VOL. 20 NO.

Electronic Design 25

FOR ENGINEERS AND ENGINEERING MANAGERS

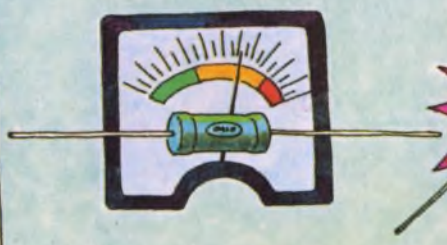
DEC. 7, 1972

Flat flexible wiring—it's great where weight, size and the labor cost of an installation are vital considerations. But how do you specify it? Off-the-shelf cable won't satisfy all requirements; most is custom-made. The data sheets don't help much either. For tips on specifying flexible flat cable and PCs, see page 60.

DOWN WITH UNTOLERANCE

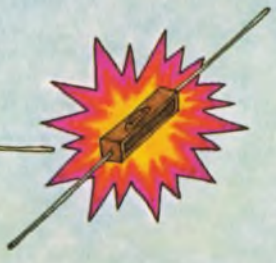
UP WITH WIREPOWER

Dale's way with wire matches your need for precision at a price...and meets your special design needs.



Shuntsmanship

Your meter needs Dale's new LVR. Dale has slashed shunt resistor prices as much as 66% and reduced resistance values to as low as .008 ohm. 2, 5, 10 watt styles. Circle 181



Fuse News

Two Dale styles combine precision resistance with predictable fusing times. Axial lead (CFR) has ¼ to 2½ W power. Special disc type for use in socket applications. Circle 182

Wirepower in RN50 Size

Dale's tiny new RS-⅛ dissipates up to ¼ watt in .155". Operates to +275°C. Molded body can be automatically inserted. T.C. as low as ±20 PPM. Circle 183

Networks with Muscle

WDP wirewound network handles up to 3.5 watts in standard 14-pin DIP size. Contains up to seven resistors which can have closely-matched tolerance (.1%) and T.C. (±5 PPM). Circle 184

It's all in the family. If the resistance function you need isn't in Dale's Catalog A... don't worry, we have it. No one beats our ability to mix and match resistance parameters.

DEPENDABLE DALE...comes to you with the courtesy of the best representatives and distributors in the business. There's a source of information near you...or call 402-564-3131 today.

DALE ELECTRONICS, INC.
1300 28th Ave., Columbus, Nebr. 68601
A subsidiary of The Lionel Corporation
In Canada: Dale Electronics Canada, Ltd.

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Voilá

Amphenol brings you a whole new line of fans. Etri, from France. A complete, established line of axial fans. With solid design advantages that make them the most widely accepted fan in Europe. Built to last longer by design.

Aluminum Frame, Not Plastic
Non-deforming aluminum body designed to conduct and dissipate motor heat, protecting bearings and sensitive motor parts from premature burn-out and wear-out.

A Lightweight Rotor, Not a Heavy One
Designed to place less stress on the bearing assembly. Laminations and windings are stationary. Fan blades are lightweight self-extinguishing plastic or aluminum alloy.

Ball Bearings, Not Bushings
Ball bearing shaft assembly is designed to reduce the friction that wears out conventional bushing-design fans before their time has come.

Standard models can handle almost any job be it an industrial, military, or space application. Customized designs take over where the standard line leaves off. We welcome special ventilation problems.

Etri is not new. Etri backed by Amphenol is new. It's one of the first products from our Alliance Marketing Service. Amphenol's AMS selects the best components on a world-wide basis and brings them to you. You get a broader component selection and increased design options. For more information, contact: Alliance Marketing Service, Amphenol Sales Division, 2875 South 25th Avenue, Broadview, Illinois 60153. (312) 345-4260.

BUNKER RAMO AMPHENOL

INFORMATION RETRIEVAL NUMBER 2

THINGS THAT STAND THE TEST OF TIME

TO-5 Relay

Time and desert sands have eroded the ancient pyramids of Egypt, but like massive stone mountains they still stand in mute testimony to man's ingenuity.
The TO-5 Transistor Case Relay is a modern-day counterpart. As tiny as the pyramids are mammoth, the TO-5 is no less ingenious or durable. Originally developed to conform to the extraordinary reliability and environmental requirements of defense and aerospace needs, the TO-5 is now available for sophisticated industrial applications.
The same pioneering spirit at Teledyne that created the TO-5 Relay is breaking new ground in the field of Solid State switching devices. This advanced family of Solid State relays will also stand the test of time. Send us your requirements.

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

TELEDYNE
RELAYS

INFORMATION RETRIEVAL NUMBER 3

VOL. 20 NO.
Electronic Design 25
FOR ENGINEERS AND ENGINEERING MANAGERS
DEC. 7, 1972

NEWS

TECHNOLOGY

PRODUCTS

Departments

Cover: Photographed by J. H. Troup, Jr., courtesy of AMP, Inc.

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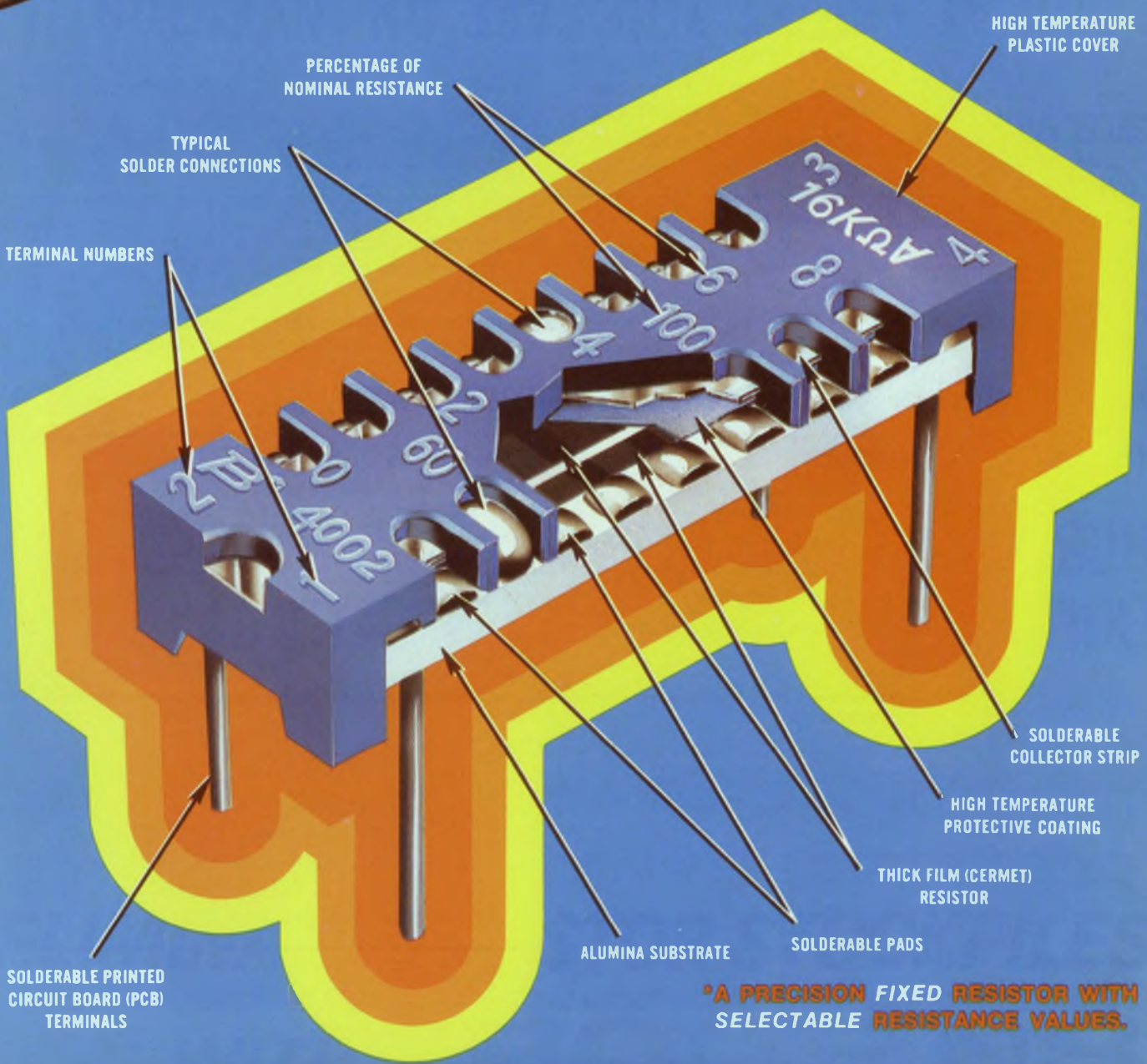
ELIMINATE RESISTOR STOCKPILES WITH... BOURNS SFR™

SELECTABLE FIXED RESISTOR*

90 SELECTABLE RESISTANCE VALUES IN 1 TINY UNIT.



*A PRECISION FIXED RESISTOR WITH SELECTABLE RESISTANCE VALUES.

BOURNS NEW...UNIQUE CONCEPT IN RESISTIVE COMPONENTS ALSO OFFERS

* *33 ohm to 1.25 megohm combined resistance range over 15 units*
* *Selectability within ±1% of required resistance value over the entire range*

BOURNS SFR™
SELECTABLE FIXED RESISTOR

- ... IS A STABLE, THICK-FILM, FIXED RESISTOR *WITH ADJUSTABILITY OF ±1% OR BETTER*
- ... REPLACES STANDARD FIXED RESISTORS IN APPLICATIONS WHERE FINAL RESISTANCE VALUE REQUIRED CAN'T BE PRECISELY DETERMINED AT THE DESIGN STAGE
- ... REPLACES "ONE-TIME ADJUST" VARIABLE RESISTORS IN APPLICATIONS REQUIRING LONG-TERM STABILITY
- ... RESISTANCE VALUE IS SELECTED, THEN *PERMANENTLY*, RELIABLY *SET* BY SOLDERING

LOOK AT THE $$ YOU SAVE ON INVENTORY!!

FOR EXAMPLE: Your application requires selection of individual resistance values from 550 ohms to 1000 ohms, or 40 different resistors at 10¢ each. One Model 4002 provides the same resistance selection within ±1% at 76¢*.

Result: **40 different resistor values: 40 x 10¢ = $4.00**
One Model 4002: 1 x 76¢ = .76

YOU SAVE . . . $3.24!!

*1,000 piece quantity price U.S. dollars. F.O.B., U.S.A.

it's easy to use

After mounting on PCB; probe the COARSE and FINE adjustment taps (Figures 1 and 2) to determine the precise resistance required. Solder the selected taps (Figure 3) and the SFR RESISTOR is permanently set.

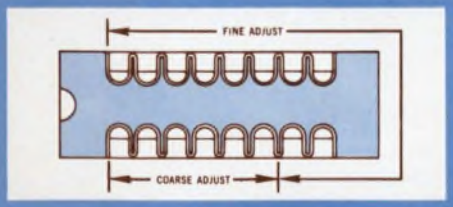


Figure 1


Figure 2


Figure 3

FOR COMPLETE DETAILS AND A BROCHURE:

- *CALL SFR RESISTOR SALES COLLECT (714) 781-0270*
- CONTACT YOUR LOCAL BOURNS REPRESENTATIVE.

BOURNS

FOR A FREE SAMPLE...write to the factory answering the following on your company letterhead.

(a) My application for the Bourns SFR Resistor is . . .
(b) It will replace (number) of fixed resistors in my inventory
(c) Approximate anticipated annual quantity usage: (number)

"SFR" is a trademark of Bourns, Inc. Patents Pending

BOURNS, INC., TRIMPOT PRODUCTS DIVISION • 1200 COLUMBIA AVE., RIVERSIDE, CALIF. 92507

INFORMATION RETRIEVAL NUMBER

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across the desk

ACE for CEEs urged so they can EOMGB

Your recent comments on acronyms deserve more concern than you displayed. Few of us can abide the repetitive use of full-length terms that lend themselves to acronymic substitution. We strongly urge, however, that acronyms be derived in some orderly fashion. We propose that Concerned Electronics Engineers (CEEs) use a systematic Acronymic Code for Electronics (ACE).

Any proper code should start with a Condition of Definition Ethics (CODE). The CODE must take into account the difference between devices that are off, for which we use the prefix X, and devices that are fake or not available, for which we use F. Thus, a de-energized IC becomes XIC (Roman numeral 89) and an uninvented Ranging and Automatic Detection system becomes FRAUD.

The basic rules of ACE can be applied in a Systematic and Comprehensive Fashion (SCF).

1. First-Use Rule. The first time an acronym appears, the expression it replaces shall precede it. Thus, if written, Radar-Assisted Pilot Ejector becomes RPE. If spoken, it becomes ARPEE (with phonetic spelling showing the preferred pronunciation).

2. First-Letter Rule. An acronym shall comprise the first letters of the principal words it replaces. Second letters or first letters of conjunctions can be included if necessary, and it is permissible to omit first letters. Thus CARP is the preferred acronym for Controlling And Regulating Auxiliary Power.

3. General-Usage Rule. Acronyms shall not have been preempted for use in another field. It might prove confusing if the Air Force were required to provide Integrated Logistic Support (ILS) for its Instrumented Landing System (ILS), or if troops were ordered to report to Armored Group Network Equipment Wavelengths (AGNEW). Avoiding such careless use of pre-empted acronyms would have prevented usurpation of MOS FET (for Metal-Oxide Semiconductor, Field-Effect Transistor), when it properly belonged to Moss On Sides of Far-Eastern Trees, an invaluable guide to self-location in Indo-China (IC).

4. Brevity Rule. Acronyms shall be shorter than their parents. One should prefer SEQS to the more ubiquitous SPEBSQSA for the Society for the Preservation and Encouragement of Barber-Shop Quartet Singing in America—and HIC for its affiliate, the Happy-Hour Improvement Club. Always, one should Exercise Obeisance to the Modern God, Brevity (EOMGB).

We recommend that the White House Office of Telecommunications (WHOT) set up a Committee On Regulation of Acronyms (CORA) to enforce ACE. CORA under WHOT would direct the use of ACE for CEEs. This would provide an SCF for CODE, which would EOMGB and allow the CEE to avoid ILS, SPEBSQSA and AGNEW, while encouraging HIC. Isn't that an improvement?

Jim Rose
Communications Management Co.
Palos Verdes Estates, Calif. 90274.

Tom Stephenson
George Yardley Co.
Westminster, Calif. 92683.

(continued on page 10)

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


containing
electrical energy
is a little more
complex

How a cable copes with the problems of voltage safety; frequencies; current; attenuation; capacitance; velocity of propagation; inductance; electrostatic and electromagnetic interference, depends heavily on what surrounds the conductors:

The coating, insulation, shielding, jacketing materials. And how they are applied. Belden has the ways and means. Material answers that can help you cope with both the electronic and physical environment your cable works in. The design and production know-how to give you the right combination of quality, reliability and performance your application demands.

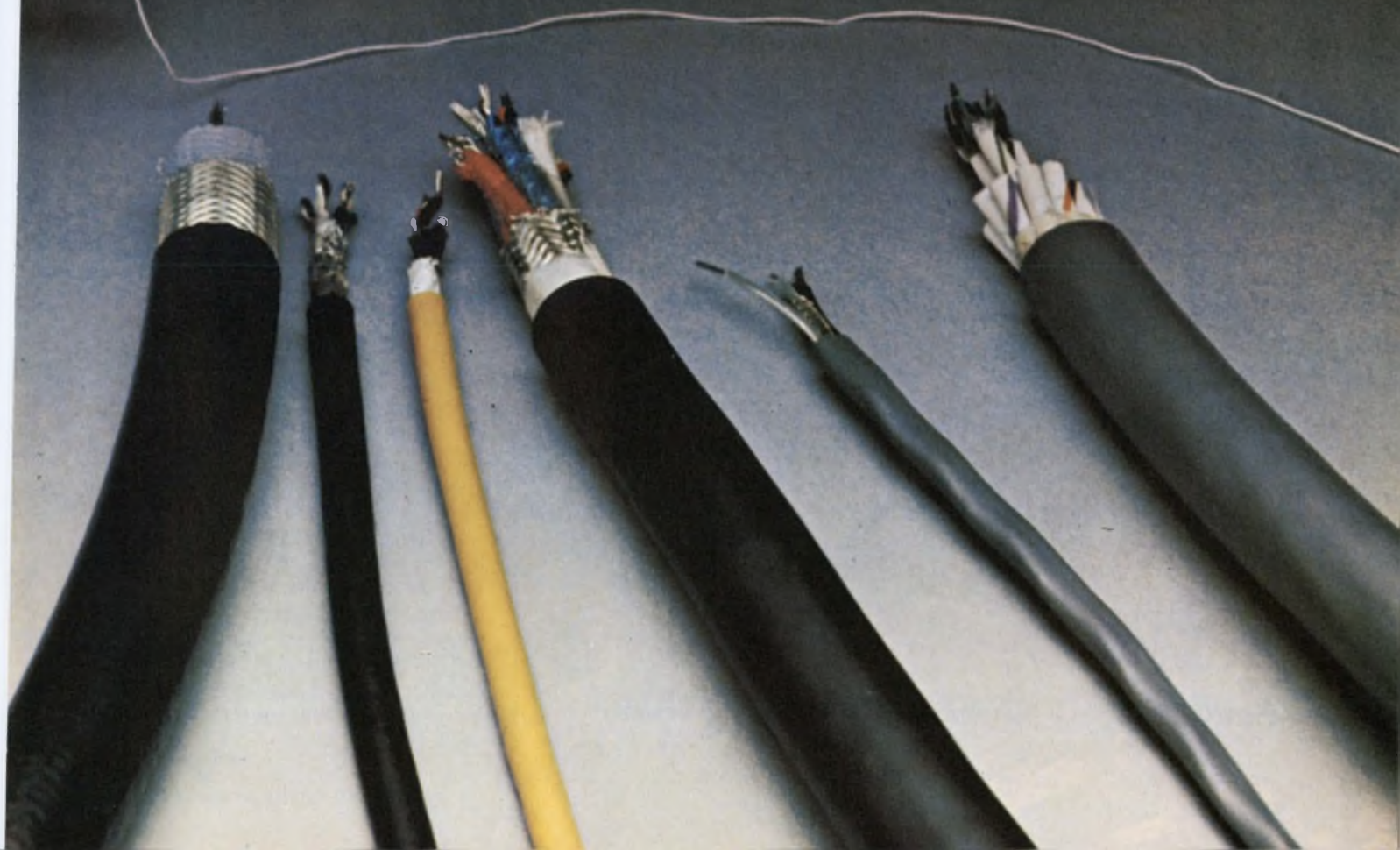
Talk to your Belden wire specialist. He has more than 8,000 standard cable items to draw from. Knows what modifications are possible. What the tradeoffs are. The costs involved. He can give you a complete cable package tailored to your needs. You won't find a better source for know-how, understanding or results.

Write for a copy of the Belden Electronic Wire and Cable Catalog. Belden Electronic Division, P.O. Box 1100, Richmond, Indiana 47374. Phone (317) 966-6681. 8-5-2

INFORMATION RETRIEVAL NUMBER 234

BELDEN

We want your cable business and are out to prove... Belden covers wire with performance, service and ingenuity



(continued from page 7)

Further focusing on MOS/LSI testers

"Focus on MOS/LSI Testers" in the Aug. 17 issue (ED 17, p. 60) appears to us to be an excellent piece of work, pulling together the contenders in this marketplace and their various points of view. The only thing that frankly dismays us is that our company, Non-Linear Systems, Inc., is totally unmentioned. I believe that the fault is primarily our own. I found that a questionnaire was indeed sent to us many months ago but evidently was not returned to you.

Non-Linear Systems has been very active for several years in the test-instrumentation and system field. We produce test systems and components, such as clocks, word generators, drivers, comparators, digital displays and test heads. We designed and manufacture an array test system that we call our Series A-2. One of these systems has been in productive use for two years at the NRMEC Div. of North American Rockwell. Most recently we have been doing custom design work and producing computer-controlled MOS/LSI test systems as well as basic acceptance testers.

Charles J. Marsh
Vice President, Marketing
Non-Linear Systems, Inc.
P.O. Box N
Del Mar, Calif. 92014.

Pythagorean squaws

Reader Jack Althouse of Palomar Engineers in Escondido, Calif., quite irrelevantly wrote to remind us of the ancient tale of the three Indian wives who bore sons at about the same time. The first squaw, who slept on a horse's hide, and the second squaw, who slept on a buffalo's hide, each bore a son. But the third squaw, who slept on a hippopotamus' hide, bore twin sons.

This proves, once again, that the squaw of the hippopotamus is equal to the sons of the squaws of the other two hides.

INFORMATION RETRIEVAL NUMBER 7 ►

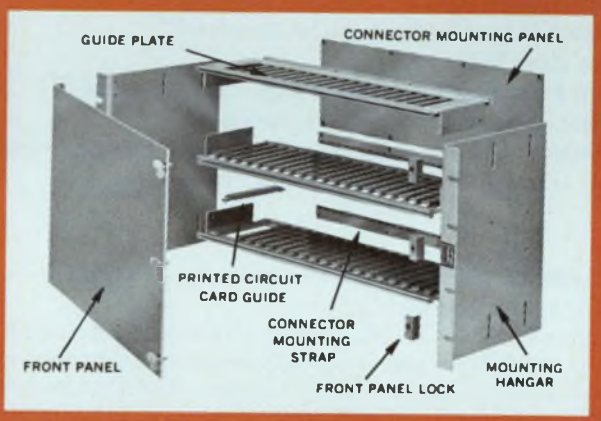
PACK YOUR CARDS TIGHTER . . . KEEP THEM COOLER . . . with a System that helps you beat the system . . .

Low cost. Easily assembled.

Varipak® II. The modular printed circuit card enclosure system. Elco's trick to help you beat problems caused by high density card packaging. Like space limitations. Component overheating. And overall systems design.

Use Varipak II to pack up to 82 cards and connectors in a row. Even with cards this tight, we've made sure you'll get plenty of air flow between them. To keep components cooler, working longer. For convenience, we mount connectors on the back panel. Makes it easy to cross wire and check out. And Varipak's modular construction lets you design around your needs. Not the limitations of your enclosure. So even special packaging adaptations require little or no tooling costs.

The Varipak II system is available in 32 standard models. In an almost infinite variety of configurations. You'll find it useful in large logic storage cabinets, as pull-out computer drawers, and even as the framework for small instrument panels. Construction is rugged aluminum. And the system will take all the hard knocks you can give it. While protecting delicate components inside. Where can you get it? From any authorized Elco distributor. He'll put it together for you. To put you ahead of the system. And keep you there. Another service in keeping with CONNECTRONICS, Elco's Total Connector Capability.



For full details on the Varipak II system 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™

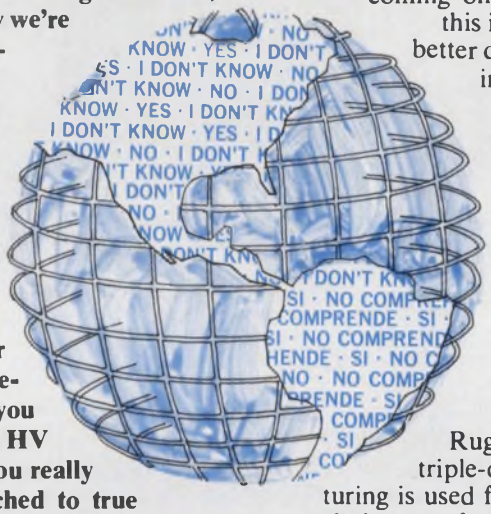
Operations in USA, Australia, Belgium, Canada, Denmark, England, France, Germany, Israel and Japan. Sales offices throughout the world. In Europe, Elco Belge, 77 Blancefloeriaan, Antwerp, Belgium, Tel. 03-190064. In the Far East, Elco International, TBR Building, 2-10-2 Nagata-cho, Chiyoda-ku, Tokyo 100, Japan, Tel. 580-2711/5.

High-Voltage

...the universal answer?

We've got more power Darlingtons than anyone else. First to introduce them. First to offer complements. First to do what they said couldn't be done — single-diffused, UniBase† power Darlingtons. Now we're offering high-voltage types in state-of-the-art, triple-diffused, etch-cut technology.

Impressive, you say. "I can use high-voltage power Darlingtons right now to get a competitive edge in my equipment market."



Hold on. Maybe one of the other high-voltage techniques, in a discrete device, would be a better answer. Double-diffused or triple-diffused Annular. And unless you understand the basics of all three HV technologies you won't get what you really want — an optimum device matched to true design needs, with the best tradeoffs in device characteristics.

Lots of designers are edueating themselves before using any process. Questioning and comparing to find out which is best for their needs. Studying. Checking. Challenging.

"Why should structure make a difference?"

"Which is best for high-speed inverters?"

"Are there SOA tradeoffs?"

"Can I get high-voltage and high-current in one?"

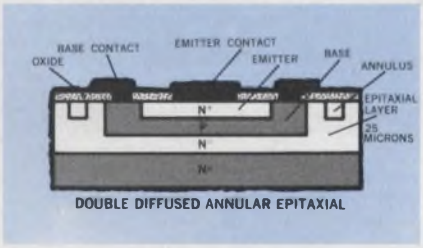
"What about complementary designs?"

If you're satisfied with your supplier's answers, your education, your design, fine. If not, listen.

YOUR POWER STRUCTURE . . .

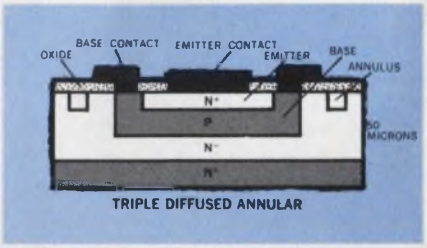
Know it before you use it.

Emitter and base on old-reliable, double-diffused Annular types are diffused into an epitaxial substrate. Devices are characterized by high frequency response, excellent switching efficiencies and complementary capability. The Annular ring retards inversion layer leakage and shapes surface electrical fields eliminating fringing field effect. But inherently narrow base width limits optimum safe operating areas. Result — devices that switch fast at high currents with excellent beta linearity . . . as long as they're not required to operate into overly reactive loads.



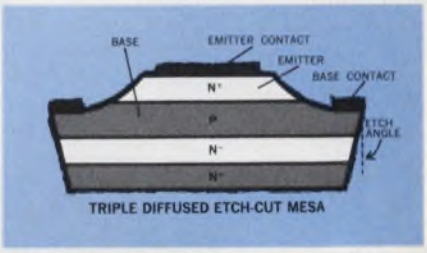
DOUBLE DIFFUSED ANNULAR EPITAXIAL

More sophistication, and more SOA, can be had with triple diffused. The Annular approach is applicable but base, emitter and collector are separately diffused. Collector layer can be ⅓ or more thicker than double-diffused with emitter and base profiles coming on proportionately deeper. Net effect of all this is allowance for wider depletion regions and better defined fringing fields (i.e. higher voltage), increased SOA and moderate f_T. One pays the price with poorer switching efficiency and lower gain.



TRIPLE DIFFUSED ANNULAR

Ruggedness with a reverse twist characterizes triple-diffused, etch-cut technology. Mesa structuring is used for ultra-deep base diffusions. But this precludes use of metal overlays to retard fringing field effects. Etch-cutting from the back side at a precise angle to define the junctions solves this problem and provides high operating voltage and SOA potential.



TRIPLE DIFFUSED ETCH-CUT MESA

TECHNOLOGY OVERVIEW . . .

If you're at home with high-speed, high-current switching, double-diffused can't be beat. Generally, gain linearity with voltage is better, too, with sat voltage coming in low because of limited epi layer thickness. In a high-speed design where most device heat stems from switch losses, it's a mistake to use super-rugged, slow types. Triple-diffused, however, is your best bet where speed and efficiency take a back seat to operating voltage and ruggedness. But the wider the base, the lower the current — and triple-diffused is basically wide-base.

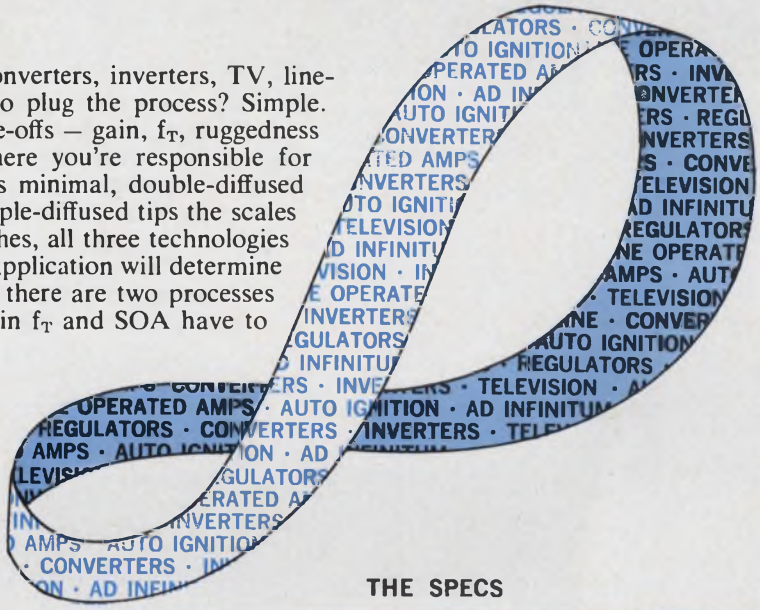
You can't have everything.

Process Characteristic	Double Diffused Annular	Triple Diffused Annular	Triple Diffused Etch Cut
fr	30-80 MHz	10-30 MHz	5-10 MHz
SOA@ 100V	7W	15W	30W
Voltage	20-300V	40-1000V	To 2000V
Current	100A	20A	20A

Power Darlingtons

THE APPLICATIONS . . .

High voltage is everywhere and more! Regulators, converters, inverters, TV, line-operated amps, auto ignition, ad infinitum. Where to plug the process? Simple. Follow our recommendations: we've factored in trade-offs — gain, f_T, ruggedness and breakdown voltage. In pulse mode designs where you're responsible for fast-changing load conditions and junction heating is minimal, double-diffused is desirable. As you go up the voltage/SOA ladder, triple-diffused tips the scales in its favor. In some cases, such as high voltage switches, all three technologies will fill the bill—and the speed/SOA demands of your application will determine your choice. HV complements can be had too — but there are two processes involved that must be matched and slight variations in f_T and SOA have to be considered.



Application	PROCESS		
	Double Diffused Annular	Triple Diffused Annular	Triple Diffused Etch Cut
Series Pass. Regulator			•
Inverter			•
TV Deflection			
Small Screen		•	
Large Screen			•
Auto Ignition			•
High Voltage Amplifier		•	•
High Voltage Switch	•	•	•
Power Switch			
Slow			•
Medium Speed		•	
Fast	•		

THE PACKAGING . . .

For your optimized form factor: plastic discretes, metal TO-66 and TO-3 discretes, plastic and TO-3 Darlingtons, plastic and metal discrete complements. For your optimized cost factor: HV prices start at 65¢, 100-up.

THE DARLINGTONS . . .

It's been said before — Monolithic power integrated circuits with revolutionary new levels of super-high gain, direct logic-to-Darlington interfacing, simplicity, cost-savings. It bears repeating. Now all the advantages are there in triple-diffused HV Darlingtons. Depending on your conclusions and your needs, your choice will be Darlingtons or discretes, in the technology that fits best.

Draw those conclusions now. Match your design need with an unmatched high voltage power capability. Write us at Box 20912, Phoenix, AZ 85036 — contact your Motorola distributor for prototype or production.

Motorola is the source for high-voltage power.
No question about it.

