forms are used as transducers in sonar, depth finders, fish finders, ultrasonic cleaners and other applications involving considerable power output. Smaller forms are used in earphones and microphones, phonograph pickups, vibration pickups and accelerometers, and frequency-sensing elements for low-precision oscillators. And smaller elements are also i-f filters for communications receivers, transceivers, and AM and FM radios.

Piezoelectric ceramic devices using ceramic resonators are produced by Radio Materials Co. for frequency-determining elements in low-frequency oscillators suitable for clock generators, sine and square-wave oscillators (Fig. 7) and carrier-current communications systems. One of these elements has a small disc resonator mounted in a proprietary way that minimizes spurious responses. The prime advantage of the ceramic devices is improved stability over IC circuits used for the same purpose. Frequency drift is less than 0.2% deviation from a 25-C value between −20 to 65 C.

Nominal frequency tolerance is 1 kHz for resonators operating with a series-resonant frequency from 180 to 550 kHz, depending upon disc diameter. The range can be increased to 1700 kHz with the use of overtone response.

The equivalent circuit of this resonator is



Crystal filters are used in applications where very sharp bandpass or band-reject characteristics are needed. Operating frequencies of these filters, by McCoy Electronics, range from about 20 to 200 MHz. The largest assembly, upper right center, is a 24-crystal, switchable bandpass filter that is used in the S3A aircraft.

identical to that of a quartz crystal. The motional inductance is on the order of a few millihenries, as contrasted with between 300 and 400 HF for a CT-cut crystal operating in the same range. The resonator material—a lead-zirconate-titanate system—has a large dielectric constant and is a relatively large ceramic capacitor. For the PC-18 material used in the device, the ratio of C_0 to C_1 is on the order of 8:1, giving an f_r-to-f_p bandwidth ratio of 1.06, as contrasted with 0.125% for the crystal.

Crystal filters are used where narrowband filtering of signals in the 10-kHz-to-100-MHz range is needed, such as in sonar receivers, AM, FM, ssb, dsb, cw and fsk radio receivers, and in radar and navigation systems. Both crystal filter designers and experienced filter application engineers indicate that the design and specification of these filters is orders of magnitude more difficult than selecting a single crystal.

Because of the complex interaction of ranges of parameters—including center frequency, bandwidth, shape factor, group delay, transient response, phase linearity, insertion loss, temperature characteristics and so on—an engineer who is not a crystal filter specialist cannot be expected to generate the optimum crystal filter spec for his application. This is one area, at least at the present state of the art, where close liaison between the equipment designer and the vendor's engineering group is essential.

Crystal filters today use both standard crystals and monolithic crystal elements. Below about 2.5 MHz standard crystals are used.

"Below about 2.5 MHz," says Vin Bates, director of operations for Damon Electronics Div., "we go to the regular filter because the physical realization of a monolithic device gets too big. And the amount of quartz that goes into the blank makes it expensive. With the regular filter, you have small quartz blanks."

Another area where conventional crystal filters would be chosen is in applications requiring ultimate rejection levels of −90 or −100 dB, Bates points out. In a monolithic filter this is still difficult, he notes.

The use of monolithic filters is still fairly new but is expanding rapidly. R. C. Smythe, president of Piezo Technology, Inc., specialists in the monolithic field, notes that in existing designs lower-cost monolithics are replacing conventional crystal filters. And new applications—like hand-held, two-way radios and pocket-paging receivers—have been made practical by the use of monolithic filters.

Most monolithic filters, Smythe says, are built up as a tandem connection of two-pole monolithic units, replacing several discrete elements with just one component. This reduces size and cost and also increases reliability.

Piezoelectric ceramic filters cover a wide range of applications in the 6-to-550-kHz region as well as at common i-f frequencies of 455 kHz, 500 kHz and 10.7 MHz. The advantages are minimum size, fixed tuning and lower costs.

Three-terminal filters in the 6-to-55-kHz range, by Andex Corp., provide a single-pole bandpass response. They can be cascaded for greater selectivity and higher stopband rejection.

A prime use of fixed-tuned ceramic filters is in the replacement of i-f amplifier transformers in receivers. Such devices include simple low-cost, three element replacements for 455 and 500 kHz—like Transfilters by Vernitron, which have a fixed-tuned resonator in a three-terminal configuration with a high-impedance input and low-impedance output, suitable for bipolar transistor matching. ■■

Need more information?

The companies and products cited in this report have, of necessity, received only brief mention. They've been selected for their illustrative qualities. The product lines of these and other companies are identified below. The code to these products is: Q—quartz crystals; X—lithium niobate and other exotic crystals; W—watch crystals; F—quartz crystal filters; PC—piezoelectric ceramic materials; PF—piezoelectric ceramic filters.

Accutronics, Inc., Div. Gibbs Manufacturing Research Corp., 628 North St., Geneva, Ill. 60134. (312) 232-2600. (F) **Check 396**

American Electronics Labs, Inc., Box 552, Lansdale, Pa. 19446. (215) 822-2929. (A. Rosset) (C) **Check 397**

American Trans-Coil Corp., 124-06 101 St. Ave., Richmond Hill, N.Y. 11419. (212) 441-5207. (W. Clancy) (F) **Check 398**

Andex Corp., 7076 Big Creek Pkwy., Middleburg Heights, Ohio 44130. (216) 845-1953. (Anthony Lungo) (PF) **Check 399**

Blackhawk Networks Corp., 14 N. Parker Dr., Janesville, Wis. 53545. (608) 752-8701. (R. W. Brandt) (F) **Check 400**

Bliley Electric, 2545 W. Grandview Blvd., Erie, Pa. 16512. (814) 838-3571 (Dave Bliley) (Q), (F) **Check 401**

Bulova Watch Co., 6120 Woodside Ave., Woodside, N.Y. 11377. (212) 335-6000. (R. Ansell) (Q), (F), (W) **Check 402**

Channel Industries, 839 Ward Dr., Santa Barbara, Calif. 93105. (805) 967-0171. (R. M. Callahan) (PC) **Check 403**

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Crystal Technology, 2510 Old Middlefield Way, Mountain View, Calif. 94040. (415) 961-9311. (Bob Carlson) (X) **Check 406**

Crystek Div., Whitehall Electronics, 1000 Crystal Dr., Fort Myers, Fla. 33901. (813) 936-2109. (Q) **Check 407**

CTS Knights Co., Sandwich, Ill. 60584. (815) 786-8411. (Q), (F) **Check 408**

Damon Corp., Electronics Div., 115 4th Ave., Needham Heights, Mass. 02194. (617) 449-0800. (N. Roy) (F) **Check 409**

Dietz Design, Inc., 100 Electronics Pkwy., Belton, Mo. 64012. (816) 331-4911. (W. Priest) (F) **Check 410**

Dittmore Freimuth Corp., 2517 E. Norwich St., Milwaukee, Wis. 53207. (414) 483-5100. (F.W. Dzurbala) (F) **Check 411**

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Erie Frequency Control, Div. Erie Technological Prods., 453 Lincoln St., Carlisle, Pa. 17013. (717) 249-2232. (K. Dance) (Q) **Check 415**

Filtech Corp., 10103 W. Pacific, Franklin Park, Ill. 60131. (312) 678-8900. (E. Argoudelis) (F) **Check 416**

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International Crystal Manufacturing, 10 N. Lee St., Oklahoma City, Okla. 73102. (405) 236-3741 (C) **Check 420**

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McCoy Electronics Co., Chestnut & Watts St., Mount Holly Springs, Pa. 17065. (717) 486-3411. (M.L. Myers) (Q), (F) **Check 423**

Microsonics Inc., Div. Sangamo Electric Co., 60 Winter St., Weymouth, Mass. 02188. (617) 337-4200. (J. Klayman) (F) **Check 424**

Monitor Products, 815 Fremont Ave., South Pasadena, Calif. 91030. (213) 682-3761. (J.W. Blasier) (Q), (F) **Check 425**

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Murata Corp. of America, 2 Westchester Plaza, Elmsford, N.Y. 10523. (914) 592-9180. (J. Alterescu) (PF) **Check 428**

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Omnitec Corp., Nytronics Filter Div., 2405 S. 20th St., Phoenix, Ariz. 85034. (402) 348-9500. (J. Matejka) (F) **Check 430**

OPT Industries, Box F, Alpha, N.J. 08865. (201) 454-2600. (J. Smith) (F) **Check 431**

Peterson Radio, 2800 W. Broadway, Council Bluffs, Iowa 51501. (712) 323-7539. (N. Anderson) (Q) **Check 432**

Piezo Crystal Co., 100 "K" St., Carlisle, Pa. 17013. (717) 249-2151. (W. Wilson) (C), (F) **Check 433**

Piezo Technology Inc., Box 7877, 2400 Diversified Way, Orlando, Fla. 32804. (305) 425-1574. (J. Dinnan) (F) **Check 434**

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Statek Corp., 1200 Alvarez Ave., Orange, Calif. 92668. (714) 639-7810. (M. Nusbaum) (Q), (W) **Check 443**

Tedford Crystal Labs., 4914 Gray Rd., Cincinnati, Ohio 45232. (513) 542-5555. (J.A. Vella) (C), (F) **Check 444**

Thermal American Fused Quartz, Change Bridge Rd., Montville, N.J. 07045. (201) 334-7770. (J. F. von Sternberg) (O) **Check 445**

TMC Systems, 930 West 23rd St., Unit 26, Tempe, Ariz. 85282. (D. R. Robinson) (C), (F) **Check 446**

Torotel, Inc., 13402 S. 71 Hwy., Grandview, Mo. 64030. (816) 761-6314. (R. Osborne) (Q), (F) **Check 447**

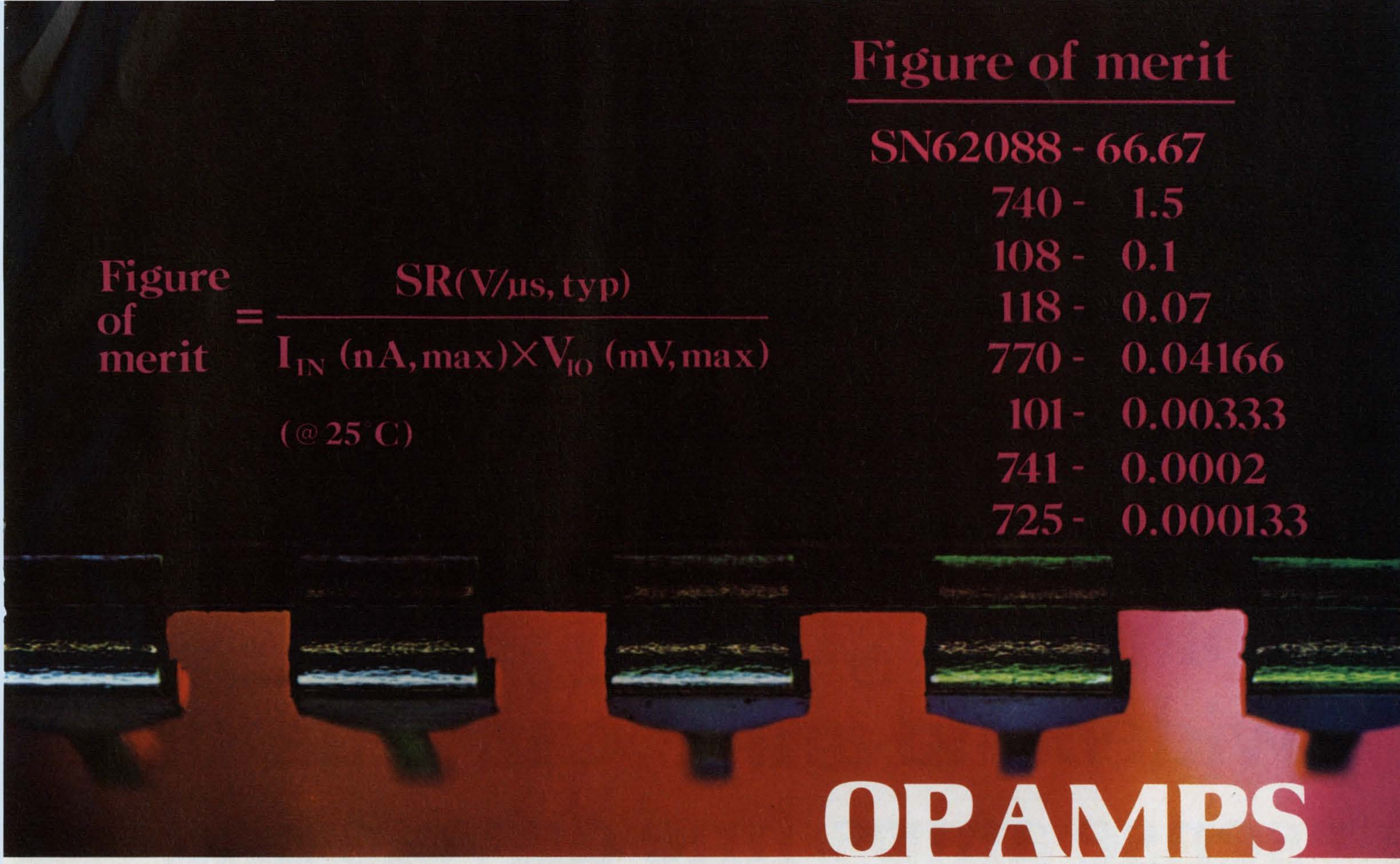
TT Electronics Inc., 2214 S. Barry Ave., Los Angeles, Calif. 90064. (213) 478-8224. (J.F. Sodaro) (F) **Check 394**

Tyco Filters Div. Inc., 3940 W. Montecito St., Phoenix, Ariz. 85019. (602) 272-7945. (H. Schinaman) (F) **Check 395**

Valpey Fisher, 1400 Highland St., Holliston, Mass. 01746. (617) 429-4322. (T. Gallagher) (Q) **Check 448**

Vernitron Piezoelectric Div., 232 Forbes Rd., Bedford, Ohio. 44146. (216) 232-8600. (Mark Rickman) (PC), (PF) **Check 449**

X-Tron Electronics, 1869 National Ave., Hayward, Calif. 94545. (415) 783-2145. (R.M. Hossack) (Q) **Check 450**



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The SN62/72088 is fabricated using a combination of technologies – including bipolar, junction field effect and P-channel MOS transistors.

The circuit design includes an internally compensated high frequency wide-band amplifier and a null amplifier of bipolar design with JFET inputs; also three linear amplifiers, a clock generator with multiple counting and decoding stages and several analog switches fabricated with MOS devices.

For data sheets please specify by type number and write: Texas Instruments Incorporated, P. O. Box 5012, M/S 308, Dallas, Texas 75222.

SN62088 Characteristics
Typical Values

40 microvolt input offset voltage
400 pico amp input current
100 pico amp input offset current
130 dB voltage gain
3 MHz unity-gain band-width
25 volt per microsecond slew rate
80 dB common-mode rejection

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Read Device Type and Specification in upper windows.

SIGNETICS MOS DEVICE SPECIFICATION

TYPE	V_{SS}	V_{DD}	V_{GG}	V_{BB}	PROCESS	PKGS.
2580	+5	0	−12	–	P-SG	N, I

SHIFT REGISTERS	REGISTER LENGTH	ORGANIZATION	SPEED (MHz)
STATIC — METAL GATE	16	16 x 2	1.0
	25	25 x 2	1.0
	32	32 x 2	1.0
	50	50 x 2	1.0
	100	100 x 2	1.0
	100	100 x 2	3.0
STATIC — SILICON GATE	50	50 x 2	1.5
	100	100 x 2	1.5
	200	200 x 2	1.5
	32	32 x 6	2.0
	40	40 x 6	2.0
	80	80 x 4	1.5
	240	240 x 2	1.5
	250	250 x 2	1.5
	256	256 x 2	1.5
	128	128 x 2	1.5
	132	132 x 2	1.5
	1024	1024 x 1	1.5
DYNAMIC	100	100 x 2	3.0
	512	512 x 1	2.5
	1024	1024 x 1	2.5
	512	512 x 1	3.0
	1024	1024 x 1	3.0
	256	256 x 4	8.0
	512	512 x 2	8.0
	1024	1024 x 1	8.0

MEMORIES	BIT CAPACITY	ORGANIZATION	ACCESS TIME (ns)
RAM STATIC	256	256 x 1	1000
	256	256 x 1	1000
	1K	1024 x 1	1000
	1K	1024 x 1	500
RAM DYNAMIC	1K	1024 x 1	310
	1K	1024 x 1	180
	2K	2048 x 1	330
ROM	1K	256 x 4	750
	1K	128 x 8, 256 x 4	750
	2K	256 x 8, 512 x 4	750
	1K	256 x 4	950
	1K	128 x 8, 256 x 4	950
	2K	256 x 8, 512 x 4	950
	4K	512 x 8	700
	8K	2048 x 4	700

	CHARACTER SIZE	ORGANIZATION	ACCESS TIME (ns)
CHARACTER GENERATOR	7 x 5	64 x 7 x 6	600
	5 x 7	64 x 6 x 8	600
	9 x 9	64 x 9 x 9	700

SPECIAL CIRCUITS	FUNCTION	ORGANIZATION	SPEED (MHz)
RECEIVER-TRANSMITTER	UAR/T	8 BIT	0.32
FIRST-IN, FIRST-OUT BUFFER	FIFO	32 x 8	1.0

PACKAGE DESCRIPTIONS:

A Package: 14-Pin Silicone DIP
B Package: 16-Pin Silicone DIP
I Package: Ceramic DIP
K Package: 10-Pin TO-100
N Package: Silicone DIP
T Package: 8-Pin TO-99
TA Package: 8-Pin TO-99
V Package: 8-Pin Silicone DIP
XA Package: 18-Pin Silicone DIP
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INFORMATION RETRIEVAL NUMBER 33

Microprogramming: More 'in' than ever

Here's a look at the basic considerations involved in using these techniques with low-cost, fast memories.

Though some forms of microprogramming have been used since the early 1950s, the techniques are growing in importance as low-cost, high-speed read-only and random-access memories make microprogrammable computers economically attractive.

Many computer manufacturers store microprograms in read-only memories (ROMs) to eliminate much of the random logic otherwise needed in processors. The result has been an increase of several orders of magnitude in operating speed, due to a reduction in lengthy instruction fetch cycles. Major computer companies, like IBM, now use microprogramming extensively. And smaller companies, like Microdata and Interdata, are already selling microprogrammable minicomputers.

Without microprogramming, generation of control signals for complex instructions requires a lot of random logic to route the appropriate control sequences. The same macro-operation can be performed more simply by use of a fixed microprogram in hardware. Complex decoding and sequencing circuits are no longer needed; only primitive logic control lines are activated by coding in the ROM and the basic processor hardware.

Most computer systems still use core memory as the basic storage medium. The accessing time is very slow, compared with the data-manipulation speed of typical processor hardware. For each instruction, a memory fetch cycle must be executed; so it's imperative to use complex instructions to avoid excessive access cycles.

But with microprogramming, fast-access semiconductor ROMs (rather than core memory) contain the micro-instructions. As a result, the access time for each fetch cycle is much faster than when program instructions are fetched from core memory. In fact, the access time from a ROM is about the same as the time required for data manipulation in the processor.

Donald R. Lewis, Consultant, Lewis Assoc., P.O. Box 33, Kew Gardens, N.Y. 11415.

Efficient microprogramming results from the rapid access time of ROMs and the elimination of excessive hardware for fetching operations. Whenever a powerful instruction, or complex macro-operation, requires processing, control transfers to the appropriate microprogram. It performs the operation with a less powerful instruction set, but it saves time by rapidly accessing instructions.

Mix ROMs with RAMs

The advantages of microprogramming can be lost if time must be spent accessing core memory for memory-reference instructions—for constants and temporary data, for example. A solution to the problem is to use a mixture of ROMs for instructions and random-access memories (RAMs) for temporary storage of data.

The RAM has the same fast access time as the ROM. However, unlike the ROM, it has the disadvantage of volatility; it cannot retain information without continuous power.

Microprograms are flexible. To change one or a portion of it, the designer need only replace the ROMs that contain the program.[1]

When microprogrammable systems contain many RAMs, the system can be used for dynamic microprogramming—that is, a desired microprogram can be loaded when needed. Dynamic microprogramming allows a smaller amount of semiconductor memory to perform many tasks. An optimal combination consists of storing the more frequently used microprograms in a ROM—including the swapping microprogram—and using some RAMs for additional dynamic microprogramming as well as temporary data storage.

Microprogram for logic-control systems

The basic idea of microprogramming originated with M. V. Wilkes, who in 1951 defined a systematic method for designing logic control systems for digital computers.[2]

Operation of a computer can be thought of as the sequential transfer of information in bit patterns. The data moves from one storage element or register to another via logic networks, such as adders, under the control of activating gates.

A macro-operation is made up of one or more data transfers in a specific sequence. These may also be controlled by low-level commands called micro-instructions. In this case, an algorithmic sequence of micro-instructions is called a microprogram.

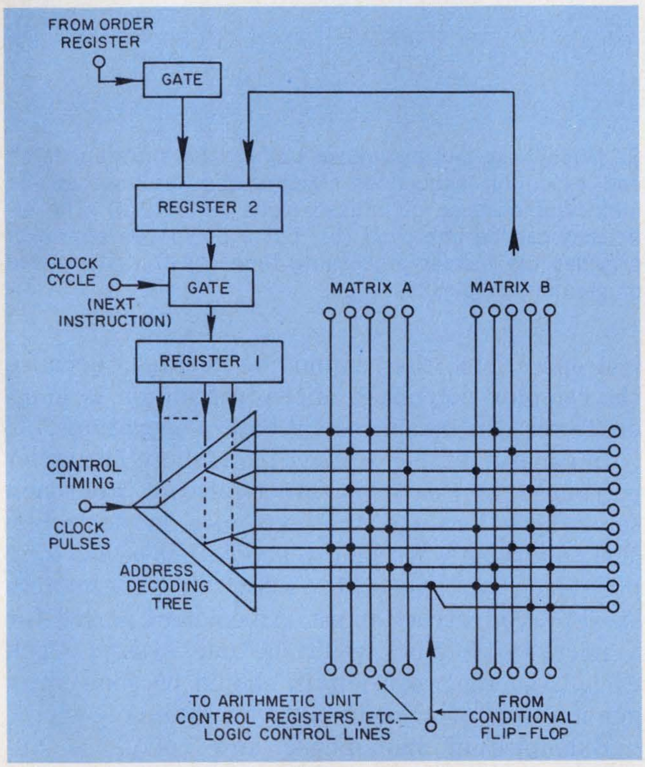
In Wilkes' model of a simple microprogrammed device (Fig. 1), a diode ROM stores the microprogram. Semiconductor diodes at appropriate junctions of the orthogonal lines define the bit pattern of the microprogram. Matrix A controls the data flow through the logic networks by generating control signals, and matrix B determines the address of the next micro-instruction.

The address lines steer control-timing clock pulses through the branches of a decoding tree so that only one horizontal line receives the clock pulse. The diodes in matrix A transmit the pulse to the vertical logic-control lines, which in turn connect to and control the various data paths. The diodes in matrix B transmit the pulse to the vertical lines that connect to the instruction-address-register.