THE SPECS

. . . NEW HIGH-VOLTAGE DISCRETES

DEVICE	BREAKDOWN VOLTAGE	SAFE OPERATING AREA	FREQUENCY
2N6306-8 Triple-Diffused Etch Cut	500-700V	250V @40mA	5 MHz
MJ7160, 61 Triple-Diffused Annular	300, 400V	100V @200mA	30 MHz
2N6277, 81 Double-Diffused	150V	10V @20A	30 MHz

. . . plus a choice between these HV discretes

2N3439 40	2N5838-40	MJ701	MJ3430
2N3738, 39	2N6233-35	MJ704, 721	MJ4645-48
2N3902	2N6259, 62	MJ702, 723	MJ9000
2N4240	2N6341	MJ1800	MJE341, 344
2N5051, 52	MJ105	MJ2251, 52	MJE350
2N5157	MJ400	MJ3010-12	MJE2160
2N5241	MJ410, 411	MJ3026, 27	MJE2360
2N5344, 45	MJ413, 423, 431	MJ3028-30	MJE3439, 40
2N5555, 56, 57	MJ420	MJ3201, 02	MJE3738, 39
2N5655-57	MJ424, 425	MJ3260	MJE5655, 56,57

. . . NEW HIGH-VOLTAGE DARLINGTONS

MJ3040-42 Triple-Diffused Etch Cut	400-500V	300V @40mA	5 MHz

. . . NEW HIGH-VOLTAGE COMPLEMENTS

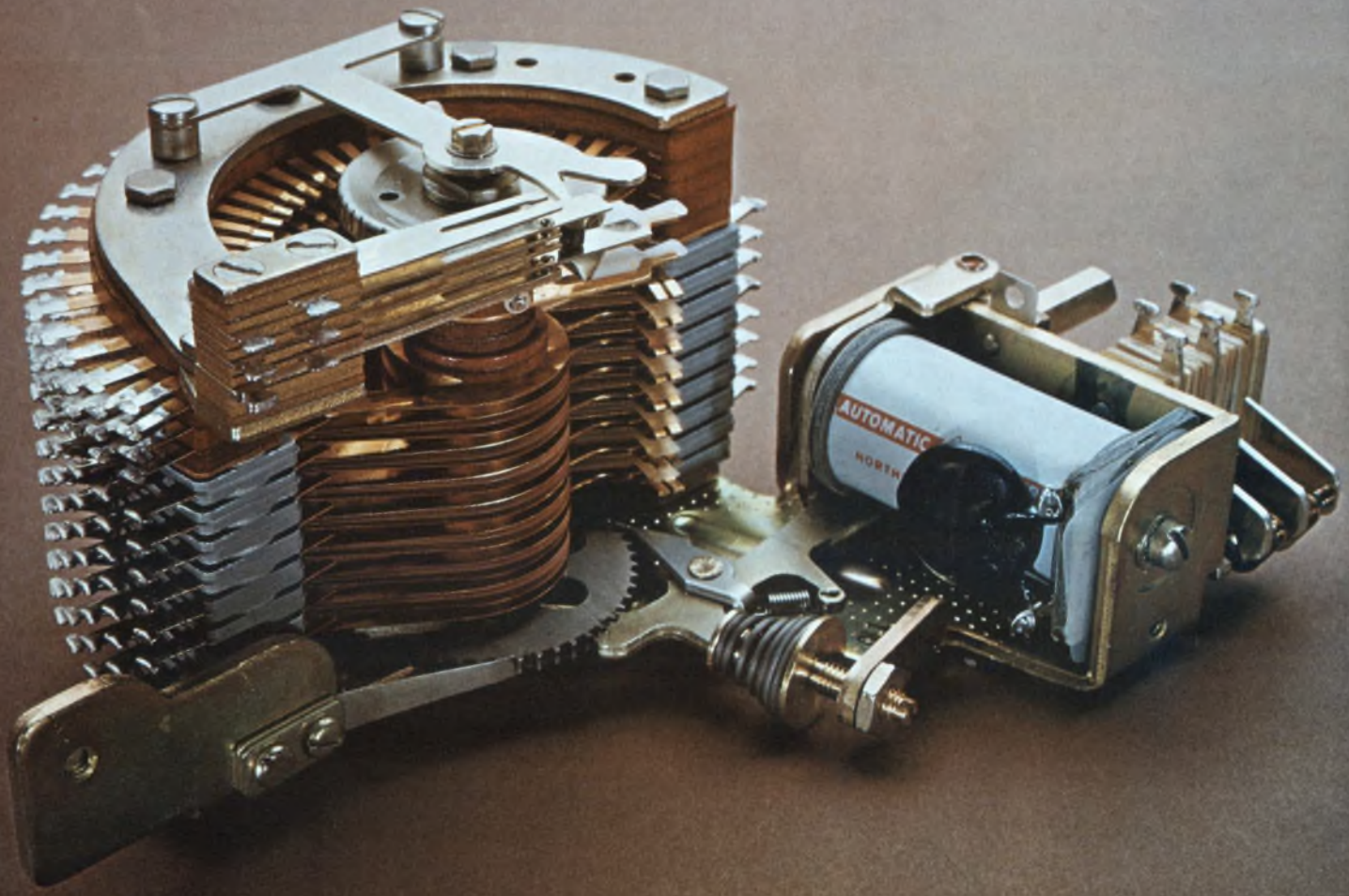
2N3583-85 Triple-Diffused Annular NPN MJ3583-85 Double-Diffused PNP	175-300V	70V @500mA	15 MHz 30 MHz
MJE340 Triple-Diffused Annular NPN MJE350 Double-Diffused PNP	300V	250V @15mA	15 MHz 30 MHz

MOTOROLA POWER
—Technology By Design, For Design

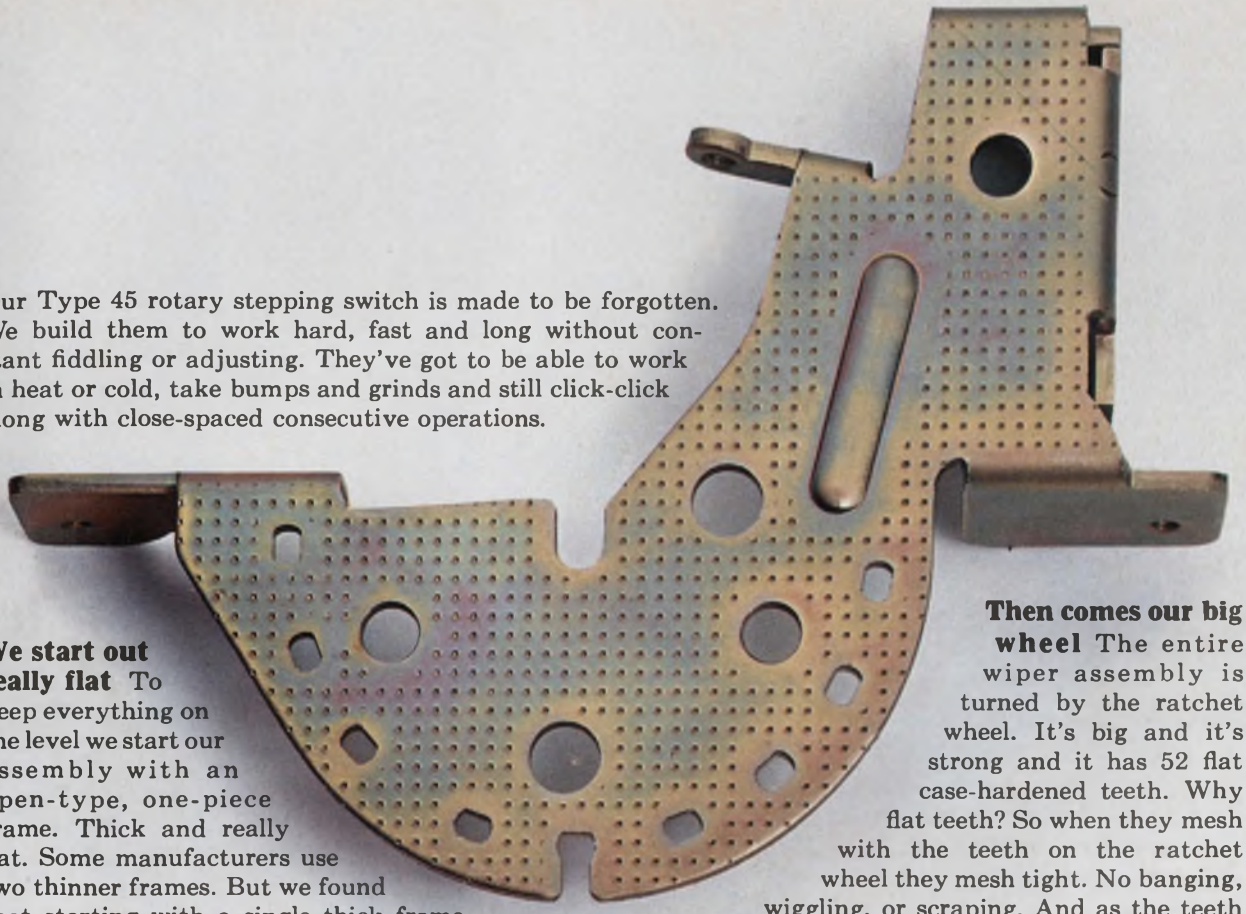
*Patented Process of Motorola Inc.
†Trademark of Motorola Inc.

INFORMATION RETRIEVAL NUMBER 10

Reliability is a single-sided frame, a ball and a cricket room.



Our Type 45 rotary stepping switch is made to be forgotten. We build them to work hard, fast and long without constant fiddling or adjusting. They've got to be able to work in heat or cold, take bumps and grinds and still click-click along with close-spaced consecutive operations.



We start out really flat To keep everything on the level we start our assembly with an open-type, one-piece frame. Thick and really flat. Some manufacturers use two thinner frames. But we found that starting with a single thick frame eliminates problems of matching the switch parts. Everything stays in line. And a single-sided frame takes a lot less room—the switch is only as wide as need be.

A lube job that lasts a lifetime The entire wiper assembly rotates on a large-diameter stainless steel shaft around a full-length hub bearing. We lubricate this bearing and seal it during assembly. So throw away the oil can.

Then we supply a pinch that's just right Each pair of wipers is tension-adjusted during assembly. As they click around the bank levels on a flat plane, we want each pair to pinch the contact just the right amount. Too hard a pinch and the contacts will wear out quickly. Too soft a pinch will cause a poor connection. We teach our wipers to pinch just right.

Then comes our big wheel The entire wiper assembly is turned by the ratchet wheel. It's big and it's strong and it has 52 flat case-hardened teeth. Why flat teeth? So when they mesh with the teeth on the ratchet wheel they mesh tight. No banging, wiggling, or scraping. And as the teeth wear, they just mesh deeper in the grooves.

Ball bearing anchor for good measure The armature assembly has to be securely fastened to keep it from wiggling up and down, or everything goes out of whack. So we choose a big stainless steel pin and secure it with wide bearings to the armature yoke. To make sure this pin never slips out of the yoke, we drill a hole in both ends. Then we force a steel ball bearing into these holes. This expands the walls of the pin into and against the walls of the armature and the whole assembly is anchored for life. We're the only ones that do it this way. So we're the only ones that offer a lifetime fit.

Then into our cricket room Every single AE stepping switch goes to the run-in test room. Or, as we call it, the cricket room, because of the chirping noise all the switches we're testing produce. Here, every switch is tested 50 times a second for 45,000 operations. Then, and only then, are they ready for delivery to our customers.

Now that we've explained all the little things we do to make our Type 45 reliable, put it through your own tests. GTE Automatic Electric, Industrial Sales Division, Northlake, Illinois 60164.

GTE AUTOMATIC ELECTRIC

INFORMATION RETRIEVAL NUMBER 11

CUTLER-HAMMER'S BIG NEW LINE OF COMMERCIAL MINIATURES.

Toggles. Pushbuttons. Rockers. Rotaries. Available in a vast array of operator styles, colors, and shapes. Including illuminated pushbuttons and rockers. Many featuring snap-in mounting. And all in stock for fast delivery!

Now the same great quality, service and availability you've come to expect from Cutler-Hammer is available in miniature size—at a competitive price!

Make your selection. Standard or watertight. Single or multiple pole. A wide range of decorator caps, buttons, bezels that extend application flexibility. And for their size, hefty electrical/mechanical ratings.

Before you place that next order, check with your new source for commercial miniature switches—your nearest Cutler-Hammer Sales Office or Authorized Stocking Distributor.

CUTLER-HAMMER

SPECIALTY PRODUCTS DIVISION, Milwaukee, Wis. 53201

Switch to No.1

More than just switches; prompt availability, field help, innovation, quality assurance, too.

INFORMATION RETRIEVAL NUMBER 17

GENERAL ELECTRIC

OPTOELECTRONIC COUPLER LINEUP

			
H10 SERIES COUPLERS	**H11 SERIES COUPLERS**	**H13 SERIES INTERRUPTER MODULES**	**H15 SERIES COUPLERS**
• 3 hermetically packaged models offer choice of SSL-Phototransistor, SSL-Photodarlington and SSL-light sensitive SCR	• 6 models offer interchangeability with popular industry types • H11A1 and H11B1 offer 50% and 500% min current transfer ratios respectively • 2,500V isolation	• 4 models offer "no contact" switching for use with shaft encoders, counters, position sensing, keyboards and limit switch application	• 4000V isolation • 4 low cost models for pulse transformer replacement, SCR and TRIAC triggering • Solid State reliability at low cost

OUR NO. 1 GOAL:
TO MAKE
GENERAL ELECTRIC
YOUR BEST BUY

BEST BUY
Our No.1 Goal
QUALITY...SERVICE...VALUE

AVAILABLE NOW FROM YOUR AUTHORIZED GENERAL ELECTRIC DISTRIBUTOR

INFORMATION RETRIEVAL NUMBER 141

(continued from p. 10)

A positive reaction to negative review

As another reader of a gratis copy of Louis Warner's book, "Stand Up! But Don't Get Off," I was quite interested in your Oct. 12 editorial ("Everything You Always Wanted to Know About Everything," ED 21, p. 59). My personal reaction to the book was almost identical to yours, and I concur in your observations. Thank you for having the courage to print your negative, but objective, review.

Warner's book, if taken seriously, could jeopardize public confidence in the engineers' professional judgment and image. I believe that Warner typifies the immature, highly vocal, shallow-thinking technician whose claims to professional status should be deliberately challenged by his associates, particularly since he claims the distinction of self-appointed spokesman.

Don L. Broderick
Chairman (1971-72)
San Gabriel Valley Section IEEE
519 E. La Sierra Dr.
Arcadia, Calif. 91006.

Help! Widget wanted to drive the mutts nuts

How can a person trying to get some sleep hush up barking dogs? Is there some type of instrument on the market or on the drawing boards that, by mimicry, barks back at the noisy canines—but in a frequency that drives them nuts while leaving humans unaware of what is happening?

I would appreciate information on where to get such an instrument or gadget. Awaiting your reply, because Mexico seems to have a zillion dogs.

David Stry
Director
Villa-V Health Spa
Apdo 1228
Cuernavaca, Morelia, Mexico

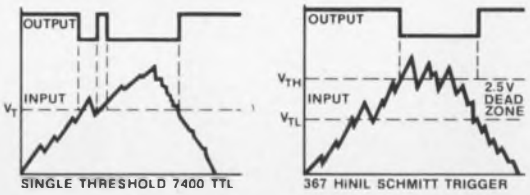
Ed. Note: Send replies to ELECTRONIC DESIGN. *We have an editor who has the same problem.*

Schmitt, the name that made the trigger famous, now makes HiNIL universal.

Schmitt is Teledyne's new HiNIL 367, noise-proof line receiver. It's the new way to go for a universal input-port to logic blocks. In industrial applications, for example, most inputs are either a switch or a relay closure. They usually cause contact bounce. But the most amazing thing about the 367 is that it has a truth table that simply eliminates contact bounce by definition.

And by the way, the noise immunity of the 367 is more than enough to handle any long lines between the logic and input. It has a 5.0 volt worst-case noise immunity and an additional 2.5 volt dead-zone Schmitt Trigger margin.

Because the 367 is a Schmitt Trigger, it holds that 2.5 volt noise immunity *even* during logic transition. Slow-down capacitors, as you all know, do not provide true noise immunity during switching. But, with the 367 in there, you can use those slow-down capacitors at the rate of 4msec/uFd *and* achieve a high guaranteed noise immunity too.



For fussy people, we put an inhibit pin on the 367 that allows information to be accepted only at times of low noise.

The new Quad Schmitt 367 is available now at $2.98 in 100 up quantities. Order now or get in line.

the challenger

TELEDYNE SEMICONDUCTOR

1300 Terra Bella Avenue Mountain View, California 94040 (415) 968-9241 TWX: 910-379-6494 Telex: 34-8416

INFORMATION RETRIEVAL NUMBER 142

"BAREFOOT" VACATIONS
to exotic islands

explore Bahamas, West Indies, Virgin Isles, Mexico.

Comfortable cabins... good "Grub 'n Grog".

10 adventurous days from **$200**

- **Great for employee incentive programs**
- **Ideal for executive meetings and parties**
- **Wonderful for customer prizes**

WRITE CAP'N MIKE FOR FULL INFORMATION AND ADVENTURE BROCHURE

P.O. BOX 120, DEPT. 787A MIAMI BEACH, FLORIDA 33139

WINDJAMMER CRUISES

If you're trying to create logic functions with your own hardwired circuitry, there's an easier way to go. Don't look now, but minicomputer state-of-the-art (and state-of-the-price) just caught up with your application.

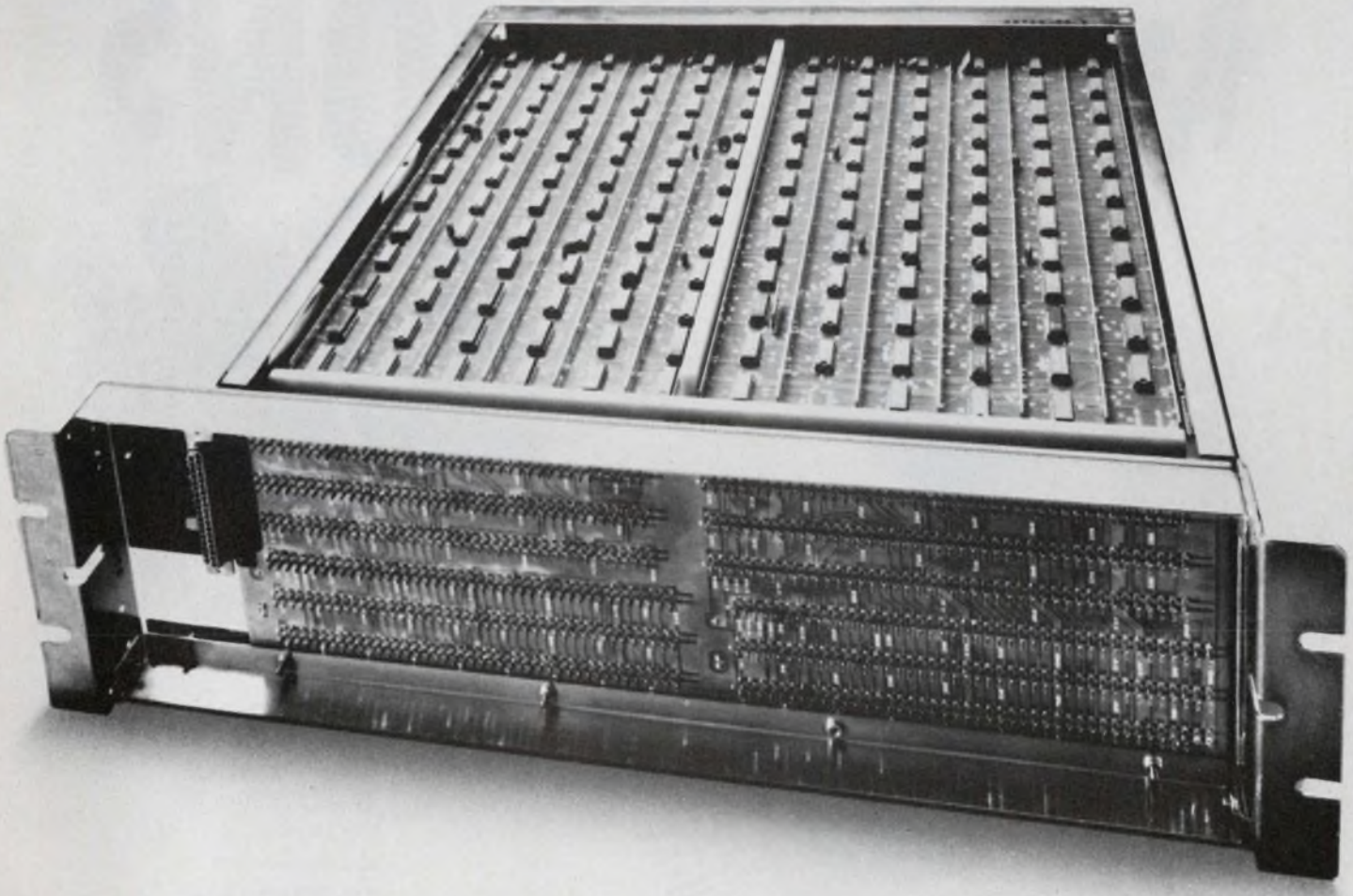
The Naked Mini 8 is a computer that's a component. A powerful, fully-operational, byte-oriented, 8-bit computer. Completely tested and easy to interface. Ready to drop into your system like a simple component.

All you add is the power supply and control panel. Everything else is already there. A 1600 nanosecond cycle time, 4K core memory (expandable to 32K), fully-parallel broadside I/O, three vectored priority interrupts, two direct memory channels, and an unconditional one-year warranty — the longest in the business.

In 200 unit OEM quantities, you get all of this and more for $1450. For full specs and price lists, write today: Computer Automation, Inc., 18651 Von Karman, Irvine, California 92664. (714) 833-8830. TWX 910-595-1767.

COMPUTER AUTOMATION, INC.
the NAKED MINI company

The computer that's a component.

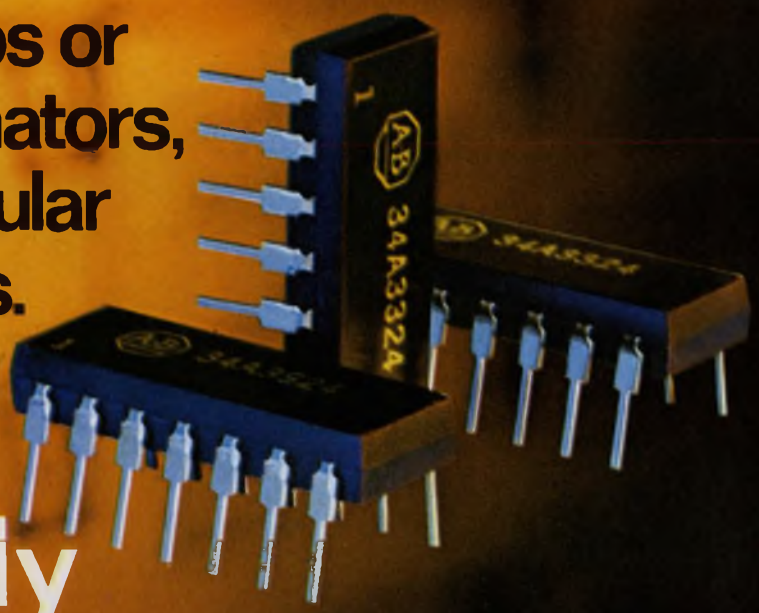


The NAKED MINI™, $1450.

INFORMATION RETRIEVAL NUMBER 13

Quality resistor networks now available off-the-shelf.

Pull ups or terminators, in popular values.



If you're really serious about cost, be serious about quality.

Now our most popular thick-film resistor networks are ready and waiting, in quantity, at your A-B electronics distributor. Pull-up networks and terminator networks with tolerances of ±2% in popular values from 68 ohms to 22K ohms. All in compatible 14 lead .300 series DIP's. Or if you need something special we'll quickly custom design any circuit that'll fit into a 14 or 16 lead DIP. And we mean quickly. Overall specs include: absolute tolerances to ±.5%. Tracking ±50 ppm/°C (and lower). TCR to ±100 ppm/°C. Write for free technical publications 5850 and 5851. Allen-Bradley Electronics Division, 1201 South Second Street, Milwaukee, Wisconsin 53204. Export: Bloomfield, New Jersey 07003. Canada: Allen-Bradley Canada Limited, Galt, Ontario. United Kingdom: Morganite Resistors Limited, Jarrow, Durham.

Actual Size

Allen-Bradley
Milwaukee, Wisconsin 53204

INFORMATION RETRIEVAL NUMBER 15

WOULD YOU LIKE A CAREFREE WEEK FOR TWO IN THE BLUE CARIBBEAN?

Relax or lend a hand, swim, scuba dive, or just put your feet on the rail. Visit exotic tropical islands and foreign ports. It's the vacation for thinking people with a spirit of adventure. Sail in air conditioned comfort on big, safe windjammers. Choice of Bahamas, Virgin Islands, Windward or Leeward islands cruises. Pick your own departure dates. It's a trip you'll always remember. AND it's only part of the big first prize offered this year.

PLUS: $1,000 IN CASH!

Everyone can use some extra money—especially on a cruise. Use it for babysitters, tropical clothes, shop the free ports, bank it or spend it. It goes along as an extra bonus to the lucky first prize winner who picks the Top Ten ads in the January 4 issue.

LAST YEAR'S TOP PRIZE WINNERS TELL HOW TO DO IT

Ronald S. Newbower
Bio Engineering Division
Harvard Anesthesia Center
Massachusetts General Hospital

Dr. Newbower looked through the contest issue with particular attention to general interest advertisements. He assumed that those ads with appeal to a large fraction of readers would place in the Top Ten. He also tended to choose ads for products that were (a) new (and of general interest), or (b) had their logos emphasized. The result: Dr. Newbower sailed off with first prize. He and his wife enjoyed their windjammer cruise; sent *Electronic Design* an enthusiastic note from the Caribbean island of Saint Lucia.

William R. Austin
Senior Engineer
Singer, Simulated Products Division
Binghamton, New York

Mr. Austin selected 37 ads which he considered potential winners. Then he made a chart, assigning points to each ad for esthetic appeal, copy approach, usefulness, etc. — six rating categories in all. The final results were then modified using a purely subjective approach. His system must be a good one. Two or three hours of work paid off with second prize.

Arthur L. Moorcroft
E.E.
Naval Underwater Systems Center
New London, Connecticut

Mr. Moorcroft first selected the 15 to 20 ads that he considered exceptional. Then culled them to pick the Top Ten. He leaned heavily toward new advertisements, new products, or new features in making his choices. The system worked well enough to make him one of the three big reader winners in last year's contest.

Electronic 1973 SUPER TOP

LOOK FOR COMPLETE INFORMATION — LIST OF PRIZES —

AND: FREE JET TRANSPORTATION

This really makes the 1st prize complete. Think about it! The cruise . . . the $1,000 in cash, AND free round-trip tickets for two on

regularly scheduled jets to the cruise's point of departure. It all adds up to the vacation of a lifetime. AND, you can be the lucky winner!

AND: YOU CAN WIN VALUES UP TO $4,500—OR MORE—FOR YOUR COMPANY

Another big feature of the Top Ten Contest is the free advertising you can win for your company. Here's what your company can win if it has an ad in the January 4 issue:

A FREE RERUN . . . for each of the ads that are voted in the Top Ten by *Electronic Design's* readers.

A FREE RERUN . . . if one of your company's engineers wins any one of the first 3 prizes — whether or not your ad placed in the top ten.

A FREE RERUN . . . if one of your company's advertising or marketing people, or your advertising agency, wins any of the first 3 prizes.

Suppose you are one of the first three prize winners. If your company has a full page, 2-color ad in the January 4 issue, your company will receive a free rerun worth $2,165. But suppose it is a 4-color spread. You've just racked up space worth $4,500 for your top brass.

Be sure to alert your advertising or marketing manager to these possibilities. Urge him to schedule your company's ad in the January 4 issue . . . It's an opportunity no company can afford to miss.

PLUS 99 OTHER VALUABLE PRIZES

There are two separate Top Ten Contests, one for *Electronic Design's* engineer-readers, and one for advertisers and their advertising agencies.

PRIZES *(Reader Contest)*

1st Prize:	Windjammer cruise for two. Jet transportation for two. $1,000 cash. Free ad rerun.
2nd Prize:	Portable color TV. Free ad rerun.
3rd, 4th & 5th Prizes:	Bulova timepieces. Free ad rerun (3rd Prize only).
6th thru 100th Prizes:	Technical books. (Title to be announced.)

PRIZES *(Advertiser Contest)*

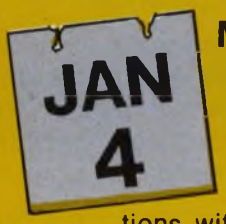
1st Prize:	Windjammer cruise for two. Jet transportation for two. $1,000 cash. Free ad rerun.
2nd Prize:	Portable color TV. Free ad rerun.
3rd Prize:	Bulova timepiece. Free ad rerun.

NO STRINGS, NO GIMMICKS . . . HERE'S ALL YOU HAVE TO DO TO ENTER

(1) Read the January 4th issue of *Electronic Design* with extra care.

(2) Select the ten advertisements that you think will be best remembered by your 78,300 fellow engineer readers.

(3) Identify the advertisements by company name and *Information Retrieval Number* (Reader Service Number) on the entry blanks bound in the issue. Mail before midnight February 15.



MARK JANUARY 4 ON YOUR CALENDAR NOW

Try for the Top Ten. Contest judges will compare your selections with "Percent Recall Seen" scores on Reader Recall—*Electronic Design's* method of rating readership. Complete information, rules, and entry blanks will appear in the January 4 issue.

Design TEN CONTEST

RULES—ENTRY BLANKS IN THE JANUARY 4 ISSUE

MCL cavities 10 to 6000 MHz all power levels

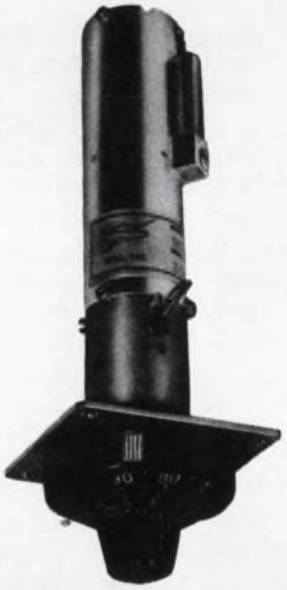
From milliwatts to megawatts, from HF to C band, MCL cavities deliver state-of-the-art performance in your RF systems. Maximum efficiency and extended tube life are possible through MCL high-reliability approach to cavity design.

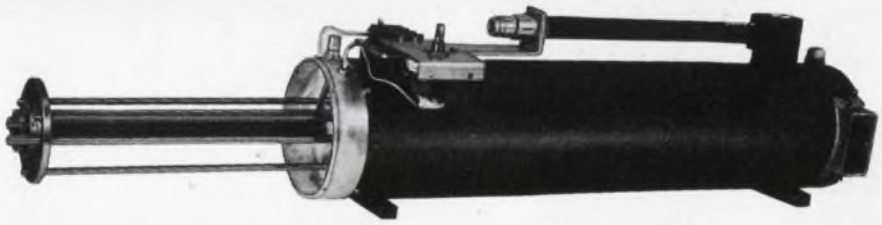
MCL can assist you in developing the most advanced microwave systems available today. Our new applications guide covers important system parameters, trade-offs, cooling and power supply requirements.

Relationships between pulse width and duty factor, tube life, and other important factors are included to help you get maximum performance from latest tube developments.

MCL engineers will also work with you directly in evaluating your application. And we will supply a fast quotation for price and delivery of the cavity that meets your needs.

For your copy of our applications guide or for assistance in meeting your requirements, call (312) 354-4350 or write: MCL, Inc., 10 North Beach Avenue, LaGrange, Illinois 60525.





MCL INC

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

INFORMATION RETRIEVAL NUMBER 16

This minicomputer memory dropped 2 bits in 7 days... and failed.

Our final performance test is rugged, and sometimes it takes guts to stick to it. But we have found through experience that it is required to be sure that you get a working disc memory that will keep working.

The test is simple: The disc is run continuously for 7 days; each day during the test repetitive write, read, and check operations are performed to verify error free performance. If more than one bit is dropped, the unit goes back for rework—it's pass or fail with no compromises.

Every minicomputer disc memory we ship is factory certified to have successfully passed this final test; the memory you put into your system has been through it.

And we have a memory just right for your system—memories with capacities ranging from 32k to 4200k words for Data General, for DEC, for HP, for Varian, and for most other minicomputers.

To find out more about the disc memories with tested reliability, call your Data Disc representative or contact us at 686 West Maude Avenue, Sunnyvale, California 94086; 408/732-7330.

DATA DISC

INFORMATION RETRIEVAL NUMBER 12

OUR ANGLE:
Low Cost D/S and S/D Modules

TYPICAL S/D MODULE SETS		
FUNCTION	LINE-LINE	FREQUENCY
S/D or R/D	11.8V	400Hz
R/D	26V	400Hz
S/D or R/D	90V	400Hz
S/D	90V	60Hz

TYPICAL D/S MODULE SETS		
FUNCTION	LINE-LINE	FREQUENCY
D/S or D/R	11.8V	400Hz
D/R	26V	400Hz
D/S or D/R	90V	400Hz
D/S	90V	60Hz

How does a choice of 14-bit resolution, 60 or 400 Hz data frequency, high accuracy, 11.8V to 90V line-line voltages and all kinds of self-protection circuitry look from your angle?

North Atlantic's Series 780 is available now. Only 5 modules make up a complete S/D or D/S converter, and any set nests in an area less than 21 square inches.

S/D specifications include 3 minutes ± 0.9LSB accuracy, and continuous tracking with low velocity errors. D/S specifications include 4 minute accuracy, 1.25 VA output and 25 μsec settling time.

Key performance specifications for both converters include 14-bit (0.22°) resolution over 360°, 0-70°C operation and 4000°/sec data rates. Both units are DTL and TTL compatible.

To shrink your prototype schedule, we offer an interconnecting PC board. Or, if you plan to integrate a converter directly onto your own PC cards, we can supply proven mylar artwork.

Any set of modules — $650. Order a set today. North Atlantic sales engineering representatives are located throughout the free world.

NORTH ATLANTIC *industries, inc.*

200 Terminal Drive, Plainview, New York 11803 Phone (516) 681-8600
California District Office: 13418 Wyandotte Street, N. Hollywood, CA 91605; Phone (213) 982-0442

INFORMATION RETRIEVAL NUMBER 18

news scope

DECEMBER 7, 1972

Two more slide rules enter calculator race

Last January the first pocket electronic slide rule was introduced by Hewlett-Packard. Now, almost a year later, at least two other calculator manufacturers are tossing slide rules into the ring: Texas Instruments and the North American Rockwell Microelectronics Co.

Continuing its big push into the calculator market, TI has announced the first of what is expected to be a series of electronic slide rules. Known as the SR-10, the new calculator features scientific-notation, squaring and square-root capabilities.

The display for the SR-10 consists of 12 light-emitting diode digits that provide eight-digit accuracy. There are two digits for the exponent, one for the sign of the exponent and one for a multipurpose symbol. The multipurpose symbol is used to indicate a minus sign, positive or negative overflow and a low battery condition.

The price of TI's electronic slide rule is significantly lower than that of Hewlett-Packard's HP-35—$149.95 vs $395. But the TI calculator is not as versatile as the HP. A TI spokesman says it never intended to be a direct competitor.

Like the HP-35, the SR-10 has nearly a 200-decade range. It has 23 keys—10 for numbers, one for the decimal point and 12 single-function keys. In addition to performing the standard mathematical operations of addition, subtraction, multiplication and division, the SR-10 also takes reciprocals, changes signs, squares and takes square roots.

The logic is contained in a special version of TI's TMS 0100 calculator on a chip. The slide rule will be sold both by direct mail and in large department stores.

Meanwhile North American's one-chip slide rule is still under development and not expected to be ready for marketing until next March. A North American spokesman says the company has no plans to market the calculator itself but is talking with several companies who are interested in bringing it out under their own labels.

North American's slide rule is expected to be a direct competitor of Hewlett-Packard's with a price of about $100. It will use a liquid-crystal display, and it will be a small-word-length machine with 10-digit accuracy. The readout devices will be liquid crystals, which are chiefly responsible for the low power consumption. It is expected that the calculator will be able to operate for 30 hours before the batteries will need recharging. The HP and TI instruments require recharging after five to seven hours of continuous use.

A 'severe' shortage of engineers feared

Remember when there were "too many" engineers? Well, now there's a shortage—in certain fields at least. And the situation is getting worse. By 1980, according to a U.S. Labor Dept. projection, it will be "severe."

A number of factors have caused this turn of events, according to a study made by the *Wall Street Journal*. They include these:

- Engineering graduates are not being produced fast enough. A few years ago young people were reluctant to enter a profession that was depositing so many of its member in the street. Now the Labor Dept. estimates that at least 48,000 engineering graduates will be needed each year during the rest of the decade. But only about 43,000 received bachelor's degrees in engineering in 1971 and again in 1972. And this total may drop to 32,000 in 1975, according to the Engineers Joint Council in New York, because of the recent recession and cutbacks in defense and aerospace spending.
- There will be fewer people of college age in the years ahead.
- Engineers are needed to match demands created by the developing economic upturn and to replace engineers who will retire in the early 1980s.
- Engineers are needed to deal with new priorities: the reduction of pollution, noise and hazardous working conditions and an energy crisis in the utility field.

The engineer in demand now, according to the study, is one with specialized skills. Litton Industries is looking for experts in analog and digital circuit design. Harris Intertype in Melbourne, Fla., wants digital-system and radio designers.

The Singer Co. is seeking microelectronics engineers. And Standard Oil of Ohio wants people with a fluidics background.

Acoustical engineers are reported commanding premium pay.

Private TV networks beginning to form

Since July, 1970, when the Federal Communications Commission authorized the use of the 2150-to-2160-MHz portion of the band for over-the-air transmission of private television signals, there has been a rush for licenses. In fact, it has led to the creation of a new industry that has come to be called Multipoint Distribution Service (MDS).

A leading company in the competition—at least in terms of the number of licenses it has requested—is the Microband Corp. of America of New York City.

The company recently demonstrated a new microwave common-carrier television system for use by business, institutions, government and general entertainment. The system involves the omnidirectional transmission of microwave signals to any number of points within a 25-mile radius. The TV signals are "address encoded" and are picked up only at certain predesignated reception sites.

The receiving locations are equipped with parabolic dish an-

tennas and equipment that converts the signal down to regular TV-channel frequencies and then decodes it. The decoded signal can be fed into one or more conventional television sets. No special attachments are required.

An MDS station such as Microband's is a common carrier, and under the FCC ruling it cannot produce or control the programs it transmits. The program is available to anyone on a first-come-first-served basis. Microband's system can transmit a variety of program formats—live, on film, on video tape or on 35-mm slides. It is also capable of transmitting data and facsimile. Two-way audio is possible over regular telephone lines.

The company says it has 33 applications for its MDC service on file with the FCC and expects to receive permits for at least 14. Permits were granted earlier for stations in Washington, D.C., and Minneapolis. Microband expects to have its first stations on the air early next year.

Laser printing system tested by Bell Labs

Printed pages, photographs and even X-rays have been transmitted digitally from distant points and recorded by pulsed laser on microfilm—all in seconds.

Developed by Bell Laboratories in Murray Hill, N.J., the experimental system can transmit an entire newspaper page over a high-capacity transmission channel (0.5-MHz bandwidth) and print it in four seconds. Over an ordinary telephone link, it would take about four minutes.

The data, or documents, are scanned by a helium-neon laser in a facsimile fashion. The light that is scattered back from the data is monitored by a light-sensitive detector, such as a photomultiplier, and then transmitted by a communications link.

Etched on film by the laser light, the image can simply be filed as a permanent record or used to make paper copies.

Eventually, Bell Laboratories says, the system could be used as a high-speed terminal for recording information from computers, for accessing remote files or records and for the low-cost production of instantly usable microfilm records.

The key components in the terminal include a simple, low-power gas laser and a device called an intracavity acousto-optic modulator, which deflects very short, high-power pulses of light from the laser cavity.

In the experimental version, pulses from a 6328-Å helium-neon laser hit the recording medium, a bismuth film, at a rate of one million per second. The laser burns millions of tiny holes of varying diameter in the metal coating, creating a transparency instantly without chemical or physical development. The result is an extremely fine pattern of dots similar to the dot patterns that create newspaper and magazine pictures.

The modulator, which is within the laser cavity, deflects light energy out of the cavity for the duration of each acoustic pulse. The short pulses the modulator is able to obtain are of much higher power than the average power the laser would normally produce.

By changing the intensity of the laser pulses, the modulator can vary the area of the holes machined in the bismuth film can be varied. In this way it's possible to achieve a wide range of shades of gray when ordinary light is directed onto the array of holes to project an image onto a screen. The total time required to write each frame is about four seconds.

Russian air spoilers stabilize TV antennas

Using wind tunnels to investigate the potentially destructive effect of strong winds on tall television towers, Soviet engineers have developed two types of air spoilers to deflect the winds.

The spoilers are placed on the outside framework of the antenna. One is simply a metal plate with its edge facing the wind. The other is a pear-shaped balloon inflated with air.

To compensate for changes in wind direction, the spoilers are moved automatically into optimum position. Since wind direction varies with elevation, the spoilers are split into several sections that can be moved independently along the vertical axis.

The work on air-spoiler development was conducted by Dr. Alexander Sokolov, head of the Dept. of Special Structures at the Central Research and Development Institute of Metal Structures in Moscow. It was started after it was observed that the TV antenna of the Moscow TV center would deflect as much as four meters during wind velocities of 30 meters a second.

Venus-Mercury flight to crack two frontiers

Two significant firsts in space science are planned when the first two-planet space flight is launched from Cape Kennedy. Known as the Mariner Venus-Mercury Project, the flight will make use of the gravitational field of Venus to propel the spacecraft toward Mercury, and there will be exploration of Mercury, the nearest planet to the sun.

The spacecraft, which is to be launched in about a year, will carry seven scientific experiments that will return data about both planets. Two television cameras will be used to provide 8000 pictures of the two planets. Signals from the two radio transmitters aboard the spacecraft will provide data on the physical characteristics of the planets and their atmospheres.

The new Mariner spacecraft is expected to fly past Venus in February, 1974, and to reach Mercury in March, 1974.

News Briefs

CMOS is starting to take hold in the automotive industry, according to Robert Mason, sales manager at Solid-State Scientific, Montgomeryville, Pa. He reports that his company—the first to deliver working prototypes to Chrysler—has received commitments for CMOS circuits to be used in electronic digital clocks and seat-belt systems. Philco-Ford is also buying circuits.

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3,072	64 x 5 x 7	+5, −5, −12V	600	0.29¢	2516N
2,560	64 x 7 x 5	+5, −5, −12V	600	0.35¢	2513N
2,048	256 x 8 512 x 4	+5, −12V	950	0.47¢	2461Y
2,048	256 x 8 512 x 4	+12, −12V	750	0.47¢	2430Y
1,024	256 x 4 128 x 8	+5, −12V	950	0.94¢	2451Y
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1,024	256 x 4	+5, −12V	950	0.88¢	2441I
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INFORMATION RETRIEVAL NUMBER 19

news

REPORT FROM NEREM

X-ray laser: Real or illusory? The stakes in outcome are high

Since the invention of the laser about 12 years ago, scientists have been tantalized by the possibility of producing an X-ray laser that would enable them to study the atomic structure of molecules. Such a laser could lead to increases in density in integrated circuits, to X-ray holography and to use in cancer therapy. So when John G. Kepros, a graduate physicist at the University of Utah, announced last August that he had produced the world's first X-ray laser, there was initial jubilation. But then a controversy began to grow.

Is what Kepros has really an X-ray laser?

There are top authorities in the field who say no. One of the skeptics, Prof. Benjamin Lax of the Massachusetts Institute of Technology's Lincoln Laboratory, made his doubts known in a paper at the recent IEEE Northeast Electronics and Engineering Meeting (NEREM) in Boston. Other scientists contacted by ELECTRONIC DESIGN agree with Lax.

But on one thing all experts are agreed: A commercially developed X-ray laser would have tremendous potential.

One application would significantly affect the semiconductor industry; the X-ray laser could be used to increase the density of ICs. A factor currently limiting the increase in density is line width. According to one laser investigator, Michel Duguay, a research scientist at Bell Telephone Laboratories, Murray Hill, N. J., it should be possible to focus an X-ray laser spot down to a diameter of only 1 Å. This would make it possible to draw lines with a width of only 10 Å—two orders of magnitude smaller than those now possible with electron-beam scanning.

Using a high power infrared laser and a copper sulphate sandwich as a target, Kepros is said to have produced the first X-ray laser.

Another added advantage, notes Duguay, is that if soft X-rays are used, the laser beam would react only with the surface of the semiconductor material—a feature that Duguay suspects would be of great interest to semiconductor manufacturers.

Aside from semiconductor applications, X-ray lasers are thought to be useful for communications. They should be capable of greater penetration and be less susceptible to weather conditions than optical lasers, and they could carry much more information. Dr. Barry Levine, a research physicist at Bell Telephone Laboratories, has proposed a method of parametric mixing of X-rays and the modulation of X-rays by an optical laser. Experimental work is being done, and the results may lead to the development of a parametric amplifier for X-rays, he reports. Such an amplifier would make possible the construction of tunable X-ray lasers.

Doubt over Kepros' laser

In his NEREM paper on "The Feasibility of X-ray Lasers," Lax cited calculations that he had done showing that the power level of the Kepros laser at 1.5 GW was much too low and could not produce a coherent beam of X-rays. Stating that Kepros' experiment and explanation were not satisfactory, Lax went on to describe a method of producing a "soft" X-ray laser, that is, one with X-rays that are very easily attenuated. He contended this would be possible if a solid target of low atomic number were excited by a laser with a power level of greater than 10^{12} W.

Duguay agrees with Lax. He has told ELECTRONIC DESIGN that according to the most optimistic calculations that he has done, at least 300,000 GW of power would be needed to produce a hard X-ray laser.

In an interview after the NEREM meeting, Kepros stood by his original claim. "The calculations that Prof. Lax has done, assume only the main pulse is present," says Kepros. "He does not take into account the spike activity present, which changes the situation significantly."

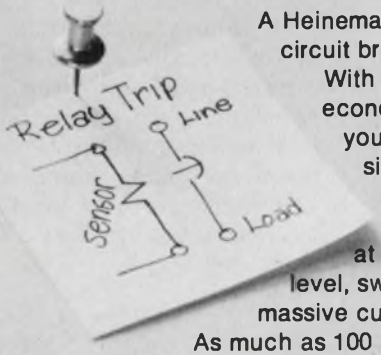
Dr. Arthur Schawlow, professor of physics at Stanford University and considered by some to be the

Jules H. Gilder
Associate Editor

Low-cost limit control for OEM's.

With a circuit breaker.

With a circuit breaker?



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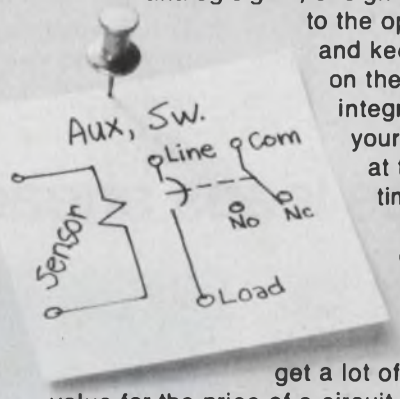

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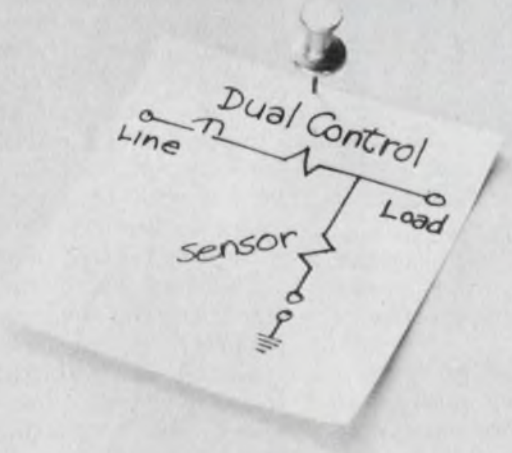
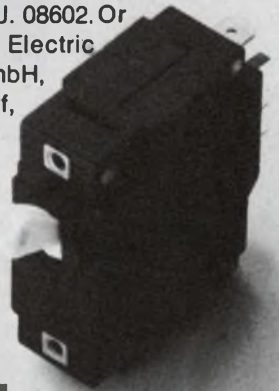
Like to find out more? Send for our Engineering Guide, and we'll include a copy of Bulletin 3352 on Dual-Control breakers. Free, of course. Heinemann Electric Company, 2616 Brunswick Pike, Trenton, N.J. 08602. Or Heinemann Electric (Europe) GmbH, 4 Düsseldorf, Jägerhof-strasse 29, Germany.





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INFORMATION RETRIEVAL NUMBER 20

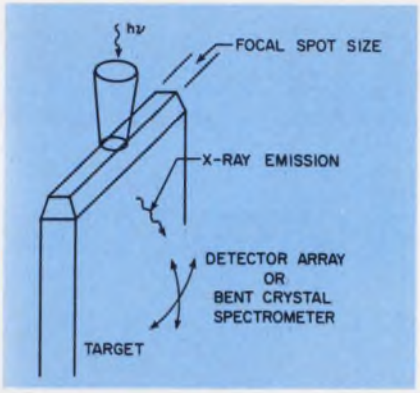
father of the laser, tends to side with Kepros. Rejecting the arguments of Lax and Duguay, Schawlow has told ELECTRONIC DESIGN:

"I am rather skeptical of theoretical calculations in this field and favor experiments, because things are so complicated . . . . . Lax's calculations are probably correct for the assumptions that he made, but there might be some process at very high excitation rates that might be more important than those he considered."

Many people, Schawlow says, have been trying to explain away Kepros' results. Noting that the Naval Research Laboratory in Washington, D. C., had confirmed Kepros' results, the Stanford physicist adds: "I find it easier to believe that he has an X-ray laser than to find an alternate explanation."

A very simple setup

The X-ray laser constructed both by Kepros and the Naval Research Laboratory is an infrared Neodymium-doped glass (type) whose output beam is focused onto a thin copper sulfate sandwich. The sandwich consists of a gelatin solution squeezed between two glass microscope covers. When the infrared beam hits the sandwich, X-rays are emitted.



A soft X-ray laser using a diamond as a target has been proposed by Prof. Lax of MIT.

Kepros says these X-rays are in a coherent beam. Skeptics theorize that the materials in the laser are opaque to X-rays and create a narrow channel that acts as a pinhole collimator, thus giving the beam laser-like qualities.

He concedes that his X-ray laser is strictly experimental and that when commercial units become available, they likely will be of completely different construction. However, both Kepros and Schawlow point out that the key advantage of the device is that it will allow scientists to study the basics of X-ray lasers and that this can pave the way for more practical devices.

According to Schawlow, the major problem in constructing X-ray lasers is the short lifetimes of the excited states of the target materials. Excited atoms cannot be stored for long periods of time—a necessary condition for lasing action. Another big problem is that as X-ray frequencies are approached, the power required to produce lasing action increases exponentially.

If Kepros' claim that he has overcome these problems proves correct—and supporting evidence is mounting—it will be one of the most exciting things to happen in lasers for years, Schawlow says.

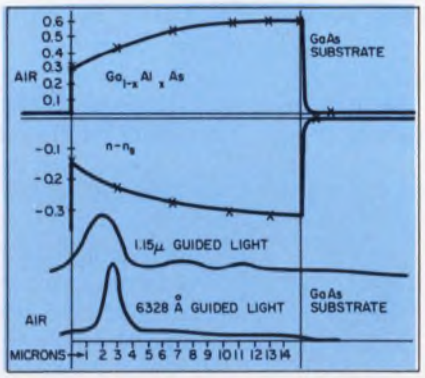
It would probably involve a new physical phenomenon, Duguay notes. ■■

Fiber optics leaps ahead of optical ICs

While optical integrated circuits continue their impressive march from the laboratory to the field with important advances in fabrication and design, fiber-optic development has surged ahead with glass-guide loss cut to a new low.

There was general agreement on this point among participants at an integrated optics session of NEREM in Boston.

A major source of excitement was the recent announcement by the Corning Glass Works, Corning, N.Y., of glass-fiber waveguides with attenuation losses reduced to 4 decibels per kilometer. This value is down several times from the previously reported 16 to 20 dB/km. The immediate significance of this development is that expensive repeater stations in laser communication systems can now be placed four or five times farther apart.



1. **Gradient guide** offers simpler fabrication alternative for thin-film semiconductor waveguides. Near-infrared waves are guided in this structure.

The low-loss fiber consists of solid glass with a core material of higher refractive index. It was tested at wavelengths between 0.6 and 1.1 μ, which includes the 0.8-to-0.9-μ wavelength region of gallium-arsenide (GaAs) lasers. The laser can be matched to a minimum attenuation frequency of the fiber over a 0.1-μ range, centered on 0.85 μ, by the addition of aluminum to the GaAs laser.

At around 1.06 μ, another attenuation minimum occurs. This is the region of operation for neodymium-doped yttrium-aluminum-garnet (YAG) lasers. Robert D. Maurer, manager of applied physics research at Corning, identified the source of fiber loss as scattering—as well as absorption—in a paper, "Optical Communication with Glass Fibers," delivered at the NEREM session. Scattering arises from material imperfections and parameter variations.

Maurer sees practical applications of fibers for incoherent sources—like LEDs—involving bundles of many fibers operating in parallel. They offer a large cross section for source-coupling efficiency while retaining flexibility, and they give redundancy to offset broken fibers.

Edward A. Torrero
Associate Editor

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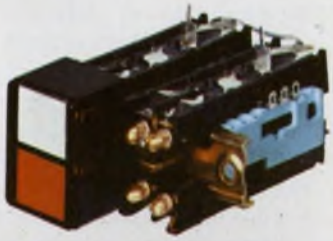

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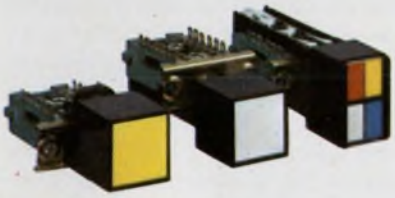

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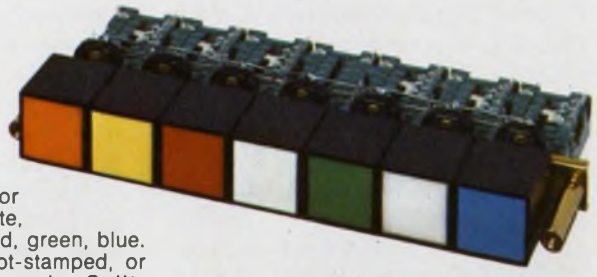

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In the developing field of optical integrated circuits, Dr. Elsa Garmire of the California Institute of Technology created a stir with a paper on optical structures fabricated with masking techniques and ion implantation. The paper, "Integrated Optics in Semiconductors," described thin-film semiconductor waveguides prepared by three techniques: the deposition of epitaxial n or n^+ films in gallium arsenide, the epitaxial preparation of gallium-aluminum-arsenide films, and ion (proton) implantation in gallium-arsenide material.

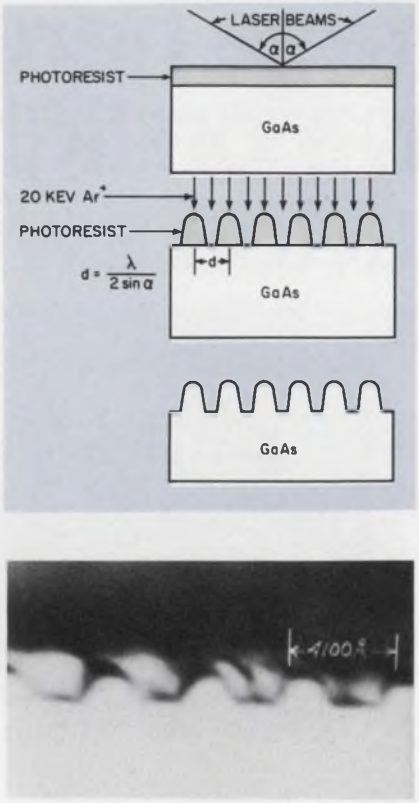
The presence of a fraction of aluminum in a gallium-arsenide compound changes the refractive index of the material. As a result, a simple waveguide can be fabricated by growing an epitaxial gallium-aluminum-arsenide layer on a substrate containing a larger aluminum concentration.

Density gradient forms waveguide

In a major new development, Dr. Garmire reported the fabrication of a thin-film waveguide having a doped-aluminum density gradient (Fig. 1). Previous efforts had concentrated on producing a uniform distribution. The guide described by Dr. Garmire conducts light in the near infrared region. However, the basic approach can be readily applied to visible light regions, according to Dr. Amnon Yariv professor of engineering at Cal Tech, who was not present at NEREM but who heads a research group on semiconductor optical waveguides. The fabrication approach also represents a simpler means of building such guides.

Another new guiding structure reported at the session was a thin-film periodic guide with center-to-center spacing of only 4100 Å (Fig. 2). According to Yariv, it's the most advanced waveguide structure of its type.

This structure could provide the foundation for important devices of the future. A backward-wave oscillator, for example, could be built with a periodic structure that has corrugated elements and an electron beam. The corrugations would trap electron-beam energy, and the interaction with the semiconductor material could result in radiated energy traveling in the direction opposite that of the exciting beam.



2. **The steps in forming a thin-film optical waveguide** (above) lead to a guiding structure that has center-to-center spacing of 4100 Å (below).

Yariv envisions obtaining 10-μ waves with this scheme.

There was wide agreement at the session that true optical integrated circuits—including integral lasers, modulators and deflectors on a chip—are years away (see "OICs: When they come, they'll revolutionize communications," ED 12, June 8, 1972, p. 26). Individual optical thin-film devices, however, are much closer, the participants agreed. In either case, further advances depend on how soon some basic problems can be licked.

Some of the problems were discussed by Fritz Zernike, senior research physicist of the Laser Products Dept. at Perkin-Elmer, Wilton, Conn. His paper, "Integrated Optics—an Overview," cited a major difficulty: Most waveguides made today are slabs; the wave is bounded in one direction only. Typical dimensions are 1-μ thick by 1-inch wide. The ideal guide, Zernike says, should have a rectangular cross section that is 1 μ thick by 2 to 3 μ wide. And that's difficult to fabricate.

Moreover the losses in optical semiconductor waveguides—due mostly to scattering—are too high to support true optical integrated circuits, according to Zernike.

In the fabrication of optical waveguides, the usual photolithographic techniques are generally not good enough, he says, since poor edge definition leads to excess scattering. That definition has to be within 1/10 to 1/20 of the optical wavelength.

Zernike sees hope in the emerging electron-beam technology, currently being pushed by manufacturers of LSI chips. In IC work, scanning electron beams are used to make devices small for higher density; for optical ICs, they could be used to keep tolerances tight.

Fully integrated circuits will most likely not be available for another ten years, says Zernike. But he sees waveguide techniques being used within five years on a much smaller scale, for example to make optical scanners.

New passive waveguides

Passive optical waveguides—containing neither active laser material nor active electro-optic material—were the subject of a paper by W. John Tomlinson of Bell Telephone Laboratories, Holmdel, N.J. He stressed two techniques that use organic materials and take advantage of photochemical reactions.

The first technique uses photoresist—the same material employed in integrated circuits. The lowest loss guides are reported to have less than about 1.5 dB/cm of attenuation. The major loss mechanism appears to be edge roughness, caused by long polymer chains.

A second technique—called embossing—uses a die with a pattern of ridges in the form of the desired waveguide circuit to emboss grooves in a thermoplastic substrate. These grooves are then filled with a transparent dielectric with a refractive index that is higher than that of the substrate.

During a discussion of loss figures, the session participants noted that published waveguide loss figures could sometimes be misleading, since they depend on type of mode and field strength. A single-mode guide with its fields strongest at the center, for example, could have markedly different loss than that of multimode operation for the same configuration. ■■

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AT THE FALL JOINT COMPUTER CONFERENCE

New system-monitors keeping tabs on computer performance

Computers are constructed, in one sense, much like humans. There's no way of looking at the outside and knowing what's going on inside. So how is it possible to tell when the data are flowing freely and when and where they're backed up, waiting to be processed? How can the user know just how much of the computer capacity is useful and how much is being wasted?

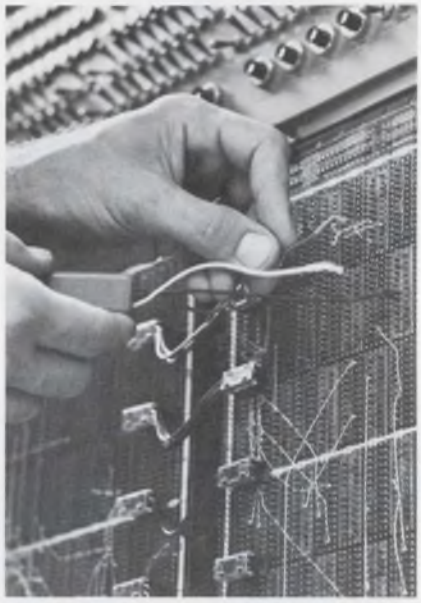
To answer questions like these, six sessions were presented at the recent Fall Joint Computer Conference (FJCC) at Anaheim, Calif. These sessions, according to the technical program chairman, Donal A. Meier, gave for the first time a comprehensive picture of an emerging technology—computer system measurement.

Computer system measurement, employing monitors, is useful to both designers and users because it can be used to do the following:

- Track down computer flaws.
- Show where the computer is spending its time in the execution of a program.
- Map core memories to determine core activity.
- Determine what data to store in core memory and what to put on discs or drums.
- Decide what action to take if storage capacity is running out.
- Reduce computer rental expenditures by eliminating excessive equipment.

The measurement of computer performance isn't exactly new. Computer manufacturers like International Business Machines have built their own monitoring equipment for years. But the commercial availability of a range of such equipment is relatively new.

Jim McDermott
Eastern Editor



Probes of a Computer Synektics Micro-Sum monitor connect to the circuits of system being measured. CRT shows computer element activity.

Computer-monitoring equipment keeps track, on a microsecond basis, of when the various computer elements are busy and when they are free. The first such equipment, sold about 3-1/2 years ago, was used only for counting or timing individual events inside the computer. The latest equipment can store sequences of simultaneous events and present the findings on CRT displays—in real time, if desired.

The basic computer monitoring equipment is comprised of these elements (Fig. 1):

- Sensors (probes) that can be attached to key signal points in a computer without disturbing the signals being monitored.
- Control logic that controls the flow of data signals from the probes to appropriate counters or timers.
- Accumulators or registers to store the counted or timed events.
- A magnetic tape deck on which the data from the accumulators is stored over a period of time.

Monitor equipment compared

At Session D-4, "Measurement of Computer Systems—Monitors and Their Applications," both manufacturers of such equipment—Computer Synektics, Inc., Santa Clara, Calif.; Allied Computer Technology, Santa Monica, Calif.; Comress, Inc., Rockville, Md.; and Tesdata Systems Corp., Chevy Chase, Md.—and users compared the merits of the equipment.

One panelist—Dr. David Copp, a member of the technical staff at Bell Telephone Laboratories, Murray Hill, N.J.—stressed that monitoring equipment was still in a state of development. Only a few hundred hardware monitors are in use around the world, he noted.

"We're still learning how to use them most effectively and also how to analyze the data we get from them," he said.

Sensors in the monitors pick up signals from registers, indicators and activity lines and combine them logically. Register activity can be compared at the control panel and then routed to accumulators for

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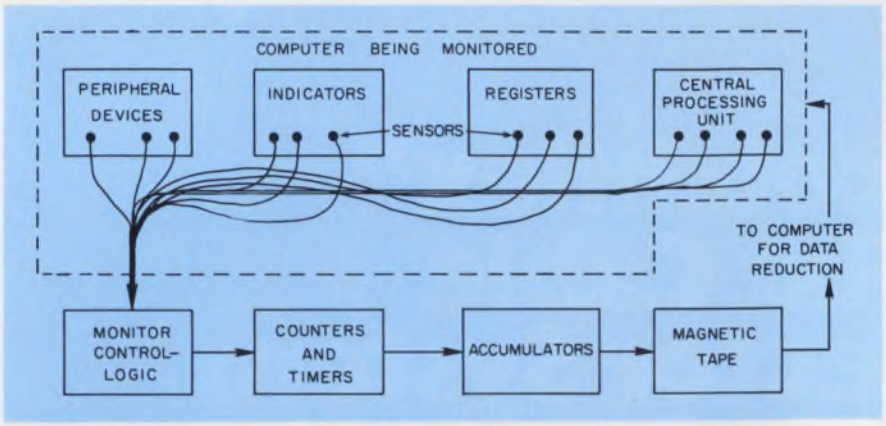

1. **The elements of a computer monitor system** serve to count and store the number of events or their durations. The data are processed in the computer.

counting or timing events.

Because monitors can keep track of when computer sections are busy or free, they can, by recording the activity of the instruction and execute-address registers, show where in the program the computer is spending its time, Copp said.

In tracking down system flaws, monitors can measure data streaming rates between computers; it's possible to measure burst as well as sustained rates.

From these data, the time the various modules use in execution can be determined. And, on the basis of this and other information gained—such as the percentage of time that the central memory and the peripheral processors are in use—the computer hardware can be modified to correct system flaws.

Nicholas R. Finamore, chief of computer applied studies at Western Electric, New York City, told the panel session of the advantages his company had obtained in using monitoring equipment built by Tesdata Systems.

For example, he pointed out, with the Tesdata equipment, which has a distributor module concept, it's possible to connect up to 96 probes on an instruction register and to sample the instructions being executed. Also, core memory can be mapped to get a measure of core activity.

The highly used data can then be put into the core after a tradeoff involving storage vs access time. Other data may be stored on a disc or drum.

The monitor can also tell what to do if the computer is running out of storage capacity, Finamore noted. For example, it helps answer such questions as: Will an increase in tape drive speeds increase storage capacity? Will changing from an IBM 2314 disc memory to a 3330 solve the problem?

Western Electric has, from computer monitor analysis, been able to reduce rental expenditures. ■■

Building-block computer setups gaining

MSI and LSI are changing the architecture of computer systems. Functions formerly independent are now merging to produce compact efficient and low-cost building blocks.

These points were covered in FJCC Session F-6 on computer architecture.

"LSI has voided the traditional barrier between logic and memories," says Dr. Tien Chi Chen, research staff member at IBM's research laboratory in San Jose, Calif.

Formerly, Chen notes, memories were comprised of cores or some exotic form of storage. Processing logic was comprised of semiconductors. And the distinction between the two has been based traditionally on the differences in technologies.

But today, Chen points out, this distinction has been removed, with storage now being performed by fast semiconductor memories.

These memories can also be used for processing, he says, such as in look-up tables.

With the new technology, Chen says, it's possible to build pieces of hardware that behave as self-sufficient items. And they can be linked together loosely—rather than with tight coupling, as in the past.

Organization like this, he says, looks inefficient, but it allows indefinite growth of the system.

LSI can now provide compact, efficient and inexpensive building blocks with arbitrary degrees of a stored program nature. This arrangement signals a new era of polycentric architecture, based on the loose coupling of autonomous modules.

MOS computer with TTL speed

The architecture of an MOS LSI minicomputer that has the speed of a TTL equivalent depends on several considerations, according to G. W. Schultz, manager of LSI minicomputer design for American Micro-Systems, Inc., Santa Clara, Calif. In a paper in Session B-5, "The MOS LSI Minicomputer Comes of Age," he defined these considerations as follows:

- Microprogramming vs conventional control.
- Instruction decoding.
- Microinstruction formats.
- Input-output interface relationships.
- Stack organization.
- Register design.
- Data bussing format.

In his paper, Schultz applied these considerations to the design of a hypothetical minicomputer capable of addressing directly 65k words or bytes. The machine, he said, would be able to function as an 8 or 16-bit machine. The mem-

This filter contact

eliminates electromagnetic pollution.

Amphenol has met the challenge of placing fragile components—ceramic and ferrite—in the rugged mechanical environment of an electrical connector. And we've done it without disturbing the electrical and mechanical integrity of the individual components.

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ory address would use 16 bits, which must be sent in a single byte transfer, even with an 8-bit oriented machine.

For cost effectiveness, Schultz noted, the TTL requirements external to the LSI unit would be minimized. And for the same reason, the computer would use only LSI techniques now employed in the mass production of these devices.

The microprogramming organization of this computer is a clear choice over conventional control, Schultz insisted, for reasons based on two criteria directly related to the use of LSI: system partitioning and its related pin limitations; and the efficiency of chip-area use.

Placing the entire computer on a single chip would simplify system partitioning, Schultz pointed out. But the limitations imposed by standard pin formats would still remain.

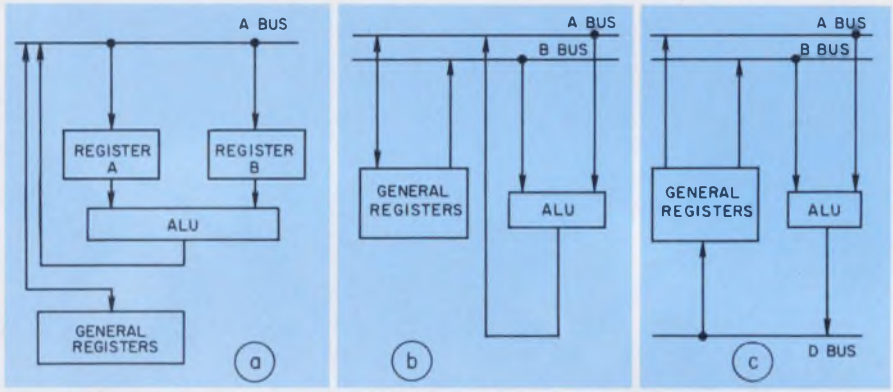
The alternative, he said, is to partition the registers and the arithmetic logic unit (ALU) and place the control on other chips.

But signal delays of 150 to 200 ns from chip to chip would reduce computer speed undesirably.

To maximize the speed, Schultz suggested the use of pipelining techniques. With these, the execution of the next instruction must be started before the last is finished. The time spent in communicating the control between chips would thus be minimum, he said. And the registers and ALU sections could be operated independently.

The Pin limitations stem from the present packaging technology and cost considerations, Schultz said. The designer of the MOS/LSI computer is faced with a choice of 16, 24 and 40-pin packages.