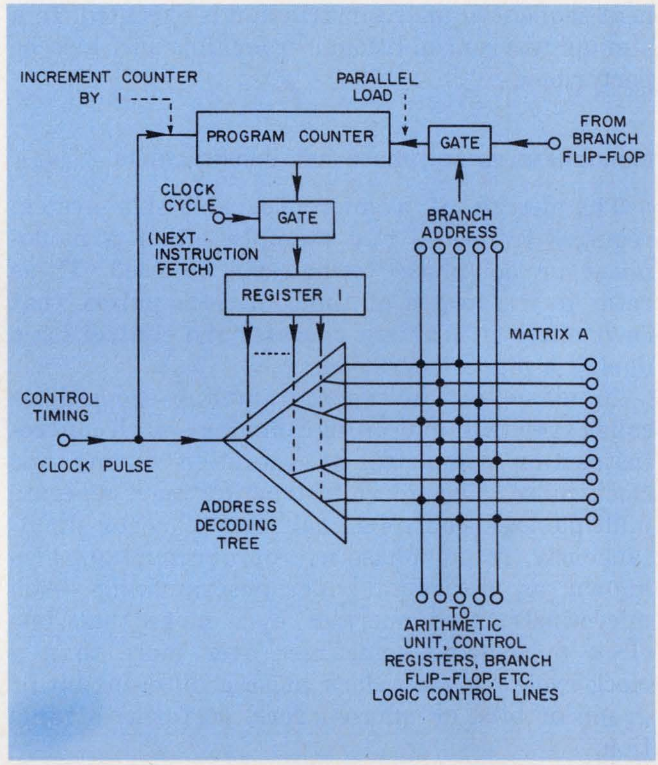
At the following clock cycle, the bit pattern in the instruction-address register causes the address-decoding tree to steer the clock pulses to the next instruction. Then the next micro-instruction is executed. This process repeats itself each time the control signals are generated and the address of the next micro-instruction is determined. As the microprogram is executed, sequential timing-control pulses go to the appropriate actuating gates.

Note that in diode matrix B, the horizontal line that the pulse travels through can be switched by external controls, such as a sign bit of an accumulator, or the state of a status flip-flop. This enables the microprogram to perform conditional branching.

Since the address of each succeeding instruction depends on the present one, instructions can be organized nonsequentially. Generally, however, it's advantageous to store instructions se-



1. **The original microprogrammed device** proposed by Wilkes. Read-only memories, in the form of diode matrices, are used to generate signals to control data flow (matrix A) and to determine the next micro-instruction address (matrix B).



2. **One matrix can be eliminated** when a semiconductor ROM and program counter are used. The next address is obtained by the program counter, which is incremented by one after each new micro-instruction is fetched.

quentially in the ROM to simplify checking and debugging.

More significantly, a high-density semiconductor ROM can be used to eliminate matrix B, as shown in Fig. 2. The address is obtained from a program counter, or incrementing register, that is updated each time a new micro-instruction is fetched.

Note that the configuration of Fig. 2 also allows for conditional branching. With the branch flip-flop set, the program counter is loaded with the next micro-instruction, which acts as data. Otherwise, the program is incremented and the next sequential micro-instruction is executed. In a similar way unconditional branching may also be performed.

Monophase vs polyphase micro-instructions

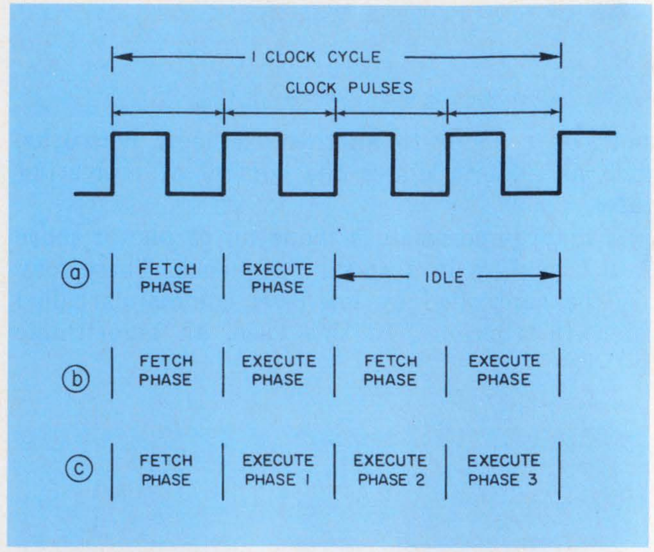
The design of a microprogrammable system requires tradeoffs. For example, either a monophase or polyphase format can be used. These refer to the length of time, in clock pulses, that each micro-instruction operates the control logic during a macro-operation.

In monophase microprogramming—sometimes called vertical microprogramming—each micro-instruction completes its operation during one clock pulse. The micro-instruction may generate multiple logic-control signals that all occur simultaneously. In polyphase microprogramming—also known as horizontal microprogramming—each micro-instruction operates over more than one clock pulse—and sometimes over more than a clock cycle. In each clock pulse a different bit or group of bits, or micro-orders, performs a function.

To execute a macro-operation using a monophase approach, many micro-instructions are required. With the polyphase approach, fewer micro-instructions are needed, since more control micro-orders can be executed for each micro-instruction. The polyphase approach also has the advantage of requiring fewer fetch cycles for each macro-operation.

Even though the monophase instructions may be short, they require a lot of storage, since many micro-instructions are necessary for a given macro-operation. Though fewer micro-instructions are used in the polyphase approach, considerable storage is needed because each micro-instruction is longer.

The monophase approach offers more flexibility than the polyphase. Because it allows a more elemental micro-instruction, monophase microprogramming requires a smaller repertoire to perform all the required operations. Polyphase microprogramming requires a larger set, since each micro-instruction is a combination of smaller subinstructions (micro-orders), or logic-control operations, that cannot be isolated. Because the complex polyphase micro-instruction is longer, fewer can be shared by macro-operations.



3. **Monophase and polyphase timing** have different fetch and execution sequences. Monophase cycling can be inefficient because of unused clock periods (a). The efficiency can be improved (b), but a polyphase approach provides the fastest processing time (c) at the expense of greater complexity.

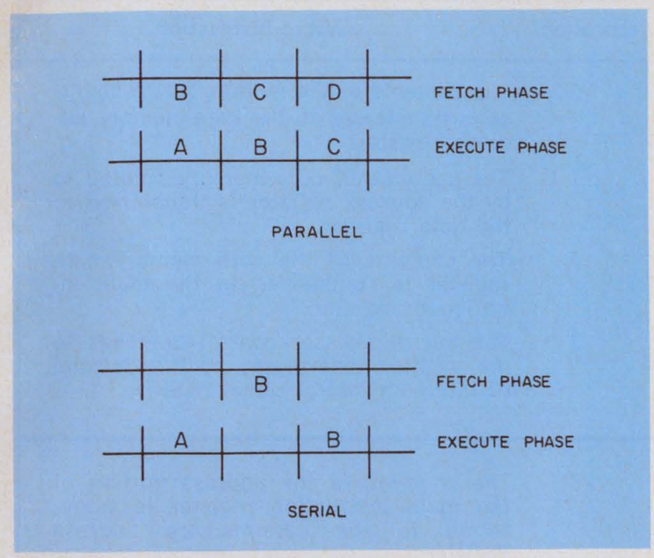
In general neither a strict monophase nor strict polyphase approach is practical; an approach somewhere between the extremes is desirable. The polyphase word length should not be too long but somewhat elemental to allow for a reasonably sized micro-instruction set. An efficient period for a micro-instruction would be one system clock cycle. And the word length should be some integer multiple of a basic eight-bit byte.

Examples of monophase and polyphase approaches are shown in Fig. 3. The idle period after the execution phase in Fig. 3a obviously wastes time, but the method is simple. In the more efficient approach of Fig. 3b, the system fetches a second micro-instruction and operates on it instead of idling. This technique decreases the processing time, even though there is still one fetch phase for each execute phase. Note that this case requires an even number of clock pulses per clock cycle.

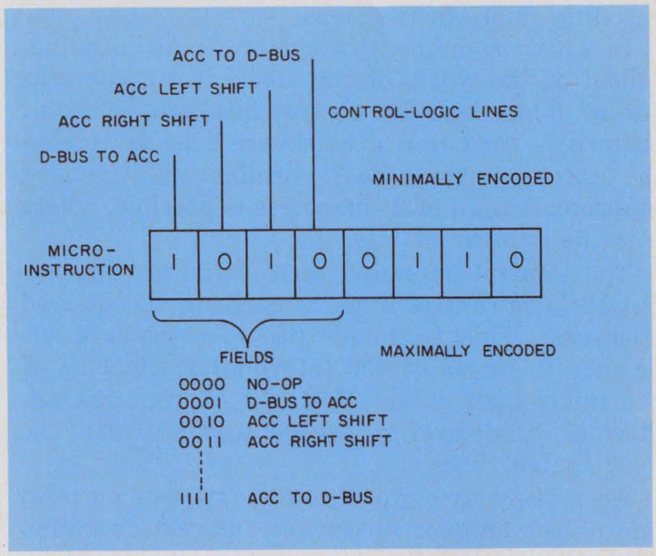
An example of the polyphase approach (Fig. 3c) shows the saving in fetch phases. During the clock cycle, a fetch phase is performed and three individual phases are sequentially executed. Each phase requires a different set of bits (micro-order) of the polyphase micro-instruction. At the expense of complexity, this arrangement yields the fastest processing time.

Parallel vs serial operation

Another major consideration in the system design relates to parallel vs serial operation.



4. **Micro-instruction sequences may be parallel or serial.** In a parallel approach, one micro-instruction can be executed while the next one is fetched. However, in the slower serial sequence, completion of a micro-instruction is required before the next one can be accessed. Letters shown denote micro-instructions.



5. **Possible word formats include minimal encoding,** with each bit in the word or in a field of a word actuating a logic-control line. In a maximally encoded word, a field or the whole word contains several possible control messages. Also, direct and indirect-coding techniques can be used.

Basically this refers to the method of obtaining the next micro-instruction.

The address of the next micro-instruction might be obtained from a field of (part of) the present micro-instruction, or from the program-counter register and status flip-flops. With the parallel approach, the address of the next micro-instruction in storage is obtained and accessed while the present micro-instruction is being executed. In the serial approach, the address of the next micro-instruction in storage is obtained and accessed upon completion of the present micro-instruction. A comparison of the two methods of operation is shown in Fig. 4.

The parallel approach appears to be faster, since there is an overlap between the next micro-instruction fetch phase and the present micro-instruction execute phase. However, a problem arises if finding the address of the next micro-instruction in storage depends on the result of the execution of the present one. In that case processing slows, especially if there are many branch micro-instructions.

Processing can be speeded by having the address of the next micro-instruction determined during the execution cycle of the present one. This may be achieved with a "best-guess" approach, based on the branching probabilities for the micro-instruction. Of course, there's no way to "best guess" if both probabilities are equal.

An example of the "best-guess" technique occurs in a microprogrammed loop. Assume there's one conditional-branch micro-instruction that can transfer out of the loop. During each traverse of the loop, this branch micro-instruction probably will not transfer out. Therefore the best guess for the address of the next micro-instruction would be the address of the next statement in the loop. When the branch-out condition occurs, a delay results from having to wait for the next instruction. As the in-loop branch would be executed many times, in contrast with the one time the program branches out of the loop, the process can be speeded considerably.

Serial microprogramming, on the other hand, requires a delay in the execution of each micro-instruction. The delay equals the time needed to access that micro-instruction from storage. If the access time of the storage is fast, compared with the execution time, the delay may be negligible. Of course, it may also be of no consequence when some external constraint—such as accessing the next macro-instruction from slow core memory—washes out the delay caused by serial microprogramming.

The parallel approach seems better than the serial if the system execution time is not limited by external constraints. Otherwise the serial approach may be equally fast and also simpler to implement.

Minimally vs maximally encoded words

There are many possible degrees of encoding for micro-instructions. In a minimally encoded word[3] each bit in the word or in a field of a word is allowed to actuate a logic-control line directly (Fig. 5). Since each bit operates a logic function, no decoding hardware is required. The register transfers and gates can be directly controlled by the ONEs and ZEROs in the micro-instruction word. This method is the simplest for encoding micro-instructions.

In another method, called maximal encoding, a field of the word, or the whole word, contains one of many possible control messages. The bit pattern is read into a hardware decoder during the execution cycle to determine the intended message. A total of 2^n messages is possible, where n is the number of bits.

The control message then activates the required logic-control lines to perform the desired operation. This technique provides the best efficiency in terms of the information capacity of the micro-instruction. However, it requires additional hardware to decode and activate the logic-control lines.

Also, there are two different types of encoded micro-instructions: direct and indirect encoding.

In direct mutually exclusive signals are encoded into fields of micro-instruction. Then, during the execution phase, the fields of the micro-instruction are decoded to produce the corresponding logic-control signals. This technique can reduce the size of a micro-instruction word by a factor of two to three.

In indirect encoding the meaning of the field is defined by another field of the micro-instruction word. The bits of a field are interpreted differently, depending upon the value of the bits in another field. This is similar to having a "mode" field or a "type" field in the micro-instruction word to define it. This type of encoding can reduce the size of the micro-instruction word by an additional factor of two to three.

To minimize storage, the micro-instruction words should be as short as possible. This means encoding the maximum information into the minimum number of bits. Therefore some flexibility can be lost unless all the encoded signals are mutually exclusive. Also, additional hardware to decode maximally encoded micro-instructions adds unwanted gate propagation delays.

Hard vs soft viewpoints

The previously discussed parameters lead to two design philosophies for microprogramming: One viewpoint is called hard microprogramming (also horizontal microprogramming). In this approach micro-instructions are considered as control words, with individual bits corresponding to logic-control signals. The approach attempts to optimize the control of these signals.

The other viewpoint—called soft microprogramming or vertical microprogramming—uses a universal set of micro-instructions algorithmically. On a lower level it's similar to conventional programming.

Both viewpoints attempt, from different directions, to optimize the operations. The "hard" philosophy strives for best efficiency in terms of data paths and logic control lines. The "soft" philosophy looks for the most efficient algorithm.

Location	Micro-instruction
0	The contents of the main program counter is transferred to the core-memory address register.
1	The contents of core memory pointed to by the address register is transferred to the data register.
2	The contents of the core memory data register is transferred to the main instruction register.
3	The microprocessor control branches to the location determined by the op-code of the main instruction register.

Location	Micro-instruction
20	The contents of the address portion of the main instruction register is transferred to the core-memory address register.
21	The contents of core-memory pointed to by the core-memory address register is transferred into the core-memory data register.
22	The core-memory data register output is gated onto the D-bus, and at the same time, the accumulator is gated from the D-bus. (Thus the contents of the core-memory data register are added to the accumulator.)
23	The main program counter is incremented by one. (This enables the next macro-operation to be fetched.)
24	The microprocessor control unconditionally branches to location 0 (for the next micro-instruction of the macro-operation fetch cycle).

A microprogram implements a macro-operation. Initially a sequence of micro-instructions fetches the macro-operation from core memory (top). Then another sequence executes the operation "add memory to accumulator" (bottom).

An example of a microprogram (see tables) shows how macro-operations can be performed by a sequence of micro-instructions. The macro-operation can be defined as a single basic assembly-language operation—in this case, "add the contents of memory to the accumulator."

The map of the read-only memory for the microcomputer starts at location 0. The upper table shows a microprogram that fetches the macro-operation from core memory.

After the fetch cycle has been completed and the op code for "add the contents of memory to the accumulator" has been determined to be 20, the microprogram branches to location 20. The lower table shows the contents of the ROM microprogram beginning at that location.

At the completion of the micro-instruction execute cycle, the microprogram returns control to location 0 and begins to fetch the next macro-instruction. Thus the cycle repeats.

There are many natural applications for microprogramming in modern computers: in numerical analysis, in the emulation of different machines, in high-level language processors and in microdiagnostics.

In numerical analysis[4] many short and simple algorithms perform mathematical and trigonometric functions. Most of these algorithms are iterative and converge rapidly to a final value. As a result, it's natural to use microprograms for these functions.

The only parameter required is the argument of the function. With a small microprogram for the algorithm and hardware registers for temporary storage of data, iterative evaluation can be simple and quick. Because there is no time lost on the lengthy fetching of individual instructions from core memory, the use of a microprogram is one of the most efficient techniques.

Algorithms for multiplication and division, such as the Boothe method, and nonconvergent algorithms for floating-point conversion lend themselves to microprogramming. Even complex functions, such as matrix manipulation, have been implemented.

Special functions, such as the fast Fourier transforms (FFT) have also been successfully microprogrammed. For example, Interdata has released a microprogrammed version of the FFT for the Interdata 4 minicomputer.

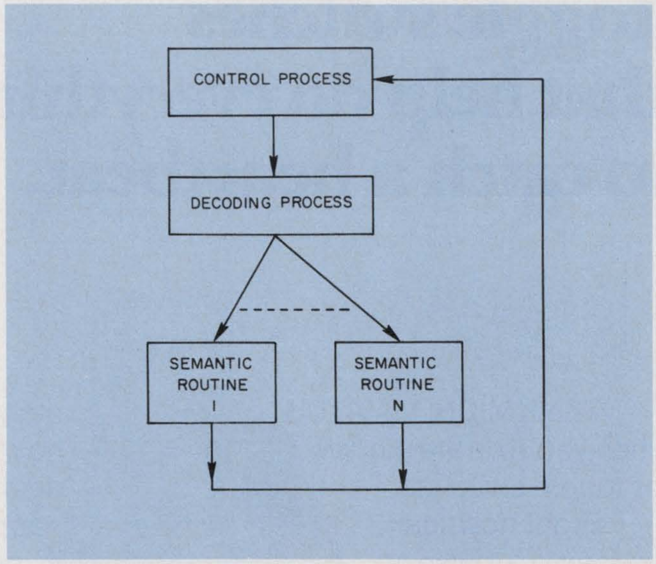
Another very useful application of microprogramming is to emulate different target machines on a host computer.[5] When lengthy standard programs are written for use on a machine that is later replaced by a machine with a different instruction set, the programs need not become obsolete. If the new machine has a microprogramming facility, it can be microprogrammed to emulate the old machine.

Microprogramming the register masking functions[6] allows different word lengths to be matched. IBM System 360/370 computers share a common instruction set by the microprogramming of the different architectures in various models. IBM also microprograms some of its System 360 computers to run programs written for second-generation 1400 and 7000 machines.

Microprogram diagnostic checks

An important feature of large computer systems is their ability to run self-diagnostic checks. These checks are usually performed with a software routine. Unless the system is very large, the basic instruction set won't be adequate for efficient checkout of the various data paths. Microprograms with a primitive micro-instruction set provide a natural way to check the elementary circuit paths.

IBM has applied diagnostic microprograms[7] to systems maintenance of the System 360, Model 30, for isolation of component failures. The microprogram resides in read-only storage, using 60-bit words.



6. **Microprogramming for high-level language processing.** This approach, and efficient microprogramming, can avoid the need for costly compilation to a lower-level assembly language.

Another application of microprogramming is to execute directly high-level language instructions. The Burroughs B6500, for example, works with ALGOL. Other machines have been built to work with APL and FORTRAN.

A machine that operates directly on a high-level language can use microprogramming. Fig. 6 demonstrates such a structure, with each box representing a microprogram. The control process acquires each successive statement in the high-level language. The decoding process steers control by branching to the correct semantic routine based on the type of statement. ■■

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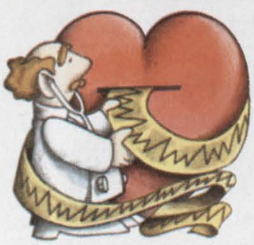

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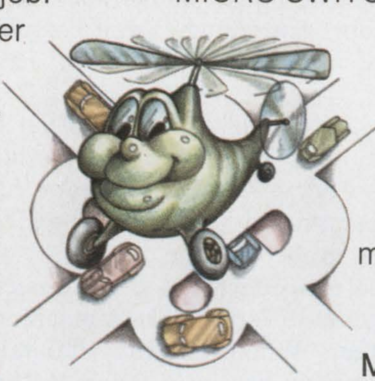

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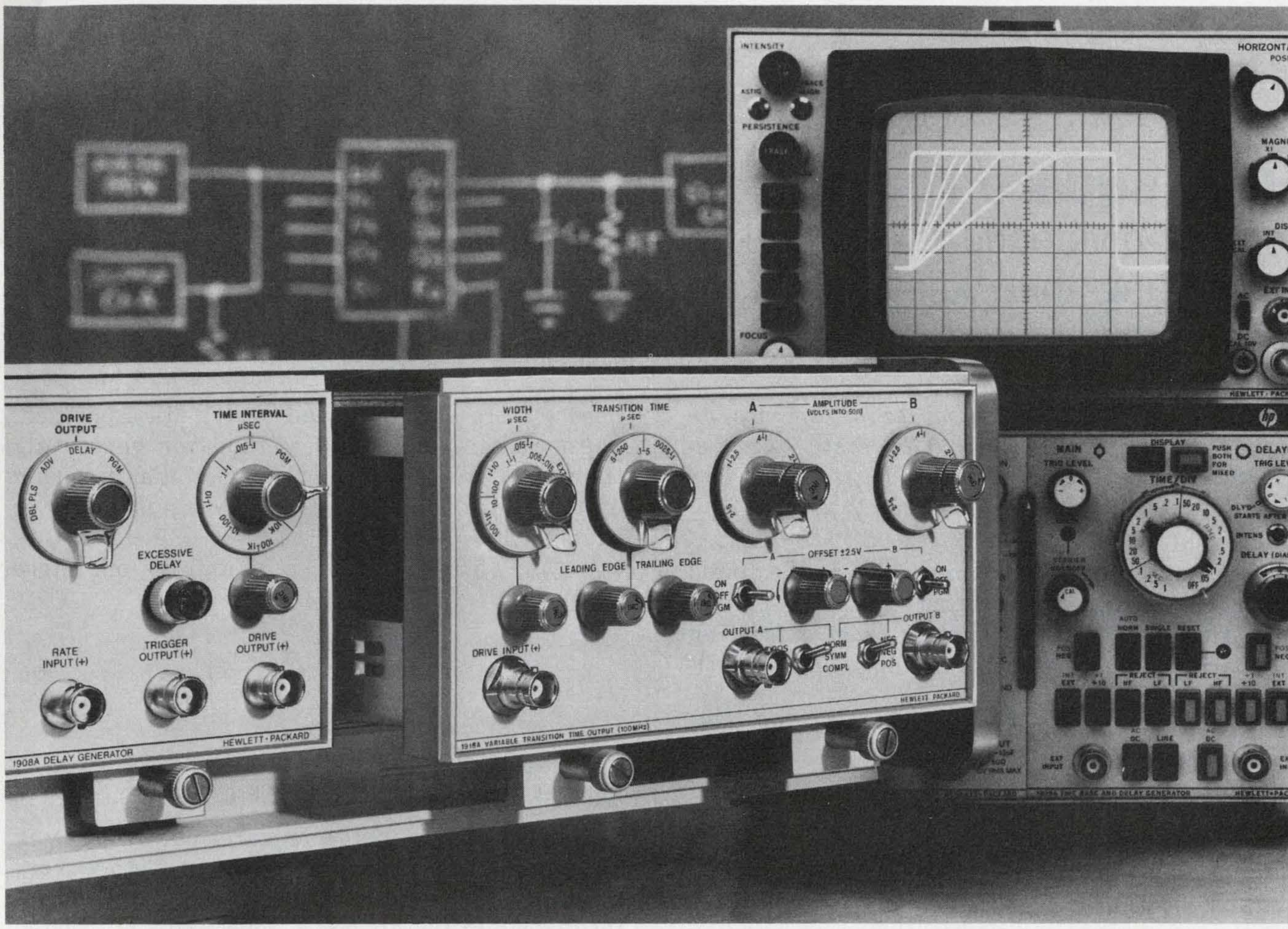

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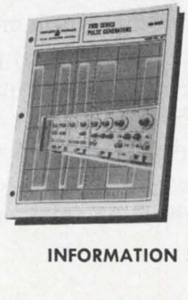

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BCD logic – Part 5

BCD square root: Radicand, radicator and root replace dividend, divisor and quotient. And except for generating the radicator, the logic is similar to division.