The 16 or 24-pin packages are not preferable, Schultz said, because the registers and ALU would have to be partitioned into four-bit slices. As a result, the chip-to-chip transitions between sections of the ALU itself would greatly reduce



2. **The simplest data-bus scheme (a) provides minimum interconnection** but reduces machine speed. Two busses (b) use the dynamic storage inherent in MOS to allow these busses to appear as registers to the computer. The scheme in "c" requires the greatest area on the MOS chip.

Improved movies simplifying simu

The output of a computer simulation program can be a mass of data that is almost impossible to wade through with concise understanding. For this reason, computer graphics in the form of motion pictures, composed of individual frames from a computer run, are being developed as a tool for obtaining a clear, visual interpretation of simulated events.

But without sound, these movies still require a significant amount of explanatory material that must be read as well. Sound tracks can be made independently and combined with the film, but this generally requires two or three weeks and is essentially useless to the experimenter. A solution was presented by Edward K. Tucker, information systems specialist at the Los Alamos Scientific Laboratories in New Mexico, in a FJCC paper on

of the paper, which was presented in Session C-4.

The key element in the system is the use of a microfilm plotter. Many of these are being used to generate the motion pictures that show the results of the simulations.

For example, Tucker said, the Los Alamos laboratory has been using one to represent the output of a code simulating what happens to a structure when it's hit by an earthquake. In digital form this would be impossible to understand, Tucker says.

The objective, he pointed out, was to get the sound track generated at the same time as the picture on one single pass through the computer plotter.

Normally, he noted, you generate a computer tape that drives the plotter. In one pass over that tape, the visual representation is generated.

System saves user time

With the new system, which may require an extra five to 30 minutes of plotter time to plot more lines for the sound track, the turnaround time for the user does not go up significantly.

To plot the sound track—which may be both computer-generated sounds, voices and other complex audio waveforms, the audio signal is periodically sampled, Tucker explains. The digital output was produced on standard half-inch, seven-track magnetic tape in a format compatible with a CDC-6600 computer.

The latest concept Tucker is working on is compiling a soundtrack file keyed to the computer program. On command, a particular sound could be extracted and plotted onto a given frame.

Another technique for making movies of a simulation program—photographing the pictures frame by frame from the face of a CRT—has been used by engineers at the Cornell Aeronautical Laboratory in Buffalo, N.Y., for the presentation of vehicle dynamics.

James P. Lynch, assistant electrical engineer at the laboratory, pointed out in a Session C-4 paper on computer animation that this type of photography—with the camera in front of the CRT—per-

MEASUREMENT NEWS
innovations from Hewlett-Packard

DECEMBER edition

in this issue

A new standard in AM/FM generators

HP's solid-state successor to the time-proven 608 signal generator.

For more than 20 years, the HP 608 series VHF signal generators have generally been recognized as the standard of the industry. Now, we introduce a solid-state VHF generator series with wider frequency coverage (450 kHz to 550 MHz), increased modulation capability (FM as well as AM), better stability, and impressive spectral purity.

The 8640 generators deliver low-noise signals that, until now, could be attained only with vacuum-tube generators. Non-harmonic and sub-harmonic outputs are down more than 100 dB and noise is less than -130 dB/Hz at 20 kHz offset from the carrier. Extremely clean

(continued on page 4)

New OEM computer discounts reflect lower memory costs

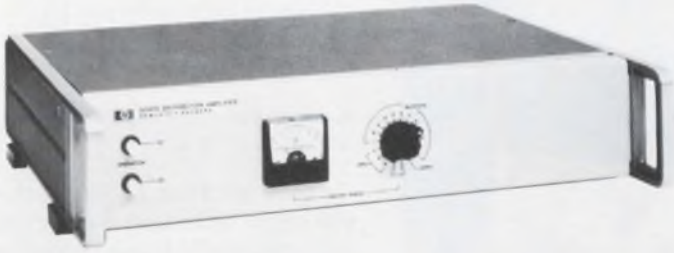
Optional Writable Control Store lets you microprogram a 2100A computer to specific applications.

Prices for the HP 2100A computer have been reduced by $2,000 for each 8K of core memory. Likewise, HP has increased its discount rate to original equipment manufacturers.

You save dollars without losing any capability. The expandable 2100A minicomputer holds up to 32K of memory in a 12-inch (30.48 cm) mainframe. Standard equipment includes 80 powerful instructions, hardware multiply/divide, memory protection, automatic restart after a power failure, unlimited levels of indirect addressing, and 14 I/O channels. With HP's proven software and a wide selection of peripherals, OEMs can tailor the 2100A to virtually any configuration.

For details on the 2100A computer and OEM discounts, check B on the HP Reply Card.

Now, distribute frequency without distortion



The 5087A is the first distribution amplifier to accept single 5 MHz input and distribute 0.1, 5 and 10 MHz outputs.

For isolated, undistorted multiple outputs from atomic or crystal frequency standards, try the 12-channel 5087A distribution amplifier. Three input channels accept 10 MHz, 5 MHz, 1 MHz or 100 kHz in any combination. You can select the number of outputs for each channel, up to a total of 12 outputs. Each output level is adjustable from 0 to 3 V rms.

The distribution amplifier boasts of excellent short-circuit isolation (< 0.1% amplitude change); exceptional phase stability (< 0.1 ns/°C for 5 and 10 MHz); low noise; and -60 dB crosstalk. Amplitude stability is ± 0.5 dB, 0° to 50°C. In the event of an ac power failure, the distribution amplifier switches over to standby dc.

Price: $1500 for the standard configuration.

Several options are available. For details, check H on the HP Reply Card.

New features, low prices for HP portables

All 1700B scopes have a new color-coded front panel for easier operation.

HP's popular 1700 series portables now incorporate lower prices with a number of product improvements. New features incorporated in all 1700B delayed sweep models include:

- Mixed sweep, external trigger input for the delayed sweep, and calibrated delay. (These three features formerly were optional.)
- HF reject for delayed sweep provides better low frequency delayed time base triggering.
- Line sync for the main sweep.
- Slower decade of sweep for the main time base (0.5, 1 and 2 sec/div.), particularly useful when viewing transduced, bio-medical or natural phenomena.

You get laboratory quality with the convenience of mobility. All 1700B portables have internal battery power and rugged construction for reliable operation at even the most remote field station. Prices for these new portables:

1700B (35 MHz)	$1475
1701B (35 MHz, delayed sweep)	$1550
1702A (35 MHz, storage)	$2375
1703A (35 MHz, storage, delayed sweep)	$2725
1706B (75 MHz)	$1500
1707B (75 MHz, delayed sweep)	$1575
1710A (150 MHz, delayed sweep)	$2300

For specifications, check A on the HP Reply Card.

Choose independent or tracking power outputs

Two versatile lab supplies each house two identical 50W regulated power supplies. A convenient front panel switch lets you select either independent or tracking operation. In the tracking mode, the right supply tracks the left within 0.2% ± 2 mV. Tracking mode is especially useful for powering operational amplifiers, push-pull stages, deflection systems, or any application where plus and minus voltages must track with insignificant error. The independent mode lets you operate the two supplies individually, in auto-parallel or in auto series.

Each side of the dual supply can be operated as a constant voltage or constant current source, and each has its own crowbar for overvoltage protection. In the tracking mode, an overvoltage condition in either supply trips both crowbars.

Output ratings for the 6227B (each side) are 0—25 V at 0—2 A; for the 6228B (each side), 0—50 V at 0—1 A. Price: $495.

For specifications, check J on the HP Reply Card.

HP 6227B dual-output power supply.

Three new solutions to your network analysis problems

You don't have to run diagnostics; the HP calculator executes network analysis self-calibration programs to maintain system accuracy.

What happens when you combine a network analyzer with a calculator? You get automatic testing of gain, phase and group delay.

Designed primarily for the production line and R & D lab, HP's new 3040A, 3041A and 3042A network analyzers measure gain with 0.01 dB resolution, phase with 0.01° resolution, and delay with 20 choices of split frequencies (or an unlimited number under calculator control). Point-by-point, swept and differential measurements can be made.

The 3040A is a manual network analyzer with a frequency synthesizer as the source and a two-channel selective tracking detector. With the synthesizer as a stable, accurate frequency standard, all measurements are precise. Use the 3040A to characterize narrow-band devices with extremely high Q.

The semi-automatic 3041A is controlled by a marked card programmer via the new ASCII interface bus. The card programmer adds limit testing capability. Simply mark the test on a card, then run it.

The 3042A runs under control of an HP 9820 programmable calculator. An ideal manufacturing and research tool, this automatic network analyzer can be operated manually or programmed by magnetic cards. The ASCII bus simplifies programming and interfacing. The calculator handles simple decision-making and performs high-level statistical manipulation of test data.

Prices range from $6,900 to $22,900.

For network analyzer information, check C on the HP Reply Card.

Electronic measurement: books on why and how

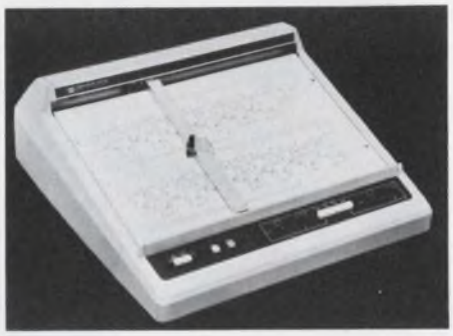
Whether you are an electronics student or highly experienced engineer, two new books by HP authors dispel the haze surrounding electronic instrumentation. Both books are available from McGraw-Hill.

The *Basic Electronic Instrument Handbook*—edited by HP's Clyde F. Coombs, Jr.—is the first text to bridge the gap between academic knowledge and a realistic working situation (where you struggle to interpret a complex instruction manual). Content ranges from basic electronic theory to specific measurement problems and solutions. An 832-page general reference for the practicing engineer or technician, it's also a valuable guide for non-electronic people involved in instrument selection and purchasing. Price: $28.50

Because "science and technology are so intertwined with measurement as to be totally inseparable from it," Dr. Bernard M. Oliver, HP R&D Vice-President, and John M. Cage of HP Laboratories co-edited *Electronic Measurement and Instrumentation* from contributions by 35 authorities. This 720-page book discusses the role of measurement, many measurement techniques, the theories behind them, their inherent limitations, and the preferred instrumentation. This definitive text for graduate EE students, engineers and physicists is part of the McGraw-Hill Inter-University Electronic Series. Price: $29.50.

Check R or S on the HP Reply Card and we'll have the publisher send you more information.

Fast, low-cost plotter for minicomputer



This quiet 11 by 17 in. (28 by 43 cm) graphic plotter draws as fast as a computer thinks.

Need a plotter that can keep up with your computer? The 7210A graphic plotter processes up to 20 coordinate pairs per second and draws symbols at the rate of 5 per second. A high-acceleration mechanism accelerates the pen to 10 in./sec. (25.4 cm/sec) in less than 12 milliseconds. Even at these fast speeds, the plotter is virtually silent.

Our secret is a built-in micro-processor that accepts pen position data in either binary or BCD codes—in other words, directly from the computer or a terminal. There's no complex software, nor do you tie up any valuable core storage.

The finished drawing has smooth arcs and circles. Because of the micro-processor, the computer doesn't calculate intermediate points. The resulting graph is free of the "stair-step" pattern typically found in most incremental plotters.

Installation is easy. If you own an HP computer, your plotter can start drawing five minutes after it arrives. Price: $3400.

For the complete plotter picture, check M on the HP Reply Card.

New pulse generator for ECL circuit tests

ECL (emitter-coupled logic) is the coming high-speed IC logic, particularly in the computer and communications industries. Now, there's another versatile laboratory pulse generator that handles general IC testing yet is fast enough to test modern ECL chips.

Two output connectors deliver simultaneous, complementary signals—ideal for driving differential inputs. Repetition rate ranges from 10 Hz to 200 MHz, so the 8008A pulse generator satisfies TTL requirements as well as ECL. The maximum 200 MHz rate satisfies the most advanced designs, while the manual and low frequencies are used for stepping through logic states. And you can vary pulse transition times from $\leq$1.2 ns to 2.5 ns with an optional risetime converter.

Price: $2700.

For more information, check N on the HP Reply Card.

(Continued from page 1)

signals are vital for such rigorous receiver tests as adjacent-channel-selectivity.

Whether you choose model 8640A with slide-rule tuning dial or model 8640B with six-digit LED display, you really get three generators in one: a stable CW source, a fully-calibrated FM generator, and a high-performance AM generator. Both cover 450 kHz to 550 MHz with power output from +19 to −145 dBm.

The economical 8640A is ideal for design labs, production testing, and field maintenance applications. Frequency accuracy is better than 0.5%, and drift is less than 10 ppm/10 min. (after two hour warmup).

The 8640B has a built-in phase-lock synchronizer to achieve output stability better than 5 x 10^{-8}/hour. Even when the 8640B is locked, spectral purity and precision FM of the unlocked mode is preserved. A built-in counter measures external signals to 550 MHz.

The 8640A costs $3100; 8640B, $4450.

For more on these new AM/FM generators, check P on the HP Reply Card.

New two-channel recorder sets new standards for sensitivity and trace

Any two-channel oscillographic recorder offers the versatility of plotting two events at once, but HP's new 7402A recorder lets you select and vary the sensitivity according to your requirements. A choice of three preamplifiers plug into the mainframe for sensitivities of : 1μ v/div. with differential, floated and guarded input; 1 mv/div. with differential, balanced to ground input; and 20 mv/div. with single-ended input.

Because the 50 mm chart width is 25% wider than other comparably priced recorders, the writing resolution is 25% better. After two months of continuous use, HP's new stainless steel pens with carbide tips had no measurable pen fatigue.

Select chart speeds from 1 to 125 mm/sec. Frequency response is ± 2% of full scale from dc to 40 Hz, and rise time is 7.0 to 7.5 ms. A complete working system starts at $1740.

To learn more about the new two-channel recorder, check L on the HP Reply Card.

Preamplifier modules easily slip into the 7402A recorder mainframe.

New automatic system delivers accurate RF signal analysis

Shown here testing a UHF component, the HP 8580B serves as a cost-effective production test station.

Knowing signal power at critical frequencies is essential for communications system operators; for agencies that manage the radio spectrum; and for manufacturers who design, build and maintain RF systems.

Now, HP's 8580B spectrum analyzer performs frequency-selective signal strength measurements automatically, from RF through microwave. This new system measures signal characteristics in a congested environment to aid in spectrum management or in the control of communications systems. The 8580B also characterizes signal sources and frequency translators as well as linear networks—which means you can test mixer, modulators, oscillators and receiver front-ends.

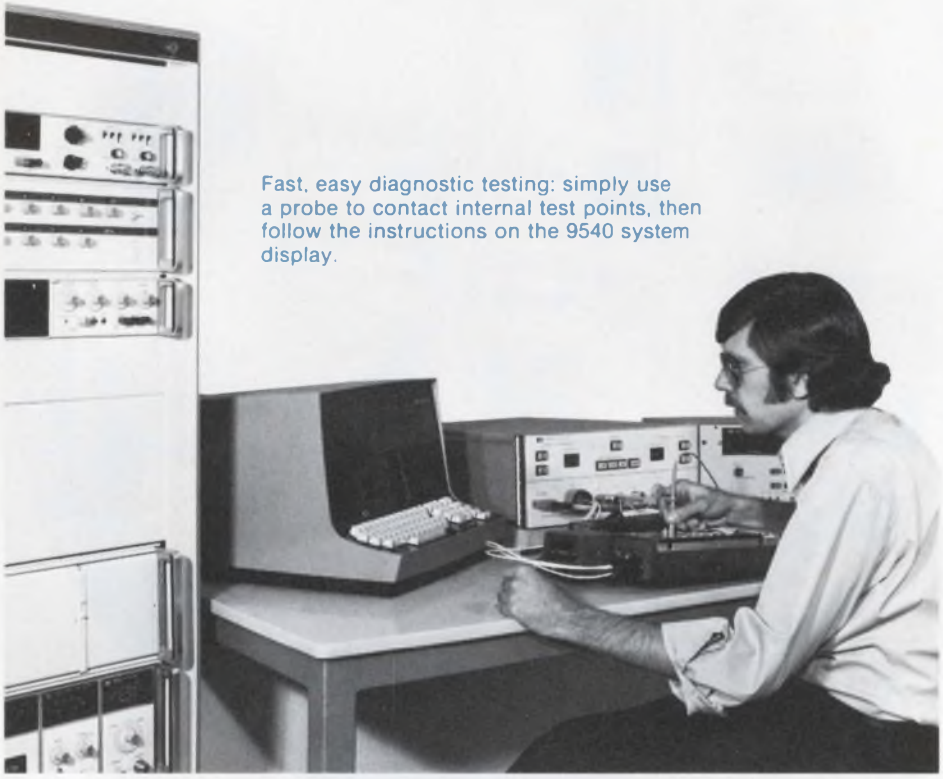
Wide frequency coverage, 10 kHz to 18 GHz, is automatic. Multiple inputs measure signals from several sources. Frequency accuracy is better than 3 parts in 10^7 at 18 GHz. The receiver can tune in increments as small as 5 Hz, with analyzing bandwidths as narrow as 10 Hz. Measurement range is +30 to −130 dBm.

Automatic operation, combined with an easy-to-use keyboard and control panel, means your operator won't require extensive training. Or let the system run unattended, with HP software doing the work.

Prices start at $96,400.

To learn more, check O on the HP Reply Card.

New HP automatic system for communication equipment tests



Fast, easy diagnostic testing: simply use a probe to contact internal test points, then follow the instructions on the 9540 system display.

Now, you can test a typical transceiver to EIA standards for land mobile communications equipment in about three minutes—that's 5 to 10 times faster than equivalent manual testing.

The 9540 automatic test system performs many common tests for the production and maintenance of AM and FM mobile transceivers. Capability includes distortion, deviation, power, frequency, stability, SINAD, and sensitivity. Special software routines let you measure FM deviation and distortion without using extra instruments. You can test radio equipment operating on any frequency from 10 MHz to 1000 MHz at transmitter powers up to 100 W (1 KW maximum is optional).

The computer runs tests and analyzes data from a test station located up to 20 feet away. For streamlined, fast troubleshooting, a dual-connector RF test head at the test station interfaces the transceiver and system. The test head contains RF switches, RF mixer and RF detector. Two sets of connectors let one transceiver warm up while the other is being tested, or they may be used for input and output when testing modules. A high-speed DVM and timer/counter are used as A/D and frequency-to-digital converters, respectively.

HP supplies typical test listings to help technicians and engineers write their own tests using the HP ATS BASIC language. Operating instructions appear on the system display; an average operator can run the system merely by pushing a button.

Select the economical 9540B paper tape system or the 9540D disc memory system with files for 2.4 million words.
Prices start at about $100K.

For more on computerized transceiver testing, check Q on the HP Reply Card.

New multiprogrammer for automatic test/control

Put your minicomputer to work in automatic test and control systems with HP's 6940A/6941A multiprogrammer. This low-cost system building-block provides a bidirectional data link between a single computer I/O channel and up to 240 individually addressable, plug-in card slots, each with a 12-bit I/O capability.

In automatic test applications, the multiprogrammer can provide stimuli for a device under test and instantly collect responses from that device. A wide range of plug-in cards lets you program analog outputs (V, R and I), output digital words, close contacts, monitor digital lines, and sense status changes.

The modular nature of the multiprogrammer permits flexible system development. You start with a master unit (6940A) and 1 to 15 plug-in I/O cards. As system needs increase, simply add extender mainframes (6941A) and plug-in cards.

The 6940A master unit costs $1500; the 6941A extender, $900. I/O cards cost $75 to $430 each. *For more on the multiprogrammer, check K on the HP Reply Card.*

Run HP's multiprogrammer under computer control, or operate it manually from the front panel switch register.

HEWLETT-PACKARD COMPONENT NEWS

The lowest noise yet for HF transistors

The lowest guaranteed noise figure ever offered in a microwave transistor is here—and it's priced below all other low-noise transistors on the market. The new 35870 series small signal NPN device boasts a guaranteed *maximum* noise figure of 2.3 dB at 2 GHz and 3.3 dB at 4 GHz. *Typical* noise figures are lower, of course: 2.0 dB at 2 GHz and 3.0 dB at 4 GHz.

The new transistor has plenty of gain, too: typically 14.8 dB at 2 GHz, 9.6 dB at 4 GHz, and 6.4 dB at 6 GHz (f_{max} is 14 GHz).

Price: only $90 each in 100+ quantities.

For details, check D on the HP Reply Card.

HP's new low-noise microwave transistors come in a rugged metal-ceramic package.

New low-cost beam-lead Schottky diode

High-level detection, switching, gating, A/D conversions, sampling and wave shaping are only a few applications for HP's new beam-lead equivalent of our 5082-2800 Schottky diode.

With fast switching, this device is ideal for applications that require large numbers of high frequency diodes or as replacements for P-N junction diodes.

Breakdown voltage is 70 V; reverse leakage current, 200 nA; capacitance, 2 pF; and carrier lifetime, 100 pico-seconds. At UHF frequencies, the diode has 95% rectification efficiency. Priced at 99¢ in small quantities.

To learn more, check F on the HP Reply Card.

New packaging protects PIN diodes

Three new 100 MHz to 12 GHz PIN diodes are available in hermetically-sealed stripline packages which pass MIL specs for a variety of environmental tests. The 5082-3140 device is for general applications from VHF through X band. Model 5082-3170 has similar characteristics but is reverse polarity. Both handle 30 W of power; dissipation is 2.5 W.

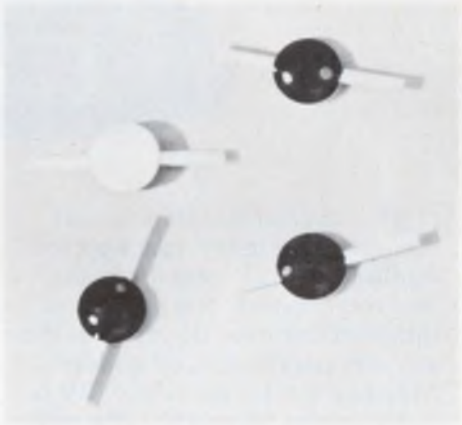
The fast-switching 5082-3141 device is also useful where low bias current is needed for maximum attenuation. Switching time is 5 ns. Power handling ability is 13 W; dissipation is 1 W. Isolation is > 20 dB for all three devices.

Prices: $25 each in quantities of 1-9, and $21.50 each for 10-99. Delivery is from stock.

For hermetic diode details, check G on the HP Reply Card.

The HP 5082-3140 hermetic stripline diode.

New microwave stripline Schottky diodes



These low-noise stripline diodes are only 0.1 inch (2.5 mm) in diameter.

For economically-priced microwave mixer Schottky diodes, consider four new low-noise devices from HP. In the 1-4 GHz range, the 5082-2213 diode has a maximum noise figure of 6.0 dB and a VSWR of 15:1. The lower-priced 5082-2215 model has a typical NF of 6.5 dB and a maximum VSWR of 2:1.

From 4 to 12 GHz, the 5082-2217 diode has a maximum NF of 6.5 dB and a VSWR of 1.5:1. The lower-priced 5082-2219 series has a typical NF of 7.0 dB with a VSWR of 2:1.

Uniformity of RF characteristics is assured so that you can replace these components in the field without circuit adjustment. Typical applications include telecommunications receivers, microwave synthesizers, ECM and radar front ends.

In quantities of 1 to 9, the 5082-2213 costs $8.25 each; 5082-2215, $6.00; 5082-2217, $12.50; and 5082-2219, $9.00.

For more information, check E on the HP Reply Card.

Universal counters offer higher sensitivity and faster time interval measurements

Whether you compare accuracy, price, versatility or performance, HP counters stack up better.

HP universal counters/timers measure frequency, ratio, period, multiple period, time intervals, and totalize with one significant difference—these do it better than any comparably-priced counter. Measure the frequency of CW or burst signals, 50 to 550 MHz with better accuracy and high sensitivity (to 15 mV). As for stability, the aging rate is as low as 5×10^{-10}/day. Now, these HP counters have FCC approval.

For time interval measurement, only HP offers averaging down to 150 ps, with resolution to 100 ps—that's 1000 times better than conventional techniques. You can also get a built-in DVM for setting trigger levels digitally. That's far more accurate and faster than using an oscilloscope, and the DVM technique works at high frequencies where the scope markers tend to blur. Because these counters have hysteresis compensation, you don't have to reset levels when switching from positive to negative inputs. Hysteresis compensation simplifies setup and reduces errors.

Be assured that HP counters also have better system capability. All front panel controls can be operated remotely and economically. A built-in three-range integrating DVM and counter can easily be programmed into your system.

With a choice of six models, select the universal counter that fits both your performance needs and your not-so-universal budget. Prices range from $995 to $2195. *A new book explains it all. For your copy, check 1 on the HP Reply Card.*

Send for our informative booklet on easier ways to make frequency and time interval measurements.

HEWLETT hp PACKARD

Measurement, Analysis, Computation

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South—P.O. Box 2834, Atlanta, Ga. 30328, Ph. (404) 436-6181.
Midwest—5500 Howard Street, Skokie, Ill. 60076 Ph. (312) 677-0400.
West—3939 Lankershim Boulevard, North Hollywood, Calif. 91604, Ph. (213) 877-1282.
Europe—Post Office Box 85, CH-1217 Meyrin 2, Geneva, Switzerland, Ph. (022) 41 54 00
Canada—275 Hymus Boulevard, Pointe Claire, Quebec, Canada, Ph. (518) 561-6520
Japan—Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-ku, Tokyo, 151.

00246

The 5-volt, N-channel MOS static RAM.

(Much more useful. Much easier to use.)

100% TTL compatibility—without clocks, without refresh. Interfacing's so simple you'll think you're working with bipolar parts. All the performance you've been itching to get your hands on. Backed by the smoothest specs ever put into MOS static RAMs. 1024 bits. 500ns access time. Single +5V supply.

N-channel technology developed by Signetics makes the difference. We designed out the kinks in competing devices, and came up with a new trouble-free line of ion-implanted N-channel MOS static RAMs.

And what a difference N-channel makes on your boards. Three times the circuit speed of P-channel RAMs. 50% lower power dissipation. Absolutely no fudging on bipolar compatibility—no clocks, no refreshing needed. So the parts are much easier to understand and put to use.

First super-RAM off the line: Signetics' new ion-implanted 2602 static RAM. N-channel delivers 1024x1 organization: four times the density of similar products. With extremely fast access time for a static RAM: 500ns. And we threw out the −12V power requirement that made terminal applications so sticky. 2602 operates from only +5 and ground.

2602

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INFORMATION RETRIEVAL NUMBER 26

SCIENCE/SCOPE

An advanced version of the successful Intelsat IV satellite has been proposed by a Hughes-led team of international companies under a Comsat study contract. The new satellite will have nearly twice the communications capacity and be operable with Intelsat's present ground-station network. At the present rate of growth, world communications traffic is expected to reach the capacity of the Intelsat satellite network in the Atlantic segment by 1975.

Two U.S. Navy aviators in an F-14A Tomcat became the first military crew in history to attack multiple targets simultaneously with multiple missiles from a single fighter aircraft when they launched two Phoenix missiles against two widely separated drones off Pt. Mugu, Calif., recently. The "double whammy" launch was a test of the multiple launch and guidance capability of the AWG-9 weapon control system. Both the Phoenix and the AWG-9 are built by Hughes. The Navy recently commissioned the first two F-14A squadrons.

Complex electronics systems for today's manned aircraft must withstand high G forces and considerable heat generated in critical units. To help solve these problems, Hughes is developing for the U.S. Air Force temperature-stabilized electronic mounting plates that use variable-conductance heat pipes in conjunction with phase-change heat-sink materials. Designed to improve component reliability, they can cool electronic units for as long as 30 minutes without using the aircraft's primary loop cooling because of a built-in emergency internal heat-sink capability.

Twelve long-range infrared devices that "see" at night are being built by Hughes for service testing under simulated combat conditions by the U.S. Army. Called NODLR (for Night Observation Device, Long Range), the portable, battery-powered device forms a TV-like image from thermal radiation of objects in view. It can be mounted on a ground tripod or installed on vehicles and will enable ground observers to detect people, vehicles, and field fortifications in total darkness.

Hughes has immediate openings for Field Engineers. Qualifications include U.S. citizenship, BSEE or Physics degree, willingness to travel, and experience in any of the following systems: electro-optical, infrared detection, laser ranging and target designation, or low-level-light TV detection. Please write: Professional Staffing, Hughes Aircraft Company, Field Service & Support Division, P.O. Box 90515, Los Angeles, CA 90009. Hughes is an equal opportunity employer.

An experimental laser communications system, developed by Hughes scientists under contract with the U.S. Army Electronics Command, provides a 5-megabit/second communications channel at 10.6 micron wavelength. With 1 watt output, and over the 8-kilometer path for which it was designed, the system is effective in all but the most severe weather. Keys to its high operating capability are the increased reliability and efficiency of the CO_2 laser in the transmitter and the optical heterodyne detection in the receiver. It has a potential in excess of 300-megabit data rate or 10 television channels.

technology abroad

Gunn oscillators that can be tuned by means of YIG spheres to the X band (8-12 GHz) and the C band (4-8 GHz) have been developed by Philips Research Laboratories in conjunction with the National Applied Physics Laboratory at Limeil-Brevannes, France. Output powers of greater than 20 mW have been achieved with temperature stabilities on the order of 0.5 MHz/°C. The research studies were undertaken for S.A. RTC-La Radiotechnique Compelec of France. The development of complete microwave generators is now planned. The group will also study the operating characteristics of Q-band devices.

CIRCLE NO. 391

Any part of a video tape recording can be located within 0.1 second without modifying the recorder when using a new English digital information system. The system—called the Tapecord—numbers every frame of a video recording without interfering with the picture content. A solid-state display shows the frame data during both recording and playback. Data added to the tape may be: elapsed time, 24-hour clock time, digital counts up to eight digits, or a binary coded output from a computer or other video tape. Produced by Video Electronics Ltd., Manchester, England, the system cost is about $800.

CIRCLE NO. 392

A computer-controlled spectrophotometer system to improve color matching in textiles will be used by the British wool textile industry. The spectrophotometer, made by Pretema AG of Zurich, measures varying intensities of colors in a sample piece of fabric and transmits this information to the minicomputer. The computer evaluates the data and derives a formula for selecting the dies that will produce the same color as that on the sample fabric. The result appears on a teleprinter. Whereas a trained operator might take up to five days to produce a perfect match, the complete computer-controlled operation takes only five seconds.

CIRCLE NO. 393

The first commercial long-distance telephone system capable of transmitting up to 10,800 simultaneous conversations over one pair of coaxial cables will be put into service by Sweden next year. Equipment for terminal operation has been developed by the L.M. Ericsson Telephone Co. under contract to the Swedish Telecommunications Administration. The system will connect cities 100-km apart.

CIRCLE NO. 394

Mapping of star radio sources to within a few seconds of arc—a degree of accuracy never before achieved—will be provided by England's latest radio telescope. Using an array of eight 42-foot dishes (four fixed and four steerable) based over a three-mile range, the system will provide a resolution that is equivalent to that of a single steerable dish having a three-mile diameter. The system is operated by a Marconi Myriad II computer that steers the antenna and also controls a complex cable delay-network that equalizes the phase delays of the signals from the different antennas.

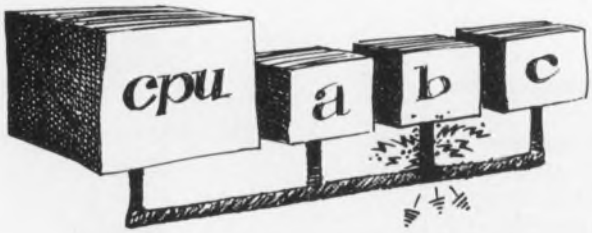
CIRCLE NO. 395

A new type photodetector combining a metal-type junction with an MOS capacitor structure has been studied by researchers at the Central Research Laboratories of Thomson-CSF in France. The device, which is a photo-MOS diode, has been tested experimentally using both indium and antimony as photo elements. These photodevices are expected to be fabricated in photomosaic arrays for sensing data in optical memory.

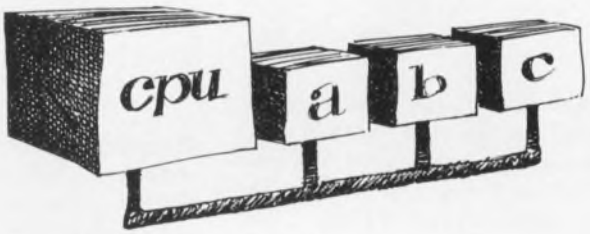
CIRCLE NO. 396

Aha!

Before Bus-Guard*



After Bus-Guard*



If you've been plagued by costly, time-consuming data bus line loading problems, our new family of Quad-Tri-State* Party Line Transceivers is just what the doctor ordered.

BUS-GUARD, EXPLAINED Thanks to an exclusive new active ingredient called Bus-Guard (made possible through the miracle of Tri-State logic), our new LM 132 series transceivers insure that the *computer bus line remains active even when one of the terminals sharing the line is down.*

ALL IN THE FAMILY But that's not all. The new DM7833, 34, 35 and 39 series also comes with a built-in hysteresis of 400 mV. *And* a receiver input current of just 50μA maximum. (Which is two orders of magnitude better than anything now on the market. Which also means at least 20 driver/receiver pairs can utilize a single bus.)

MORE INTERFACE CIRCUITS WHERE THESE CAME FROM For complete data on our new DM7833, 34, 35 and 39 series of Quad-Tri-State Party Line Transceivers (as well as our other great Interface Circuits), just call (408) 732-5000.

Or write National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051.

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National

washington report

Major shuffles due in Congressional posts

Changes in the chairmanship of the two Congressional space committees are due as a result of this year's elections. The House Science and Astronautics Committee chairman, George P. Miller (D-Calif.), lost a primary election, paving the way for Olin Teague (D-Tex.) to take over the post. Teague, who would have to surrender his leadership of the Veterans Committee to succeed Miller, is—like the Californian—a staunch advocate of a strong space program.

On the Senate side, Stuart Symington (D-Mo.) is in line for the chairmanship of the Aeronautical and Space Sciences Committee because of the retirement of Sen. Clinton P. Anderson (D-N.M.). Symington, a former Air Force Secretary, has generally been a tougher critic of some of the Government's big programs than Sen. Anderson has.

Meanwhile the defeat of the influential Republican Senator from Maine, Margaret Chase Smith, means that Strom Thurmond (R-S.C.) becomes ranking minority member on the Senate Armed Services Committee.

Justice Department vs. IBM

The Justice Dept. is hoping Judge David Edelstein of the U.S. District Court will decide not to grant IBM's request for an early trial to determine what portion of the computer market the great company actually controls. Antitrust division attorneys, already handling several other large antitrust cases, say such an early trial would take manpower away from their efforts to discover specific instances in which the company may have acted in a way to monopolize the market. Meanwhile, Computer Industries Association's Dan McCurk reports that industry executives attending special meetings across the country have agreed to back the Government's suit.

EIA sees rise in Government electronics spending

A rise in electronics content of most major Government programs is predicted for the 1970s by the Electronic Industries Association. The EIA estimates that electronics will account for 16.6% of a $94-billion defense budget by 1980 and 41.3% of a $3-billion NASA research and development budget.

In other Government spending, the trade association sees electronics accounting for $426-million of a $2.4-billion Federal Aviation Administration budget by 1980; $201-million of a $6.6-billion Federal Highway Administration budget; $48-million of an $822-million Urban Mass Trans-

portation Administration budget; $168-million of a $6.1-billion Health, Education and Welfare budget, and $455-million of a $3.9-billion Environmental Protection Agency budget.

New commerce trade office opens

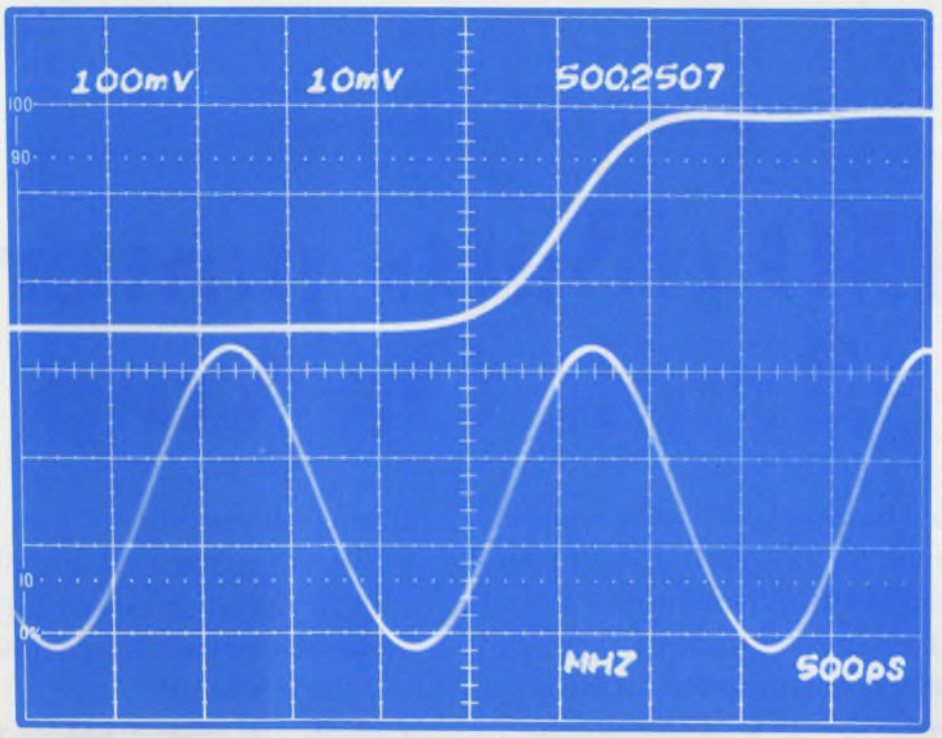
In line with the Nixon Administration's goal of improving relations with the Soviet Union and mainland China, the Commerce Dept. has opened a new office here to foster increased exports to communist countries. The new East-West Trade Bureau will include Russian, East European and People's Republic of China desks, as will the U.S. Export Control Office and other advisory offices.

Space-shuttle subcontract race shaping up

North American Rockwell plans to start competition for major subcontracts on its space-shuttle project in about six months. Company representatives outlined the plans at three business symposia held late last month in Long Beach, Calif.; Fort Worth, Tex., and Boston. The company expects to let more than $1.3-billion in subcontracts on the $2.6-billion program. It has already released requests for proposals for design definition and fabrication of major structural components, and bidders' conferences for these projects will be held this month or next. Intermetrics, Inc., has been signed to provide an advanced programming language for the shuttle flight computers.

Capital Capsules:

President Nixon's former campaign director, Clark MacGregor, is expected in his new job with the United Aircraft Corp. **to "tell the business story" to the Government.** United Aircraft was named with 19 other companies in an antitrust suit by the Justice Dept. on March 19. . . . NASA and the Dept. of Health, Education and Welfare are **looking for the ideal remote community to field-test a new computerized system called the Integrated Medical and Behavorial Laboratory Measurement System.** Built by Lockheed, the system is designed to transmit medical information from remote areas on earth and in space. . . . The Pentagon reports that **Lockheed, for the fourth time, is the largest defense contractor** with $1.7-billion of defense business. This is an increase of 12% over last year, despite problems on several programs. . . . Apollo 17, scheduled to be launched Dec. 6, will repeat **an experiment to test the production of crystals in zero gravity.** NASA believes this may one day be more economical for the electronics industry than production on earth. . . . The Navy hopes to cure its communications ills, which have been sharply criticized by Congress, with the new fleet satellite-communications system it has contracted TRW Systems, Inc. to build. . . . Sen. William Proxmire (D-Wis.) reportedly is considering **a probe of the Defense Dept.'s ship overrun problems.** The Senator also called for grounding the F-111 aircraft after recent losses in Southeast Asia. . . . In line with its effort to streamline bureaucracy, the White House is considering **merging the Defense Supply Agency with the General Services Administration.** DSA buys many standard electronic items used by all three services. . . . NASA is reportedly asking for $3.4-billion for fiscal 1974. Although the space shuttle is the biggest single item on the budget, **the agency is trying hard to show the relevance of space research to earth problems.** Skylab, scheduled to go into orbit next spring, will carry a number of earth resources projects.



CRT READOUT

CHAR. SET ABCDEFGHIJKLMNPQRSTUVWXYZ0123456789mμnpd↓</.>Δ±-Ω

Actual Size

TEKTRONIX 7000-Series Oscilloscope Systems

CRT READOUT, unique to the *TEKTRONIX 7000-Series Oscilloscope Systems,* provides a combined display of waveforms, measurement parameters and symbols on the CRT for direct reading.

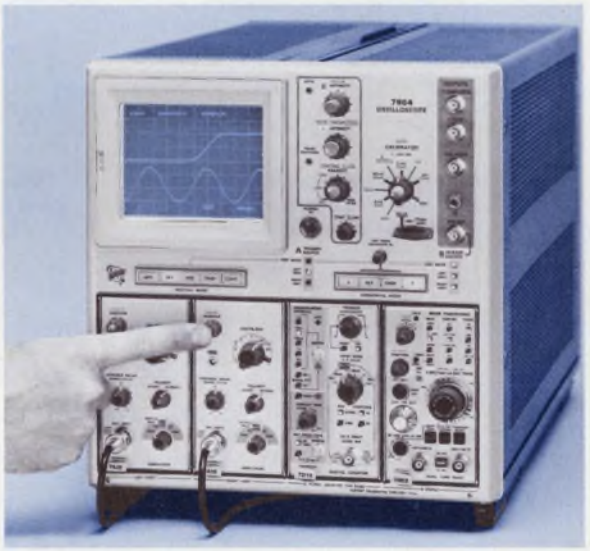
Wrong answers because of overlooked control settings are now passé. CRT READOUT tells you the full story. Speed, perception and convenience are available because the scale data is printed right on the display. These values are automatically corrected for both probe attenuation and sweep magnification. There are also special symbols for identifying trace position (IDENTIFY), amplifier polarity (↓) and uncalibration (>).

Correct answers are always on your photographs with CRT READOUT. The photos will show the waveforms along with their parameters and symbols — A REAL TIME SAVER.

CRT READOUT is available for 7000-Series plug-ins working in *frequency, time, voltage, current, resistance* and *temperature* domains - - - AND there are MORE coming.

CRT READOUT functions in all 7000-Series mainframes and plug-ins except those having a suffix N (7403N, 7B53N, etc.).

Tektronix, Inc. lease and rental plans are available in the U.S.A. For information, call your local TEKTRONIX Field Engineer or write: Tektronix, Inc., P. O. Box 500, Beaverton, Oregon 97005.



CRT READOUT responding to various functional instructions and generating up to 50 symbols is shown using the 500-MHz 7904, a four-plug-in Oscilloscope with a pair of 500-MHz, 10-mV 7A19 Amplifiers, a 525-MHz 7D14 Digital Counter and a 500-ps/cm 7B92 Dual Time Base.

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INFORMATION RETRIEVAL NUMBER 29

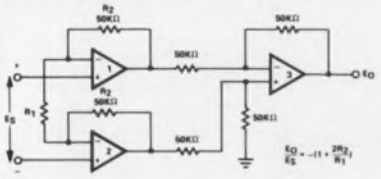
Here's a versatile new IC for
portable or battery-powered instrumentation

150 μWatts powers Triple Op Amp

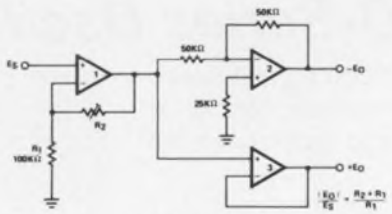
The Siliconix L144 is a *low-power* monolithic IC with three complete op amps and a common bias network on the same substrate. The circuit operates over a power supply range of ±1.5 to ±15 V, with a supply current set by an external bias resistor. With a ±1.5 V battery, only 50 μA is required for all three op amps!

Other features:

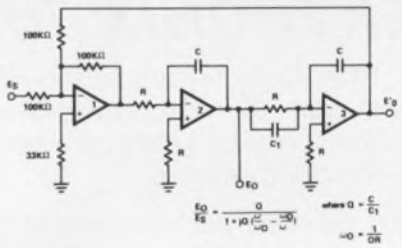
- Internal compensation provides stable operation for any feedback circuit—including capacitive loads >1000 pF
- 80 dB gain with 20KΩ load
- Typical slew rate 0.4 V/μsec
- Military or commercial versions available



Instrumentation amplifier for high input impedance with differential operation.



Precision phase splitter with good gain, high input impedance, low output impedance.



Active filter with high Q and excellent stability.

Applications? Above are three suggestions.
There are more: Low-drift sample-and-hold, inverting amplifiers, voltage comparators, and so on.
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INFORMATION RETRIEVAL NUMBER 30

editorial

A civilian NASA? It'll take a little push

A coordinated effort is needed to apply this nation's scientific manpower and resources to the solutions of problems in such areas as health care, poverty, public safety, pollution, unemployment, productivity, housing, education, transportation, nutrition, communications and energy resources. This effort is best organized through a single administration with wide-ranging authority to plan and spend. An organization with the same dedication to purpose as NASA is what is required.

Such an organization is close to reality. It is part of a bill before the House of Representatives called the National Science Policy and Priorities Act of 1972, or S.32. The bill declares the following as national policy: (1) Federal funds for science and technology must be raised to an adequate level and then continue to grow in proportion to the growth of the GNP; (2) There must be continuing employment opportunities for scientists, engineers and technicians in positions commensurate with their capabilities; (3) Federal funds for civilian research and engineering must be maintained at least at a level of parity with Federal funds for defense research and engineering; and (4) Federal funds for civilian research and engineering must be focused on meeting human needs in national priority problem areas.

The civilian NASA is to be called the Civil Science Systems Administration. It is to be under the National Science Foundation. The new authority would have broad-ranging power to plan and fund civil systems projects. It would be advised by the National Science Foundation Board. The foundation would be required to develop the basic policies for the use of technology in solving civil problems, and the new authority would work within those guidelines.

Additional parts of S.32 require the study of the transition of manpower to civilian programs and the protection of pension rights of engineers and scientists. The National Science Foundation would assist state and local governments in formulating transition programs and would give placement assistance. Pension-right protection would be through a rewriting of Federal procurement regulations.

The Senate version of the bill was passed on Aug. 17. It provides for spending $1.02-billion over three years, from 1973 to 1975. The House version also provides $1.02-billion, and did not get out of committee in this session of Congress. Why not write your Congressman and push for speedy passage of this bill.

David N. Kaye

DAVID N. KAYE
Senior Western Editor

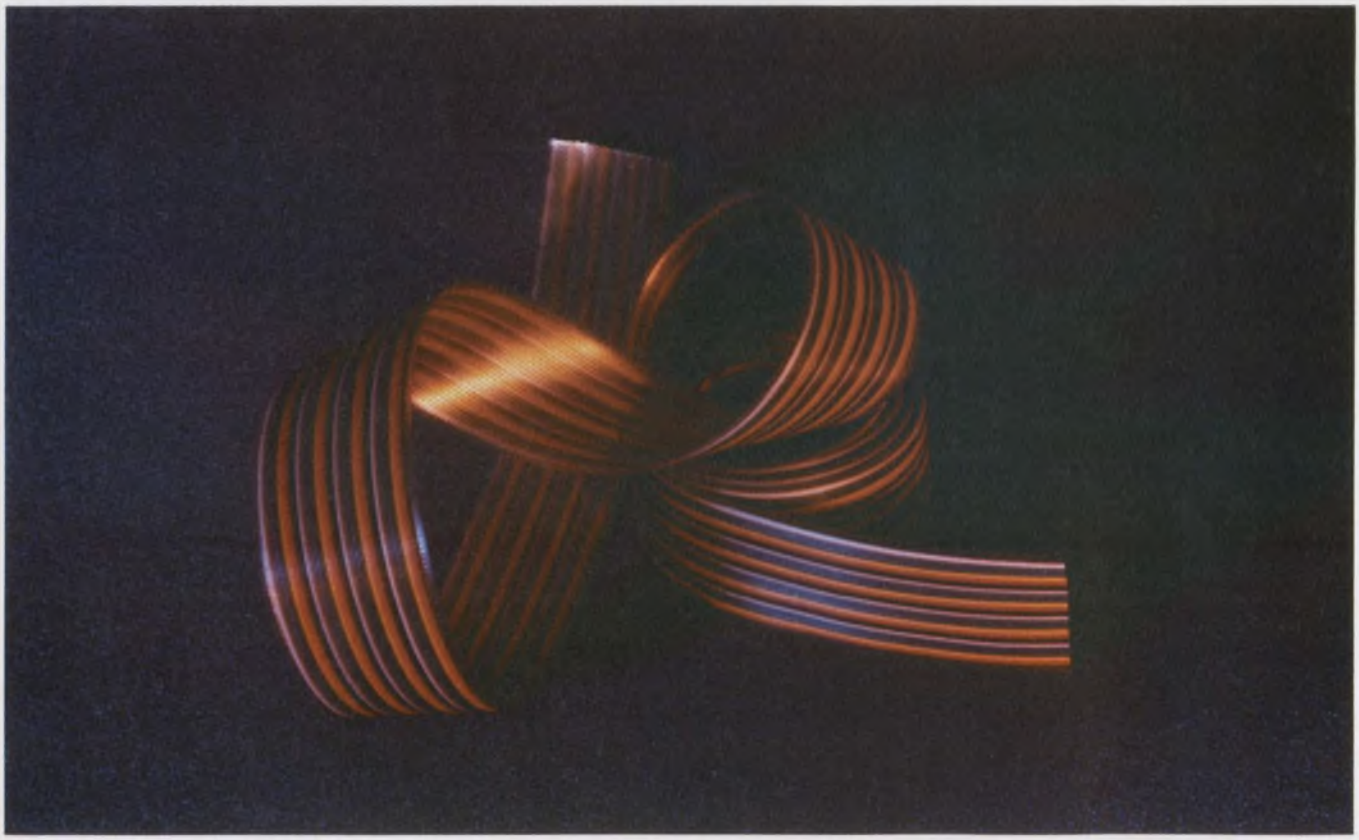
FOCUS on Flexible flat cable and PCs

Flat flexible wiring offers so many advantages that you'd think conventional round wiring would be obsolete by now. But it isn't. Why not?

It boils down to this: Flat flexible cable can offer the optimum solution to many wiring problems. But it's tough to specify it, because there are few published specs. Typical data sheets say more about the limits of the manufacturer's capability than about matching his wiring to a specific application.

The designer must be thoroughly familiar with the options and tradeoffs in flat flexible cable because he'll likely end up telling the manufacturer in detail what he wants. Off-the-shelf styles —when they exist—can't satisfy the require-

Richard Lee Goldberg
Associate Editor



Spectra-Strip's 3C Controlled Characteristic Cable uses a copper-mesh ground-plane shield to increase isolation and reduce crosstalk. It is compatible with all standard connectors that accept round conductors.

ments of all designs. Vendors are reluctant to stock flat flexible cable in a large variety of sizes and styles because of small demand. For this reason, most of the cable being made today is custom-manufactured. Usually, the buyer simply can't look in a catalog and specify a part number.

But for the designer who persists, flat flexible cable has decided advantages where weight, size and the labor cost of the installation are critical. Consider military and aerospace systems, computers and consumer products. The interconnection task is large, and reliability is essential. Flat flexible cable is commonly used.

It's a product with a promising future, too. The automotive and construction industries, appliance manufacturers and machine-tool makers —all are considering the replacement of conventional wiring with flat flexible.

Two major types available

In specification, start with the basics. Flat flexible cable consists of parallel insulated conductor lines held together in one plane. There are two major categories: *extruded-conductor cable* and *etched-conductor cable.*

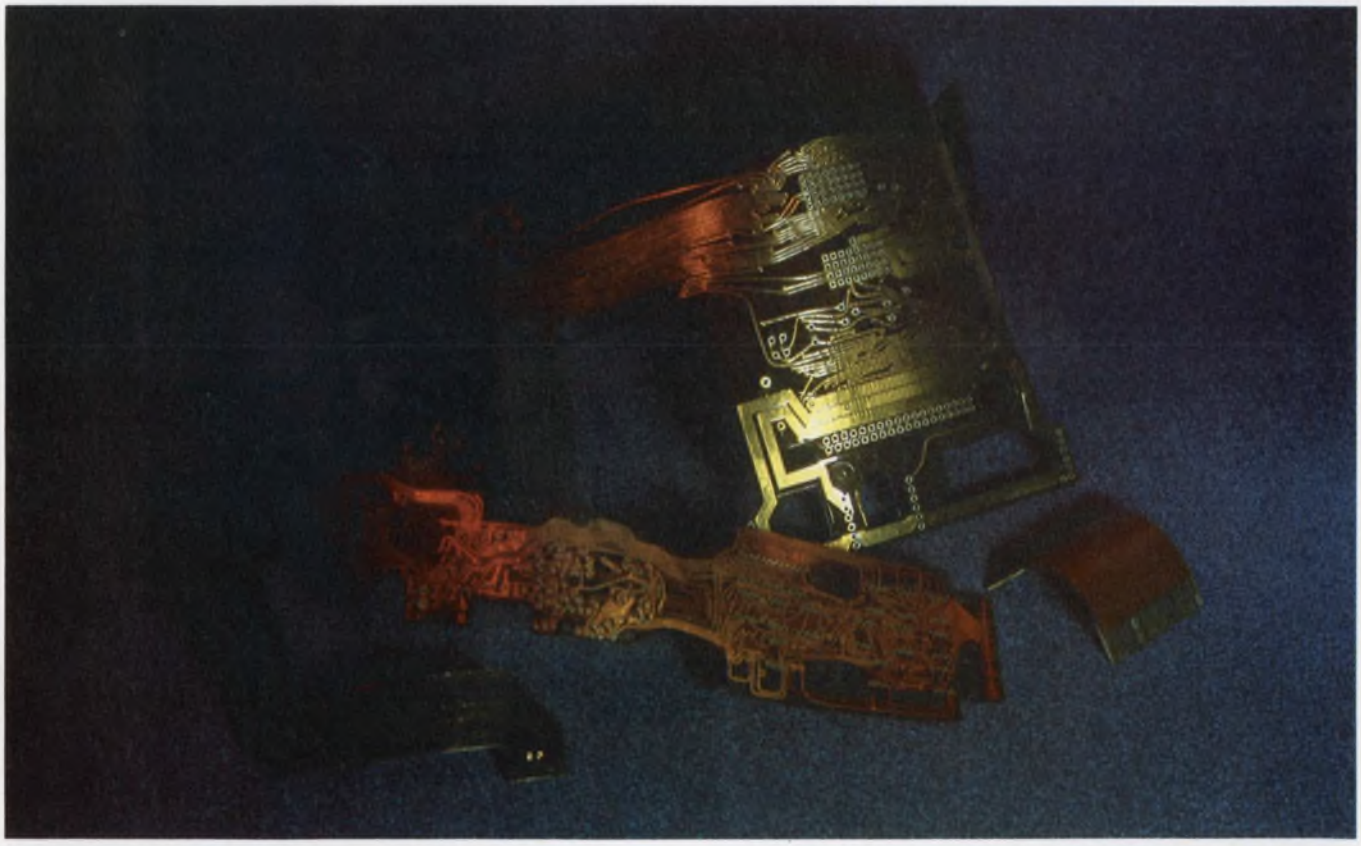
Under extruded, three options—describing ways in which the conductors and insulators are held together: *bonded, laminated* and *woven.* Here are some of the leading characteristics of each:

Bonded cable. Made in the same way as conventional insulated wire and the cheapest of all styles. It has the appearance of individually insulated wires stuck together in a row by fusing of their insulations. The conductors can be extruded in any shape, but for economic reasons, they are generally round. Round-conductor flat cable is commonly referred to as ribbon cable.

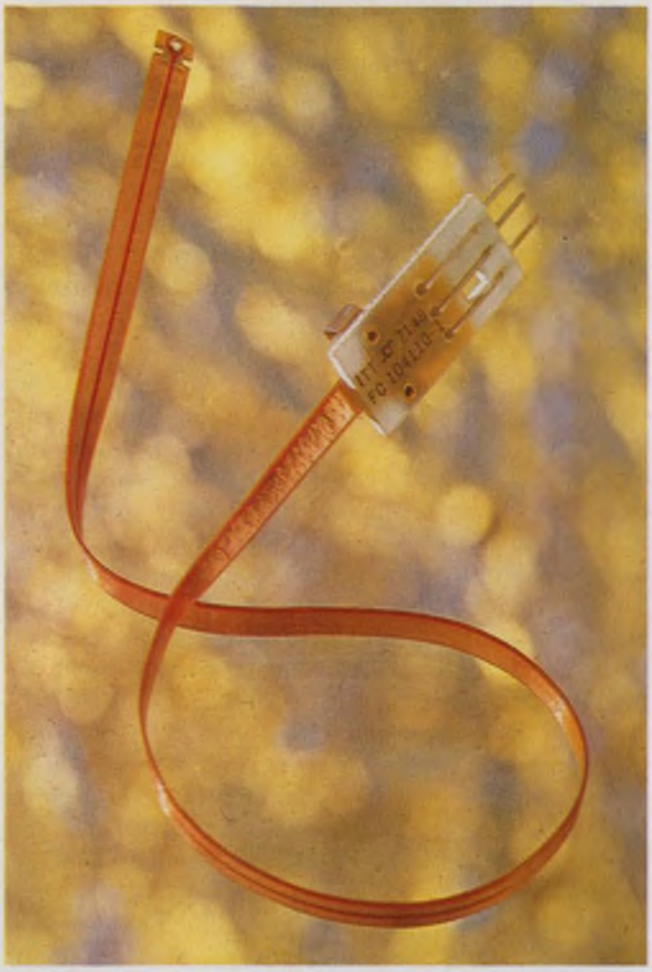
Laminated cable. Offers a choice of either round or rectangular conductors, or even both in the same cable. In the lamination process the conductors are laid between two sheets of insulation. The insulating layers are usually pretreated with an adhesive that reacts to heat and pressure. For high-temperature insulations, such as Teflon, fusion-bonding with heat and pressure works without an adhesive. When adhesives are used, their temperature characteristics must be matched to those for the insulation.

Woven cable. A version of ribbon cable in which the individual conductors are woven together in a flat configuration. It allows slight movement within the cable, for added flexibility, and the possibility of conductors with different individual insulations.

The second major category of flat flexble cable —etched conductor—is formed on a common,



Flexible printed circuitry from Parlex Corp. comes with crossovers to circumvent the limitations of predetermined connector addresses. Plated-through holes provide interconnections for two-sided and multilayer boards.



Laminated three-conductor power lead from ITT Cannon Electric acts as a jumper cable between a PC board and a wrapped-wire termination.

flexible substrate. It can be thought of as a replacement for a rigid printed circuit, a flat flexible cable and appropriate connections, all in one package:

Etched-conductor cable has conductors of rectangular cross-section only. The etching process is similar to that for printed circuits. In fact, if the conductors run in nonparallel patterns, the resulting etched wiring is known as flexible printed circuitry.

Guidelines in specification

Comes now the nitty-gritty in specifying extruded-conductor cable. It's not enough merely to pick a broad category of cable—bonded, laminated or woven. Three other major decisions are involved:

1. The shape of the conductor.
2. The kind of insulation to be used.
3. How to terminate the cable.

Flat vs round conductors

Like conventional round wires, and unlike flat conductors, round-conductor cables are easy to terminate. Conventional-wire connectors are, of course, designed for round conductors. Unfortunately most round-wire connectors don't allow termination of more than a dozen conductors. So it is only for cables with less than a dozen conductors that round conductors are easier to terminate. For larger numbers of conductors, other termination schemes, such as mass bonding and welding, must be used. These work at least as well for flat conductors as round, thus offsetting the advantage of round conductors.

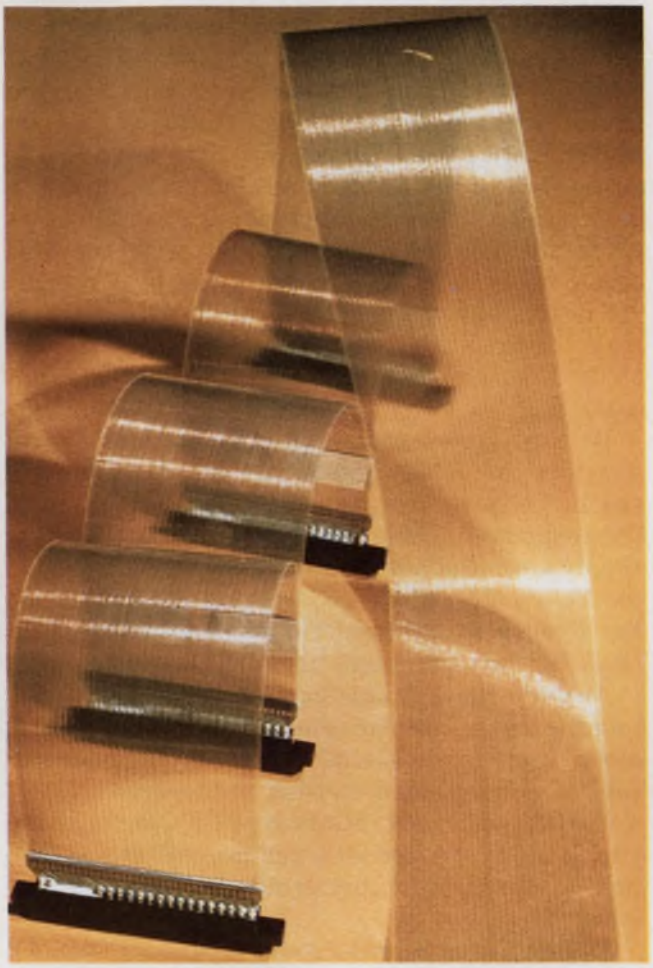
Flat conductors are usually more flexible than round—but not if the round conductors are stranded. Flat conductors tend to be better for continuous-bending applications—but only over a limited range of wire sizes. For conductors smaller than No. 34 AWG (or the equivalent size for flat conductors), the conductor shape has negligible effect on flexibility. For wire sizes larger than No. 26 AWG, both round and flat conductors become so stiff that they tend to break after several flexes (though manufacturers of flat-conductor cable claim that, even in heavier gauges, flat cable still offers superior life. One company cites a six-to-one flex-life advantage for 4 × 125-mil flat wire when compared with No. 22 AWG round wire, which has the same cross-sectional area.) It's generally agreed, however, that only for conductors between No. 26 and No. 34 AWG do flat conductors have a useful flexibility advantage.

With their greater surface-to-volume ratio, flat conductors can carry more current than round. Thus, for the same current, a smaller-sized conductor can be used, reducing cable weight and bulk. But though flat conductor cables are thinner, ribbon cables, using round conductors, are narrower. They have about a third the width of flat conductor cables of the same current capacities, because the individual round conductors are narrower than equivalent flat conductors.

Flat conductors dissipate heat better than round ones, because of their greater surface area. But at typical signal frequencies and power levels, heat dissipation usually is not a problem. Also, round conductors offer better electrical characteristics for transmission-line applications. Of course, the electrical characteristics depend on the insulation as well as on the size and shape of the conductors. So let's look at the important characteristics of the more commonly used insulation materials.

Which insulation?

Before specifying an insulation, the designer should consider electrical parameters, flexibility requirements, maximum temperature and other environmental factors. If the insulation meets these requirements, the decision then boils down



Preterminated cable from Ansley Electronics Corp. comes with flat conductors for maximum flexibility, or with mixed round and flat conductors.

to a straight-forward question of cost.

Mylar polyester is the cheapest type of insulation. Ribbon cable with Mylar polyester insulation is the closest in price to round wire harnesses of any flat flexible cable. It costs only about 20% more than a round-wire harness with the same insulation material and the same sized conductors. Mylar has the highest tensile strength and modulus of elasticity of any flat cable dielectric. If used with the proper adhesives, it works to 150 C. Some companies offer self-extinguishing types of polyester.

Polyvinyl chloride, polyethylene and polypropylene are priced about the same as Mylar but have only about 25% of its tensile strength. Their upper temperature limits range from 80 C for polyethylene to 125 C for polypropylene. Only PVC is self-extinguishing.

Silicone rubber is probably the best choice for continuous flexing applications. But don't expect much strength. It has only 1/25th the tensile strength of Mylar.

Teflon ranks next on a scale of ascending prices. Teflon FEP works to 200 C, offers excellent chemical resistance, does not burn and is easy to strip thermally. Teflon TFE operates to 250 C, the highest rating of any existing cable insulation. Both FEP and TFE can be bonded without adhesives. But with a tensile strength roughly a tenth that of Mylar, they are susceptible to cold flowing.

Kapton polyimide, though increasingly popular, is the most expensive insulation. It combines the strength of Mylar with the high temperature rating of Teflon TFE, while exhibiting less shinkage and more stability than any of the other insulations.

Combinations of materials can, in some cases, combine their advantages. For example, vinyl can be added to Kapton to reduce cost without sacrificing strength.

What termination?

The termination choices for flat flexible cable are limited by the number of conductors and their configuration. The connector type and spacing must be compatible with the cable material. To be used with automatic termination systems, for example, the cable must have exact pitch. For cables that have more than a dozen conductors and for large-volume orders, the designer should consider a ready-made and terminated cable system.

Soldering is the most popular termination method. For prototype cable assemblies, hand soldering works satisfactorily with many available types of conventional round-wire connectors. But since hand soldering is sequential and slow, it is not suggested for cables with more than about a dozen conductors. Bar soldering allows all the conductors to be fastened simultaneously, but it is usually restricted to PC board connections and cables with pitch (center-to-center spacing of conductors) of greater than 40 mils.

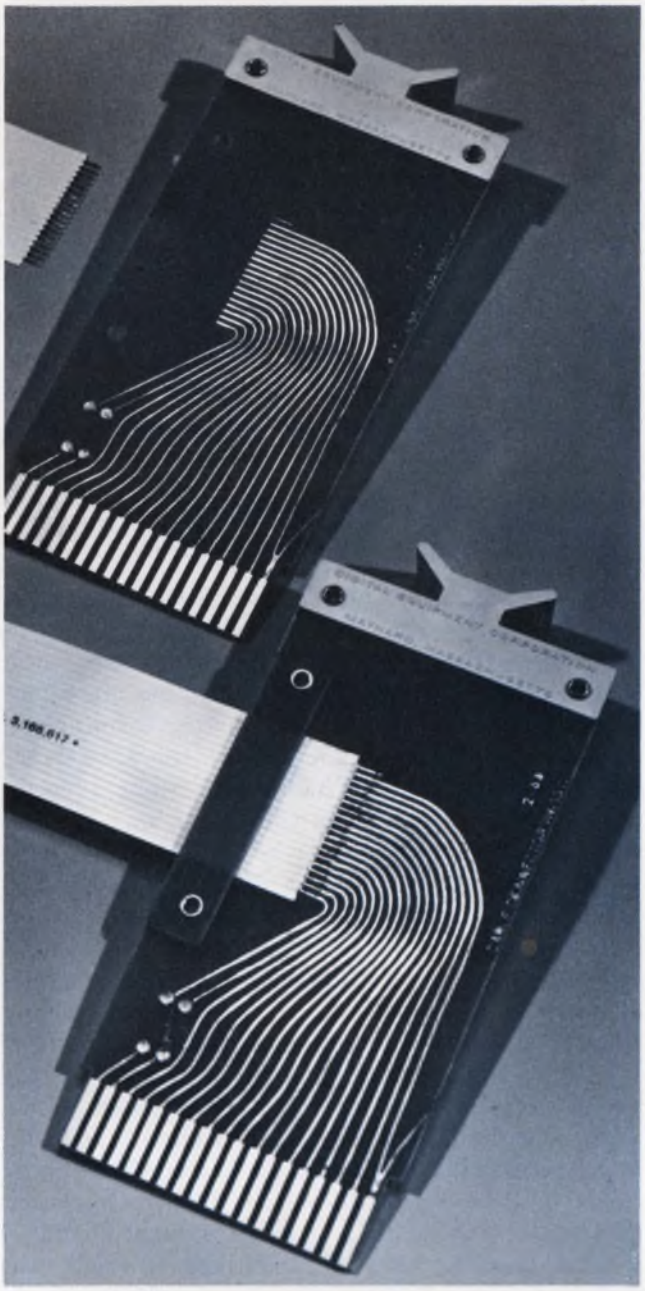
Mass bonding uses infrared heat to create reflow solder, and thereby simultaneously to attach up to 500 conductors to a connector. In this case, the conductor pitch can be less than 40 mils.