This is the fifth of a series of articles on binary-coded-decimal logic. The first four discussed the four basic arithmetic operations and techniques for handling the decimal point.

The square root of a number X can be found by an estimating process that closely resembles long division. This also applies when extracting a square root with the use of binary-coded-decimal methods.

A quantity Z_0 is estimated, squared and subtracted from X. The remainder

$$R_1 = X - Z_0^2$$

is then inspected for its polarity. If the polarity is negative, Z_0 must be made smaller and the process repeated. This subtraction procedure continues for gradually increasing values of Z_i until the desired degree of accuracy is obtained.

By analogy to division, where the terms dividend, divisor and quotient are used, in the square root process we use radicand for X, radicator for Z_i (sometimes called root extractor) and root for the answer. The remainder R_i, as in division, becomes smaller and approaches zero as the process proceeds. Only for a perfect square does R_i ever become zero. Table 1 illustrates this process as you might do it by a paper-and-pencil method.

Note that the radicand digits are grouped into pairs, and each radicator after the first estimated one equals $Y_i\ (2\ S_{i-1} + Y_i)$, where Y_i is the new, or i-th, partial root digit and S_{i-1} is the previous accumulation of partial roots. Thus in Table 1 partial root $Y_2 = 2 \times 10^2$ is the second estimated partial root and $S_1 = 600$ is the accumulated root. Therefore the second radicator becomes

$$Y_2\ (2S_1 + Y_2) = 20(2\times600+20) = 24{,}400.$$

Partial roots Y_3, Y_4 and so on are then estimated, and the process is repeated to obtain the desired degree of accuracy. The paper-and-pencil method, however, uses inspection and estimation to generate the radicator. This is difficult to duplicate directly with hardware.

Inspection and estimation are actually a rapid mental trial-and-error method. Electronic circuits need a more definitive and systematic approach.

An easy-to-understand method for generating the radicator stems from the fact that the sum of the series of n odd numbers equals n^2. For example $1 + 3 + 5 = 3^2$, $1 + 3 + 5 + 7 = 4^2$, $1 + 3 + 5 + 7 + 9 = 5^2$ and so on. More generally

$$n^2 = \sum_{i=1}^{i=n} (2i - 1).$$

Squares from odd integers

Table 2 illustrates a square-root extracting algorithm that employs a restoring method very much like that used in division. Here, the radicator instead of the divisor is repeatedly subtracted —first from the radicand—and then the remainders until a negative remainder results. The value of the radicator is increased after each subtraction in accordance with the odd-number sequence. After a restoring operation to correct the sequence when too large a root is reached, the radicator is divided by 10. Subsequent radicator increments are again odd numbers, as in the first cycle, but now the increments are divided by 100. Likewise each increment cycle, which follows each succeeding restoring operation, is divided by 100 and radicants are divided by 10.

Close comparison of Tables 1 and 2 clearly show the equivalence of the paper-and-pencil and odd-number series methods. Note that remainders labeled R_1 through R_4 are identical in both methods.

From examination of the algorithm of Table 2, it should be clear that major portions of a dividing circuit can be used for obtaining square roots. And while Table 2 uses a restoring method, as in division, a nonrestoring technique can also be used.

But implementation of either the restoring or nonrestoring method requires an odd-number radicator generator to replace the divisor input in the divider circuit. This is the major change required. And with a few small adaptations, most of the other circuit versions that are used in division are also applicable to extracting the

Hermann Schmid, General Electric Co., P.O. Box 5000, Binghamton, N.Y. 13902.

Table 1. The square root of 385981.18 by a paper-and-pencil method.

Radicand (X)	Radicator(Z)	Estimated partial root	Accumulated root
38 59 81. 18	$Y_i(2S_{i-1}+Y_i)$	Y_i	S_i
−36 00 00.	600	600	600.
2 59 81. 18 = R_1			
− 2 44 00.	20 × 1220	20	620.
15 81.18 = R_2			
− 12 41.	1 × 1241	1	621.
3 40. 18 = R_3			
− 2 48. 44	0.2 × 1242.2	0.2	621.2
91. 74 = R_4			

To determine the value of the radicator, let

$$X = (Y_1 + Y_2 + Y_3)^2$$
$$= Y_1^2 + 2Y_1Y_2 + Y_2^2 + 2(Y_1Y_2)Y_3 + Y_3^2$$
$$R_1 = X - Y_1^2 = Y_2(2Y_1 + Y_2) + Y_3\,[2(Y_1 + Y_2) + Y_3].$$

By induction then:

$$R_{i+1} = R_i - \sum_{i=1}^{i=n} Y_i(2S_{i-1} + Y_i)$$

Table 2. The odd-number series method—$\sqrt{385981.18}$

Radicand (X)	Radicator (Z)	Root
38 59 81. 18		
− 1 00 00	10,000	100
37 59 81. 18		
− 3 00 00	30,000	200
34 59 81		
− 5 00 00	50,000	300
29 59 81		
− 7 00 00	70,000	400
22 59 81		
− 9 00 00	90,000	500
13 59 81		
−11 00 00	110,000	600
2 59 81		
−13 00 00	130,000	700
−10 40 19		
13 00 00	restore	600
2 59 81. 18 = R_1		
− 1 21 00	12,100	610
1 38 81		
− 1 23 00	12,300	620
15 81		
− 1 25 00	12,500	630
− 0 09 19		
1 25 00	restore	620
15 81. 18 = R_2		
− 12 41	1241	621
3 40		
− 12 43		
− 09 03	1243	622
12 43	restore	621
3 40. 18 = R_3		
− 1 24. 21	124.21	621.1
2 15. 97		
1 24. 23	124.21	621.2
91. 74 = R_4		

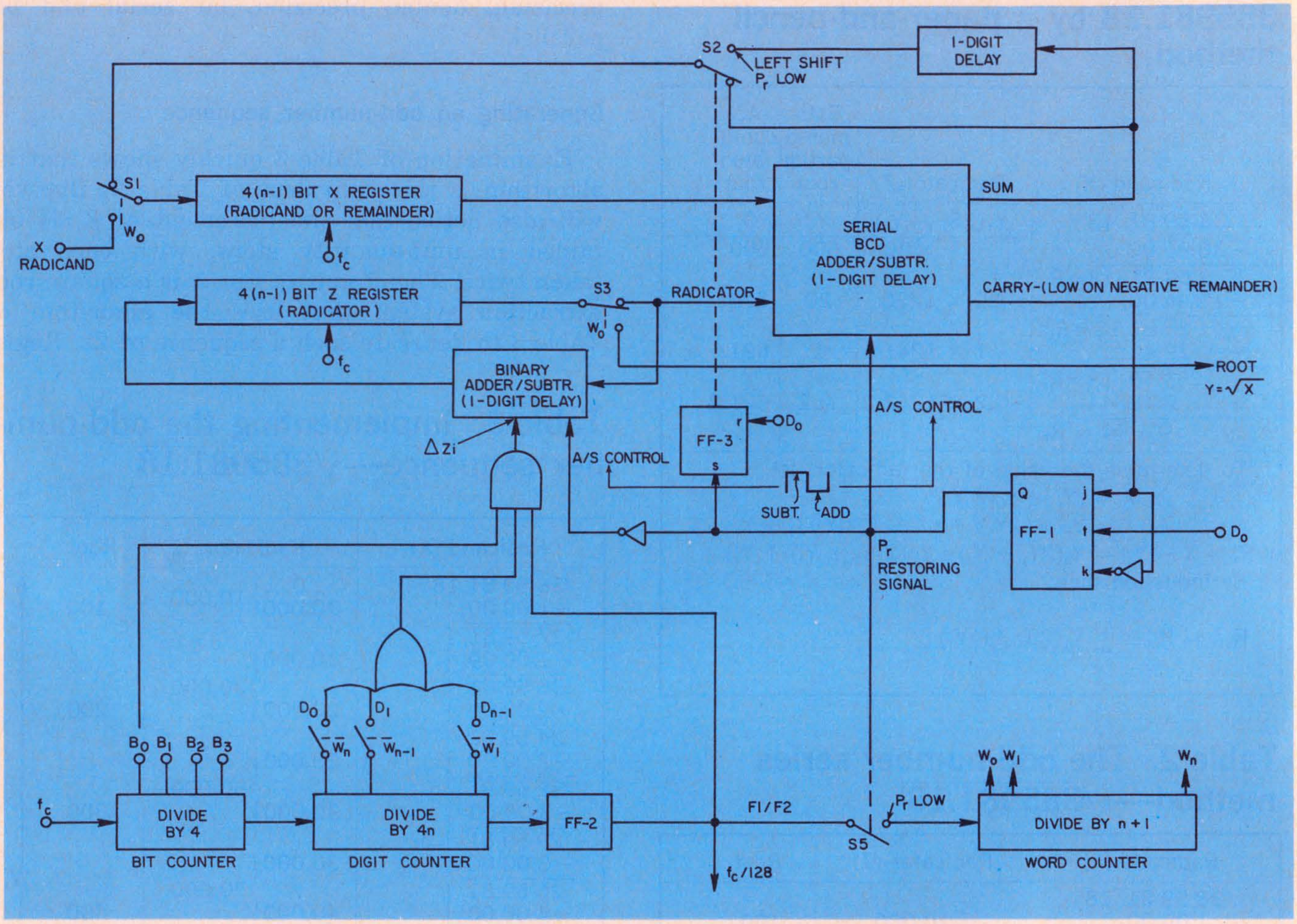
square root. Some of these versions are single precision, double precision, bit serial and bit parallel.

Generating an odd-number sequence

Examination of Table 3 quickly shows that its algorithm is the equivalent of Table 2. But you will also notice that the increment of Z_i is obtained in unit-quantity steps, with each step taken twice. The circuit in Fig. 1 is a square-root extraction system that uses the algorithm of Table 3 to generate such a sequence of Zs. Regis-

Table 3. Implementing the odd-number sequence—$\sqrt{385981.18}$

Radicand (X)	Radicator (Z)		Root	
38 59 81.18	0	10,000		↑
−1 00 00	10,000		100	
37 59 81				
−1 00 00	10,000			
36 59 81		30,000		
−2 00 00	20,000		200	
34 59 81				
−2 00 00	20,000			
32 59 81		50,000		
−3 00 00	30,000		300	
29 59 81				
−3 00 00	30,000			
26 59 81		70,000		W_1
−4 00 00	40,000		400	
22 59 81				
−4 00 00	40,000			
18 59 81		70,000		
−5 00 00	50,000		500	
13 59 81				
−5 00 00	50,000			
8 59 81		110,000		
−6 00 00	60,000		600	
2 59 81. 18 = R_1	Restoration operation			↓
−60 00	6000			↑
1 99 81		12,100		
−61 00	6100		610	
1 38 81				
−61 00	6100			W_2
77 81		12,300		
−62 00	6200		620	
15 81. 18 = R_2	Restoration operation			↓
−6 20	620			↑
9 61		1241		
−6 21	621		621	W_3
3 40. 18 = R_2	Restoring operation			↓
−62. 10	62.10			↑
2 78. 08		124.21		
−62. 11	62.11		621.1	
2 15. 97				
−62. 11	62.11			W_4
1 53. 86		124.23		
62. 12	62.12		621.2	
91. 74 = R_4				↓



1. **A square-root extraction circuit** has many features in common with a divider system. The odd-number-sequence radicator that is generated in the Z register successively subtracts from the radicand in X. A restoring algorithm is used, and the output is an n−1 digit root. The remainder is found in register X.

ters X and Z are both shifted at the clock frequency, f_c, and each has $4(n-1)$ stages. And since the adder/subtractor in each register circulation path has a one-digit delay, each register needs only $4(n-1)$ bit stages to provide a complete circulation in 4n clock pulses. The binary adder/subtractor in the Z register's feedback is part of the radicator generator circuit, and the serial BCD adder/subtractor combines the contents of the X and Z registers.

Because the most-significant radicator digit is generated first, the digit interval D_{n-1} must be connected first to the binary adder/subtractor. This D_{n-1} connects to the AND gate during W_1, D_{n-2} during W_2, and so on to D_0 during W_n. Signal B_0 provides the pulse that adds a unit quantity to the proper digit of the contents of the Z register, and FF_2 provides the frame intervals F_1 and F_2 such that the radicator increments only during frame F_1. Thus the contents of the Z register remain the same for two circulations. The word counter advances on the next leading edge of $f_c/128$, when S_5 is closed during a restoring operation to add the increments to the next-lower significant radicator digit. It is clear from Table 3 that each word interval can include several register circulations, as needed. Also, note that the timing chain, except for S_5, is very similar to that used in the divider circuits.

Dividing by 10

The actions of signals W_i and D_i are thus equivalent to dividing the radicand increment by 10 for each successive word interval. The restoring operation also causes a one-digit left shift of the contents of register X via the one-digit delay and S_2. This left shift is, relatively speaking, equivalent to dividing the whole radicator by 10. Thus the increments are, in effect, divided by 100.

The contents of the Z register are either subtracted from or added to the contents of the X register by the serial BCD adder/subtractor. The remainders, R_i, are then loaded back into the X register via S_2, when S_2 is in its lower position. Initially the X register contains the radicand and subsequently the remainders.

The BCD adder/subtractor's carry output is sensed by the leading edge of D_o, which clocks the carry's state into FF_1. A high carry signal indicates that the result of the previous subtraction is positive. As long as the remainder polarity stays positive, the contents of the Z register are subtracted from X. When the polarity becomes negative, and thus signal P_r is low, the Z-register's contents are added back to X to restore the previous positive remainder.

A nonrestoring technique analogous to the system used in division can also be used. As before, the algorithm would start with the subtraction of the radicator from the radicand, and after each subtraction the remainder would be tested for polarity. If the remainder remains positive, the subtracting process continues. But as soon as the remainder polarity changes, the remainder would be left-shifted two digits and the process would now continue with the addition of the radicator to the remainder until the remainder again changes polarity, and so on.

Placing the decimal

During interval W_0 the X register can receive a new radicand while register Z unloads the answer, and the remainder is available from register X, if required. Obviously the answer can have n−1 digits. However Fig. 1 does not show the circuit for placement of the decimal point. The decimal is handled by a separate circuit (see "BCD Decimal-Point Location," ED No. 16, Aug. 2, 1973, p. 80). The decimal shown for the radicator in Table 3 is only symbolic and in reality represents only the relative positions of the digits in the X and Z registers. Only the mantissa of the contents of register Z appears in the output.

The location of the decimal-point in square-root extraction is determined by a divide-by-two operation of the number of digits in front of the decimal of the radicand. When the radicand has an odd number of digits, the number of digits is rounded off to the next higher even number. Thus the three-digits radicand 200 is taken as having four digits—02 00 = 14.14. The root then has two digits in front of its decimal.

In the true-normalized exponential notation, 200 becomes 0.2×10^3. In this case the radicand's power of 10 is converted to the next higher number: $0.02 \times 10^4 = 0.1414 \times 10^2$. The exponent is divided in half when the circuit extracts the square root and the mantissa is in true-normalized form. ▪▪

The sixth article will discuss the BCD generation of logarithms and exponentials.

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SIGNAL SOURCES

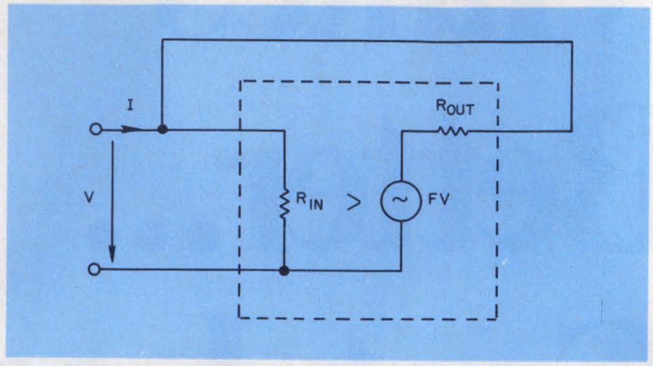
INFORMATION RETRIEVAL NUMBER 38

Banish inductors from resonant circuits.

Cascaded RC phase shifters act like conventional tuned circuits, and you can get either 'parallel' or 'series' response.

Resonant tuned circuits usually require bulky and drift-prone inductors. But inductors can be eliminated by employing active RC networks. Simple RC phase-shift stages can be cascaded to approximate the response of LC resonators.

These active RC resonators are especially useful in the design of filters that require sharp frequency selectivity. In fact, the frequency selectivities of these simple RC circuits are better than those of most commonly used passive LC circuits. Both parallel-resonant and series-resonant LC circuit characteristics can be simulated by the RC circuits.



1. **The basic transistor feedback circuit,** with the amplification factor, F, dependent on frequency, serves as the model for building subsequent "series" and "parallel" resonance circuits.

Understanding the theory

Fig. 1 shows a basic feedback circuit. Its output impedance without feedback is very small—around 5 Ω—and it is denoted R_{out}. Its input impedance in the absence of feedback is very large and is denoted R_{in}. Both R_{in} and R_{out} are resistive. The amplification factor, F, is unity, and it has some phase angle, θ, that depends on frequency.

Denoting the input impedance for the circuit of Fig. 1 as Z_{in}, we get

$$Z_{in} = (R_{in} R_{out})/[R_{out} + R_{in}(1-F)], \quad (1)$$

where

$$F = \cos\theta + j\sin\theta, \quad (2)$$

$$R_{in} >> R_{out}.$$

We can see immediately that if

$$\theta = 0° \text{ and } F = 1,$$

then

$$Z_{in} = R_{in}; \quad (4)$$

if

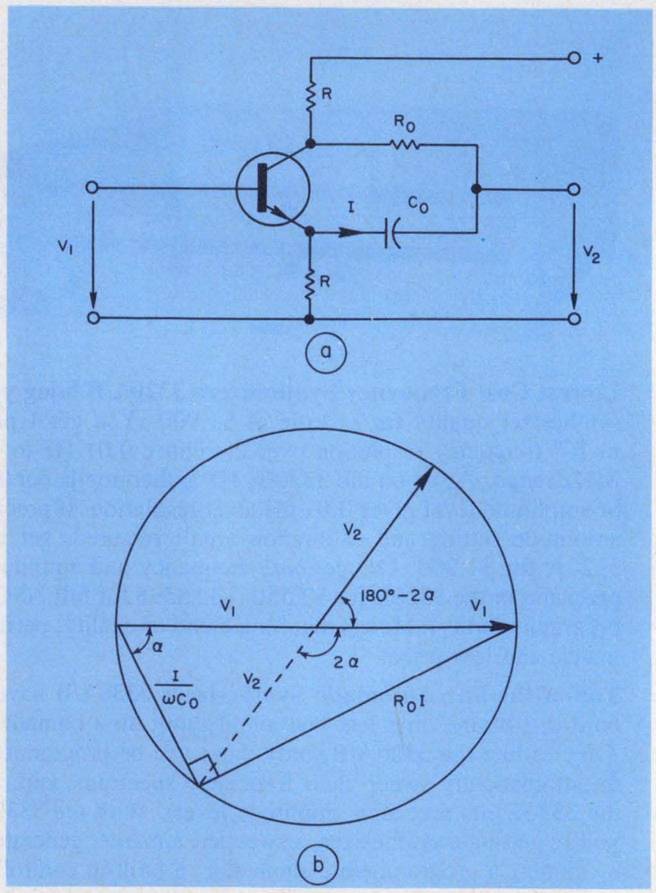
$$\theta = 180° \text{ and } F = -1,$$

then

$$Z_{in} = R_{out}/2. \quad (5)$$

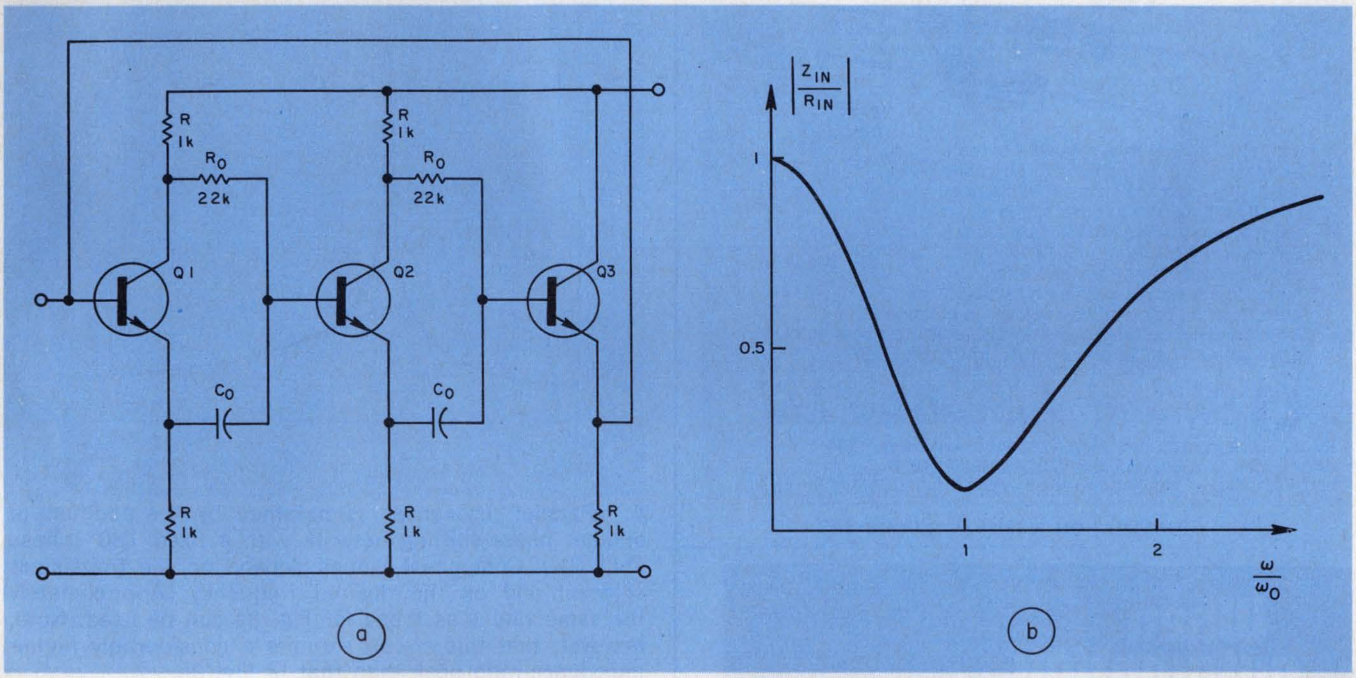
In other words, as the phase varies from 0° to 180°, Z_{in} varies from a high value of R_{in} to a low value of $R_{out}/2$.

Fig. 2a depicts a basic RC phase-shift network. In this circuit, collector and emitter re-



2. **In a practical phase-shift network** (a) input and output voltage amplitudes remain constant, but the phase shift between them varies (b).

Ulf Thoren, Engineer, Muninvagen 11, 852-45 Sundsvall, Sweden.