Crimping offers advantages in field servicing, because it requires only hand tools. This method has a lower pitch limit of about 100 mils and can be only partly automated. It requires a precisely pitched cable.

Some specialized connectors have piercing contacts that penetrate the insulation. The technique provides a suitable termination for cables with fewer than two dozen conductors.

In the so-called pressure method of termination, the cable conductors serve directly as contacts. But first they must be separated and spread apart. Each conductor is forced between two cantilever spring members in the socket. Some sockets require tinned conductors.

Welding is the most secure termination method, but it is also the most expensive. Since weld-



Burndy's S1281 laminated cable attaches to a PC right angle by reflow soldering. This termination technique is especially popular among computer manufacturers.

ed joints are the most reliable, they are used in military and aerospace applications, where shock and vibration are major considerations.

Don't overspecify

A few words of caution: When specifying flat flexible cable, an engineer should, of course, include tolerances. But if tolerances are overspecified in the hope of getting a better product, you may get only a more costly one instead.

In pursuit of optimum performance, designers may specify flat cable per MIL-C-55543. But this standard lists over 1200 possible cable styles, many of which represent impossible combinations of cable characteristics. Some performance requirements can't be met by existing technology. And no single manufacturer offers all the types listed. Commercial spec IPC-FC-220 (published by the Institute of Printed Circuits) is generally acknowledged by cable manufacturers to be a more realistic spec. Unfortunately, not all users of flat flexible cable are familiar with the IPC spec.

Though flat flexible cable is largely custom-manufactured, the standard products that are stocked demonstrate the range of possible applications.

Burndy mixes round and flat conductors in one type of cable, and a variety of conductor spacing is available. Gore's PSE Multi-Strip, a flat-conductor cable with polyester self-extinguishing insulation, meets all the requirements of IPC-FC-220, Type BS, Tolerance Class IV. It has tolerances designed for commercial applications that use automatic termination systems.

Ansley's Black Magic cable features low crosstalk for signal-transmission lines. 3M and several other companies specialize in round-conductor cable for signal-transmission applications.

Parlex, AMP, 3M, Methode, ITT Cannon Electric, S/Ronics Associates and several other companies manufacture preterminated cable assemblies.

Rogers Corp., Storm Products Co. and Calmont Engineering produce ribbon cable designed for dynamic flexing applications. Calmont's Siliflex and Storm's Flex cable both have silicone rubber insulations. Siliflex comes with up to 500 conductors in sizes from No. 40 AWG to 14 AWG.

Brand-Rex PVCA cable uses a single aluminum conductor large enough for power-distribution applications. Daburn and many other companies also make flat flexible cables with PVC insulation.

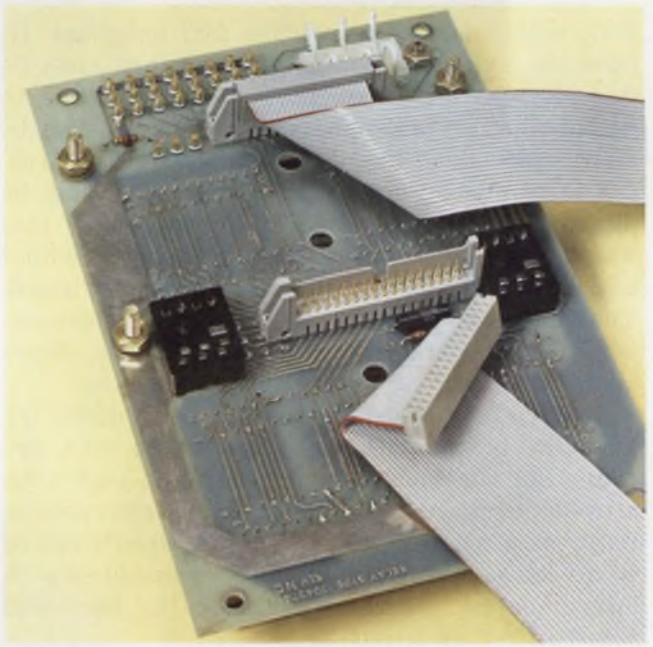
Woven cable is manufactured by Woven Electronics, Philadelphia Insulated Wire and several other vendors. The conductors are individually color-coded and can be separated for easy termination without additional apparatus.

Flexible printed circuitry has great promise

Flexible printed circuitry offers many of the same advantages over rigid PCs that flexible flat cable does over more rigid cable harnesses. An important advantage is that flexible printed circuitry can be tucked into tight spaces. Its efficiency here surpasses even that of flat flexible cable when the latter links several rigid PCs.

But, like flexible flat cable, flexible printed circuitry is not as widely used as you might expect it to be. The main reason—difficulty in specifying—parallels that for flat flexible cable. But there are other reasons peculiar to flexible PC—

Laminated flat-conductor cable from AMP, Inc., comes preterminated for easy installation.



Ribbon cable from the 3M Co., preterminated to a PC connector, plugs directly into a PC board socket. This allows rapid circuit-board changes.

the circuit's reputation as a high-cost item, used only where weight and space restrictions prevent the use of rigid PC boards, for example. Most engineers think of flexible circuits as an expensive and glamorous commodity. In most cases it is used only when nothing else will work. But flexible PC boards can be even better suited for high-volume, commercial products than rigid boards are.

Whereas there are some off-the-shelf flexible cables, all flexible PCs are custom-made. The vendor is not selling a product but rather a process and a capability. Unfortunately, flexible PCs do not allow for breadboarding; therefore the designer must determine the requirements for his particular application.

Among the things the designer will consider in drawing up his specs are these:

Laminates. In addition to Kapton polyimide, Mylar polyester and Teflon, the more popular glass epoxy is available. It's similar to that used for rigid PC boards, but it's much thinner. Combinations such as a polyester-impregnated glass mat or an epoxy-impregnated woven glass can boost impact strength without greatly increasing the cost.

Density limitations. Many of the design problems with flexible PCs are similar to those for rigid PC boards. For example, if the density is such that very fine lines—say, 10 mils—and tight spacings—25 to 30 mils—are required on a single-sided board, prices and delivery times increase markedly. If the use of both sides of the board allows wider lines with larger spacing, a two-sided board may actually cost less. In any event, fine lines and close spacings should be avoided where possible. A tiny speck of dust that wouldn't bother 25-mil lines on 50-mil centers can cause a defect in a 10-mil line. A speck of dust in a resist coating, for instance, could interrupt a fine line or short out adjacent lines with small spacing. And if that speck of dust appears on a large board, the defect can be really costly. Therefore, it's wise to keep dense boards small.

Line spacings are also dictated by the spacing between holes on a board and by the diameter of pads. A finished hole should have a diameter that is about 10 mils greater than the diameter of a component lead (and perhaps more for automatic insertion). Thus the hole may have a diameter of 30 mils for a 20-mil lead. The pad should have a diameter that is at least 10 mils greater than the hole diameter, which calls for a 40-mil-diameter pad. If 10-mil-wide conductors are on 50-mil centers, it's possible to put a 40-mil pad between them.

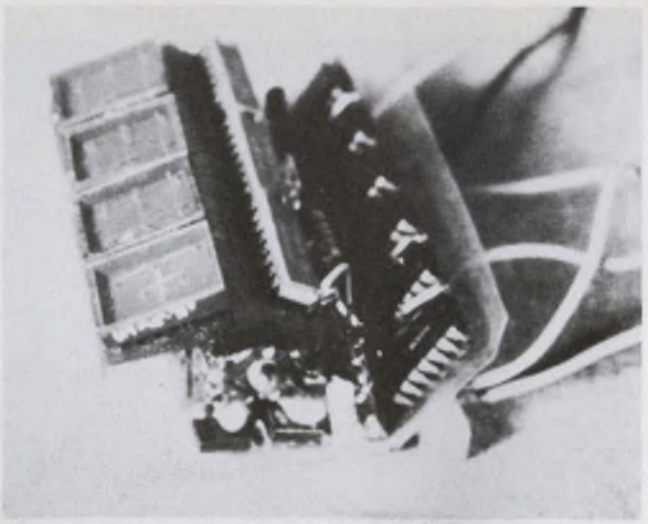
Tight tolerances

Avoid specifying them. Flexible circuitry need not be dimensioned as precisely as metal, because its flexibility and elasticity help to compensate for mismatched hole locations caused by loose tolerances or tolerance buildup. But for machine insertion, the hole-position tolerances will need to be tighter. Also, tight tolerances require precision tooling, resulting in higher manufacturing costs and longer delivery times.

Circuit complexity

As wiring on a board becomes more dense and as tolerances get tighter, dimensional stability increases in importance. A material of poor stability can be quite suitable for a single-sided board

Woven cable from Woven Electronics demonstrates easy conductor identification with color-coded insulations. Simple conductor separation facilitates termination.



Analogic's Model 2535-1 DPM with LED readouts has all of its circuitry on a single flexible printed circuit. Packaging is thus greatly facilitated.

Advantages of flat flexible cable are apparent in this complex interconnection task—the wiring of an IBM computer mainframe.

with rather large line widths and spacings. If, however, conductor widths and spacings must be decreased to less than 1/16 inch, you have to decide whether to use larger single-sided boards, more single-sided boards or double-sided boards.

The number of boards and their sizes may be dictated by the dimensions of the equipment into which the boards will go, as well as the number of components you're willing to mount on a board. The number of boards is also limited by the number of connectors you're planning to use. Small boards are also less susceptible to warping.

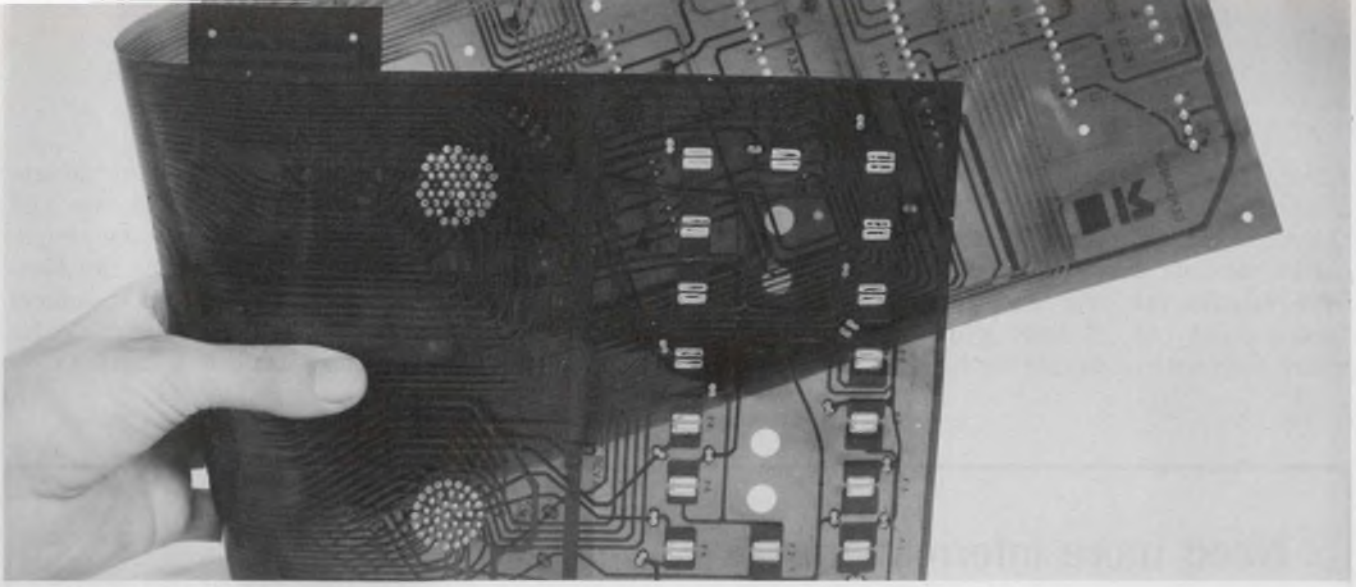
To keep both board size and quantity down, try two-sided boards with etched wiring on both surfaces. For the same wiring density on each side, a two-sided board generally costs at least twice as much as a single-sided board, but the two-sided board can save money if it allows wider lines with larger spacing. At the same time the two-sided board increases reliability.

The same consideration—circuit density—that encourages the use of double rather than single-sided boards also favors a transition to multilayer boards.

Most multilayer boards consist of thin layers (perhaps 2 or 4 mils thick) of copper-clad glass epoxy (usually G-10), sandwiched between layers of thin prepeg, perhaps 3.5 mils thick. The prepeg is an epoxy-impregnated glass cloth that's not fully cured. When subjected to heat and pressure, it liquifies, then gels as it flows around the printed wiring before it is fully cured and hardens.

It's possible to use a copper-foil plane for one layer. This can serve as a ground or shield plane for decoupling and reducing noise interference. Or, for greater flexibility, you can use a wire-mesh screen. It's possible to design strip transmission lines with controlled impedances from about 50 to 150 Ω.

Most vendors prefer two-sided copper-clad



Rogers Corp.'s multilayer two-sided flexible PC combines the complexity of a rigid multilayer with the flexibility of an etched flat flexible cable. The resulting flexible circuit is suited to dynamic flexing applications. Board strength is sufficient to support components over board areas of several square yards.

sheets to equalize strain on both sides, thereby reducing warping. Others feel they get lower scrap rates and more perfect sheet-to-sheet registration if they use single-sided sheets.

Each layer of copperclad is etched the same way a conventional rigid board would be etched. But the individual sheets must be lined up perfectly before they are pressed together to form a multilayer board.

The method of connecting from layer to layer differs among vendors. Most use plated-through holes. In almost all cases each hole goes through all layers, but the plating makes connection only at layers where a pad surrounds the hole.

Interconnections. With two-sided boards, you have to decide how to connect through the holes from one surface to the other. Through-hole plating is by far the most popular method. When it's used, it's necessary to maintain proper clearance between the hole and the component lead. If the hole is too small, the lead may not fit or solder may be unable to rise into the hole to make a good bond with the lead. If the hole is too large, there may be inadequate capillary action to drive the solder into the hole. This can pose a problem because of the variation in lead diameter.

Eyelets, preferred for many years as more reliable than through-hole plating, are costly. For small-diameter holes, the parts and assembly can cost twice as much as plating through. But they can be very useful in precise control of the position of force-fitted components. Eyelets have a further advantage in that they can be used in punched glass-epoxy boards.

The clearance-hole, or buildup, method for interconnecting layers is less costly, especially in small quantities, but it requires more space. In this method succeeding layers of laminate have increasingly larger holes. Each hole has a copper pad, and the copper pads are bridged during soldering. One advantage of this method is that it's not necessary to go through all the layers of a board. You can interconnect just the first three or four layers if necessary. But the outermost hole can get to be rather large.

Another method uses pillars of copper or electroformed nickel tubelets. These, too, don't require holes through all the layers, and they don't require successively larger clearance holes toward the surface.

Multilayer tradeoffs. Double-sided boards, too, may need interconnections from one surface to the other. Occasionally several layers are bonded together, and wide copper pads in corresponding positions are actually welded together. Holes can be punched or drilled through the centers of the welds. This structure is strong enough to support small components whose leads can be soldered into the holes. About seven layers, each about 2 mils thick, can be bonded together in this way. The resulting flexible multilayer is not overly flexible, but it can be bent around corners or "glued" to curved surfaces.

Flexible printed circuits come in a variety of types with different degrees of flexibilities, numbers of layers and types of materials. Parlex offers two-sided and multilayer circuits with plated-through holes. Schjeldahl mounts rigid stiffener boards to portions of a flexible circuit. This allows the mounting of components to a rigid structure in more than one plane without the use of jumper cables or the purchase of more than one circuit.

Rogers Corp. has developed a treatment, called MBT, for enhancing the bond strength of rolled copper. This combines its desirable mechanical properties of rolled copper with the good adhesion ability of electro-deposited copper. Buckbee-Mears Co. has narrowed line spacings to 2-mil lines on 5-mil centers. ITT Cannon Electric, AMP and S

Ronics Associates offer flexible circuitry preterminated to a flat flexible cable. This is perhaps the most versatile form of flat flexible wiring.

Flat flexible cable and flexible circuitry have been around for over 15 years. Yet, manufacturers point out, it took longer than that for many electronic concepts to be widely accepted.

As more designers become aware of the advantages of flat flexible wiring, sales will rise and prices should drop. As Wilhelm Angele, an articulate proponent of flat flexible wiring at the Marshall Space Flight Center, has said: "If engineers were more knowledgeable about flat flexible cable and PC, they wouldn't use anything else." ■■

Need more information?

The companies and products cited in this report have, of necessity, received only cursory coverage. The products mentioned don't represent the vendors' full lines. Readers may wish to consult the manufacturers listed here for further details:

Flat Flexible Cables

Accu-Flex, Inc., P.O. Box 177, Warrington, Pa. 18976. (215) 345-6688. **Circle No. 400**

Alpha Wire Corp., 711 Lidgerwood Ave., Elizabeth, N.J. 07207. (201) 925-8000. (Norman Miller, Vice President) **Circle No. 401**

AMP Inc., Harrisburg, Pa. 17105. (717) 564-0101. (James T. Pletcher, Product Information Manager) **Circle No. 402**

Ansley Electronics Corp., a subsidiary of Thomas & Betts Corp., Old Easton Rd., Doylestown, Pa. 18901. (215) 345-1800. (John Rocks, Sales Manager) **Circle No. 403**

Automatic Die Cutting Machine Co., 149 Church St., New York, N.Y. 10007. (212) 962-7658. (G. Cosgrove, Advertising Manager) **Circle No. 404**

Berk-Tek, Inc., Box 60, RD 1, Reading, Pa. 19607. (215) 376-8071. (Ray Lyons, Sales Manager) **Circle No. 405**

Brand-Rex Co., P.O. Box 498, Willimantic, Conn., 06226. (203) 423-7771. (George Graeber, Industry Manager) **Circle No. 406**

Burndy Corp., Richards Ave., Norwalk, Conn. 06856. (203) 838-4444. (Keith Woodman, Manager, Advertising and Sales Promotion, Components Group) **Circle No. 407**

Calmont Engineering & Electronics Corp., 420 E. Alton St., Santa Ana, Calif. 92707. (714) 549-0336. (Virgil George, Sales Manager) **Circle No. 408**

Cicoil Corp., 9324 Topango Canyon Blvd., Chatsworth, Calif. 91311. (213) 882-2021. (L. L. Longstaffe, Sales Manager) **Circle No. 409**

Daburn Electronics & Cable Corp., 2360 Hoffman St., Bronx, N.Y. 10458. (212) 295-0050. (Howard Danziger) **Circle No. 410**

Flexible Circuits Inc., Paul Valley Industrial Park, Warrington, Pa. 18976. (215) 343-2300. (Jim Hannun, Director of Marketing) **Circle No. 411**

General Circuits Inc., 95 Mount Read Blvd., Rochester, N.Y. 14611. (716) 235-2880. (Andrew Pluta, Vice President and General Sales Manager) **Circle No. 412**

W. L. Gore & Associates, Inc., 555 Paper Mill Rd., Newark, Del. 19711. (302) 738-4880. (Roger S. Kauffman, Product Specialist) **Circle No. 413**

Haveg Industries Inc., Super Temp Wire Div., Box 7, Winooski, Vt. 05405. (802) 655-2121. (Jim Brooks, Market Development Supervisor) **Circle No. 414**

Hughes Connecting Devices, 500 Superior Ave., Newport Beach, Calif. 92663. (714) 548-0671, ext. 535. (David Cianciulli) **Circle No. 415**

ITT Cannon Electric, a div. of ITT Corp., P.O. Box 929, 666 E. Dyer Rd., Santa Ana, Calif. 92702. (714) 557-4700. (R. L. Harmon, Director of Public Relations) **Circle No. 416**

ITT Wire & Cable Div., 172 Sterling St., Clinton, Mass. 01510. (617) 365-6331. (C. Gerald Generre) **Circle No. 417**

Jermyn, 712 Montgomery St., San Francisco, Calif. 94111. (415) 362-7431. (Janice Pascoe, Director of U.S. Operations) **Circle No. 418**

Methode Electronics, Inc., 7447 W. Wilson Ave., Chicgo, Ill. 60656. (312) 867-9600. (William Grell, Marketing Manager) **Circle No. 419**

Microdot Inc., 220 Pasadena Ave., S. Pasadena, Calif. 91030. (213) 682-3351. (Bill Hunter) **Circle No. 420**

Minco Products Inc., 7300 Commerce Lane, Minneapolis, Minn. 55432. (612) 786-3121. (Larry G. Hanson) **Circle No. 421**

Mohawk Wire and Cable, Box 707, Leominster, Mass. 01453. (617) 537-9961. (Richard Van Vleck, Sales Manager) **Circle No. 422**

3M Co., Electro-Products Div., 3M Center, St. Paul, Minn. 55101. (612) 733-1110. (Carl R. Goodwin, Senior Div. Publicist) **Circle No. 423**

New England Electric Wire, 365 Main St., Lisbon, N.H. 03585. (603) 838-6628. (C. McKenzie, Advertising) **Circle No. 424**

Parlex Corp., 145 Milk St., Methuen, Mass. 01844. (617) 685-4341. (Herb Pollack, President) **Circle No. 425**

Philadelphia Insulated Wire Co., a subsidiary of General Wire Corp., 333 New Albany Rd., Moorestown, N.J. 08057. (609) 235-6700. (W. J. Wind, Marketing Manager) **Circle No. 426**

Rogers Corp., Rogers, Conn. 06263. (203) 774-9605. (Robert E. Sanders, Product Manager, Mektron) **Circle No. 427**

Sanders Associates, Grenier Field, Manchester, N.H. 03103. (603) 669-4615. (Thomas Stewart, Marketing Manager) **Circle No. 428**

Spectra-Strip Inc., P.O. Box 415, Garden Grove, Calif. 92642. (714) 892-3361. (Jack H. Woolpert, Sales Office Manager) **Circle No. 430**

S/Ronics Associates, 2405 S. Broadway, Santa Ana, Calif. 92707. (714) 979-1493. (S. Rovin) **Circle No. 429**

Storm Products Co., 2251 Federal Ave., Los Angeles, Calif. 90064. (213) 272-5371. (George Heisler, General Manager) **Circle No. 431**

Tensolite Div., Carlisle Corp., W. Main St., Tarrytown, N.Y. 10591. (914) 631-2300. (Joseph Tavano, Vice President of Sales) **Circle No. 432**

Woven Electronics, a div. of Southern Weaving Co., P.O. Box 189, Mauldin, S.C. 29662. (803) 288-4411. (J. W. Burnett III, Sales Manager) **Circle No. 433**

Flexible Printed Circuts

AMP Inc., Harrisburg, Pa. 17105. (717) 564-0101. (James T. Pletcher,. Product Information Manager) **Circle No. 434**

Berk-Tek, Inc., Box 60, RD 1, Reading Pa. 19607. (215) 376-8071. (Ray Lyons, Sales Manager) **Circle No. 435**

Buckbee-Mears Co., 245 E. Sixth St., St. Paul, Minn. 55101. (612) 227-6371. (L. E. Dugan, Marketing Manager, Circuitry) **Circle No. 436**

Cinch-Graphik, Div. of TRW Inc., 200 S. Turnbull Canyon Rd., City of Industry, Calif. 91744. (213) 333-1201. **Circle No. 437**

Electro-Mechanisms, 29 Crown St., Nashua, N.H. 03060. (603) 889-6191. (Dan Simoef, Customer Service) **Circle No. 438**

Flexible Circuits Inc., Paul Valley Industrial Park, Warrington, Pa. 18976. (215) 343-2300. (Jim Hannun, Director of Marketing) **Circle No. 439**

General Circuits Inc., 95 Mount Read Blvd., Rochester, N.Y. 14611. (716) 235-2880. (Andrew Pluta, Vice President and General Sales Manager) **Circle No. 440**

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Parlex Corp., 145 Milk St., Methuen, Mass. 01844. (617) 685-4341. (Herb Pollack, President) **Circle No. 443**

Philway Products, Inc., 701 Virginia Ave., Ashland, Ohio 44805. (419) 322-1587. (J. F. Crunkilton, Director of Sales) **Circle No. 444**

Poly Cable, 5235 Rose, Rosemount, Ill. 600 8. (312) 671-1640. (Leo Hansman) **Circle No. 445**

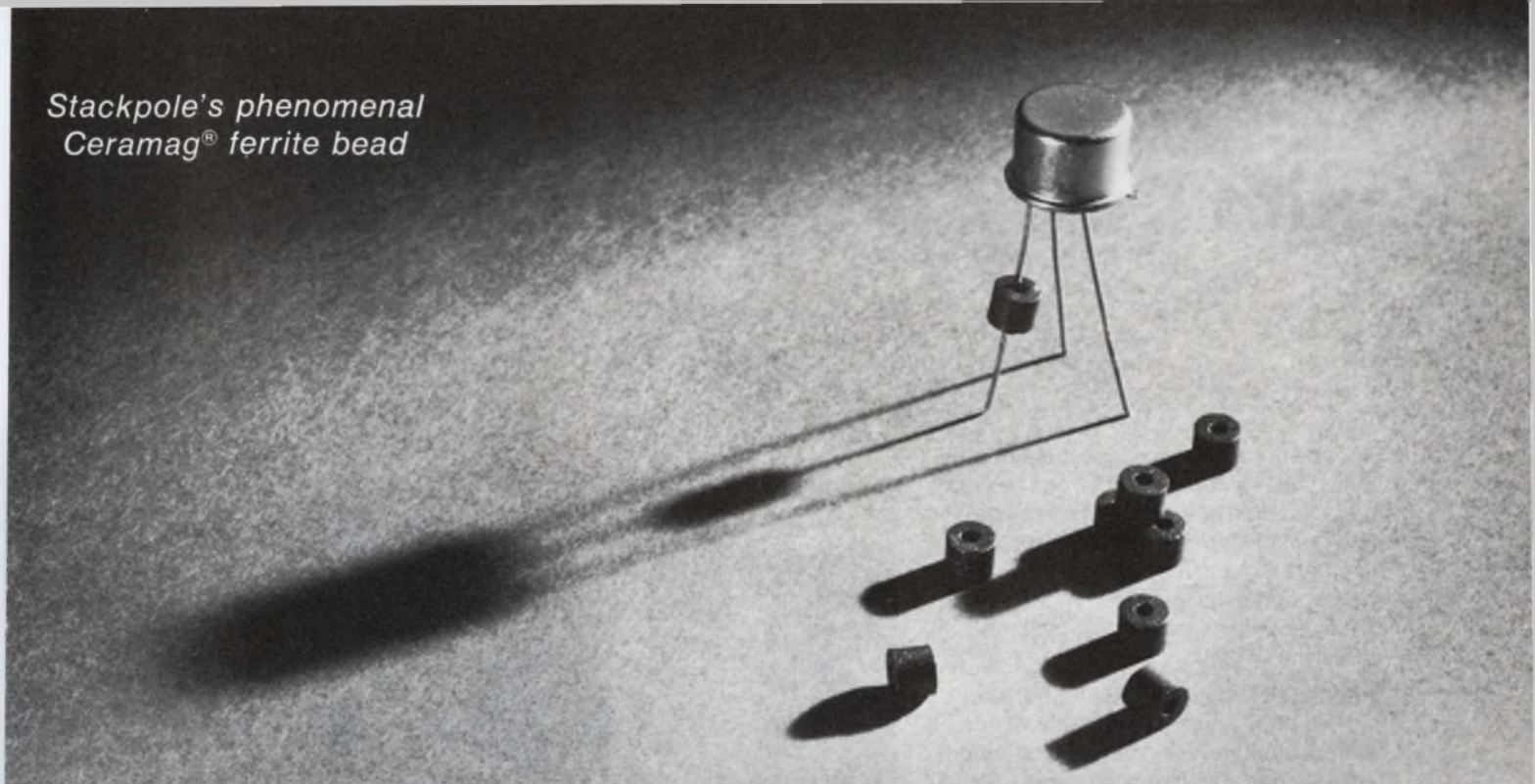
Rogers Corp., Rogers, Conn. 06263. (203) 774-9605. (Robert E. Sanders, Product Manager, Mektron) **Circle No. 446**

Sanders Associates, Grenier Field, Manchester, N.H. 03103. (603) 669-4615. (Thomas Stewart, Marketing Manager) **Circle No. 447**

G. T. Schjeldahl Co., Electrical Product Div., Northfield, Minn. 55057. (507) 645-5633. (Fred La Marche, Sales Application Engineer) **Circle No. 448**

Spectra-Strip Inc., P.O. Box 415, Garden Grove, Calif. 92642 (714) 892-3361. (Jack H. Woolpert, Sales Office Manger) **Circle No. 449**

S/Ronics Associates, 2405 S. Broadway, Santa Ana, Calif. 92707. (714) 979-1493. (S. Rovin) **Circle No. 450**

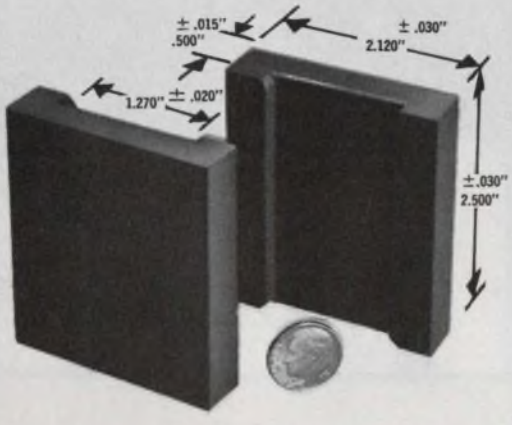


The Silencers

Ceramag® Beads Do Away with Noise

Stackpole ferrite beads offer a simple, yet effective means of suppressing spurious RF signals to prevent them from entering areas susceptible to such "noise." No other filtering method is as inexpensive as a ferrite bead.

How can you use a bead? Consider it as a frequency-sensitive impedance (Z) element. Beads are available in a variety of Stackpole Ceramag® materials. Depending upon the material selected, beads can provide increasing impedances. From 1 MHz to over 200 MHz. Keep in mind, the higher the permeability, the lower the frequency at which the bead becomes effective.



Should a ferrite bead be small? Not necessarily. The unique, giant bead shown below is used by IBM to eliminate the effect of transient noise.

The impedance of Stackpole ferrite beads can be changed by simply varying the length or the O.D.-I.D. ratio.

Installation of Stackpole beads is easy. And inexpensive. Simply slip one (or several) over the appropriate conductor(s) for the desired noise suppression or high frequency isolation.

Additional savings in production time and labor costs are possible by utilizing automatic insertion equipment to install ferrite beads *with leads* in printed circuit boards.

CERAMAG® FERRITE BEAD CHARACTERISTICS

	24	7D	5N	11
Initial Permeability	2500	850	500	125
Volume Resistivity @ 25°C	1.0×10^2	1.4×10^5	1.0×10^3	2.0×10^7
Effective Suppression At:	1 MHz.	20 MHz.	50 MHz.	100 MHz.
Curie Temperature	205	140	200	385

Beads are available in sleeve form in a range of sizes starting at .020 I.D., .038 O.D., and .050 long. For special compact filtering applications, beads can be supplied to tight mechanical tolerances.

Sample quantities of beads and beads with leads are available upon request. Send your requirements to: Stackpole Carbon Company, Electronic Components Division, St. Marys, Pa. 15857. Phone: 814-781-8521. TWX: 510-693-4511.

STACKPOLE
ELECTRONIC COMPONENTS DIVISION

INFORMATION RETRIEVAL NUMBER 31

Increase life expectancy with Dow Corning silicones.