3. **A "series-resonant" circuit is built** with two phase-shifting networks (a). Capacitor values depend on the desired resonant frequency. Transistors should have high betas at the frequency limit (at least 10 times the f_0). Frequency selectivity is demonstrated in b. The null is sharper than for most LC circuits.

sistors, r, are small compared with R_0. The phase relationship between the input voltage, V_1, and the output voltage, V_2, is shown in a vector diagram in Fig. 2b. Note that the phase angle between V_1 and V_2 is expressed by the variable $\tan \alpha = \omega R_0 C_0 = X$. Thus we can write two equations for $\sin(4\alpha)$ and $\cos(4\alpha)$ that we will need for designing the actual circuits, as follows:

$$\cos(4\alpha) = (1 + X^4 - 6X^2)/(1 + X^4 + 2X^2) \quad (6)$$

$$\sin(4\alpha) = 4X(1 - X^2)/(1 + X^4 + 2X^2) \quad (7)$$

Designing practical circuits

A practical phase-shift circuit built with two single phase-shift networks is shown in Fig. 3a. The two phase-shift stages are followed by an emitter follower, Q_3, that provides low output impedance. Note that the output signal is fed back into the input directly.

For this case, we can write

$$\theta = 2(180^\circ - 2\alpha), \quad (8)$$

where α is defined in Fig. 2b. On the basis of Eq. 2,

$$F = \cos(4\alpha) - j\sin(4\alpha), \quad (9)$$

which results in the following:

$$F \rightarrow 1 \quad \text{as } X \rightarrow 0, \quad (10)$$

$$F \rightarrow 1 \quad \text{as } X \rightarrow \infty. \quad (11)$$

The limits expressed in Eqs. 10 and 11 indicate that the circuit of Fig. 3a has a high input impedance for both low and high frequencies (also see Eq. 4). A low input impedance, however, occurs at some definite frequency given by

$$X = 1;\ \omega_0 = 1/(R_0C_0);\ F = -1. \quad (12)$$

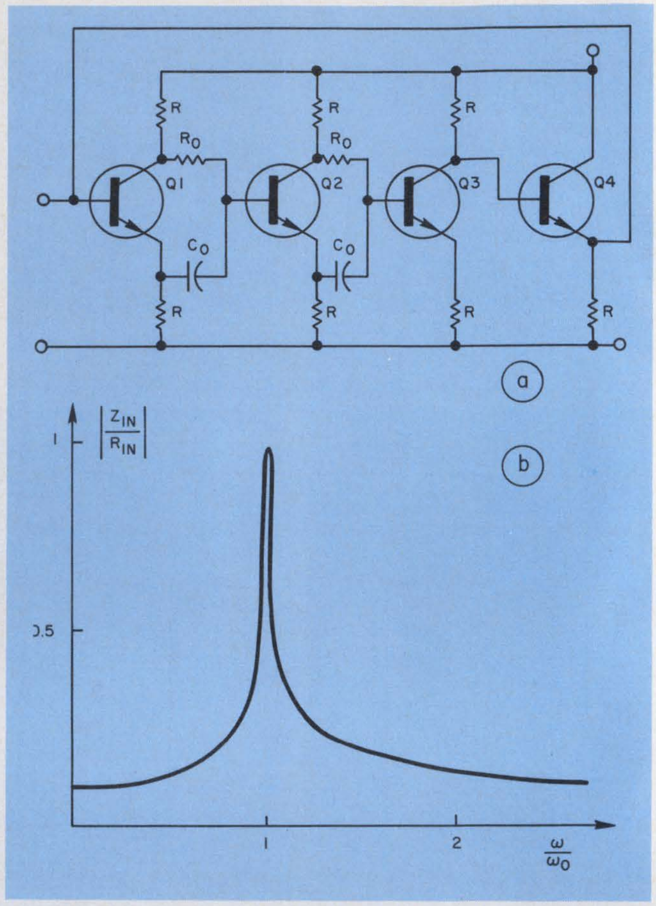
The circuit of Fig. 3a has performance similar to that of a conventional series-resonant LC circuit. However, as seen in Fig. 3b, it has a sharper impedance null than is possible with an LC circuit.

For an RC resonator, the circuit's Q is given by

$$Q_{equ} = \sqrt{2R_{in}/R_{out}}. \quad (13)$$

The bandwidth of the circuit is given by

$$BW = 2\omega_0/Q^2_{equ} \quad (14)$$



4. **"Parallel resonance" is obtained** by the addition of another phase-shifting network with a fixed 180° phase shift (Q_3). Component values depend on the transistors selected and on the desired frequency. Approximately the same values as those for Fig. 3a can be used. Note, however, that this circuit exhibits a considerably higher impedance-ratio peak than that of Fig. 3a.

The addition of a fixed 180° phase-shifting network to the circuit of Fig. 3a produces a circuit with parallel resonance characteristics (Fig. 4a). The phase shift for this case is

$$\theta = 180^\circ + 2(180^\circ - 2\alpha), \qquad (15)$$

so that

$$F = -\cos(4\alpha) + j\sin(4\alpha). \qquad (16)$$

Thus we can write the following limits:

$$F \rightarrow -1 \quad \text{as } X \rightarrow 0; \qquad (17)$$

$$F \rightarrow -1 \quad \text{as } X \rightarrow \infty. \qquad (18)$$

This means that a low input impedance occurs at both low and high frequencies, with a high impedance peak at some definite frequency:

$$X = 1;\ \omega_0 = 1/(R_0C_0);\ F = 1. \qquad (19)$$

Impedance variations as a function of frequency for the "parallel-resonance" circuit of Fig. 4a are plotted in Fig. 4b. The circuit's Q and bandwidth are given by Eqs. 13 and 14.

In both circuits the factor, F, should be adjusted fairly precisely. A potentiometer should be used in conjunction with collector resistors. The value of Q_{equ} can be trimmed by the addition of external resistance to either R_{in} and R_{out} or both. ■■

Good managers are made, says this head engineer. Grid seminars point the way to individual learning, team building and group interface.

Thomas J. Frampton, Manager of Engineering, Signetics, Sunnyvale, Calif. 94086.

Because some managers seem to deal so effortlessly with the management task, I used to believe that the good engineering managers were born, not made. I've learned since that the knowledge and skills it takes to manage both the task problems and the people problems can be learned.

The approach we're using at Signetics is the managerial grid seminar, which is focused on understanding how the organization can most effectively integrate its tasks, goals and long-range objectives with the needs of the people performing them.

The emphasis in the seminar is, first, on individual learning—a grid from one to nine is used to assess the strengths and weaknesses of a manager. Each participant assesses himself, and then he is assessed by the other members of the grid seminar.

Next, the seminar turns to team building, which requires the managers to find out how they can increase their effectiveness as a group. Each team is given a problem to solve. Typically, these sessions generate questions about the style of leadership that's being used, the communications pattern of the group and the way that conflicts are handled, whether they're worked out or submerged as they turn up.

Finally, the seminar looks at the relationships between groups and how they can interface between two different departments, such as design and marketing.

I think I can best tell you what the new approach has meant to the company by explaining how the company is set up and how it has made me more effective as an engineering manager within that organization.

Learning when middle ground is far-out

The more technical a company is, the more difficult it is to organize the communications network. Part of the reason is that multiple disciplines have trouble understanding one another. Half of Signetics is composed of linear, digital, and MOS lines, with product-engineering groups and process-engineering groups. The other half is the assembly operation, with groups of electrical and manufacturing engineers.

Everyone has his own goal within his own product group, but the support of the other groups is essential, too. If we can communicate, we can solve the problems, and that means getting everyone to speak openly at the engineering meetings.

One of the reasons I had trouble speaking openly was that I would do almost anything to avoid conflict. I pretty much accepted what other groups said, and I usually went to a middle-ground solution to please everybody. If anybody got a little bent out of shape or a little angry, I tried to smooth it over or ask my boss to make a decision.

The managerial grid seminar taught me that avoiding conflict was one of my most serious management weaknesses, and if I was ever going to be effective as a manager, I'd have to overcome the problem. After the seminar was over, I put what I had learned about myself to work on one of the production men I had to interface with.

My engineering group had designed a semiconductor, and we had tried to get the production man to agree to be responsible for a particular rate or a particular yield. The second or third day after production started he didn't meet his goals. So he said, "Well the engineer didn't support me." I asked him why he didn't resolve it at the open meeting. He said that he had but that he didn't get the full commitment. So I let it ride for about a week, until I was hearing in the halls that my engineers were dumb. I attended the next meeting and listened to everybody being very polite for about an hour.

The chairman adjourned the meeting, but I locked the door before anyone could get out and said that I thought there was something we ought to get out in the open because it was hurting our performance. I said I wanted the production man to tell my engineer to his face that he was dumb, so we could see what he had to say about it. The production man got red in the face

Thomas J. Frampton of Signetics ►

Tom Frampton discusses a fine point with Kaz Hayashi, Engineering Section Leader, Signetics.

Thomas J. Frampton

Responsibilities: Directs a corporate group which is responsible for development and sustaining engineering of commercial and military products; the group is also responsible for developing and sustaining various processes used in the manufacture of all bipolar integrated circuits.

Experience: Held a number of positions as designer and project engineer before joining Signetics in 1966. He has served successively as project engineer, supervisor of process engineering, section head of sustaining engineering, and manager of the engineering department. He actively participated in the development and production of 1200 different types of integrated circuit products, most of which are bipolar digital and linear devices now being produced in high volume.

Personal: Married; four children, two boys and two girls; conducts fishing expeditions on the Pacific Ocean and in the Sierra-Nevada Mountains.

Employer: Signetics Corporation, Sunnyvale, California, a subsidiary of Corning Glass Works, is among the five largest commercial manufacturers of integrated circuits. The primary product categories include bipolar digital, bipolar linear, and metal-oxide semiconductor (MOS) devices. The company was founded in 1961 by four engineers who developed and produced the industry's first commercial line of diode-transistor logic (DTL), which was intended for the nation's aerospace programs and is still being used. Today, the company manufactures comprehensive lines of transistor-transistor logic (TTL) elements. Although best known for its digital logic elements, Signetics has also developed broad lines of MOS memories and linear circuits for use in applications that range from electronic data processing equipment to home entertainment systems. Signetics manufactures integrated circuits in six plants located in the U.S., Asia, and Europe.

and said, "Well I didn't really mean it that way."

"On the other hand," I told the production man, "the maintenance man here says that you're a dummy. Now why aren't you guys talking to each other?"

One man said, "Well, everytime I come over to your group, I don't get any service." And my man got mad and said, "The hell you don't; every time I give you what you want." This went on for three hours.

Underlying causes were revealed that showed why none of the groups was functioning as a team.

When humor isn't funny

Before the grid seminar, I probably wouldn't have gone to that meeting. I would have stayed out of it and waited to see what would happen. Now I don't hesitate to tell a man if I think he's wrong—and I tell him why. Perhaps, if we discuss it, he can convince me I'm wrong. At any rate, we both gain from the confrontation.

I learned about the use of humor at the grid seminar, too. By nature, I'm not an extrovert, unless I'm with a lot of people I know. I joke quite a bit at work. I use it to relieve tensions and also to sell myself. I found out that my jokes were quite distracting to people. Humor in the right places is very good; in the wrong place, it's distracting. I was using humor too much. So now I'm a little more careful when I use it and how I use it. If there are tensions, I'll drop a joke in; if a customer is a little bit cold at first meeting, I'll try to relax everybody with a story.

I also learned a bit about conviction at the seminar. I used to operate with strong convictions only when I thought something was important. I found out you can't do that. You should have strong convictions about minor problems, too, particularly if you're interfacing with everybody from the VP down to the last girl on the line. When she tells you something that she thinks is important, you should have your own convictions about what she is saying. This helps her clarify her own thinking on the subject. It's amazing what you can get people to tell you if you have established your own convictions.

An overbearing personality—what they call a nine-one grid—may make the decisions, tell his people what to do and have no other opinions. But once he's challenged, he will usually turn off totally, or he will convert to a one-one mode on the grid. I used to manage that way, but the seminar taught me to convince people of my ideas, or let them convince me.

I also gained more insight into people. I can look within my group of people and spot those,

Dr. Gerald R. Pieters, Manager of Organizational Development, conducting a training course for Signetics.

with managerial talents now. I couldn't do that before. Most engineers do well if you sit down with them once every six months and tell them where their relationship is within the group, why you see it that way and how you feel about it. I tell them why someone gets a promotion; I tell them how I preceded them in the organization and what I think of their career goals. I have about 40 people in my group. Their morale is good. Communications are open, and I think that's because they all know pretty much where they are at.

Polling the management perception

Should an engineer who wants to be a manager attend a grid seminar? Definitely. After a week he'll be better qualified to determine whether or not he's management material.

Should an engineer attend even though he doesn't want to be a manager? I feel he should. At Signetics only the managers were going to the seminar at first. Now we're giving it at the engineering level.

Grid offers a common base for communications. People who've been exposed to the seminar have a common set of experiences, and the terminology becomes knowledge. People are able to use what they've learned more readily in the work situation. I saw two grid graduates arguing one day, neither of them getting anyplace. One of the guys looked at the other one and asked, "Were you at the grid seminar?" and the other guy said yes. Then the first guy observed: "You know what we're doing? We're win-losing with each other; we're not really trying to solve the problem." Recognizing that and understanding the difference between win-lose and problem solving, they were able to reach an agreement.

Since we started these management approaches, Dr. Gerald R. Pieters, manager of organizational development at Signetics, has conducted periodic surveys through a questionnaire that we all helped to develop. The salaried people in the company are asked to assess the effectiveness of management processes by answering the following questions:

- Are your needs being met, and, at the same time, do we have enough drive, structure and control to meet the company's needs?
- Are your jobs and those of your subordinates designed to be challenging and interesting, or are they menial and less than satisfying?
- To what extent are you and your subordinates involved in the planning and decision-making that effects them?
- Do you or your subordinates have a stake in the jobs you've been committed to, or has the job been assigned to you haphazardly?

Through this kind of polling, we try to determine what areas of management are not functioning effectively and then plan action for improvement.

Has the managerial grid, team-building. and group interface approach made our management more effective? Successive company surveys have indicated that the approach has helped—a bit more each time—especially with communication and in coordinating activities. ■■

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5 volt powered, 5 ranges—from 20mV through 200V full scale, the Model 253 changes ranges almost as fast as you can change your mind. Without rewiring. More OEM delights: the 253 comes standard with BCD output, 200-volt overload protection, autopolarity, and big, bright LED digits. All of this fits into a neat, small ANSI cutout, 3.32" x 1.14".

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ICs give automatic selection of range for frequency counters

In almost all frequency counters, the range selection is by means of a band switch—a method that presupposes that the order of magnitude of the frequency to be measured is known. With the addition of a few ICs, the correct range can be selected automatically, with a high degree of reliability, and the extra cost to do this is low.

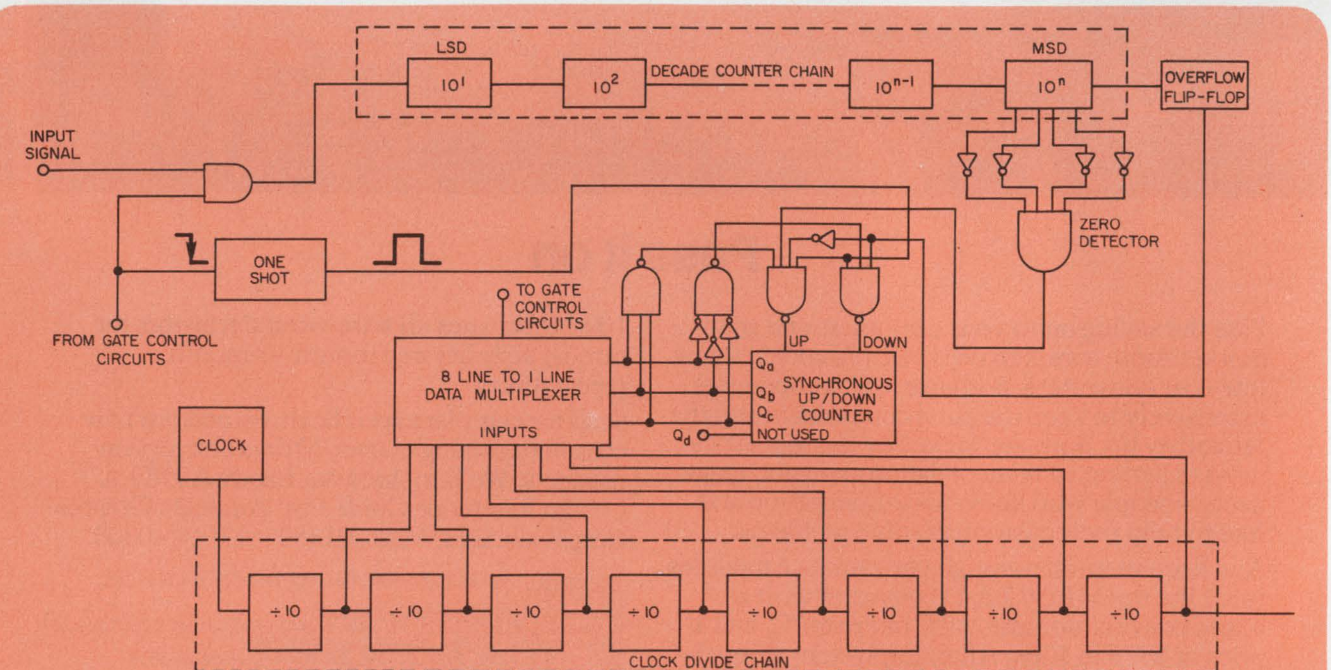
In the circuit shown, the internal clock output is applied to a chain of decade dividers that supply the necessary time bases. Normally the desired time base is selected manually. But if the switch is replaced with an eight-line-to-one-line multiplexer, a synchronous up/down counter and some gating, the correct range can be selected automatically.

The multiplexer is controlled by the three least significant outputs of the up/down counter. Gates are connected to the most significant digit and overflow latch of the count chain. They sense the presence of the input signal. If the chosen gating period is too high, there is an overflow that sets the overflow flip-flop. A short pulse applied to the range adjust line before the next counting period decrements the counter by one count. Hence the next lower gate period is selected, and this process is repeated until there is no overflow.

If, on the other hand, the gate period is too low, one or more of the most significant digits are zero. Thus the respective decade counter outputs will be ZERO. The ZERO state of the most significant digit is now sensed, and the up-count line of the up/down counter is activated by the range-adjust pulse signal, incrementing the count by one. This continues until there is a number aside from zero in the most significant decade.

To overcome the possibility of endless counting, the end states for both up and down (in this case seven and zero) are sensed and used to inhibit the counter. The state of the counter can also be decoded to give the decimal point location. This scheme requires a maximum of seven full cycles to guarantee the correct range selection. In most cases this time span is not critical.

S. A. Mageswaran, Senior Research Assistant, School of Automation, Indian Institute of Science, Bangalore 560012, India. CHECK NO. 311



Manual range switching is eliminated by replacement of the switch with several ICs.

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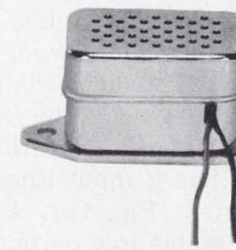
THE REMARKABLE MICRO-BUZZERS

SHOWN ACTUAL SIZE

RMB-03 (3-volt)
RMB-06 (6-volt)
RMB-12 (12-volt)

SHOWN ACTUAL SIZE

INTERMITTENT ALARM
IMB-03 (3-volt)
IMB-06 (6-volt)
IMB-12 (12-volt)



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Model	RMB-03	RMB-06	RMB-12
Rated Voltage	3 V DC	6 V DC	12 V DC
Rated Current	35 mA	33 mA	23 mA
Voltage Range	2—4 V	4—8 V	6—16 V
Sound Pressure	Over 90 db.		
Life	300 hours minimum		

PRICE:

QUANTITY	UNIT PRICE
1-100	$3.00
101-1,000	2.75
1,001-5,000	2.60

Model	IMB-03	IMB-06	IMB-12
Rated Voltage	3 V DC	6 V DC	12 V DC
Rated Current	40 mA	38 mA	28 mA
Voltage Range	2.5—4 V	4—6 V	6—16 V
Sound Pressure	Over 90 db		
Life	Over 300 hours		
Sound Period	0.5 second on, 1.0 second off		

PRICE:

QUANTITY	UNIT PRICE
1-100	$4.80
101-1,000	4.55
1,001-5,000	4.40

SMB-01 (1.5-volt)	
Rated Voltage	1.5 V D.C.
Rated Current	15 mA
Voltage Range	1.1—1.65 V
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QUANTITY	MODEL	UNIT PRICE	AMOUNT
		SUB-TOTAL	
		POSTAGE & HANDLING	$2.50
		TOTAL ($9.70 minimum)	

Build the n-flop, a multiple pulse-input, level-output device that uses simple gates

The traditional R-S flip-flop is a bistable element having two input lines, two output lines and two stable states. Placing a true pulse on one of its input lines causes its respective output to go true, and remain true, until the other input line is pulsed. The output is not defined for more than one input true at the same time.

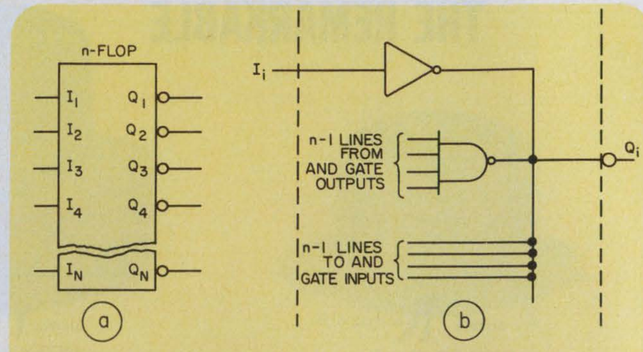
A logical extension of the flip-flop is the n-flop, which has n input lines, n output lines and n stable states (Fig. 1a). A positive input pulse produces a stable low output level.

This function can be implemented with flip-flops and steering gates. A more efficient implementation is to use one NAND gate and one inverter per state. The basic concept is shown in Fig. 1b. An example of a 3-flop is shown with its truth table in Fig. 2.

To analyze this circuit, assume that the Q_1 output is low. Then the A_1 inputs to A_2 and A_3 are low and the outputs from A_2 and A_3 are high. The high A_2 and A_3 inputs to A_1 cause the A_1 output to stay low. This is a stable condition. By symmetry, it can be seen that A_2 and A_3 have stable output-low conditions. If a positive pulse is applied to I_2, the A_2 output is pulled low and the outputs of A_1 and A_3 go high. This is a stable condition for A_2 low.

As an example of a possible application for the n-flop, Fig. 3 shows a control sequencer and its timing diagrams built with a 4-flop. Here only one of several outputs is on at any time, and the time of the ON duration can vary from output to output.