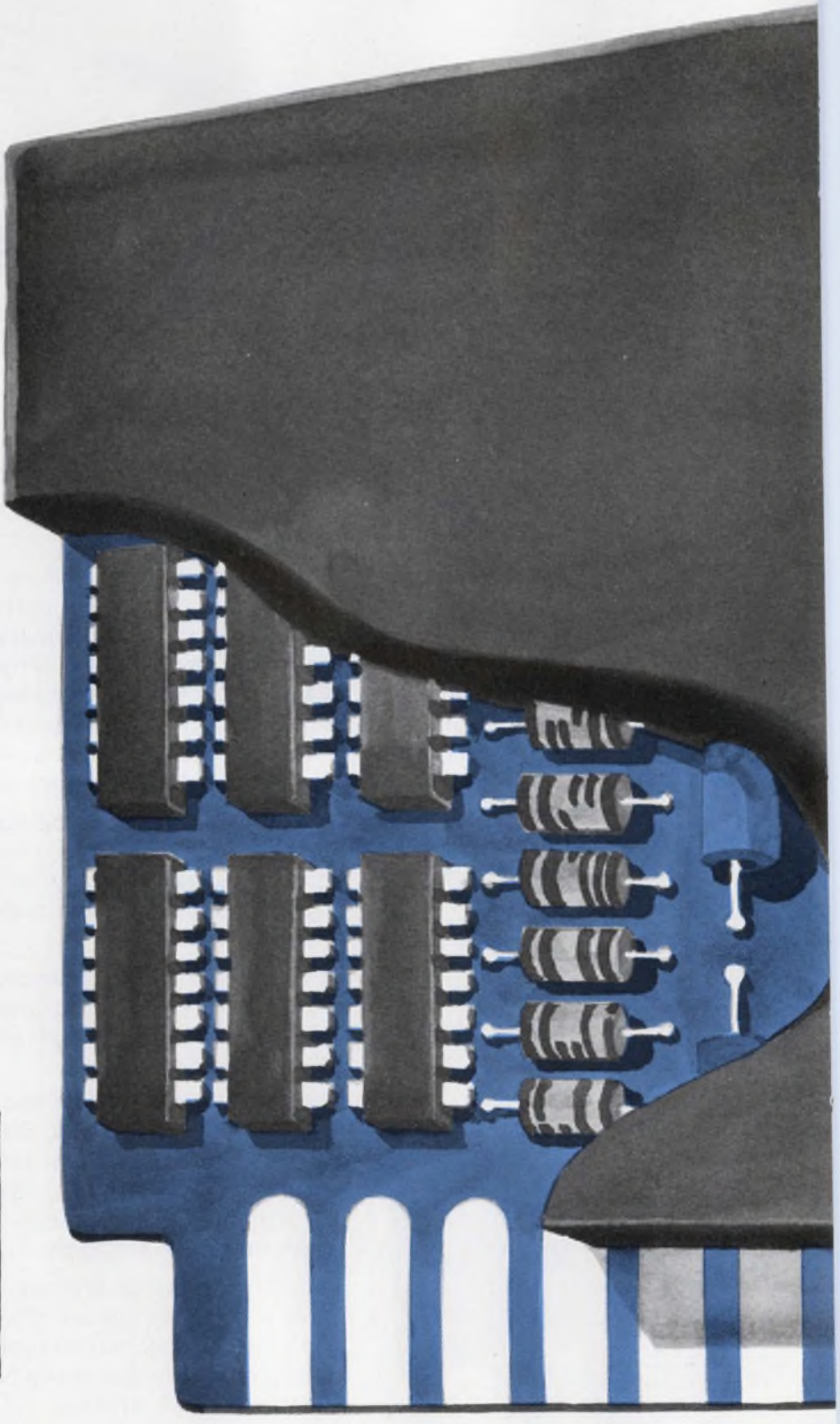
Silicone materials increase the life, reliability and safety of microcircuitry. They battle adverse environments, especially high temperatures, as no other material can. This module may give you an idea or two about the use of silicones to add efficiency and life to your next consumer, industrial or military design:

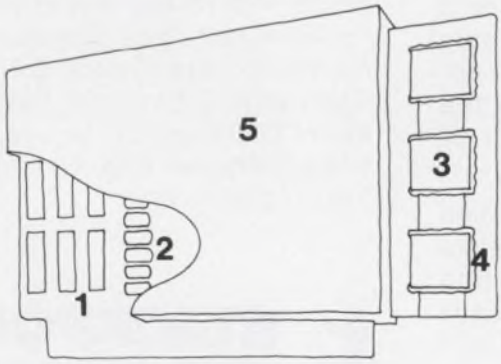
Silicone encapsulated ICs (1) perform with reliability approaching that of hermetics. Similar performance is obtained with silicone-packaged **resistors** (2) and **power transistors** (3). Flame-retardant thermosetting molding compounds from Dow Corning opened the door to this advance in low-cost, transfer-molded plastic packaging. Years of service, and device life tests in the millions, record the superior moisture and mechanical shock resistance, thermal life and dimensional stability of silicones over all other plastics.

Silicone heat-sink compound (4) helps maintain device efficiency, guards against premature device failure. Bridging the gap between devices and the heat sink, this compound ensures high thermal conductivity and high-temperature stability.

Flame-retardant silicone elastomer (5), encapsulating the module, adds safety, protects circuitry from moisture, dirty atmospheres, mechanical shock and vibration. This pourable material cures to a tough, flexible rubber without exotherm or corrosive byproducts.

Want more silicone reliability ideas? Write for our Silicones for Electronics brochure. Dow Corning, Dept. A-2206, Midland, Michigan 48640. Circle Information Retrieval Number 151.





Reduce noise in feedback circuits

Usually the best signal-to-noise ratio results from high preamp gain and multiple feedback.

A circuit designer frequently needs to minimize the output noise of a linear feedback circuit. However, it isn't obvious which part of a closed loop affects the output S/N ratio most—that is, where noise-reducing measures should be applied. Analysis shows that the best procedure is to increase the forward gain preceding the point of noise entrance. To do this you may find it necessary to use multiple loops. Let's see why.

Depending upon the specific situation, unwanted noise may be caused by many factors. These include random perturbations in the conductance of active or passive circuit devices (thermal noise, shot noise, 1/f noise), undesired pickup from stray magnetic fields, ripple injected from the power supply, very low frequency temperature-dependent shifts (drift) and harmonic distortion in a nonlinear amplifying stage.

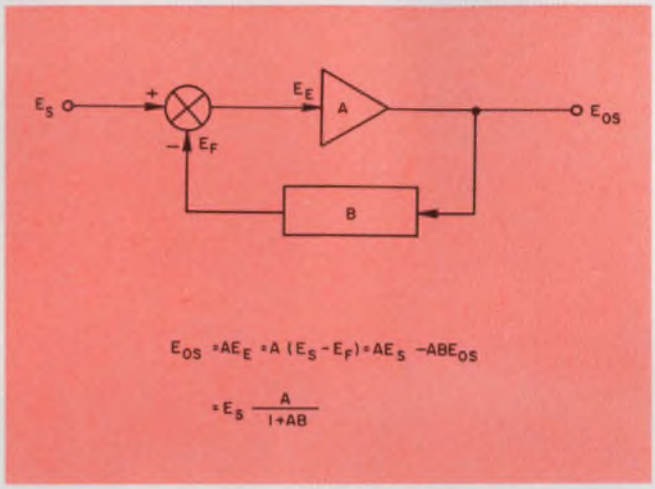
For the purpose of analysis, the effects of these unwanted signal disturbances within feedback circuits can all be treated in the same way; thus we will not distinguish between different kinds of noise sources. Also, for simplicity, we will assume that there is only one noise source injected into a feedback loop. Since we are dealing with linear circuits, the designer can look at the effects of one noise source at a time and then superimpose the effects of several such sources on the output.

Performance depends on feedback

The basic equation for the gain of a feedback amplifier (Fig. 1) is given by:

$$E_{os} = \frac{E_s A}{1+AB}$$

Normally $AB >> 1$, so this gain is approximately $1/B$. This means that the use of feedback shifts the dependence of many essential performance characteristics from the active forward gain elements to the feedback elements. These are usually passive components and therefore less subject to undesired variations. But this deliberate dependence on the feedback elements also means that the circuit is especially vulnerable to noise injection into the feedback path.



1. **Analysis of noise-free circuit** shows that performance depends mostly on the feedback elements.

Assume that a noise signal is somehow coupled into the feedback path between the output and the feedback elements (Fig. 2). Then:

$$\text{For } E_s = 0: \quad E_o = E_{oN} = \frac{E_N(-AB)}{1+AB}.$$

Since normally $AB >> 1$, $E_{oN} \approx -E_N$. Thus a 1-V noise signal results in nearly 1 V of inverted output noise.

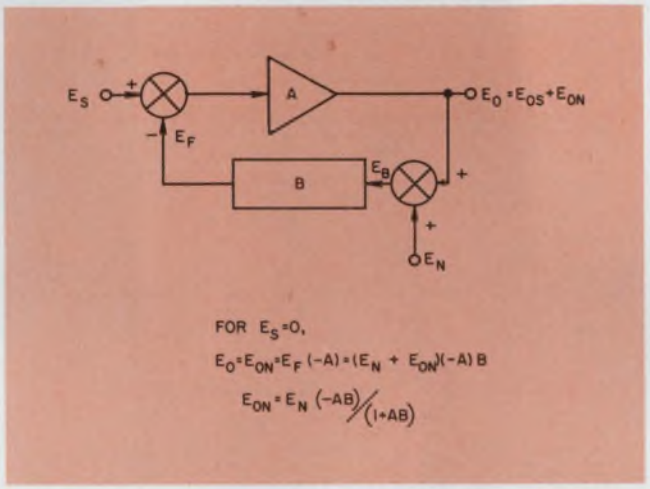
Things can get worse. Suppose the same noise disturbance is injected between the feedback elements and the summing point (Fig. 3).

$$\text{For } E_s = 0: \quad E_o = E_{oN} = \frac{E_N(-A)}{(1+AB)}.$$

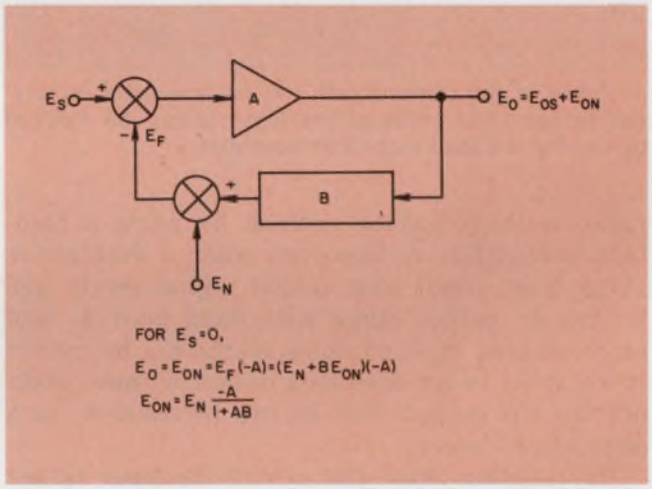
With $AB >> 1$, $E_{oN} \approx -E_N (1/B)$. Since B is usually less than unity, the noise output E_{oN} is $1/B$ times worse. In fact, in comparing equations, we see that the amplifier offers as much gain for E_N as for E_s (this is reasonable, since the noise has been added at the input to the amplifier).

So the designer must be careful not to let disturbing signals creep into the feedback path. Noise-free and drift-free components—for example, noninductive wirewound resistors—should be used here and the circuit shielded or spaced to

Arthur M. Darbie, Engineering Manager, Hewlett-Packard, Rockaway, N.J. 07866.



2. **Noise in the feedback path before** the feedback elements appears at the output almost unattenuated.



3. **Noise in the feedback path after** the feedback elements appears at the output—multiplied by 1/B.

exclude the effects of stray fields.

The circuit designer has to live with the feedback-path noise constraints. But by careful design he can usually reduce the output noise that would otherwise result from unavoidable noise sources in the forward-gain path.

Preamp gain is important

We can simulate noise injection anywhere along the forward-gain path of a multistage amplifier by breaking apart the forward-gain element, A, into two elements so that $A_1A_2 = A$ (Fig. 4). The equations for the output are:

$$\text{For } E_N = 0: \quad E_{OS} = E_S \frac{A_1A_2}{1 + A_1A_2B}. \tag{1}$$

$$\text{For } E_S = 0: \quad E_{ON} = E_N \frac{A_2}{1 + A_1A_2B}. \tag{2}$$

To obtain the equations for noise injected at the output of the A path, we would select $A_1 = A$ and $A_2 = 1$ in Fig. 4. Then, from Eq. 2 we obtain the well-known equation:

$$E_{ON} = E_N \frac{1}{1 + AB} \tag{3}$$

Similarly, for noise injected between the summing point and the input to A, select $A_1 = 1$ and $A_2 = A$, and the noise-caused output becomes:

$$E_{ON} = E_N \frac{A}{1 + AB}. \tag{4}$$

This is identical in form to the basic gain equation for a feedback loop. Closing a feedback loop around an amplifier, therefore, does not reduce the effects of noise or drift at the input of the first stage.

If we divide Eq. 1 for E_{OS} by Eq. 2 for E_{ON}, we get:

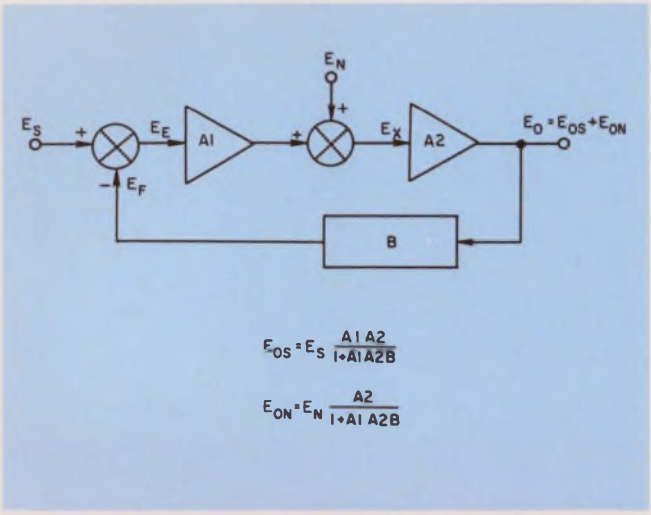
$$\frac{E_{OS}}{E_{ON}} = \frac{E_S}{E_N} A_1. \tag{5}$$

This is an important relationship—it says that to improve the signal-to-noise ratio of a closed loop, the designer should increase the noise-free gain preceding the point of noise injection. Thus increased gain in early stages can reduce output drift, distortion, power-supply ripple and other noise effects introduced by later stages. The output noise is a factor, A_1, less than if the same noise had been injected at the input to the feedback amplifier.

How does this compare with the nonfeedback amplifier? Removing the feedback path from Fig. 4, we get:

$$\frac{E_{OS}}{E_{ON}} = \frac{A_1A_2E_S}{A_2E_N} = \frac{E_S}{E_N} A_1 \tag{6}$$

Since this agrees exactly with Eq. 5, it would seem that, with respect to output signal-to-noise



4. **Noise in the forward path** will be attenuated by preceding gain. But noise at the input cannot be reduced by closing the loop around an amplifier.

ratio, we have gained nothing by using a feedback configuration. However, when a designer is given fixed input and output signal levels and he has an output stage with fixed gain A_2 and an associated injected noise source E_N, he cannot increase A_1 in an open-loop design without overdriving the output. But he can increase A_1 in a closed-loop design.

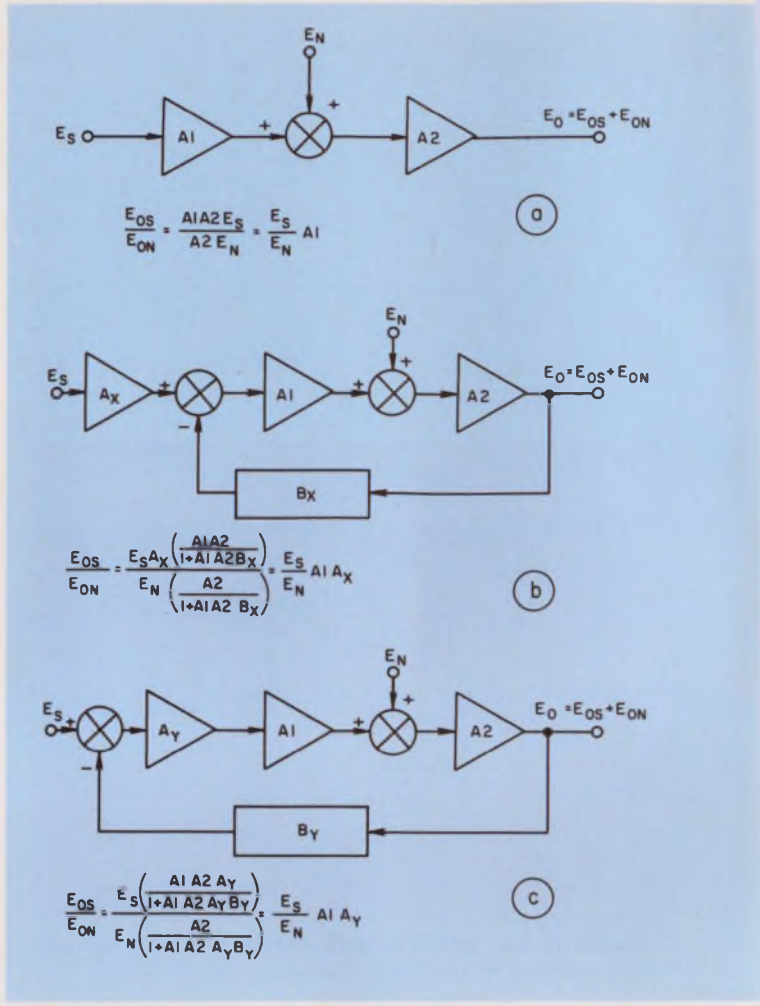
Put another way, the circuit designer is not faced with the alternatives of using the identical building blocks of Fig. 4 in either an open-loop or closed-loop configuration, because two quite different values of over-all gain would result. Instead, the designer is usually faced with a desired output signal level, E_{OS}, and an available input signal level, E_S.

He may choose to use amplifiers A_1 and A_2 (which presumably have the proper over-all gain to boost E_S to E_{OS}) in an open-loop configuration, and accept a certain output signal-noise ratio because of an unavoidable noise disturbance, E_N.

Alternatively, he may choose to close a feedback loop around the same gain elements, A_1 and A_2, thus reducing over-all gain by $1+A_1A_2B$ without affecting the output signal-noise ratio. He can then restore the lost gain and also improve output signal-noise performance by inserting noise-free gain ahead of the noise-injection point.

Which configuration is best?

Fig. 5 shows five alternate amplifier configurations. For comparison, all five are assumed to have the same values for E_S, E_{OS}, E_N, A_1 and A_2. Some amplifiers have additional elements in common—for example, the feedback factor B_X and the preamp gain stage A_Z. Except for the injected noise disturbances, E_N, all other elements are assumed inherently noise-free. The designer can proceed by analyzing one noise source at a time

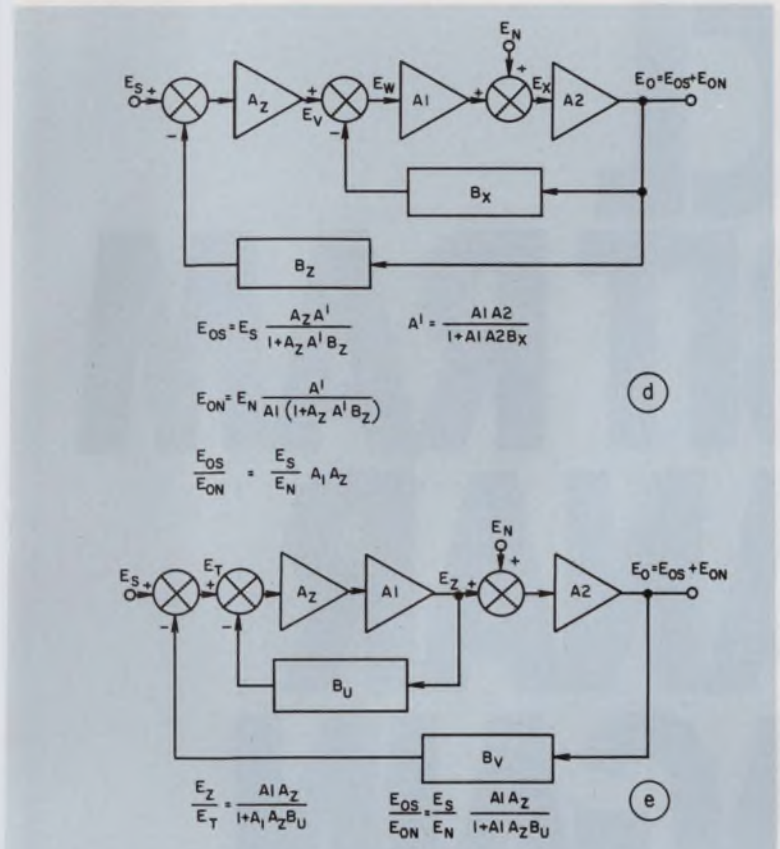


and then adding the output effects of all noise sources.

Comparing output equations, we see that the circuit with the preamp outside the loop (Fig. 5b) has less output noise than the open-loop circuit (Fig. 5a) by a factor of A_X. Since the two circuits are to have the same over-all gain from input to output, A_X must equal $1 + A_1A_2B_X$, the factor by which the gain A_1A_2 is reduced when we close the loop with B_X. If we move the preamp inside the loop (Fig. 5c), the signal-to-noise ratio is again improved by the preamp factor, A_Y. Thus compared with the open-loop arrangement, both closed-loop circuits offer an output signal-noise ratio improvement.

Which is the better configuration? If the designer is concerned primarily with output noise reduction, he will most likely choose the circuit with the preamp inside the loop, because it allows higher values of preamp gain. With the preamp outside, and with fixed levels of E_S and E_{OS}, A_X must equal $1+A_1A_2B_X$. With passive elements in the feedback path, B_X is limited to a maximum of unity (in some circuits transformers can permit Bs greater than 1), and A_X is thus limited to a maximum value of $1+A_1A_2$.

Even this may not be practical: In high-gain systems unity feedback results in unity voltage



5. **Signal-to-noise ratio is improved** by preamp gain factor (5b and 5c). Multiple loops allow higher preamp gain than a single closed loop.

gain for the closed-loop portion of the amplifier. Thus the preamp output voltage must equal the main amplifier output. This is generally impractical.

There is no similar constraint on the maximum value of A_Y in the fully enclosed circuit of Fig. 5c. But with the large number of stages inside the loop, the designer may find it difficult to avoid closed-loop oscillation. To get around this problem, yet still retain the benefits of added preamp gain, the designer may in some cases prefer a two-loop circuit.

A two-loop amplifier with the inner loop enclosing the point of noise injection is shown in Fig. 5d. The output equation shows the S/N ratio is improved by A_Z. But this circuit can have a value of A_Z that exceeds the highest practical value of A_Y in Fig. 5c (limited by the need to avoid loop gain oscillations). Similarly A_Y can be made larger than A_X in Fig. 5b (limited by over-all signal gain considerations).

Multiple loops require caution

As more loops are added, or as more gain is used inside the loop, greater demands are placed upon the designer to avoid loop oscillation. Reference 2 contains a useful discussion of design techniques for circuits containing inner (minor) loops.

It is interesting to compare the two-loop configuration with another alternative (Fig. 5e) using the same forward-gain elements, A_Z, A_1 and A_2, but with the inner loop closed around input stages preceding the point-of-noise injection. For this circuit, the closed-loop gain of the inner loop is:

$$A'' = \frac{E_Z}{E_T} = \frac{A_1 A_Z}{1 + A_1 A_Z B_U} \quad (7)$$

And the signal-to-noise ratio is:

$$\frac{E_{OS}}{E_{ON}} = \frac{E_S}{E_N} A'' = \frac{E_S}{E_N} \frac{A_1 A_Z}{1 + A_1 A_Z B_U} \quad (8)$$

In comparison, we see that the circuit of Fig. 5e is inferior to that of Fig. 5d with respect to injected noise, E_N, by a factor of $(1 + A_1 A_Z B_U)$—usually a large number. The inferior performance results because, in closing the inner loop of Fig. 5e, we have reduced the forward gain preceding the point-of-noise injection.

Probably the single most important feedback noise relation for the designer to remember is

$$\frac{E_{OS}}{E_{ON}} = \frac{E_S}{E_N} A_1$$

This equation states that the output signal-to-noise ratio is improved whenever we increase the forward gain preceding the point of noise injection. In interpreting this equation, it is important to recognize that E_S, E_N and A_1 are, in general, frequency-dependent terms and that the noise improvement at a particular frequency depends upon the values of these terms at that frequency.

Referring to the circuit with the preamp inside the loop (Fig. 5c), we see that if E_N represents a drift or a disturbance caused by temperature effects, then A_1 and A_Y should have high gain at dc and very low frequencies. If E_N is a wideband noise source or a source of distortion, then it's important that A_1 and A_Y have sufficient bandwidth to insure high gain over those frequencies where output noise reduction is desired. For this reason, it is often preferable to place wideband stages ahead of narrowband stages. However, this decision will be influenced by other factors, including the ease with which necessary loop-equalization networks can be inserted at various points in the forward-gain path.

In any case, the designer will do well to check the open-loop signal vs frequency profile at the input to each stage to see if there are frequencies at which the signal level is lower than at the input to the first stage, or low compared with potential noise sources present in each stage. ■■

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2. Eveleigh, V., *Introduction to Control Systems Design*, pp. 256-282, McGraw-Hill, New York, 1972.

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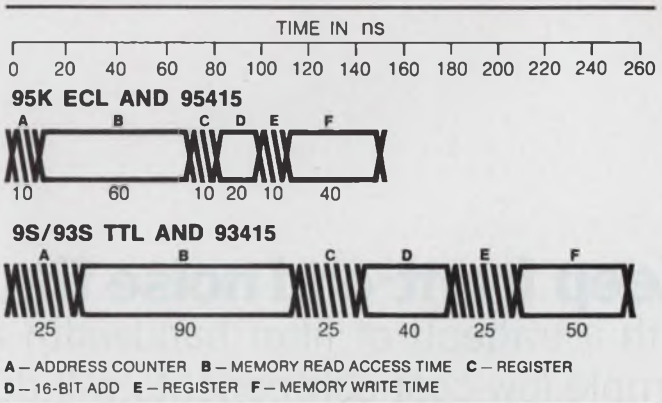

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INFORMATION RETRIEVAL NUMBER 32

Keep front-end noise figures low

with a tradeoff of filter bandwidth and loss. Simple low-cost components will do the job.

One of the major design problems in building microwave receiver front-ends is keeping the noise figure of the front-end elements from degrading the performance of the receiver system. This consideration becomes especially important when a phase-locked loop is used in the receiver system to detect very low-level input signals—as, say, in deep-space probe applications. The phase-locked loop sensitivity advantages can easily be nullified by high noise margins.

A simple way to solve the problem, using easy-to-build inexpensive elements, is to tradeoff bandwidth and insertion loss in the front-end filter elements shown in Fig. 1. In general, filter insertion loss decreases as the filter bandwidth increases. If the filter is placed in front of the preamplifier serving as a preselector, its loss adds directly to the noise figure.

Accordingly, if the preselector bandpass filter is built to have a large bandwidth (and low loss), an image-rejection filter can be used to narrow the bandwidth to meet the receiver specs. The image-rejection filter's loss will have a minimal effect on noise figure, since this filter follows a preamp stage.

Here's an example: An S-band phase-locked loop receiving system is required to detect signals in the range −60 to −145 dBm. The noise figure of the front-end subsystem must be held to 6 dB; its power consumption, below 200 mW. Also the image rejection should be greater than 10 dB, while gain is specified at 13 dB.

Gain tradeoff

In order to meet the gain requirement, the filter-amplifier combination should provide 20-dB gain. This allows a reasonable 5.5-dB loss in the mixer stage, leaving an over-all 14.5-dB gain for the front end—or 1.5 dB more than specified. To meet the power requirement, the amplifier—the only element using dc power—can be limited to 120-mW dissipation.

For the individual elements in the front-end receiver, let's start with the filters.

Microwave filters using a coaxial comb-line structure[1,2] are selected for our design since they can be tuned over a wide range of frequencies without suffering serious deterioration in performance. An S-band comb-line filter can be tuned over a frequency range of as much as 200% of the design frequency[3]. Moreover, they are relatively inexpensive to build.

An alternative choice could have been a bandpass filter on a high dielectric substrate in a microstrip or stripline configuration. While this approach could provide additional size and weight reduction, it suffers from possible filter detuning due to mechanically and thermally induced stress on the dielectric substrate. The dielectric constant of the substrate can also change with time and temperature. Therefore, a high-grade dielectric substrate material would be necessary.

Furthermore, microstrip and stripline filters are not easily tuned and require very close tolerances in their fabrication. While the microstrip or stripline filter pattern is being etched on the dielectric substrate, any variations in the etching process can seriously degrade the filter bandpass characteristics. When dimensional tolerances and temperature variations significantly affect the performance of highly selective bandpass filters, yield becomes an additional problem.

A five-pole comb-line filter, covering the 1.2-to-3.0 GHz frequency range, serves as the basic filter design for the preselector. A similar three-pole comb-line filter provides additional image rejection. The five-pole filter has a 4 to 6% bandwidth at the 1-dB points and a 10 to 14% bandwidth for the 30-dB points. Tuning screws placed at the comb-line filter input and output ports help compensate for mismatches of up to 3:1.

Select the amplifier

For the preamplifier, a low-noise three-stage microstrip amplifier can readily be built with

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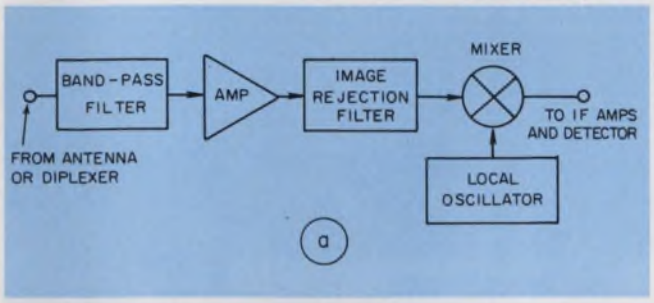
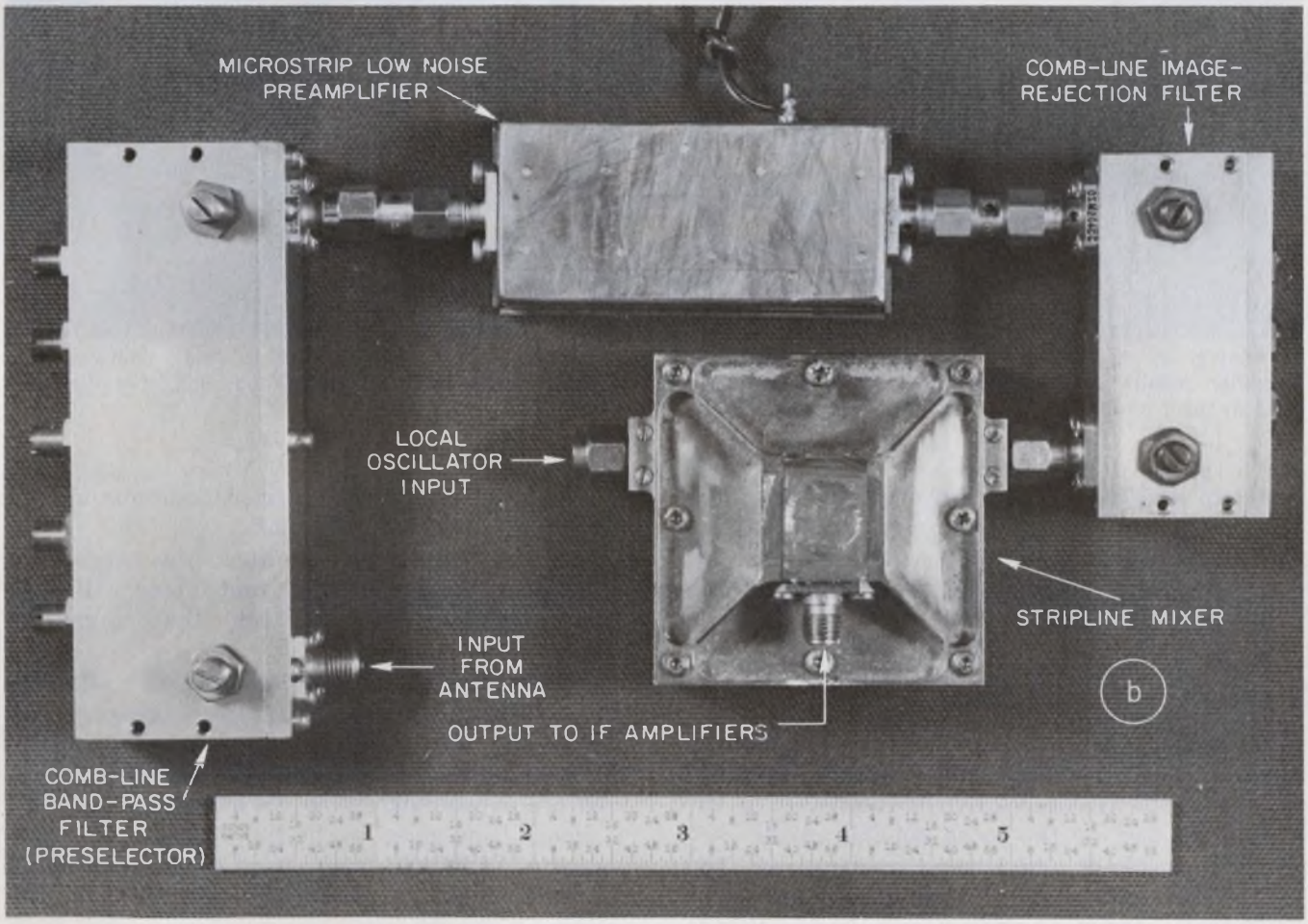


1. **The basic microwave receiver front-end** (a) can be designed simply and easily to limit noise figures with a tradeoff of filter bandwidth and loss between the preselector and image-rejection filters. The final design (b) uses coaxial filters built with comb-line structures.



high performance transistors and carefully chosen input-output matching and interstage coupling circuits. The resulting microwave amplifiers can yield high gain, excellent stability, and low dc power consumption.

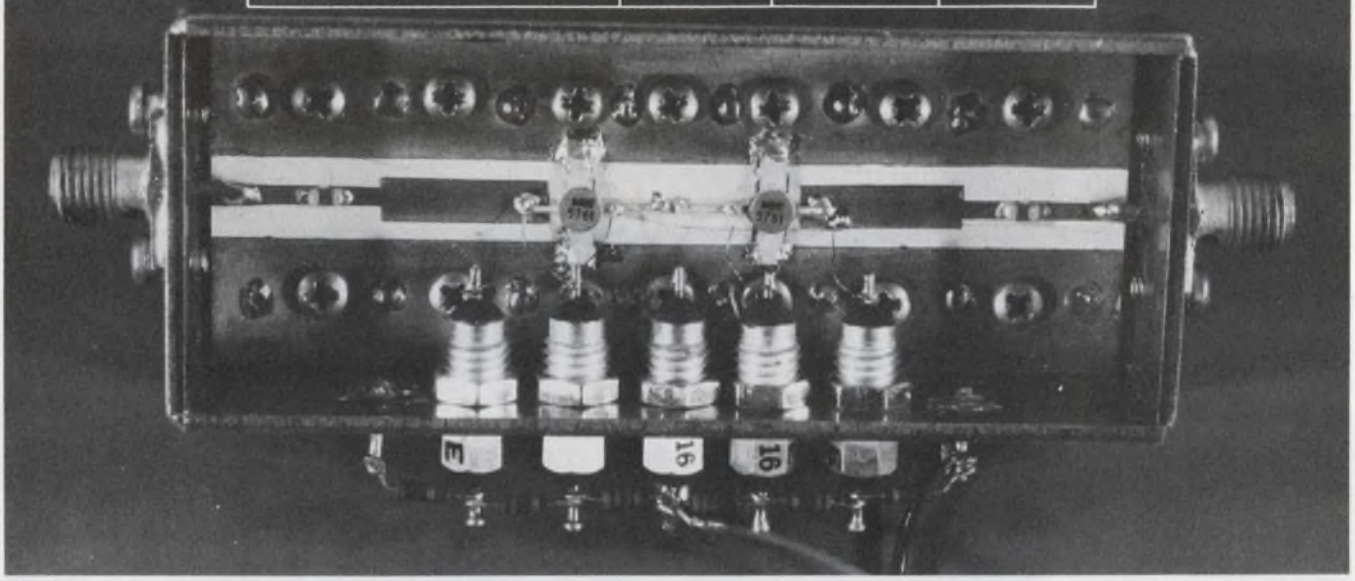
Moreover, microwave transistors with noise figures of 3.0 dB and gains of 10 dB at 2.0 GHz are currently available for as little as one third the price they were two or three years ago.