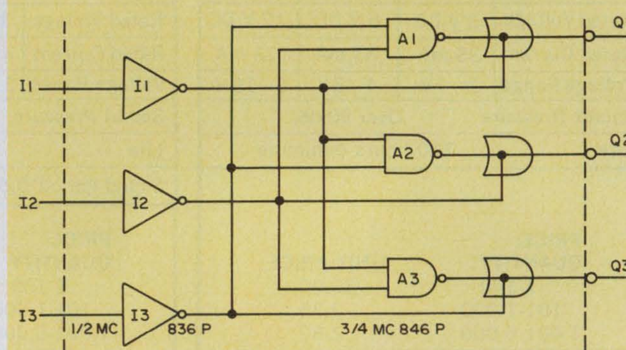
Jack Goldberg, Fisher Controls Co., Marshalltown, Iowa 50158. CHECK No. 312



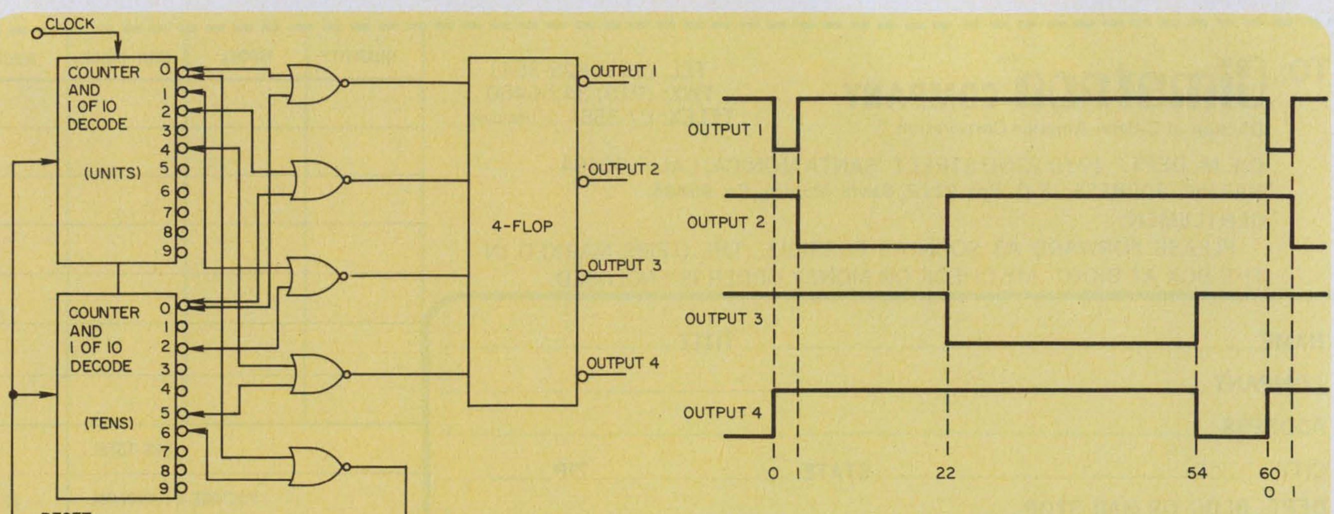
1. **The basic n-flop** needs only inverters and gates to produce stable outputs for pulse-inputs.

TRUTH TABLE

INPUTS	OUTPUTS
ANY OR ALL I_N = 1	Q_N CORRESPONDING TO TRUE I_N ARE 0
ALL I_N = 0	Q_N CORRESPONDING TO THE LAST I_N WHICH WAS 1 WILL BE 0



2. **A 3-flop needs only 2 ICs** to produce stable states.



3. **A control sequencer uses a 4-flop** to produce four timing levels of different widths.

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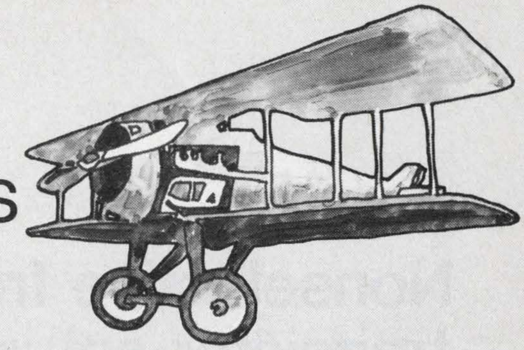

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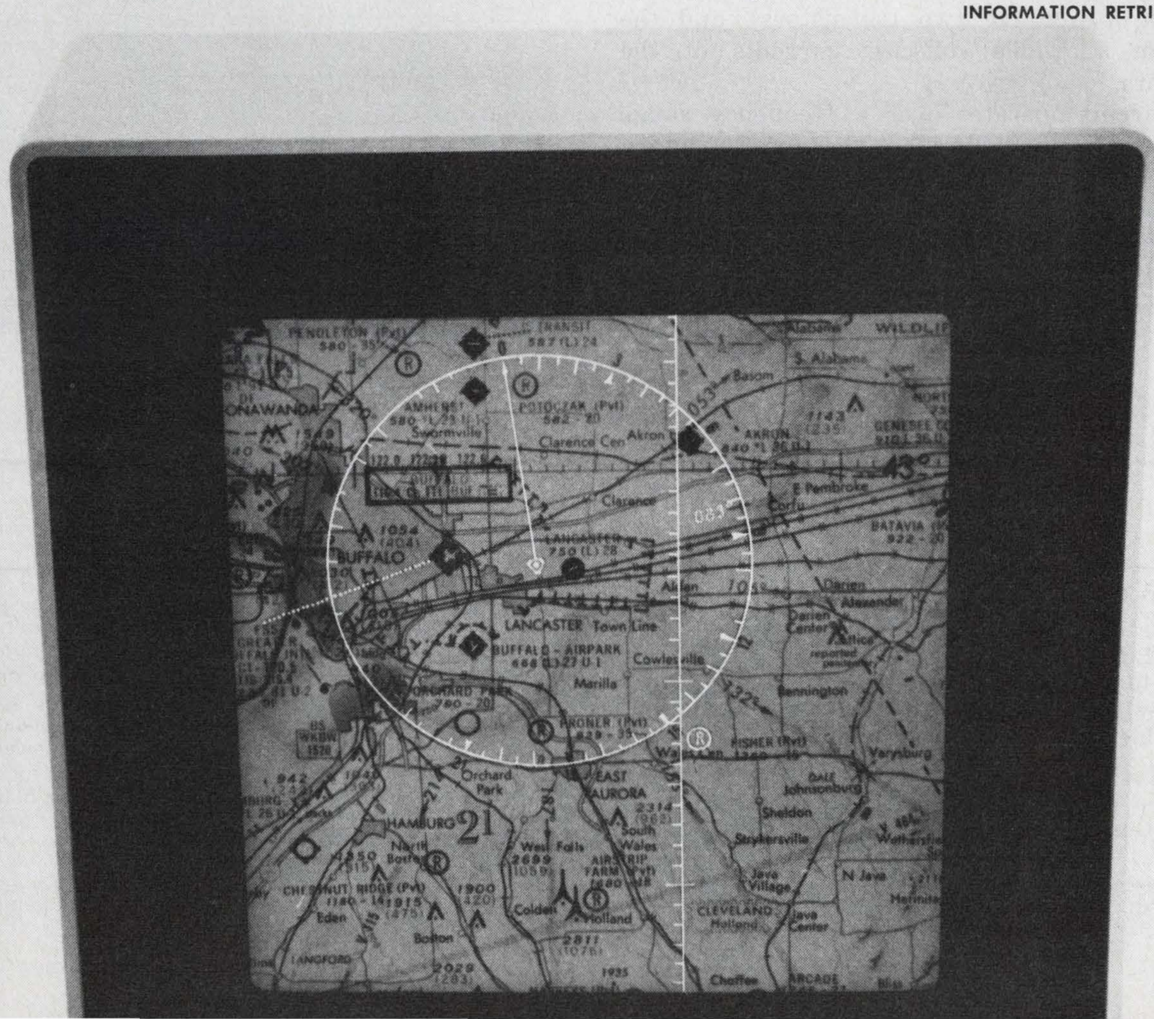
INFORMATION RETRIEVAL NUMBER 45



Simulation of rear projection on screen.

Nonselective frequency tripler uses transistor saturation characteristics

The turn-on and turn-off characteristics of two complementary transistors can be combined to attain nonselective frequency tripling. The resulting circuit handles any periodic waveform with nonvertical sides.

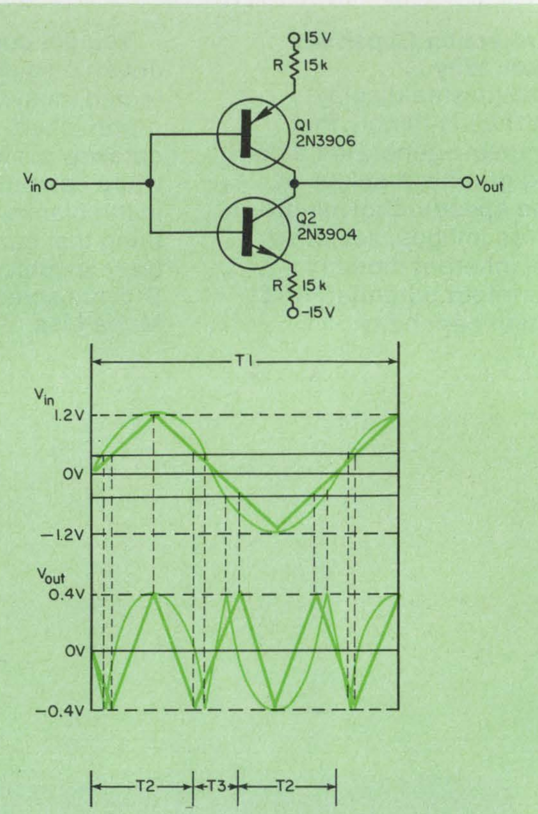
Consider a triangular waveform input. As the input increases from zero volts, V_{CE} of Q_2 decreases while V_{CE} of Q_1 increases and the output voltage swings in the negative direction. When V_{CE} of Q_2 reaches its saturation level, the output voltage swing reverses and starts to follow the triangular wave to its positive peak. The same pattern occurs in reverse as the triangle wave returns to zero.

The entire sequence is duplicated—with the roles of Q_1 and Q_2 interchanged—on the negative cycle of the input signal, giving—as before—three output signal peaks per input signal peak.

The choice of values for the resistors, R, is limited mainly by the effect on input impedance (through h_{fE} of the two transistors) and the maximum allowable collector currents of the transistors.

The circuit operates over a frequency range from dc to the upper limits of the complementary transistor pair. About the only disadvantage of the circuit is the lack of symmetry of the output signal peaks.

Robert K. Lockhart Jr., Chief Engineer, Systek Laboratories, P. O. Box 158, Orland Park, Ill. 60462. CHECK NO. 313



Each input signal peak produces three output signal peaks with this nonselective tripler circuit. The additional peaks occur where the input signal causes saturation of one of the two transistors.

IFD Winner of April 12, 1973

Eliezer A. Sheffer, Tamkin Computers Ltd., P.O. Box 11014, Tel Aviv, Israel. His idea "Countdown technique simplifies BCD-to-binary conversion circuitry" has been voted the Most Valuable of Issue Award.

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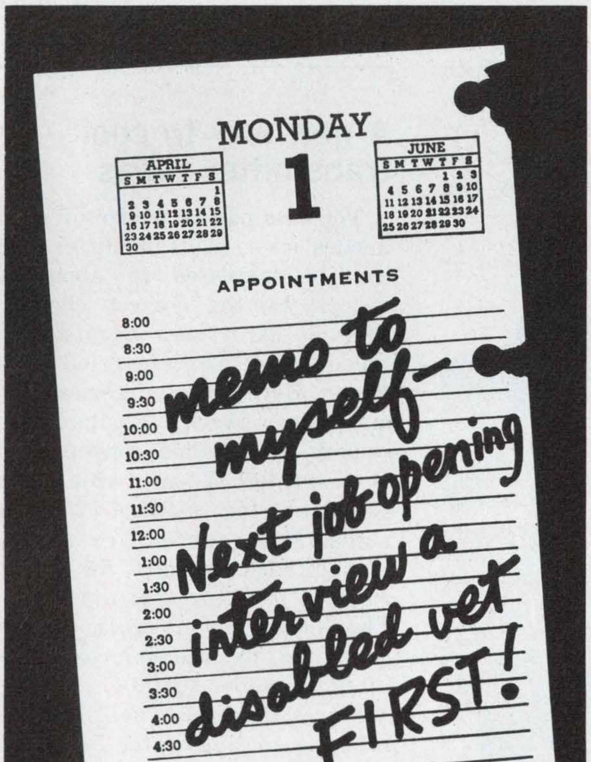

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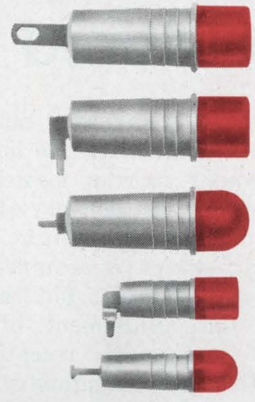

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INFORMATION RETRIEVAL NUMBER 47

Advanced mortar locator delivered to British Army

The British Army may soon be using what is said to be the most advanced mortar locator yet developed. First delivery of the highly mobile, lightweight (860 lb) radar—which is designed not only to locate mortars but can be used for the adjustment of artillery fire—was made recently to the British defense ministry.

Developed by EMI Electronics Ltd., Hayes, Middlesex, and called Cymbeline, the locating system consists of an X-band radar, hinged antenna system, analog computer, combined display and indicator unit and a generator. It is normally carried on a specially developed two-wheeled trailer towed by a Land Rover or similar vehicle. It can also be mounted on a self-propelled vehicle or carried by four men for short distances. The locator has a maximum range of 12.5 miles, but actual range of detection depends upon the calibre of the projectile.

When a projectile passes through the Cymbeline radar beam an echo shows on the display and is marked by the operator in pencil. The operator then presses a button which tilts the beam by a small amount and, as the projectile's trajectory interrupts the beam a second time, the operator makes another mark on the display. The time taken for the projectile to pass between the two intercepts on its trajectory is measured and passed to the computer, together with azimuth and slant range data obtained from the display unit.

From this data and from knowledge of the coordinates of the radar position, the computer calculates the mortar position which is shown on an indicator unit as an eight figure grid reference. The complete sequence takes about 20 seconds and is carried out by two operators.

Highly mobile mortar locating radar developed for the British Army is mounted on a two-wheeled trailer.

MNOS memory arrays finding wider use

Storing small volumes of data under power-off situations can't be done economically with presently available memory systems, but the MNOS transistor (metal nitride oxide semiconductor) is an electrically alterable nonvolatile memory that can be used to produce economical lightweight assemblies for long-term data storage. GEC Semiconductors Ltd. of Britain has produced a range of MNOS devices, comprising single, dual and quad transistors, and an undecoded 8-by-8 array. The range will be extended with larger arrays, of both undecoded and decoded format. Applications are seen in microprogramming, numerical control, data scrambling, automatic dialing, data logging and in calculator program stores.

Plessey Semiconductors is another British company that has produced MNOS electrically alterable nonvolatile memories, and it is planning to introduce arrays of up to 1024 bits and interface circuits.

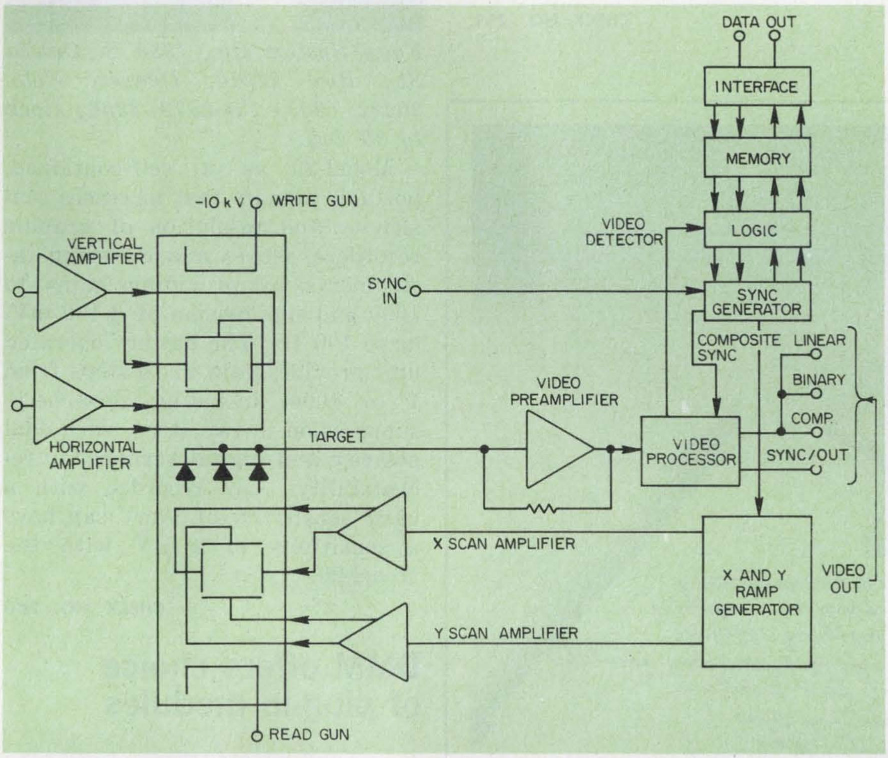
CHECK NO. 393

A new way to cool transmitter tubes

The dissipation power of copper anodes used in transmitter tubes can be increased to about 400 W/cm^2 by the correct choice of surface structure, according to recent experiments carried out by Brown Boveri in Switzerland. The maximum power dissipation of smooth, thin-walled copper anodes is about 120 W/cm^2, which is insufficient for modern tube designs. Most anodes are now designed with various fin or corrugated structures to aid cooling. The Brown Boveri work has concentrated on the microstructure of the anode surface. A rough surface increases heat transfer into the cooling water because of improved bubble formation and higher bubble frequency. Sandblasting improved the dissipation power by up to 20%, while a highly porous surface produced by electroplating increased it by up to 40%.

new products

Catch a transient pulse—store it, display it and digitize it



Tektronix, Inc., P. O. Box 500, Beaverton, Ore. 97005. (503) 644-0161. See text; 8 wk.

Need to catch a 0.35-ns single pulse, display it or digitize it? The R7912 Transient Digitizer from Tektronix is your instrument. And if you have repetitive pulses, the R7912 can convert the pulse train to a standard video format and display it on one or more large-screen TV monitors.

At the heart of the instrument is a new scan-converter tube. In this tube a 10-kV electron gun writes a charge image of the input waveform onto a target composed of an array of silicon diodes. This gun is driven in much the same way as a conventional oscilloscope CRT:

The waveform is amplified and applied to the vertical plates, while the horizontal plates are driven by a sawtooth waveform. A reading gun is placed on the opposite side of the silicon target. Its function is to scan the charged image written on the target by the writing gun. Every time the reading gun crosses a charged image, a signal current is developed in the target lead. The silicon target has a latency of about 100 ms. The target is addressed as a 512-by-512 matrix. However, because of nonzero spot size and other limitations, the resulting resolution of the instrument is 320 lines vertical by 400 lines horizontal. For display of a single transient, this is said to be at least twice the resolution of any oscilloscope on the market today.

In the digitizing mode the R7912 acts like a super-fast analog-to-digital converter. The clock rate can be as high as 100 GHz, since 512 samples can be taken in a time window as short as 5 ns. The target is scanned vertically in steps, with each image location represented by two nine-bit data words. One word gives the horizontal coordinate and the other the vertical. In addition a 10th bit is added to denote whether the word is the horizontal or the vertical. These data can be directly accessed, or they can be stored in an optional 4096-word semiconductor memory that costs an extra $1500. This memory serves as a buffer for driving a digital-to-analog converter, which in turn can feed a storage scope for display of the transient.

The base price for the R7912 without any options is $8400, including a scale-factor readout generator. If an electronic graticule is desired for display purposes, it costs $400. The extra cost is attributed to the need for plug-in vertical and horizontal amplifiers. All Tektronix 7000-series plug-in amplifiers will work in the R7912. The range in price from $95 to $1250. These plug-ins have bandwidths of up to 500 MHz.

In the repetitive-pulse video-out mode, the equivalent writing rate is 30 divisions/ns. The terminology "divisions/ns" means that the display can be on any sized TV monitor having the same writing rate. If the internal graticule generator is used, the screen is separated into eight divisions high by 10 divisions wide. The equivalent writing rate in the digitizing mode is only eight divisions/ns.

The basic instrument is 5.2 in. high by 17.6 in. wide by 22.9 in. deep, and rack-mounting hardware is provided.

Major areas of application for the R7912 are expected to include laser research, destructive testing, IC testing, X-ray damage testing, nuclear response, EMP, radar and other fast single-shot measurement situations.

CHECK NO. 254

INSTRUMENTATION

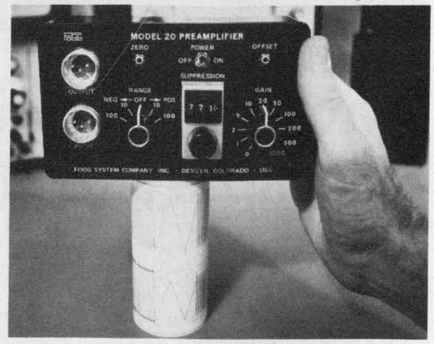
DMM/counter protects against overloads

California Instruments, 5150 Convoy St., San Diego, Calif. 92111. (714) 279-8620. $895; stock.

Called Model 8421, this four-digit DMM offers dc and ac voltage, resistance and frequency measurements, with a maximum continuous safe input voltage of 10,000% of range or 1000 V dc (whichever is greater) on dc ranges, 10,000% of range or 500 V rms (whichever is greater) on ac ranges, 200 V dc or peak ac on resistance ranges and 250 V rms on frequency ranges. 100% overrange is provided on all ranges.

CHECK NO. 259

Portable preamp boosts instrument sensitivity



Fogg System Co., 1380 S. Dahlia St., Box 22226, Denver, Colo. 80222. (303) 758-2979. $396; stock to 30 day.

Model-20 is a self-contained, portable preamp that increases sensitivity and resolution of graphic recorders, scopes and metering instruments by providing gains to 1000 and suppression of ±100 mV, dc to 100 Hz. The battery-operated unit provides gain in 10 steps from 1 to 1000, including zero-check, suppression in two steps, with dual polarity and digital vernier for repeatability. Any recorder with a basic sensitivity of 1 mV can have a sensitivity of 1 μV with the Model-20.

CHECK NO. 260

DMM offers choice of plug-in modules

Electro Scientific Industries, 13900 S.W. Science Park Dr., Portland, Ore. 97229. (503) 646-4141. 1700: $850; modules: $350 to $650.

Here's a modular approach to digital resistance measurements. The Model 1700 system consists of a digital converter and four ohmmeter plug-in modules, each with a different measurement range: to 20-Ω with resolution to 1 μΩ, to 200 Ω with resolution to 10 μΩ, to 2 kΩ with resolution to 100 μΩ, and to 20 kΩ with resolution to 1 mΩ. The customer orders positive or negative logic, and specifies only the plug-ins needed.

CHECK NO. 261

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Wood Electric—known for top quality circuit breakers for more than 20 years—is a recent P&B acquisition. There is an authorized Wood Electric Circuit breaker distributor near you. He has a long list of standard models in stock for immediate delivery. Both thermal and magnetic types. Ratings range from 1 to 60 amperes in voltages from DC to 400 Hz. Trip times are from instantaneous to 100 seconds at 200% of rated load.

Many are U/L recognized and CSA listed. Thermal units include single pole push-pull, single pole toggle and three pole (phase) push-pull. Magnetic-hydraulic units include single pole, two pole and three pole models. For technical literature and the name of your nearest Wood Electric distributor call your P&B representative, or write or call Potter & Brumfield Division AMF Incorporated, Princeton, Indiana 47670. 812/385-5251.

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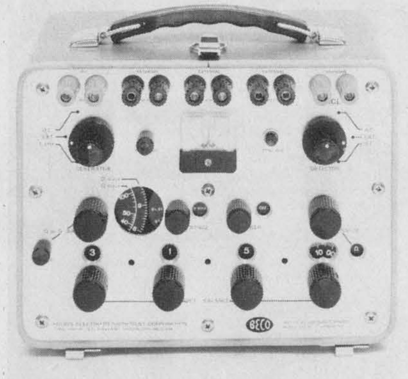
INFORMATION RETRIEVAL NUMBER 51

Portable bridge reads RLC to 0.5%

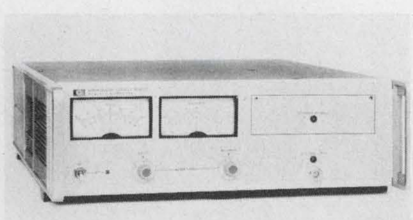


Brown Electro-Measurement Corp., 11060 118th Pl. N.E., Kirkland, Wash. 98033. (206) 822-6092. $545; stock.

The 315A is a portable, battery-powered, universal impedance bridge. A quick glance at the five-place direct digital readout, with automatic lighted "floating" decimal, informs you of the value of the device under test. The parameter and its magnitude is also displayed. The bridge measures (R) from 0-12 MΩ, (C) from 0-1200 μfd and (L) from 0-1200 H in seven ranges with resolutions of 0.1 mΩ, 0.01 pfd and 0.01 μH. Sensitivity is 5 μV.

CHECK NO. 262

Digital current source resolves 500 nA



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 493-1501. $2500; 8 wk.

A new dual-range, digitally programmable current source, the 6140A, provides current outputs from −99.99 to 99.99 mA (BCD input) or −163.84 to ±163.835 mA (binary input), at compliance voltages up to 100 V dc. In the XI range (±9.999 or ±16.384 mA), resolution is 500 nA (binary) and 1 μA (BCD); accuracy is 1 μA and programming speed is 300 μs.

CHECK NO. 263

Digital V/I/W meter offers 0.1% accuracy

Yewtec Corp., 1995 Palmer Ave., Larchmont, N.Y. 10538. (914) 834-3550. $3395; 10-15 wk.

This digital volt/amp/wattmeter provides 0.1% accuracy for true rms measurements. The Model 2503 uses a patented time-division multiplier technique to provide the accuracy on both sines and distorted ac waveforms over a wide frequency range. Over-all measuring range of the Model 2503 is from 3 to 600 V, from 0.1 to 5 A and from 300 mW to 18 kW. Digital readout is via a 4-1/2-digit LED.

CHECK NO. 264

4-digit DMM is also a 5-digit 20-MHz counter

Hickok Electrical Instrument, 10514 Dupont Ave., Cleveland, Ohio 44108. (216) 541-8060. $750; 60 days.

The Model 3420 combines a four-digit multimeter with a five-digit 20-MHz counter. As a counter, sensitivity is 100 mV up to 20 MHz. Frequency measurements can be made to crystal accuracy: 1×10^{-6} for one year without recalibration. As a multimeter, the 3420 has five dc voltage ranges, from 10 μV to 1200 V; five ac ranges, from 10 μV to 1000 V; and six resistance ranges, from 10 mΩ to 10 MΩ. Accuracy of the basic dc function is ±0.01% of reading ±1 digit.

CHECK NO. 265

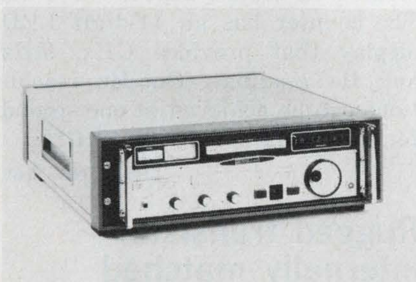
Digital alarm scanner checks critical signals

Doric Scientific, 7601 Convoy Ct., San Diego, Calif. 92111. (714) 277-8421. Basic system: $4035; 45-90 days.

Digitrend alarm systems scan, measure, display, print, and indicate alarm or shutdown conditions in any process where critical parameters can develop low-level dc voltage or current signals. Outputs from thermocouples, other millivolt transducers, or current transmitters are digitized and converted to physical units of temperature, pressure, torque, etc. These measurements are compared to digital limits, and the scan-point address and data magnitude are printed for any point that is in an alarm condition.

CHECK NO. 266

Receiver reduces sweep time by 70 s



Watkins-Johnson, 6006 Executive Blvd., Rockville, Md. 20852. (301) 881-3300. $9000 to $12,000; 120 days min.

A new receiver, the WJ-8888, with a single control and variable-rate tuning circuit, allows tuning increments as small as 10 Hz, while still permitting complete band-edge-to-band-edge tuning in less than 20 s. The receiver also offers complete digital control of operational parameters and a four-channel memory, which stores and recalls all receiver functions on command.

CHECK NO. 267

INFORMATION RETRIEVAL NUMBER 53

Avalanche diode amp has pulsed or cw mode

Raytheon, 130 Second Ave., Waltham, Mass. 02154. (617) 890-8080.

An X-band avalanche-diode amplifier, the VXM-5004, features a built-in rf modulator that permits operation in either pulsed or cw mode. Measuring just 6 × 4 × 1 inches the amplifier operates at 9.6 to 9.9 GHz with power output at 2 W peak or cw. Gain is 30 dB minimum and noise figure is 30 dB typical. When operated in the pulsed mode, rise/fall time is 10 ns.

CHECK NO. 268

18-GHz counter handles MIL-spec conditions

EIP Inc., 3130 Alfred St., Santa Clara, Calif. 95050. (408) 244-7975.

The E01-351C counter performs frequency measurements from 20 Hz to 18 GHz automatically with an electronically tuned YIG filter. Moreover, the counter meets all performance specs when exposed to the environmental conditions described in MIL-T-21200, Class II. The counter has an 11-digit LED display that provides GHz, MHz and Hz readings. One-Hz resolutions can be achieved in one second for all measurements to 18 GHz.

CHECK NO. 269

Rugged transistor internally matched

Communications Transistor Corp., 301 Industrial Way, San Carlos, Calif. 94070. (415) 591-8921. $108 (100-499); 10 days.

A 28-V linear power transistor, called the 2N6364, covers the frequency band of 200 to 400 MHz. The transistor reportedly features extreme ruggedness. It has internal matching, eliminating common problems resulting from low input impedance and high input Q. The 2N6364 is guaranteed to withstand rated VSWR at all phase angles when operated at rated power and supply voltage.

CHECK NO. 270

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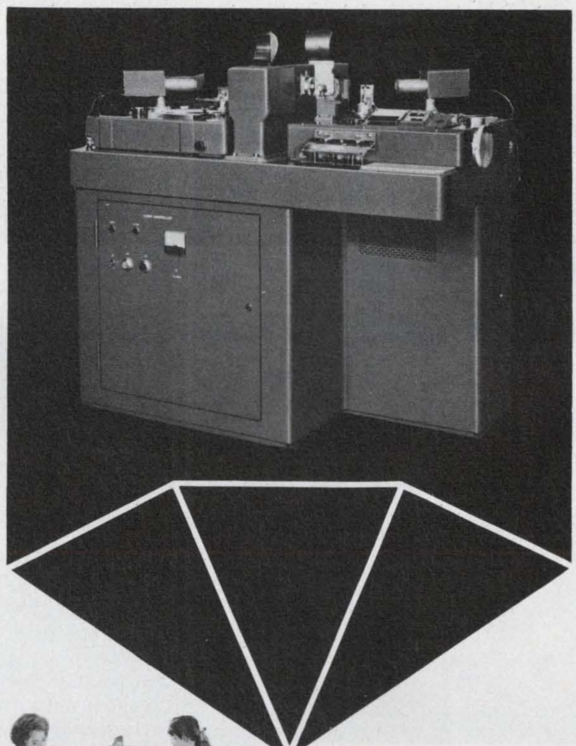

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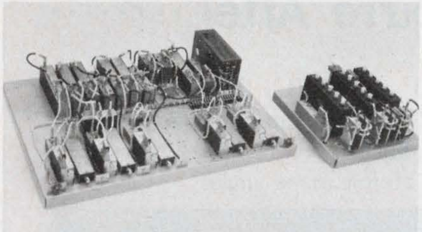
INFORMATION RETRIEVAL NUMBER 56

Monopulse receiver available

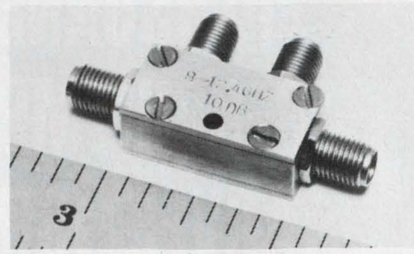


RHG Electronics Laboratory, 161 E. Industry Ct., Deer Park, N.Y. 11729. (516) 242-1100.

An L-Band, three-channel monopulse receiving system known as Model ARMIA allows the microwave-converter channels to be remotely mounted on an antenna up to 100 ft from the i-f video portion of the system. The receiver system has a frequency range of 0.95-1.2 GHz, noise figure of 9 dB and image rejection of 80 dB.

CHECK NO. 271

Miniature couplers cover 4-18 GHz range



Microwave Systems, Inc., 1 Adler Dr., East Syracuse, N.Y. 13057. (315) 437-9951.

A line of miniature coaxial couplers cover the 4-to-18-GHz frequencies in octave ranges. The units measure 1 × 0.5 × 0.375 inches and coupling values range from 6 to 20 dB. The couplers are supplied with SMA 3-mm connectors.

CHECK NO. 272

4-way power divider has .1-200 MHz range

Mini-Circuits Laboratory, 2913 Quentin Rd., Brooklyn, N.Y. 11229. (212) 252-5252. P: See below.

The PSC-4-1 four-way power-divider/combiner operates over the frequency range of 100 kHz to 200 MHz, has a port-to-port balance of 0.05 dB typical and offers an isolation between output ports of typically greater than 40 dB. In addition, it occupies only 0.128 cubic inches and costs $24.95 in six-piece quantities.

CHECK NO. 273

Gunn osc varactor tunes over K_u band

Omni Spectra, 1040 W. Alameda Dr., Tempe, Ariz. 85282. (602) 966-1471. $3000; 6-8 wk.

A varactor-tuned oscillator, the A30389, covers the frequency range of 12.4 to 18.0 GHz with a tuning rate of 10 MHz. It has an isolator, heater and voltage regulator that guarantees 10-mW output power and 0.3% frequency stability. Spurious rejection exceeds 70 dB.

CHECK NO. 274

We just outnumbered all the other function generators.

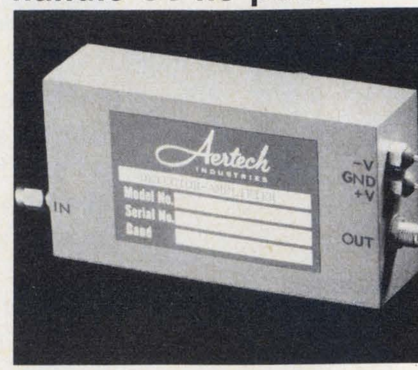
They don't have numbers at all. Just marks on a dial. The brand new Wavetek 147 has numbers. Numbers like 4.53 kHz. Or +2.83 V. Because it has the first digital display ever to appear on the face of a function generator. And those numbers cover a sweep range to 10 MHz.

But numbers aren't everything. So the 147 has more: precise resolution of sweep start and stop. Manual as well as electronic trigger control. A single dial for coarse and fine frequency control. And a bargain price of $1,295. If you'd like more information, use one of your own digits...and dial Wavetek.

WAVETEK® P.O. Box 651, San Diego, California 92112
Telephone (714) 279-2200, TWX 910-335-2007

INFORMATION RETRIEVAL NUMBER 58

Detector video amps handle 50-ns pulses

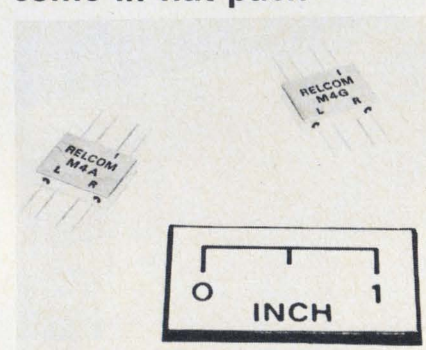


Aertech Industries, 825 Stewart Dr., Sunnyvale, Calif. 94086. (408) 732-0880.

A series of dc-coupled detector video amplifiers can handle pulse widths down to 50 ns. The amplifiers are available in two basic series. Units in the AD1100 series have a nominal video bandwidth of 7 MHz and rise time of 50 ns. The AD1200 series has greater video bandwidth and faster rise time.

CHECK NO. 275

Double-balanced mixers come in flat pack

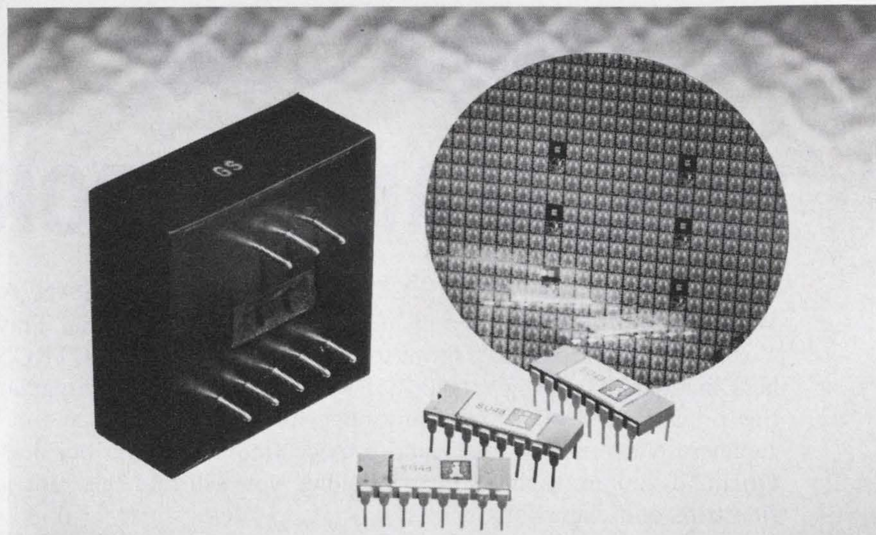


Watkins-Johnson, 3333 Hillview Ave., Palo Alto, Calif. 94304. (415) 493-4141.

Two series of double-balanced mixers are now available in flat packs. The M4A has an L and R-port frequency range of 10 to 1500 MHz and I-port frequency range of dc to 1000 MHz. At 500 MHz, the isolation is typically 40 dB and the noise figure is typically 6.0 dB. The M4G has an L-port frequency range of 800 to 3500 MHz, R-port frequency range of 800 to 2500 MHz and I-port frequency range of dc to 1500 MHz. Isolation is typically 30 dB and noise figure is typically 6.5 dB.

CHECK NO. 276

Low-cost IC contains complete log amplifier



Intersil Inc., 10900 N. Tantau Ave., Cupertino, Calif. 95014. (408) 257-5450. P: see below; stock.

Designers building logarithmic amplifiers with discrete components now have a low-cost IC alternative —Intersil's 8048 and 8049, the first single-chip log and antilog amplifiers, respectively. Each circuit contains FET-input op amps and a thin-film temperature-compensating resistor network.

Compared with higher-priced discrete-component modules that perform the same functions, the new devices don't have the range or accuracy. And comparable performance can probably be achieved by circuits using inexpensive components. But the 8048 and 8049 amplifiers offer the advantages of DIP packaging, minimum parts count and low price. Unit cost for a 16-pin package in 100-piece quantities will be in the $10 to $20 range.

The 8048 can accept over six decades of current input—from 1 nA to 1 mA. It can also operate over three decades of voltage input—from 10 mV to 10 V. For these values, the maximum full-scale error (referenced to the output) is ±2% over the full 0 to 70 C temperature range.

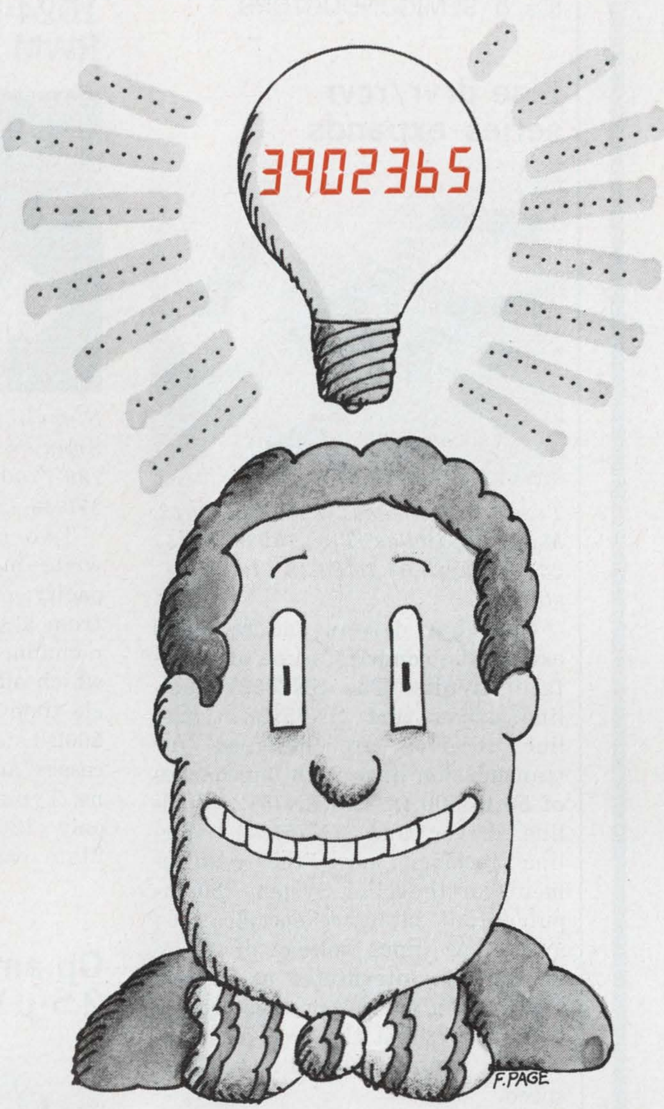
For either current or voltage inputs, the 8048 requires an external scale-factoring resistor (a 1-kΩ resistor yields a 1-V/decade factor) and a 150-pF compensating capacitor. When voltages are applied to the input, an additional resistor is required. Externally accessible terminals also allow adjustment of offset voltage (a maximum of 25 mV over the temperature range) and reference current (a maximum of 1 mA).

The log amp operates from supplies of nominally ±15 V. However, it can meet its specifications with supplies as high as ±18 V and as low as ±10 V or less. Output voltages reach, typically, ±14 V with a 10-kΩ load resistor.

The op amps on the 8048 chip are essentially Intersil's popular 8007 FET-input amplifiers. Accordingly slew rates up to 6 V/μs and bandwidths up to 150 kHz can be obtained at higher input currents.

The 8049 antilog amplifier, unlike the 8048, works with a voltage input only. However, the key specs are essentially the same. Both the log and antilog amplifiers dissipate about 200 mW and draw a maximum supply current of about 6.5 mA.

CHECK NO. 253



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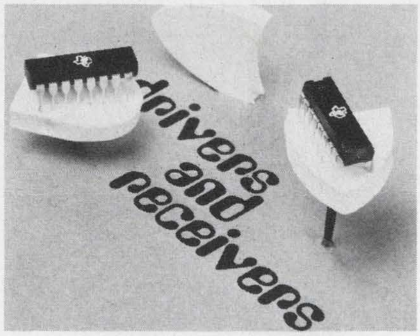
INFORMATION RETRIEVAL NUMBER 63

Line drvr/rcvr series expands



Texas Instruments, P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. $2.03 to $3.43 (100-999); stock.

Four line drivers and receivers extend the company's line of interface circuits. The SN75121 dual-line driver and SN75122 triple-line receiver are designed for transmission lines with impedances of 50 to 500 Ω. The SN75123 dual-line driver and SN75124 triple-line receiver meet the requirements of the IBM System 360 input/output interface specification; a receiver input voltage of 1.7 V or more is interpreted as a logic ONE. Each device operates from a 5-V supply, and the receivers feature a 20-ns typical switching speed.

CHECK NO. 277

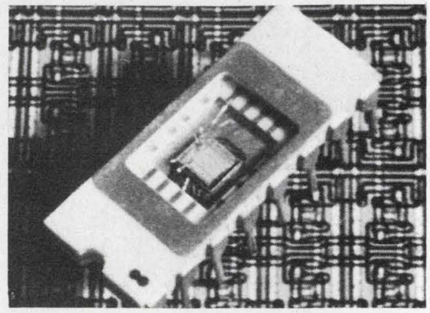
D/a converters offer fast response time

Motorola Semiconductor Products, P.O. Box 20924, Phoenix, Ariz. 85036. (602) 244-3466. MC1406L and MC1408L-6: $3.95 (100 up).

Two d/a monolithic converters—the six-bit MC1506L/MC1406L and the eight-bit MC1508L/MC1408L—feature fast response time, use as a multiplying converter and the flexibility allowed by a current-mode output. The MC1506L has a maximum error of ±0.78%, settling time of 150 ns typical and power dissipation of 85 mW typical (at 5 V). The MC1508L provides a maximum error of ±0.19%, settling time of 300 ns and slew rate at the multiplying input of 4 mA/μs. Both devices use standard supplies of +5, −5, and −15 V.

CHECK NO. 278

1024-bit NMOS static RWM uses 5-V supply

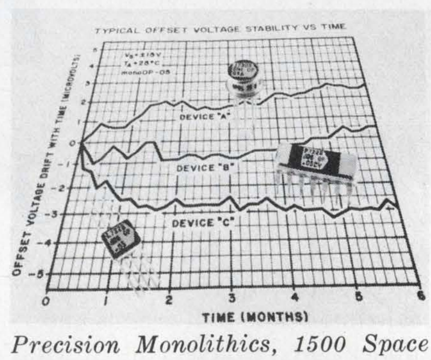


Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700. 2602B: $16, 2602-1B: $20.48 (100); stock.

Two medium-speed, static read-write memories, each with a capacity of 1024 bits, can operate from a single 5-V source. The two n-channel MOS ICs are the 2602 which offers an access and read cycle time of less than 1 μs, and the 2602-1, a faster version that accesses and reads in less than 500 ns. Typically, each RWM dissipates only 120 mW and features Tri-State outputs.

INQUIRE DIRECT

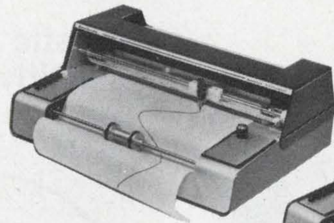
Op amp provides 2.5-μV/month stability



Precision Monolithics, 1500 Space Park Dr., Santa Clara, Calif. 95050. (408) 246-9225. monoOP-05AJ: $44.95 (100-249); stock to 3 wks.

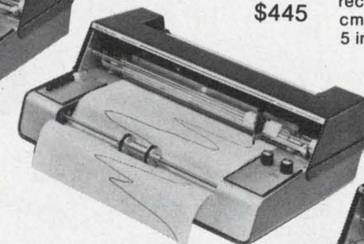
The monoOP-05A combines tight accuracy specs with low drift parameters vs both temperature and time. The device features a maximum initial offset voltage of only 150 μV, maximum offset voltage drift of 0.5 μV/°C (from −55 to 125 C) and offset drift vs time of typically less than 2.5 μV per month (8 μV per month maximum). Selected versions offer guaranteed drifts of less than 5.0 μV/month.

CIRCLE NO. 279



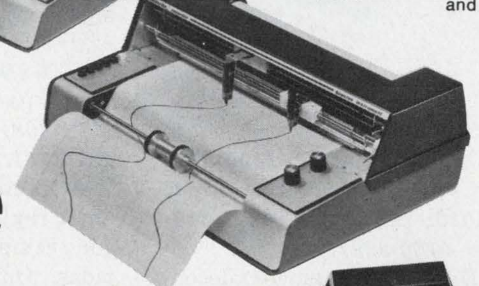
$395

Model 5112-1 single pen recorder with 1, 2, 5, 10 in/min. chart speeds and 10 mv fixed input spans.



$445

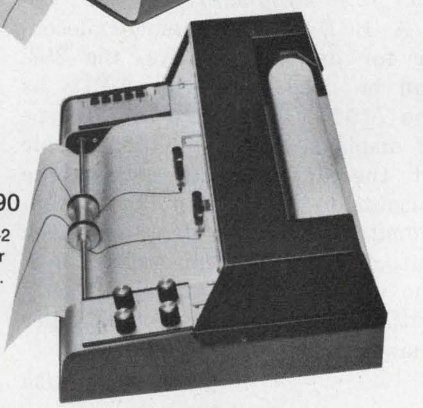
Model 5110-2 single pen recorder with 2.2, 5, 10, 20 cm/min. chart speeds and 5 input spans of 10 mv up.



$595

Model 5212-1 two pen recorder with 1, 2, 5, 10 in/min. chart speeds and 10 mv fixed input spans.

Here's how you draw the right conclusions:



$690

Model 5212-2 two pen recorder with 1, 2, 5, 10 in/min. chart speeds and 5 input spans of 10 mv up.

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CIRCLE NO. 201

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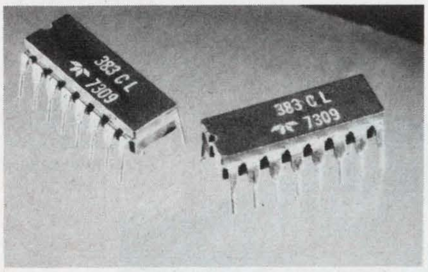
IC drives LED displays

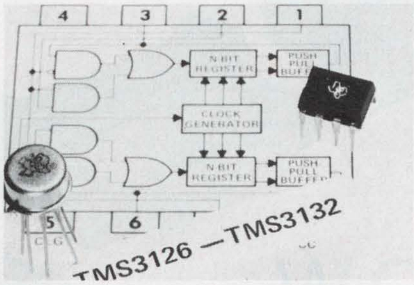


Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94040. (415) 968-9241. 383-CJ: $2.83 (100-999).

A BCD-to-seven-segment decoder for driving displays, the 383, can be used with such LEDs as the MAN-1 and Data-Lit-10 type of displays. A four-bit binary code at the data inputs causes the outputs to turn on in the conventional 7-segment code. Since each output of the 383 can sink 20 mA, the display can be driven directly without external components other than current-limiting resistors.

CHECK NO. 280

Static SRs for computer uses

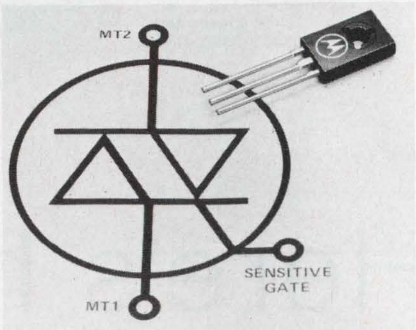


Texas Instruments, P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. $4.00 (100-999).

A family of seven MOS static-shift registers have various lengths for computer peripheral applications. Offered in eight-pin plastic dual-inline and eight-lead metal can packages, the shift registers are the TMS3126, dual 96-bits; TMS3127, dual 100-bits; TMS3128, 128-bits; TMS3129, dual 132-bits; TMS3130, dual 133-bits; TMS3131, dual 136-bits; and the TMS3132, dual 144-bits. Maximum guaranteed speed is 2.5 MHz. A single external TTL-level clock drives an internal clock generator.

CHECK NO. 281

Plastic triacs feature sensitive gate levels



Motorola Semiconductor Products, P.O. Box 20924, Phoenix, Ariz. 85036. (602) 244-3466. 56¢ to 64¢ (100-999).

The 2N6068 through 2N6075 series of plastic triacs span the voltage range of 25 to 600 V with worst case gate sensitivity ranges of 30 mA for standard models, 10 mA for the A series and 5 mA for the B series. All devices have a 4-A rms capacity and a 30-A surge capability (1 cycle at 60 Hz). The controlling element may be driven by TTL, HTL or CMOS levels, or op amps.

CHECK NO. 282

FREE

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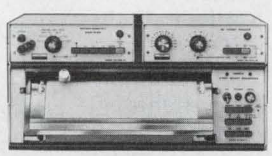

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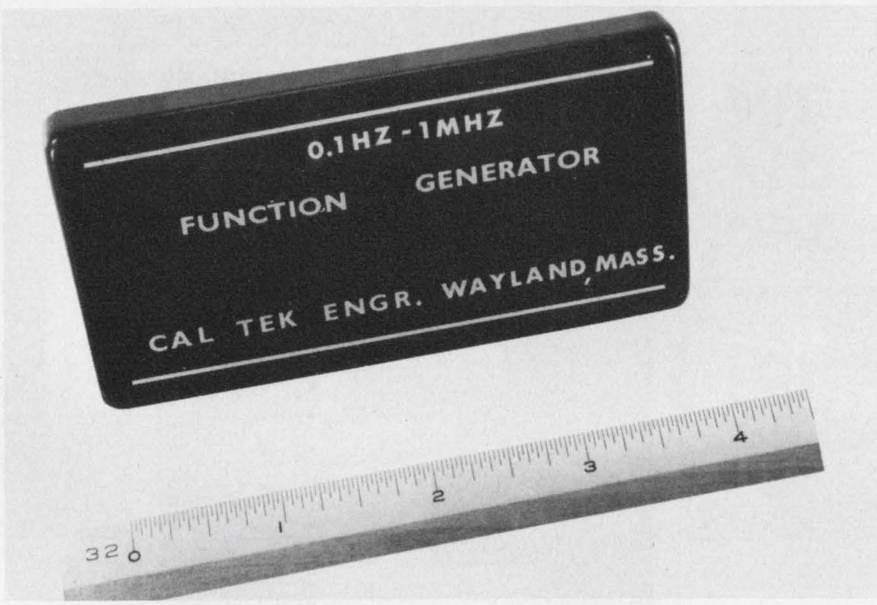
EK-394

INFORMATION RETRIEVAL NUMBER 67

Modular function generators output waveshapes to 1 MHz



Cal Tek Engineering, 29 Pemberton Rd., Wayland, Mass. 01778. (617) 653-0355. See text; 10-12 wk.

Function generators currently exist as ICs, discrete modules and complete instruments. Each has its own area of application, of course, but for OEM and PC-card applications, the choice narrows to the monolithic and modular types.

Cal Tek Engineering specializes in function-generator modules; just plug them in, apply ±15 V and out pops a square wave, triangle and sinusoid—all ready to stimulate the widgets in the rest of your system.

Cal Tek's only known competitor for the modular line is Wavetek—best known for complete instruments. But Wavetek's modules output to 100 kHz, while Cal Tek's units jump one order of magnitude to 1 MHz.

Just two external components are needed with the Cal Tek line: a frequency-determining potentiometer and decade capacitor.

At least 18 models are offered, spanning the frequency range of 0.001 Hz to 1 MHz and the price range of $76 to $239, and higher.

Both 50 and 600-Ω output impedances are offered, at the buyer's option. Standard output is 5-V pk-pk into an open circuit for all waveshapes, but an optional built-in power amplifier is available that boosts the voltage to 20-V pk-pk, and delivers 100 mA into a 50-Ω load. The power amplifier is short-circuit-proof to the common lead.

As for performance, Cal Tek claims that the modules are equivalent to many instruments and superior to the monolithic function generator.

The square wave has a rise and fall time of less than 60 ns, a tilt of less than 0.6% and overshoot and ringing of better than 5%; one-hour stability (jitter) is ±0.06% maximum, while 24-hour stability is listed as a max of ±0.029%.

Distortion of the sine wave is limited to 0.5% to 10 kHz, and nolinearity of the triangle is better than 1%. Operating temperature range of the modular line is 0 to +71 C, and Cal Tek states that no heat sink or derating is necessary. However, the specs are listed for 25 C at $f_o = 1$ kHz.

All outputs are simultaneously available; each waveshape delivers full current concurrently with the others. This contrasts with some IC units, which require switching between outputs.

IC function generators also require 10 to 20 external components, says Cal Tek, whereas the company's modules need only two.

Options of the modular line include a variable dc-offset of up to ±5 V, with a built-in pot, and models offering just squares and triangles. Case size ranges from 2 by 2 by 0.4 to 3 by 3.5 by 0.5 inches, depending on model and options.

For Cal Tek **CHECK NO. 250**
For Wavetek **CHECK NO. 251**

S/d converter delivers accuracy of ±4 arc min

Computer Conversions, 6 Dunton Ct., E. Northport, N.Y. 11731. (516) 261-3300. $400 (prod. qty.); 4 wk.

The SDC series of 14-bit synchro-to-digital tracking converter modules provides accuracies of ±4 min of arc, ±0.9 LSB. The modules are 2.6 × 3.1 × 0.82 in. and are designed for PC board mounting. They convert 400-Hz synchro inputs of 11.8 or 90 V, 60 Hz inputs of 90 V into 14-bit parallel binary outputs. The converters have isolated reference and synchro inputs and can track rates up to 1800°/sec at either 60 or 400 Hz. They are insensitive to input amplitude and frequency variations. The digital output is buffered and DTL/TTL compatible. Model SDC-40 requires a 26 or 115 V ac reference input, ±15 V at 50 mA, −15 V dc at 30 mA, and +5 V dc at 350 mA. The two operating temperature ranges are 0 to 70 C or −55 to +85 C.

CHECK NO. 283

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When we decided to go into the pressure transducer business we surveyed the existing products, and here's what we found.

At one end, there were inexpensive transducers that were too inaccurate to be of much interest to anyone. And at the other there were expensive, $150-ish customized transducers.

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Our transducers come in three basic types, for measuring:

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2. gage pressure (all pressure signals referenced to room ambient pressure rather than vacuum, LX16XXG and LX17XXG).
3. differential pressure between two points or inputs (LX16XXD).

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For further information about our pressure transducers write National Semiconductor Corporation, 2900 Semiconductor Dr., Santa Clara, California 95051.

Expensive, inaccurate, or National. With a choice like that, you really don't have a choice.

National

A/d converter delivers 3-1/2-digits plus sign

Analog Devices, Route 1 Industrial Pk., P.O. Box 280, Norwood, Mass. 02062. (617) 329-4700. 1100: $67 (100 up); 1103: from $430 (10 to 9): stock.

The ADC1100 is a dual-slope integrating 3-1/2 digit-with-sign a/d converter. It requires a supply of +5 V, and has a 40 dB line-noise rejection. The unit accepts bipolar or unipolar input signals, operates over the 0 to ±199.9 mV range, has automatic zero correction and can be used for ratiometric operations. The device is packaged in a 2 × 4 × 0.4 in. module. The ADC1103 is available in eight-bit, 10-bit, and 12-bit resolution and accuracy. The units convert in a maximum of 1, 1.2 and 3.5 μs, respectively. They feature accuracy of ±1/2 LSB relative to full scale and are guaranteed to have no missing codes over the range of 0 to 50 C. Also, they offer a choice of three user selected input ranges, 0 to +10, ±5 and ±10 V. It is packaged in a 2 × 4 × 0.75 in. module.

CHECK NO. 284

Repetition-rate coder covers dc to 33 MHz

Xincom Corp., 20931 Nordhoff St., Chatsworth, Calif. 91311. (213) 341-5040. $600 (1 to 3); stock to 30 day.

The 6620 Pinto module is a complete programmable period generator. The input frequency to the unit is divided down in one of 1023 steps, selectable by a standard 10-bit data word. Applications include frequency synthesis, multiphase clock systems, digital timing and calibration, precision pulse generation, and semiconductor memory testing. The programmable frequency range is from dc to 33 MHz.

CHECK NO. 285

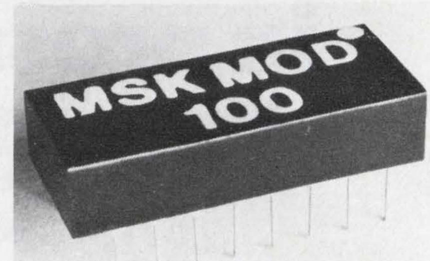
Photomultiplier housing has built-in amplifier

Pacific Photometric Instruments, 5745 Peladeau St., Emeryville, Calif. 94608. (415) 654-6585.

By incorporating a nanosecond rise-time amplifier into the Model 62/2A32 photomultiplier tube housing, photomultiplier current is converted to low impedance voltage signal. Thus a faithful reproduction of signal is delivered through coaxial cable while the signal rise time is preserved. The amplifier portion of the unit is dc coupled and operates in the noninverting mode. The housing portion of the unit includes tube socket, voltage divider and magnetic electrostatic shielding. It needs only the tube for operation. Model 62/2A32 accommodates all end-on tubes of up to 2.38 in. diameter.

CHECK NO. 286

Hex relay/lamp driver handles 150 mA at 1.2 V



M.S. Kennedy, Pickard Dr., Syracuse, N.Y. 13211. (315) 455-7077. $15 (small qty); stock.

The Model-100 hex relay/lamp driver can sink 150 mA at 1.2 V on each output. Inputs are TTL compatible, but the unit can operate over supply voltages of 5 to 30 V. The operating temperature range is 0 to 70 C for the 16-pin DIP circuit.

CHECK NO. 287

Low-distortion amplifier delivers 100-W class AB

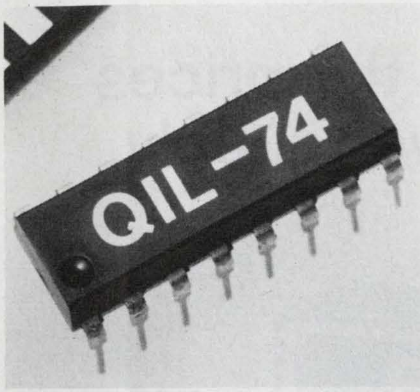
RCA, Route 202, Somerville, N.J. 08876. (201) 722-3200. $12.90 (1000 up); stock (sample qty.).

The TA8651A is a developmental power hybrid low-distortion, 100-W linear amplifier. The output section can be externally biased to class AB for low intermodulation (0.05% at 50 mW) and low total harmonic distortion. Terminals are available for external frequency compensation, short-circuit protection, and inverting and noninverting inputs. The device is intended for use in applications requiring very low distortion (less than 0.1% IMD at 50 mW). It is supplied in an hermetic package.

CHECK NO. 288

INFORMATION RETRIEVAL NUMBER 69

Quad opto-isolator saves space, cuts costs



Litronix, Inc., 19000 Homestead Road, Vallco Park, Cupertino, Calif. 95014. (408) 257-7910. Price: see text; stock.

Designers of circuits requiring a number of optically isolated channels can save space, reduce assembly time and cut component costs by using the industry's first quad opto-isolater—the IQL-74 from Litronix.

Possible applications for the new unit include multiple-point power supply or relay monitoring, multiple-input logic isolation, and multiline receiver circuits.

Packaged in a 16-pin DIP, the IQL-74 contains four coupled pairs, each consisting of a gallium-arsenide infrared LED and a silicon npn phototransistor. Each of the four is similar to Litronix's IL-74 logic-driver opto-isolator. They are compatible with medium speed TTL circuits such as the 7400 series, and feature a minimum input-to-output breakdown voltage of 1500 V, a 35% typical current-transfer ratio, a 0.5 pF coupling capacitance and a 150 kHz bandwidth. The operating temperature range is −55 to +100 C.

Litronix is also introducing two dual opto-isolators: the IDL-74 with the same operating characteristics as the quad unit, and the ILCT6, a direct replacement for the Monsanto MCT6 dual opto-isolator.

Both of the dual units are packaged in an 8-pin mini-DIP and two may be inserted in a standard 16-pin DIP socket.

In thousand quantities the IQL-74 sells for $3.30, the IDL-74 for $1.70 and the ILCT6 for $2.50 compared to $2.95 for the Monsanto MCT6.

CHECK NO. 289

INFORMATION RETRIEVAL NUMBER 70

Down, down go the prices for op-amp power supply

Semiconductor Circuits, 306 River St., Haverhill, Mass. 01830. (617) 373-9104. P741-1015: $29.95 (100 up).

Suppliers of modular power supplies for op amps are even more numerous than those of the op amps themselves. At least 60 companies sell the supplies, and others are entering the marketplace. With so many vendors competing, pricing tends to be fiercely competitive.

Semiconductor Circuits, a company that not only makes its own power supplies but many private-label ones as well, has set new price lows with its latest encapsulated line—the P741 series.

For example, the plug-in P741-1015 provides a regulated ±15 V at ±100 mA for just $33.95 in single quantities. This, says Semi, is a 31% reduction in price vs previous units of similar performance. For 100-up quantities, the price plunges even further—to $29.95 each.

Semi's new line uses discrete components throughout. This contrasts sharply with a recently introduced competitive line of supplies that uses an IC regulator.

But, says Semi, IC regulators are greatly inferior to discrete types; because they are inefficient, IC types run 10 to 15 degrees hotter and consequently tend to drift more. This can result in high dissipation and thermal runaway. That's why, Semi says, thermal shutdown is essential with IC regulators.

Specifications of the 1015 include 0.2% line and load regulation; tempco of 0.02%/°C, typical; a warm-up drift of, typically, 30 mV; and output voltage factory-set to ±1%. The size of the compact unit is 2.25 by 2.50 by 1.25 inches.

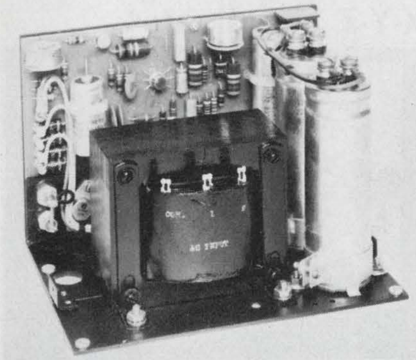
There is no derating of performance within the entire operating temperature range of −25 to +71 C. And the PARD of the P741-1015 is listed as 1 mV rms.

PARD is the acronym used by the National Electrical Manufacturers Association for periodic and random deviation of a dc output from its average value. The association's standard on dc-output supplies—PY1-1972—says that PARD may be stated in rms and/or peak-to-peak values for a specified bandwidth.

Other models in the series include a 5-V, 0.5-A unit, selling for $29.95 and a dual 12-V, 100-mA module priced at $33.95.

CHECK NO. 252

Open-frame supply has wide choice of outputs



ERA Transpac, 311 E. Park St., Moonachie, N.J. 07074. (201) 239-3000. From $43; 30 day.

The OE series of open-frame power supplies operates with an input of 105 to 125 V ac, 47 to 63 or 380 to 410 Hz. The outputs available include 5, 6, 12, 15, 18, 24 or 28 V dc. Current ranges are from 3 to 20 A. Input/output regulation is better than 0.05% and ripple is less than 1 mV rms. Response time is better than 50 μs for a full-load change. The operating temperature range is −20 to +71 C and the temperature coefficient is better than 0.01%/°C. The units also have built-in foldback overcurrent protection, adjustable overvoltage protection, thermal cutout and floating outputs.

CHECK NO. 290

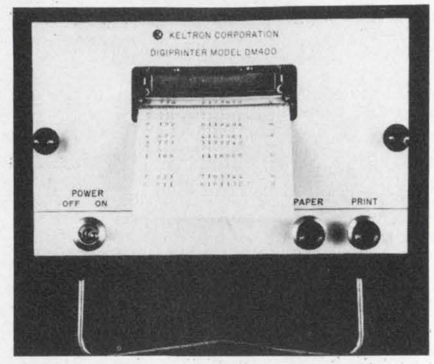
Low cost power supply delivers 13.8 V at 6 A

Clifford Industries, 321 N. Lewis Rd., Camarillo, Calif. 93010. (805) 484-1018. $38.95.

The Vista VI-R is a solid-state regulated power supply. It has an output voltage of 13.8 V dc and a maximum load current of 6 A. Regulation is 0.1% when the input is 120 V, 60 Hz.

CHECK NO. 291

Drum printer logs X-Y-Z coordinates



Keltron Corp., 225 Crescent St., Waltham, Mass. 02154. (617) 894-0525. $1000 (qty 5); 1-2 wks.

The DM400 series of digital printers are designed for use with X, Y positioning systems, coordinate measuring machines and X, Y, Z plotting systems. This series of drum printers contains in one package, all of of the logic required to interface with bi-directional counters that monitor the position of each axis. The buffered outputs of each bi-directional counter are applied in parallel for all three axes (in a 3-axis system). The printer contains circuitry to multiplex all three channels and to print them out one below the other with appropriate axis symbols. It also features a 3-digit presettable "item-sequence-number counter." This counter can be preset to some number other than "0". At the end of every print cycle, the counter is updated by one count, and can be used to identify a given sequence.

CHECK NO. 292

Minis have overlapped core memory access

Data General Corp., Route 9, Southboro, Mass. 01772. (617) 485-9100. From $3850.

Nova 2 minicomputers users can mix 1.2 μs (16 k) memory modules with faster (0.8 μs) 4-or-8-k memory units without altering hardware or software. Overlapped memory operation increases system throughput by letting the CPU read the next address while it is restoring data accessed from the previous core location. Prices start at $3850 for a Nova 2/4 with 4 k of core memory to $10,150 for a Nova 2/10 with 32 k memory.

CHECK NO. 293

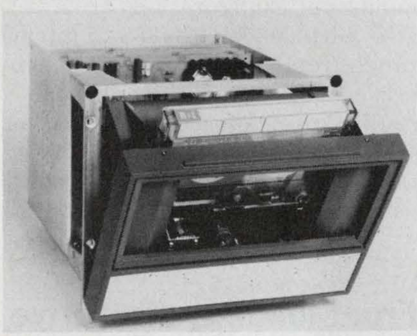
Printer-series gives 9 or 18-col. numerics

Anadex Instruments, Inc., 7833 Haskell Ave., Van Nuys, Calif. 91406. (213) 782-9527. See text; 5 wks.

The DP-500 series of numeric digital printers are available in either nine or 18-column configurations. They accept 1, 2, 4, 8 binary-code inputs and operate with DTL or TTL logic levels. Print speed is 2.5 lines/s, red or black, with a choice of 13 characters in each column. The drum-type print mechanism has an MTBF of 3-million print cycles. The price of the 18-column unit (DP-500-18) is $545; the price of the 9-column unit (DP-500-9) is $495.

CHECK NO. 294

Cartridge drive meets proposed ANSI std.



3M Co., P.O. Box 33600, St. Paul, Minn. 55133. (612) 733-2925. $330 (OEM qty); see text.

A drive for the Scotch brand DC300A data cartridge has been designed by the developer of the data cartridge. The DCD-3 drive conforms to the proposed ANSI standards for 1/4-in. cartridge devices. Available with one, two or four-track, read-while-write heads, the drive has such standard features as 1600 bit/in. recording density, 48 k bit/s transfer rate, 30 in/s bi-directional read/write speed and 90 in/s bi-directional shuttle speed. The DCD-3 will be offered initially in a "door-load" configuration intended for half-rack mounting or for applications requiring a stand-alone unit. The basic drive unit can be expanded with the optional addition of a prewired card cage, read/write, encode/decode and direction-control circuit cards. Evaluation units are available immediately.

CHECK NO. 295

Buffer unit stores 2560 characters at 2400 bit/s

Plantronics, 385 Reed St., Santa Clara, Calif. 95050. (408) 249-1160. $1595; stock.

Slower speed printers can be used with fast processors by interposing the model 1300 A buffer. The buffer accepts serial data at any rate between 37.5 and 2400 bit/s and retransmits the data at rates up to 1200 bt/s. The 1300 A operates with five, six, seven or eight-level data and stores 2560 characters in parallel form using MOS shift registers. Additional plug-ins permit storage expansion to 20,480 characters. The buffer operates with EIA or logic-level signals. High-level options are available.

CHECK NO. 296

Industrial mini system uses BASIC language

Digital Equipment Corp., 146 Main St., Maynard, Mass. 01754. (617) 897-5111. Under $20,000.

Priced at under $20,000, the IDACS 8/C industrial real-time minicomputer system consists of three major elements: the PDP-8/F minicomputer with 8-k core, a dual-drive magnetic tape unit and an industrial interface. The industrial interface provides noise immunity as well as multiplexing capability. It can be configured with a variety of input/output modules to convert transducer signals to computer usable form or convert computer output to levels compatible with industrial devices. The user defines his process in BASIC language that has been modified to provide control and reading of analog and digital processes. The language also provides for user-designed process interrupt routines written in the style of BASIC subroutines. The systems package includes the real-time industrial BASIC software, training, support and installation.

CHECK NO. 297

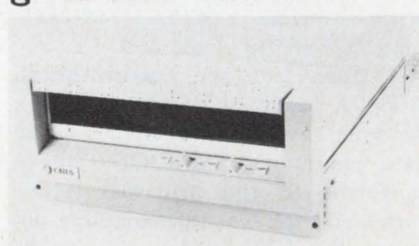
Data acquisition unit's range is programmable

Varian Data Machines, 2722 Michelson Dr., Irvine, Calif. 92664. (714) 883-2400. $6000; 90 days.

Model 620-855 for use with Varian 620 and V73 series computers are self-contained units that include an a/d converter, low-level multiplexer, sample-and-hold amplifier and programmable timer. The unit's multiplexer accepts eight levels of full-scale voltage input ranging from ±9.77 mV to ±1.25 V via a computer-selectable, programmable-gain amplifier. Input channels and gains are sequentially or randomly selected (under computer control) than sampled and held by the a/d converter. The a/d converter outputs a 13-bit word in binary two's complement format. The a/d conversion can be initiated under program start, external pulse or by the built-in timer. A number of configurations are available with Model 620-855. Systems range from a minimum of 16 channels (Model 620-855-16) through a maximum of 256 channels. Larger systems hierarchies extend operation to a maximum of 2048 channels.

CHECK NO. 298

Front-loading disc drive gives 200 tracks/in.



Caelus Memories, Inc., Div. of Electronic Memories & Magnetics Corp., 12621 Chadron Ave., Hawthorne, Calif. 90250. (213) 644-9881. $3800; 90 days.

Model 206 disc drive is configured either with one removable cartridge (48 Mbits) or one fixed plus one removable cartridge for a 96 Mbit capacity. The 200 track/in. drive affords a 9 ms track-to-track access time and an average access time of 35 ms. The units interface with most minicomputers and provide up to 384 Mbits of storage in a daisy-chain configuration.

CHECK NO. 299

application notes

Dual-gate MOSFETS

Bulletin CA-173 provides details on using high-gain dual-gate MOSFETs for TV design. Application in TV tuners and i-f amplifiers is discussed. Texas Instruments, Dallas, Tex.

CHECK NO. 300

Measuring gain and phase

"Low-Frequency Gain-Phase Measurements," a 26-page booklet, gives a number of applications that represent phase-measurement solutions. The booklet bridges the gap between theoretical analysis and practical measurements. The last section discusses instruments presently available, and a chart summarizes significant alternatives and their capabilities for the cost. Hewlett-Packard Co., Palo Alto, Calif.

CHECK NO. 301

Freq meter/signal generator

How to test and service two-way radio equipment with the FM-10 frequency meter/signal generator is described in a set of 16 application notes. Each note gives an equipment set-up diagram and explains how to perform the test in a simple step-by-step procedure. Notes are available on measurements of frequency, deviation, audio distortion, sensitivity, modulation bandwidth and other parameters. Singer Instrumentation, Los Angeles, Calif.

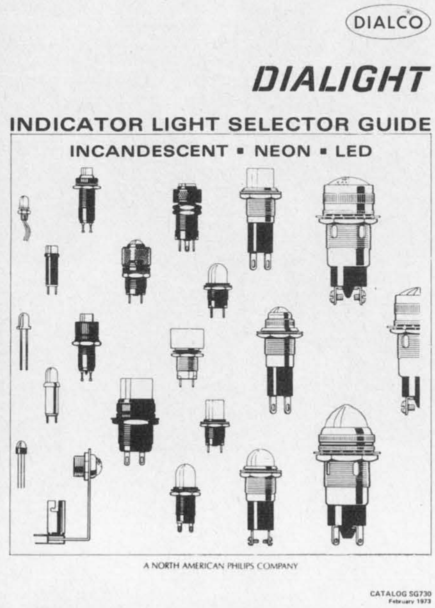
CHECK NO. 302

IC analog switches

A 16-page tutorial discussion of all types of analog switches covers hybrid FET and bipolar switches, CMOS, virtual-ground and positive-signal switches and contrasts them all with small-signal reed relays. Performance parameters are compared, switching waveforms, schematic diagrams and relay-equivalent contact forms are shown, and typical applications of various IC switches are diagramed. Intersil, Cupertino, Calif.

CHECK NO. 303

new literature



Indicator lights

"Indicator Light Selector Guide," a 56-pager, details the indicators made to accommodate incandescent, neon, and light-emitting-diode light sources. The guide describes over 1.5-million indicator lights, presented in 12 sections by either size, product groups or MIL-Spec references where applicable. Dialight Corp., Brooklyn, N.Y.

CHECK NO. 320

Disc memory systems

A bulletin gives details of a plug-compatible controller as well as highlights of a family of fast-access, head-per-track discs covering the storage range of 64 k to 2.5 M words per drive. Alpha Data, Canoga Park, Calif.

CHECK NO. 321

Solid-state keyboards

Product Brochure SW consolidates current solid-state keyboard listings and acquaints readers with engineering advancements in Hall-effect keyboards. The 16-page publication highlights switch operating characteristics, switch mounting and termination, buttons, legends and encoding. Descriptions and photographs are included. Micro Switch, Freeport, Ill.

CHECK NO. 322

Pushbutton switches

A six page, foldout catalog features PB-400 series modular, miniaturized, PC-board pushbutton switches and button types. Dimensional tables are provided, giving center-to-center spacings, mounting-hole centers and diameters. Standard Grigsby, Aurora, Ill.

CHECK NO. 323

Drills and wire coilers

An eight-page brochure features Perkins wire coilers and Sigourney sensitive drilling machines. Specifications for both are detailed and photographs and illustrations of the machines and accessories are shown. Tec Special Machinery Div., Bloomfield, Conn.

CHECK NO. 324

Flatpacks

A hybrid 5/8-by-5/8-in. metal-back package is described in a two-page data sheet. Specifications of a 20-lead package, including physical dimensions, lead resistance, leakage and hermeticity, are given. A new concept in hybrid package design, applicable to 10, 11 and 22-lead versions as well as the 20-lead standard, is included. National Beryllia Corp., Haskell, N.J.

CHECK NO. 325

Relays

Specifications and engineering data on 125 basic relay models are given in a 226-page catalog. Included in the catalog are standard, power, sensitive, miniature, latching and impulse relays, dry and mercury-wetted reed relays, hybrids and time delays and interval timers—many UL listed or recognized and CSA listed. Potter & Brumfield, Princeton, Ind.

CHECK NO. 326

Microwave capacitors

A humorous four-page data sheet tells how to double your power output with microwave porcelain capacitors. American Technical Ceramics, Huntington Station, N.Y.

CHECK NO. 327

Terminal users' guide

A guide for terminal users explains the technical requirements and ordering procedures for specifying proper data-access arrangements. Lack of user knowledge of Bell System interconnection requirements for non-Bell terminals has been a major cause of terminal installation delays. Western Union, Data Services Co., Mahwah, N.J.

CHECK NO. 328

Thermocouple connectors

A thermocouple connector for use to 850 F continuous and 1000 F intermittent ambients is presented in a brochure. The brochure points out the structural efficiency, compatibility, identification symbols, deep channeled interior and materials. Thermo Electric, Saddle Brook, N.J.

CHECK NO. 329

Component leads

Information on an adjustable bending block for component leads is contained in a two-page product sheet. Included are step-by-step instructions for optimizing use of the bending block. Instructions cover establishing the correct center-to-center spacing for component leads with varying body lengths and processing large volumes of common-sized components. Webtek Corp., Los Angeles, Calif.

CHECK NO. 330

Instruments

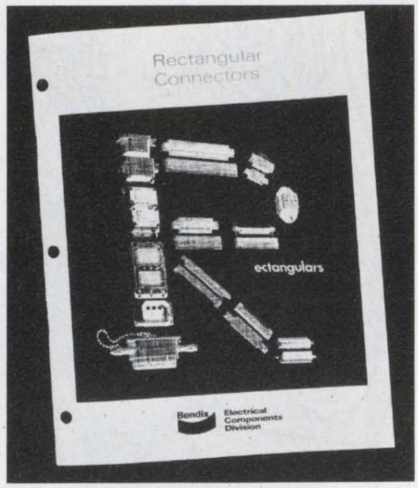
A product selection guide describes, illustrates and lists principal specifications for the company's test equipment and card readers. Prices are included. The Hickok Electrical Instrument Corp., Cleveland, Ohio.

CHECK NO. 331

Film capacitors

Series 3000/4000 film capacitors for instrumentation, data processing, telecommunications and industrial controls are highlighted in a 20-page catalog. Specifications on the four major capacitor types—metalized polyester, metalized polycarbonate, polyester and foil and RC networks—are included as well as data on styles. The Potter Co., San Diego, Calif.

CHECK NO. 332



Rectangular connectors

Rectangular connectors are described in a 66-page catalog. Electrical and physical specifications are given. Bendix Electrical Components, Sidney, N.Y.

CHECK NO. 333

High-voltage power supplies

A six-page catalog contains information on solid-state, regulated and unregulated, rack-mounted, miniature and modular high-voltage power supplies. Photos, general information and specifications describe and illustrate over 1300 models. Spellman High Voltage Electronics Corp., Bronx, N.Y.

CHECK NO. 334

Analog converters

A two-page technical bulletin on analog converters that accept contact-closure or logic-input signals includes information on design, specifications and diagrams. Brooks Instrument Div., Hatfield, Pa.

CHECK NO. 335

Frame grabber

A data sheet describes how live TV images can be stored in a storage tube and then later printed, on demand, in 45 seconds, or transmitted over dial-up voice-grade telephone lines and printed out as permanent hard-copy records on a frame-by-frame basis at voice-band speeds using the company's frame grabber system. Alden Electronic & Impulse Recording Equipment Co., Westboro, Mass.

CHECK NO. 336

Silicone materials

Nearly 300 different silicone materials and their applications are described in a 40-page catalog, "A Guide to Dow Corning Products." Among products detailed are silicone encapsulants and sealants, varnishes, heat-sink compounds, damping fluids and dielectric coolants. Dow Corning, Midland, Mich.

CHECK NO. 337

Electronic timers

Just off the press is a guide that presents a simplified and logical system for matching a timer to an application. Syracuse Electronics Corp., Syracuse, N.Y.

CHECK NO. 338

TO-8 and circular headers

TO-8 and other circular headers for microelectronic circuit applications are described in a four-page bulletin. Detailed are package styles, sizes, dimensions, materials and plating. Specifications of flange-type covers, with and without windows, are indicated. Tekform Products, Anaheim, Calif.

CHECK NO. 339

Electrical hardware

Electrical/electronic hardware, spring clips, washers and military standards are listed in a colorful catalog specially indexed for ready reference. Seastrom Manufacturing Co., Glendale, Calif.

CHECK NO. 340

Wire/cable harnesses

A 16-page brochure describes wire/cable harnessing, wire/cable marking and accessories. Each product is described and illustrated with dimensional drawings, and tables provide physical and chemical properties, specifications, applications and ordering data. Electrovert, Mount Vernon, N.Y.

CHECK NO. 341

Batteries

A specifications brochure describes lithium primary batteries. The brochure includes voltage-time discharge curves, at both 70 F and −20 F, for three of the company's batteries. Power Conversion, Mount Vernon, N.Y.

CHECK NO. 342

bulletin board

Software Technique's seminar catalog includes a program on Microcomputer Selection and Programming, and several related workshops each devoted to a specific model. The programs are available in three and five-day packages; all literature and course materials are provided. Prices for presentations in client's offices start at $1200.

CHECK NO. 343

A National Drafting Library Network to make high power graphics programs available to digital plotter users, on a time-sharing basis, has been introduced by Adrec, Inc., in cooperation with **Xynetics, Inc.**

CHECK NO. 344

Lundy Electronics & Systems has introduced a **kit containing 15 one-foot lengths of electromagnetic interference suppressant tubing,** with inside diameters ranging from 0.060 to 0.500 inch in 0.020 to 0.025 inch increments. The kit is priced at $35.

CHECK NO. 345

A family of advanced **line-voltage thermostats** rated for 1/2 hp has been announced by **ITT General Controls.**

CHECK NO. 346

Fairchild Camera & Instrument Corp. has announced that it is accepting orders for prototype quantities of the company's **charge-coupled image sensor.** The single unit price for the CCD-101, a 1 × 500-element linear image sensor, is $1200. Delivery time is four weeks.

CHECK NO. 347

Electronic Arrays has built a plant devoted exclusively to making **n-channel MOS semiconductor memories.** Its ultimate production capacity is estimated to be a quarter-million n-channel RAMs per month. The facility is now producing 1024-bit RAMs and will later produce 4096-bit n-channel RAMs under development.

CHECK NO. 348

Xerox Corp. has announced that its **6500 color copier** makes full-color copies on ordinary, unsensitized paper or on transparent material for projection on a screen. Deliveries will be made in New York in the fourth quarter of 1973; elsewhere, in 1974.

CHECK NO. 349

Itel Corp. has announced a **monolithic (MOS) main memory** for the IBM 370 Model 155 system that improves system performance 20 to 50% over previously announced IBM core and Itel 155 semiconductor memory modules.

CHECK NO. 350

TRW/IRC Potentiometers has introduced low-cost **1-1/4-inch rectangular cermet trimmers.** Designated Type 45, these trimmers come in three mounting configurations. Rated 3/4 W at 70 C, they are available in 13 standard resistance values from 100 Ω to 1 MΩ, ±20%. Operating temperature range is −55 to 150 C. Price ranges from $2.25 to $3.80 depending on quantity.

CHECK NO. 351

A family of high-performance peripherals, designed to match the operational characteristics of the company's "New Series" line of minicomputers, plus all necessary software has been announced by **Interdata, Inc.** The peripherals are led by a 10-megabyte disc, a 1600-bpi magnetic tape transport, two CRT terminals and a 600-lpm line printer.

CHECK NO. 352

Motorola HEP Semiconductors has announced a **"Design-In," an electronic project design contest** offering scholarship prizes totaling $9000. The contest runs from July 1 through December 31, 1973. The contest is divided into two general categories: nonprofessional—students, hobbyists, experimenters, technicians, teachers or inventors—and professional engineers, with equal prizes for each. Grand prize in each category is a $2500 scholarship, first prize $1000 scholarships, second prize $500 scholarships and two third prizes of $250 scholarships. Scholarships can be used at any school and are transferable to any individual named.

CHECK NO. 353

Electronic Design

ELECTRONIC DESIGN's function is:

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

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- To publish prompt corrections whenever inaccuracies are brought to our attention. Corrections appear in "Across the Desk."
- To encourage our readers as responsible members of our business community to report to us misleading or fraudulent advertising.
- To refuse any advertisement deemed to be misleading or fraudulent.

Microfilm copies are available of complete volumes of ELECTRONIC DESIGN at $19.00 per volume, beginning with Volume 9, 1961. Work is now in process to complete the microfilm edition of Volumes 1-8. Reprints of individual articles may be obtained for $2.00 each, prepaid ($.50 for each additional copy of the same article) no matter how long the article. For further details and to place orders, contact the Customer Services Department, University Microfilms, 300 North Zeeb Road, Ann Arbor, Michigan 48106 telephone (313) 761-4700.

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ABP BPA

INFORMATION RETRIEVAL NUMBER 901

advertiser's index

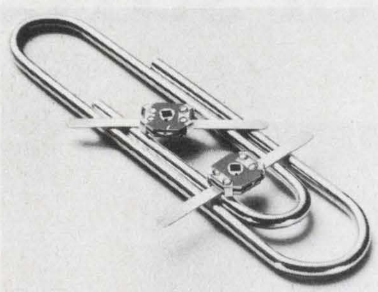
Design Data from Manufacturers

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

(Advertisement)

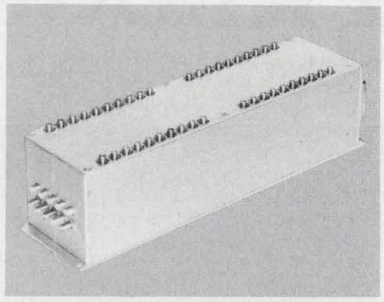
quick ads

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



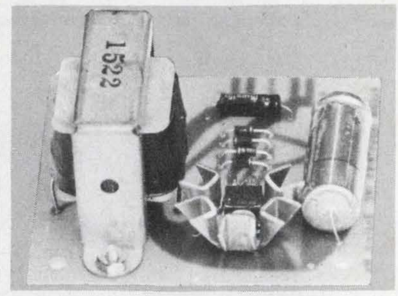
Thin-Trim variable capacitors provide a reliable means of adjusting capacitance without abrasive trimming or interchange of fixed capacitors. Series 9401 has high Q's and a range of capacitance values from 0.2-0.6 pf to 3.0-12.0 pf and 250 WVDC working voltage. Johanson Manufacturing Corporation, Boonton, New Jersey (201) 334-2676.

INFORMATION RETRIEVAL NUMBER 181



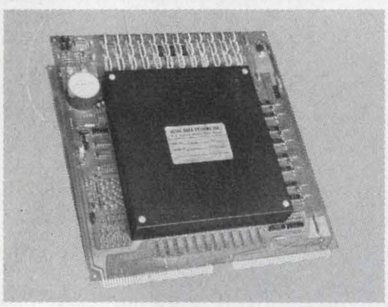
5 x 20 COAXIAL RELAY MATRIX features thruput connection for indefinite X, Y, expansion. Unit employs high reliability reed switches which may be computer controlled thru plug-in compatible control logic. Dual 5 x 10 unit also available in same package size. MATRIX SYSTEMS CORP., 9411 Lurline Ave., Chatsworth, Ca. (213) 882-2008.

INFORMATION RETRIEVAL NUMBER 182



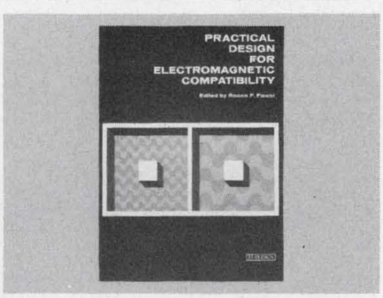
5 watt regulated power supplies. Low cost power supplies designed around 7800 series of voltage regulators, these units are available in 5, 6, 8, 12, 15, 18, and 24 volts with a 5 watt output rating. Short circuit protected. $9.75 in unit quantity. ELCOM Industries, Inc., Civil Air Terminal, Bedford, Ma. (617) 274-6656.

INFORMATION RETRIEVAL NUMBER 183



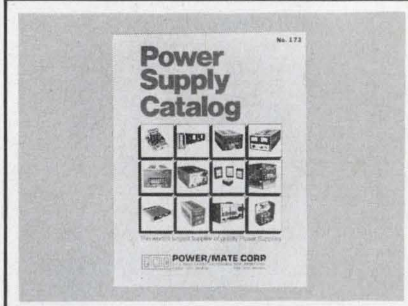
Aztec Data Systems has developed the only single board electrically alterable read-only memory in configurations of either 1K X 16 or 4K X 16 bits on a 15" X 15" PC board. Priced in quantity as low as 5¢ per bit. AZTEC DATA SYSTEMS, INC., 17805 Sky Park Circle, Irvine, Ca. 92707. 714-540-8445.

INFORMATION RETRIEVAL NUMBER 184



Practical Design for Electromagnetic Compatability, edited by Rocco Ficchi. An on-the-job manual giving designers practical techniques for analyzing, predicting, controlling, and reducing unwanted signals. 272 pp., 7-1/8 x 9-3/4, illus., cloth, $13.95. Circle number for 15-day examination copy. Hayden Book Company, Rochelle Park, N.J. 07662.

INFORMATION RETRIEVAL NUMBER 185



Free catalog of 34,500 power supplies from the worlds largest manufacturer of quality Power Supplies. New '73 catalog covers over 34,500 D.C. Power Supplies for every application. All units are UL approved, and meet most military and commercial specs for industrial and computer uses. Power Mate Corp. (201) 343-6294.

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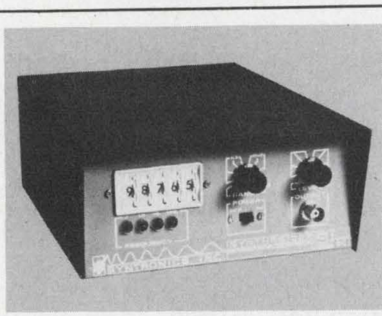

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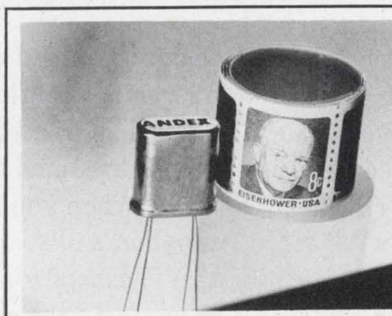

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product index

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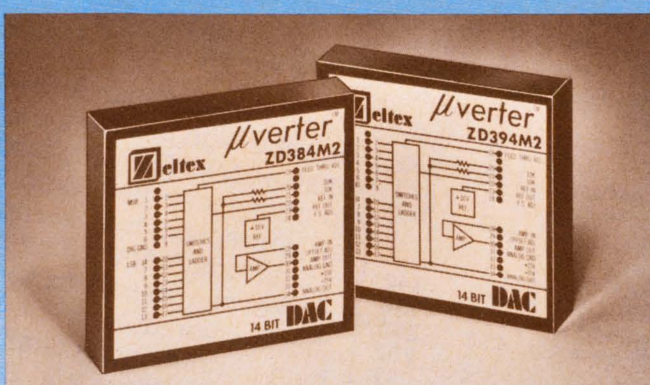
* Appears in the International Technology Section.

new literature

application notes

NEW! from ZELTEX...

14-Bit DAC's from $85



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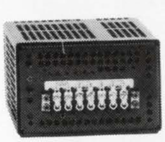

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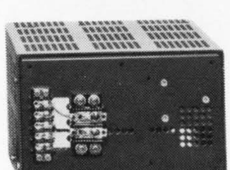

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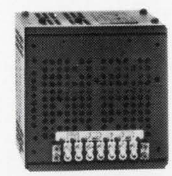

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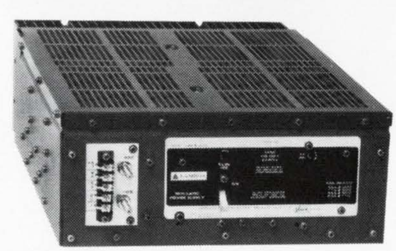

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