A basic two-stage low-noise microwave amplifier design, shown in Fig. 2, includes a microstrip quarter-wave input matching network on an alumina substrate. The two-stage amplifier uses Nippon Electric (NEC) 2N5761 transistors with Erie Filtercons serving as bypass and dc-isolation elements.

An exact analysis for precise determination of microstrip dimensions is difficult, and the low unloaded Qs of the transmission-line method of amplifier design cause some difficulty in optimiz-

TWO-STAGE 2.0 GHz AMPLIFIER
PERFORMANCE DATA OVER TEMPERATURE

TEMPERATURE (°F)	0	75	120
GAIN (dB)	15.4	15.5	15.1
NOISE FIGURE (dB)	4.3	4.4	4.7
VSWR	1.2	1.25	1.35
CURRENT DRAIN (ma) AT 10V dc	8.5	11.0	12.2



2. **Adding an extra stage to this two-stage microstrip amplifier** results in the three-stage low-noise amplifier used in the front-end receiver design. Performance characteristics are fairly insensitive to small changes, due to the effects of temperature and aging, in the substrate dielectric constant.

ing gain and bandwidth. However, the loss of a few dB in gain using the microstrip transmission line technique is well compensated by the low cost, simplicity and temperature stability of the resulting amplifier.[4]

Branch-line vs rat-race mixer

In the selection of mixers, the choice generally narrows down to either a 90° (branch line) hybrid or a 180° (rat-race) hybrid coupler (Fig. 3). These are two of the most popular mixer configurations for S and C-band applications. The 180° hybrid mixer has the advantage of wider bandwidth, better isolation and lower VSWR compared with the 90° hybrid mixer configuration. While the 90° hybrid is smaller, the 180° hybrid mixer is selected for its electrical advantages.

Another important advantage is the rat-race mixer's reliability and reproducibility—it's almost impossible to make one that doesn't work.[5] The rat-race mixer configuration also exhibits reciprocity: It can be operated as an up-converter with the same loss that it possesses as a down-converter.

Our front-end design uses a stripline configuration for beam-lead hot-carrier diode mixing elements in a 180° hybrid mixer.

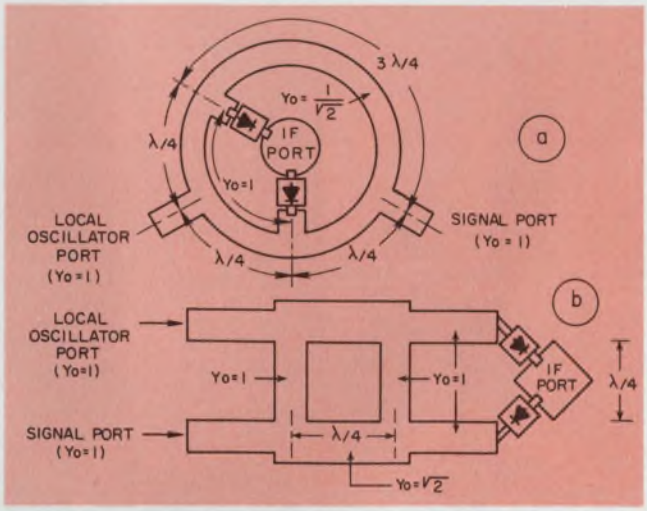
Due to third-order nonlinearities and gain saturation, the preamplifier and mixer will have intermodulation products (IM) that cannot be filtered.[5,7]

For a preamplifier input signal of −30 dBm the mixer input signal is approximately −10 dBm. The mixer and preamplifier third-order IMs are almost equal at the i-f amplifier input, and are approximately 50 dB below the carrier.

Image-band noise can be suppressed by the preselector. Additional image-band noise suppression is provided by the image-rejection filter at the mixer input-port.

Design the local oscillator

Finally, with the ideal local-oscillator power to the matched pair of hot-carrier mixer diodes of approximately +7 dBm, several stages of frequency multiplication are generally required in a conventional oscillator-frequency multiplier chain. The various types of available varactor and charge-storage diodes have parametric effects that enhance frequency multiplication. Although conventional transistors offer gain, the efficiency of



3. **The most popular microwave mixers** are the 180° (rat-race) hybrid coupler (a) and the 90° (branch-line) hybrid coupler (b). The design described uses the rat-race hybrid with beam-lead, hot-carrier, diodes as the mixing elements. The coupler selected provides wider bandwidths, better isolation and lower VSWR.

a conventional transistor amplifier beyond a ×4 frequency multiplier is low compared to a varactor frequency multiplier.

However, some of the "new generation" transistors also exhibit parametric effects that provide very efficient—up to ×10—frequency-multiplication[8] thus limiting the number of stages required in the multiplier chain and reducing the over-all power requirement. ■■

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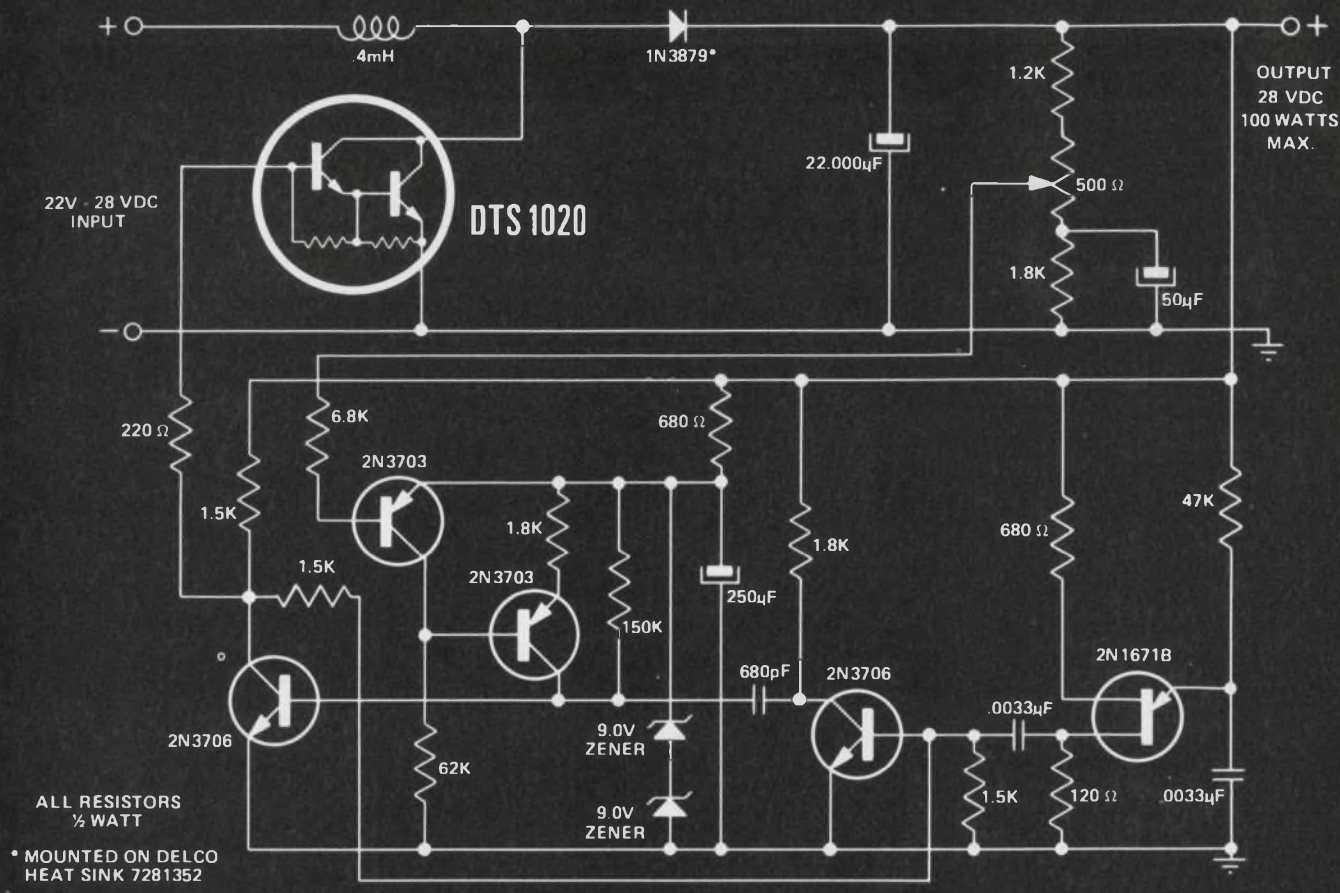

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DTS-1010	120V	7V	80V	12	200	1.8V	10A	100W*
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*100 percent tested at 2.5A, 40V.

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MARK OF EXCELLENCE

INFORMATION RETRIEVAL NUMBER 34

Get a statistical analysis in seconds

with this inexpensive Fortran program. It provides tabulations, summaries and variance estimates.

Whether you are evaluating a batch of resistors or checking a worst-case design, you can have a detailed statistical analysis of a mass of measurement data within seconds with a simple, penny-pinching Fortran program (Fig. 1). It arrays the data in ascending order, then computes the mean, median, range and standard deviation. The data are also summarized by their distribution within class intervals. A glance at the printout suffices to check on the homogeneity, tolerance and precision of the input data.

Preparation and running times vary, of course, with the quantity of data. For the example cited here—200 resistance measurements—15 minutes are required for keypunching the data, and 0.675 seconds for executing the program on a Univac 1108 computer. The cost of the run: about 20 cents.

Key statistical data are extracted

Measurement results are read into the program by means of punch cards. The program sorts the values into ascending order, and the sorted values are used to compute the following data:

- Lower and upper measurement limits.
- Arithmetic mean.
- Median.
- Standard deviation (sigma).
- Percentages of measurements that lie within the one, two and three-sigma limits about the mean.
- Frequency distribution for the measurements.

From these, the user can judge tolerance, see if the mean lies within acceptable bounds, decide whether the variance is excessive, set confidence limits for population tolerance and judge symmetry by comparing the mean and median.

The distribution tabulation is useful in determining the quality of the data. For example, the presence of two peaks may indicate two causative factors or a lack of sample homogeneity.

Finally, and perhaps most important, the convenient summary makes it easier to decide on the sample size needed for future tests. In many cases the reduced expenditures for test effort readily offset the costs incurred in preparing and using the program.

Preparation is straightforward

Before the program of Fig. 1 can be used, the engineer must prepare a source deck. Once it has been punched, the only remaining task is to supply the job-control and data cards containing the measurement values.

Input 10 values per card

To illustrate how the program can be used, a sample of two hundred 1000-Ω 10 percent resistors was measured to four significant figures on a General Radio 650A bridge. Computer statement 0010 (refer to the numbers in the left margin of Fig. 1) is the READ statement, and statement 0011 is its corresponding FORMAT statement. The FORMAT statement indicates that the first data card must contain the numerical value of N, the number of data values.

The remaining data cards must supply the measured (resistor) values, 10 items per card and each in E8.4 format. Fig. 2 shows three of the data cards for this 200-resistor example. The first data card indicates that the value of N, which must be right-justified, equals 200. The second data card gives the values of the first 10 resistor measurements, and the third data card the values of the next 10. The remaining 18 data cards are not shown.

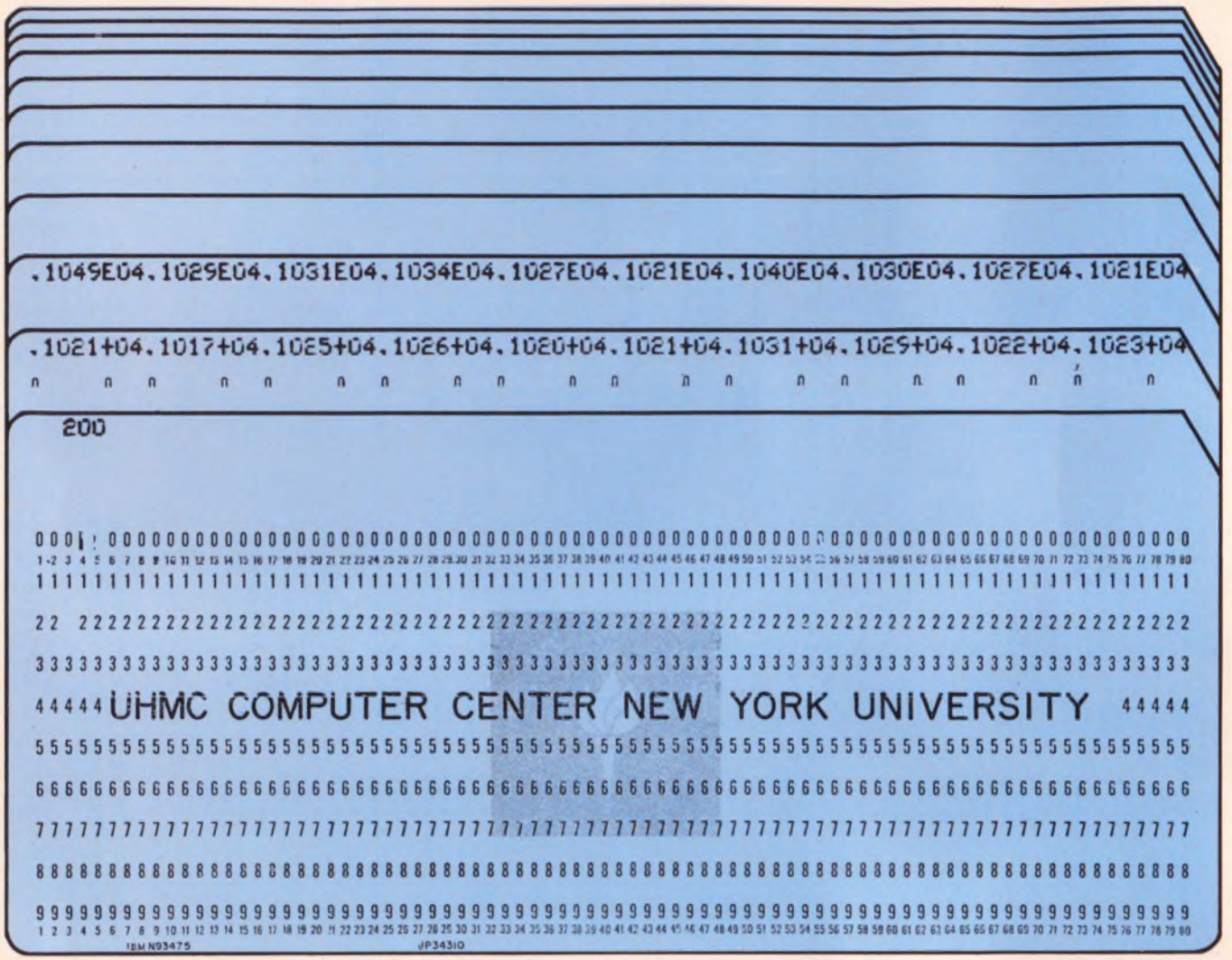
Program operation is easy to follow

Since Fortran algebraic statements are used for arithmetic, readers should be able to follow the operation quite easily.

B. James Ley, Professor, New York University, Bronx, N.Y. 10453.

```
0001  C
0002  C     EVALUATION OF INSTRUMENT MEASUREMENTS.
0003  C
0004        DIMENSION VALUE(200),DIST(20)
0005  C
0006  C     READ INPUT DATA
0007  C        N = NUMBER OF DATA VALUES.
0008  C        VALUE = AN ARRAY FOR STORING MEASURED VALUES.
0009  C
0010        READ(5,1)N,(VALUE(I),I=1,N)
0011      1 FORMAT(I5,/,(10E8.4))
0012  C
0013  C     DETERMINE SMALLEST VALUE, LARGEST VALUE, AND MEDIAN VALUE.
0014  C
0015        LIMIT=N/2+1
0016        DO 10 I=2,N
0017        SMALL=VALUE(I-1)
0018        K=I-1
0019        DO 20 J=I,N
0020        IF(SMALL-VALUE(J))20,20,30
0021     30 K=J
0022        SMALL=VALUE(J)
0023     20 CONTINUE
0024        IF(K-I+1)10,10,40
0025     40 VALUE(K)=VALUE(I-1)
0026        VALUE(I-1)=SMALL
0027     10 CONTINUE
0028        IF(N-N/2*2)50,50,60
0029     50 AMEDIA=(VALUE(LIMIT-1)+VALUE(LIMIT))/2
0030        GO TO 70
0031     60 AMEDIA=VALUE(LIMIT)
0032     70 CONTINUE
0033  C
0034  C     DETERMINE AVERAGE OR MEAN VALUE.
0035  C
0036        SUM=0.
0037        DO 100 I=1,N
0038    100 SUM=SUM+VALUE(I)
0039        AVE=SUM/N
0040  C
0041  C     DETERMINE STANDARD DEVIATION.
0042  C
0043        SSQDIF=0.
0044        DO 110 I=1,N
0045        DIF=VALUE(I)-AVE
0046    110 SSQDIF=SSQDIF+DIF**2
0047        SIGMA=SQRT(SSQDIF/N)
0048  C
0049  C     DETERMINE PERCENTAGE OF MEASUREMENTS WITHIN ONE,
0050  C     TWO, AND THREE STANDARD DEVIATIONS.
0051  C
0052        STD1=0.
0053        STD2=0.
0054        STD3=0.
0055        DO 120 I=1,N
0056        IF(ABS(VALUE(I)-AVE)-SIGMA)130,130,140
0057    130 STD1=STD1+1.0
0058    140 IF(ABS(VALUE(I)-AVE)-2.*SIGMA)150,150,160
0059    150 STD2=STD2+1.0
0060    160 IF(ABS(VALUE(I)-AVE)-3.*SIGMA)170,170,120
0061    170 STD3=STD3+1.0
0062    120 CONTINUE
0063        PER1SD=STD1*100./N
0064        PER2SD=STD2*100./N
0065        PER3SD=STD3*100/N
0066  C
0067  C     PRINT REORDERED INPUT DATA.
0068  C
0069        WRITE(6,2)N,(VALUE(I),I=1,N)
0070      2 FORMAT('1EVALUATION OF INSTRUMENT MEASUREMENTS',///,5X,'NUMBER OF
0071       1MEASUREMENTS =',I5,///,4X,' MEASURED VALUES',//,(5F10.4))
0072  C
0073  C     PRINT LOWEST VALUE, HIGHEST VALUE, MEDIAN VALUE, MEAN VALUE,
0074  C     STANDARD DEVIATION, AND PERCENTAGE OF MEASUREMENTS WITHIN ONE,
0075  C     TWO, AND THREE STANDARD DEVIATIONS.
0076  C
0077        WRITE(6,3)VALUE(1),VALUE(N),AMEDIA,AVE,SIGMA,PER1SD,PER2SD,PER3SD
0078      3 FORMAT('1',1X,'LOWEST VALUE =',E10.5,2X,'HIGHEST VALUE =',E10.5,//,
0079       12X,'MEDIAN VALUE =',E10.5,5X,'MEAN VALUE =',E10.5,///,10X,'STANDAR
0080       2D DEVIATION =',E10.5,//,' PERCENTAGE OF MEASURMENTS WITHIN ONE SIG
0081       3MA =',F5.1,//,' PERCENTAGE OF MEASUREMENTS WITHIN TWO SIGMA =',F5.
0082       41,//,' PERCENTAGE OF MEASUREMENTS WITHIN THREE SIGMA =',F5.1)
0083  C
0084  C     COMPUTE DISTRIBUTION OF MEASURED VALUES.
0085  C
0086        NUMB=20.
0087        SMALL=990.
0088        STEP=5.0
0089        DO 180 I=1,NUMB
0090    180 DIST(I)=0.0
0091        DO 190 I=1,N
0092        K=(VALUE(I)-SMALL)/STEP+1.0
0093    190 DIST(K)=DIST(K)+1.0
0094  C
0095  C     PRINT DISTRIBUTION
0096  C
0097        WRITE(6,4)
0098      4 FORMAT(///,' DISTRIBUTION',//,9X,'NUMBER OF MEASUREMENTS BETWEEN',
0099       1/)
0100        A=SMALL
0101        DO 200 I=1,NUMB
0102        B=A+STEP
0103        WRITE(6,5)A,B,DIST(I)
0104    200 A=B
0105      5 FORMAT(11X,E9.4,' AND',E9.4,' = ',F4.0)
0106        STOP
0107        END
```

1. **Fortran program sorts the input data** into ascending order and then computes the range, mean, variance and frequency distribution.



2. **Each data card contains 10 measurement values** in E8.4 format. The first card contains the number of measured values in I5 format. This sample deck shows the values punched for the first 10 measurements.

Computer statements 0015 through 0032 rearrange the input values so they are in ascending order. The lowest, highest and median value can then be determined.

The median value is defined as the middle datum after the measured values are arranged in ascending order. If N is even, this definition does not work. Computer statement 0028 is therefore used to determine if N is even or odd. In those cases where N is found to be even, the median value is set equal to the average of the two measured midvalues (see computer statement 0029).

Computer statements 0036 through 0039 determine the average or mean measured value, 0043 through 0047 the standard deviation, 0052 through 0065 the percentage of measurements within one, two, and three standard deviations, and 0086 through 0093 the distribution of the measured values.

Computer statements 0069 through 0071 print the output heading EVALUATION OF INSTRUMENT MEASUREMENTS, the number of measured values N and the ascending measured values of the input data (Fig. 3). Computer statements 0077 through 0082 print the lowest value, the highest value, the median value, the mean value, the standard deviation and the percentage of measurements within one, two, and three standard deviations (Fig. 4). Computer statements 0097 through 0105 print the distribution of the measured values (lower part of Fig. 4).

Use the normal distribution as a guide

The printout in Fig. 3 indicates that this particular set of 1000-Ω 10% resistors had actual values ranging from 992 to 1088 Ω rather than the expected 900 to 1100 Ω.

In the purchase of any component the user will rarely find that the measured values range from the nominal value minus the tolerance

EVALUATION OF INSTRUMENT MEASUREMENTS

NUMBER OF MEASUREMENTS = 200

MEASURED VALUES

.9920+03	.1000+04	.1001+04	.1002+04	.1003+04
.1005+04	.1005+04	.1005+04	.1005+04	.1006+04
.1007+04	.1009+04	.1010+04	.1011+04	.1013+04
.1014+04	.1014+04	.1015+04	.1016+04	.1016+04
.1016+04	.1017+04	.1017+04	.1017+04	.1017+04
.1018+04	.1019+04	.1020+04	.1020+04	.1020+04
.1021+04	.1021+04	.1021+04	.1021+04	.1021+04
.1021+04	.1022+04	.1022+04	.1022+04	.1022+04
.1022+04	.1022+04	.1023+04	.1023+04	.1023+04
.1023+04	.1024+04	.1024+04	.1024+04	.1024+04
.1024+04	.1025+04	.1025+04	.1025+04	.1025+04
.1025+04	.1025+04	.1026+04	.1026+04	.1027+04
.1027+04	.1027+04	.1027+04	.1027+04	.1027+04
.1028+04	.1028+04	.1028+04	.1028+04	.1029+04
.1029+04	.1029+04	.1029+04	.1029+04	.1029+04
.1029+04	.1030+04	.1030+04	.1030+04	.1030+04
.1030+04	.1031+04	.1031+04	.1031+04	.1031+04
.1031+04	.1032+04	.1032+04	.1033+04	.1033+04
.1033+04	.1033+04	.1034+04	.1034+04	.1034+04
.1034+04	.1034+04	.1034+04	.1035+04	.1035+04
.1036+04	.1036+04	.1036+04	.1037+04	.1037+04
.1037+04	.1037+04	.1037+04	.1037+04	.1038+04
.1038+04	.1038+04	.1038+04	.1038+04	.1038+04
.1039+04	.1039+04	.1039+04	.1039+04	.1039+04
.1039+04	.1039+04	.1039+04	.1040+04	.1040+04
.1040+04	.1041+04	.1041+04	.1041+04	.1041+04
.1042+04	.1042+04	.1042+04	.1042+04	.1042+04
.1042+04	.1043+04	.1043+04	.1043+04	.1043+04
.1043+04	.1043+04	.1043+04	.1044+04	.1044+04
.1044+04	.1044+04	.1044+04	.1044+04	.1044+04
.1045+04	.1045+04	.1046+04	.1046+04	.1047+04
.1047+04	.1048+04	.1048+04	.1048+04	.1048+04
.1048+04	.1049+04	.1049+04	.1049+04	.1050+04
.1051+04	.1051+04	.1051+04	.1051+04	.1052+04
.1052+04	.1052+04	.1052+04	.1052+04	.1053+04
.1055+04	.1055+04	.1055+04	.1056+04	.1057+04
.1058+04	.1058+04	.1059+04	.1059+04	.1059+04
.1059+04	.1060+04	.1060+04	.1063+04	.1064+04
.1065+04	.1066+04	.1068+04	.1070+04	.1074+04
.1077+04	.1077+04	.1078+04	.1080+04	.1088+04

3. **The first printout** shows the input data rearranged in ascending order.

LOWEST VALUE = .99200+03 HIGHEST VALUE = .10880+04

MEDIAN VALUE = .10355+04 MEAN VALUE = .10356+04

STANDARD DEVIATION = .16604+02

PERCENTAGE OF MEASURMENTS WITHIN ONE SIGMA = 74.0

PERCENTAGE OF MEASUREMENTS WITHIN TWO SIGMA = 94.5

PERCENTAGE OF MEASUREMENTS WITHIN THREE SIGMA = 99.5

DISTRIBUTION

NUMBER OF MEASUREMENTS BETWEEN

.9900+03	AND	.9950+03	= 1.
.9950+03	AND	.1000+04	= 0.
.1000+04	AND	.1005+04	= 4.
.1005+04	AND	.1010+04	= 7.
.1010+04	AND	.1015+04	= 5.
.1015+04	AND	.1020+04	= 10.
.1020+04	AND	.1025+04	= 24.
.1025+04	AND	.1030+04	= 25.
.1030+04	AND	.1035+04	= 22.
.1035+04	AND	.1040+04	= 25.
.1040+04	AND	.1045+04	= 27.
.1045+04	AND	.1050+04	= 14.
.1050+04	AND	.1055+04	= 11.
.1055+04	AND	.1060+04	= 11.
.1060+04	AND	.1065+04	= 4.
.1065+04	AND	.1070+04	= 3.
.1070+04	AND	.1075+04	= 2.
.1075+04	AND	.1080+04	= 3.
.1080+04	AND	.1085+04	= 1.
.1085+04	AND	.1090+04	= 1.

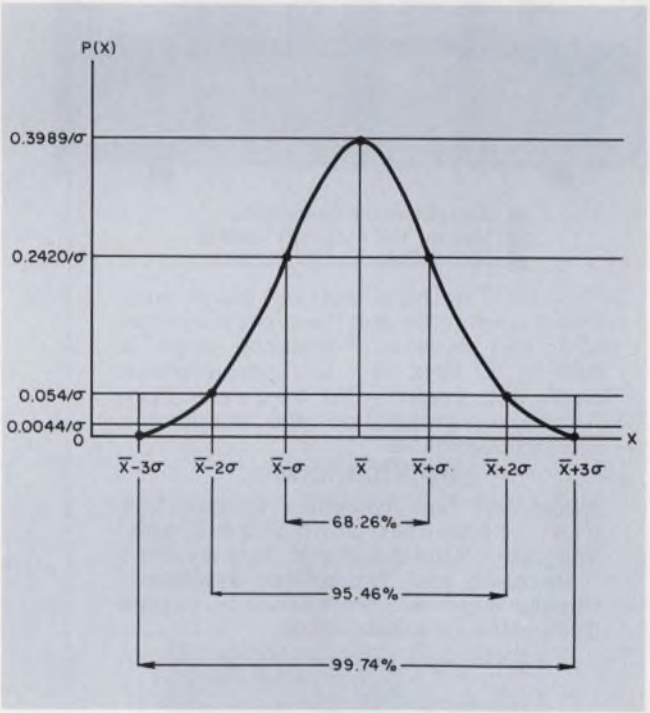
4. **Continuation of printout** summarizes the statistical characteristics and lists the frequency distribution. The intervals for the distribution are set by the user.

(1000 − 100 = 900) to the nominal value plus the tolerance (1000 + 100 = 1100). Note also that the mean value of 1035.6 Ω and the median value of 1035.5 Ω (Fig. 4) differ from the nominal value of 1000 Ω. Since in this example the mean and median values are essentially the same, this shows very little skew in the input data.

The standard deviation, σ, is given by

$$\sigma = \sqrt{\frac{\sum_{I=1}^{N} (\text{Value (I)} - \text{AVE})^2}{N}},$$

where N is the number of measurements and AVE is the mean (average) value. Variance, σ^2, is a measure of the dispersion of the measured values and is defined as the average of the square of all off-averages. For a very large number of measurements, a Normal distribution should be expected. The Normal distribution is given by the expression



5. **Normal (Gaussian) distribution,** defined by this curve forms an estimate of the population percentages that fall within one, two or three standard deviations from the mean. At least 30 data points are necessary.

$$P(X) = \frac{1}{\sqrt{2\pi}\,\sigma}\,\epsilon^{\frac{-(X-\overline{X})^2}{2\sigma^2}},$$

where $\overline{X}$ is the mean value, σ is the standard deviation and σ^2 is the variance. Thus, for a large number of measurements, most of them will cluster about the mean value $\overline{X}$, and the probability distribution of the measured value X will approach the Normal distribution shown in Fig. 5. Note, from an examination of Fig. 5, that if a measurement being made is Normally distributed, 68.26% of the sample values will fall between $\pm\sigma$ of the mean, 95.46% between $\pm 2\sigma$ of the mean value and 99.74% between $\pm 3\sigma$ of the mean value. For the σ of 16.60 (Fig. 4), the percentages of resistors computed within one, two and three standard deviations of the average value show that the input data in this example had an essentially Normal distribution.

Choose SMALL, STEP and NUMB

Values for SMALL, STEP and NUMB are fixed in statements 0086 through 0088 as 20, 990 and 5.0 respectively. The value of NUMB represents the number of incremental steps in the distribution and according to Sturgess' rule should be at least equal to

$$\text{NUMB} = 1 + 3.322 \log_{10} \text{N}.$$

SMALL represents the value of the lowest measured value, and STEP represents the numerical value of the incremental step. In initially running the program, SMALL was set equal to 900—the smallest value expected. The first run showed that the values ranged from 992 to 1088 Ω rather than 900 to 1100 Ω, as originally expected. Resolution was improved by setting SMALL to 990 and STEP to 5.0—that is, the user chooses the final values of STEP and SMALL after at least one trial run. The rule used is:

$$\text{largest value} = \text{SMALL} + (\text{NUMB} \times \text{STEP}).$$

Extend your options

Many other types of parameter measurements —for example, inductance, slew rate, h_{FE}, capacitance or computer-job throughput—can be evaluated by this program. Supplying the appropriate data is all that is necessary. The array, VALUE, must be redimensioned to the largest number of points used, if that number exceeds 200. It is also a simple matter to use the program as a subroutine, so long as NUMB, SMALL and STEP are supplied as argument values along with measured data values. When small numbers of points, say less than 30, are being inputted, it is advisable to add corrections to the standard deviation computation (statements 0042 to 0047). ■■

INTRODUCING THE EA 1502 BIPOLAR COMPATIBLE 1024-BIT RAM

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INFORMATION RETRIEVAL NUMBER 36

Cut the testing time of digital circuits

with a straightforward programmable clock that can be built with a few inexpensive ICs.

When testing digital circuitry, the engineer often finds it convenient to be able to run the system clock either continuously or in single pulses. If the circuit doesn't function properly with the normal running clock, he can usually uncover the trouble by single-stepping the clock with a pushbutton. But this can pose problems.

The engineer's finger may get pretty tired pushing the button, say, 1024 times. This could occur when he's single-stepping through a 1024-bit shift register (to insure that the data in are the same as data out, or to check what is happening at a certain point in time, such as 4096 clock pulses after initialization).

To relieve finger fatigue, and to cut testing time, try building a simple programmable clock with readily available components.

How the clock works

The programmable clock ("clock" in the diagram) operates in two modes—automatic or manual. In the automatic mode, it runs continuously. In the manual mode, the operator selects the number of pulses and pushes the button. The selected number of pulses are then generated.

The clock uses a binary down counter (Fig. 1a). While TTL is used here, the same basic approach can be used with any type of logic. The manual clock can be a pushbutton, with a latch to prevent jitter due to contact bounce (Fig. 1b). Assuming a positive pulse from the manual clock, and with the mode switch in the AUTO position (thus clearing FF_2), the clock should produce continuous clock pulses at the output.

When the mode switch is flipped from AUTO to MANUAL, FF_2 will still be cleared and will allow the clock to pass through G_1 until the count reaches zero. At this point the ripple output of the counter presets FF_2 (Fig. 2), inhibiting G_1.

The desired binary number is inserted with the toggle switches (Fig. 1a). Logical ONE is represented by +5 V. Logical ZEROs are represented by 0 V (ground), because this is the simplest and most straightforward method. The manual clock loads the selected number into the counter. FF_1 synchronizes the manual clock with the clock. The output of FF_1 clears FF_2 to allow the clock to pass through G_1 until the count again reaches zero. Note that the inverted clock passes through G_1 (Fig. 1a). If the clock were sent to G_1 in the same phase as that used to clock FF_1, the delay due to FF_1 and FF_2 would allow only part of the first clock pulse to pass through G_1.

James S. Burrill, Electrical Engineer, Sanders Associates, Inc., Nashua, N.H. 03038.

Use an up counter instead of a down counter

Figure 3a depicts a schematic of a programmable clock built with an up, rather than a down, counter. Actually this scheme is very similar to that of Fig. 1a, using the same number of ICs.

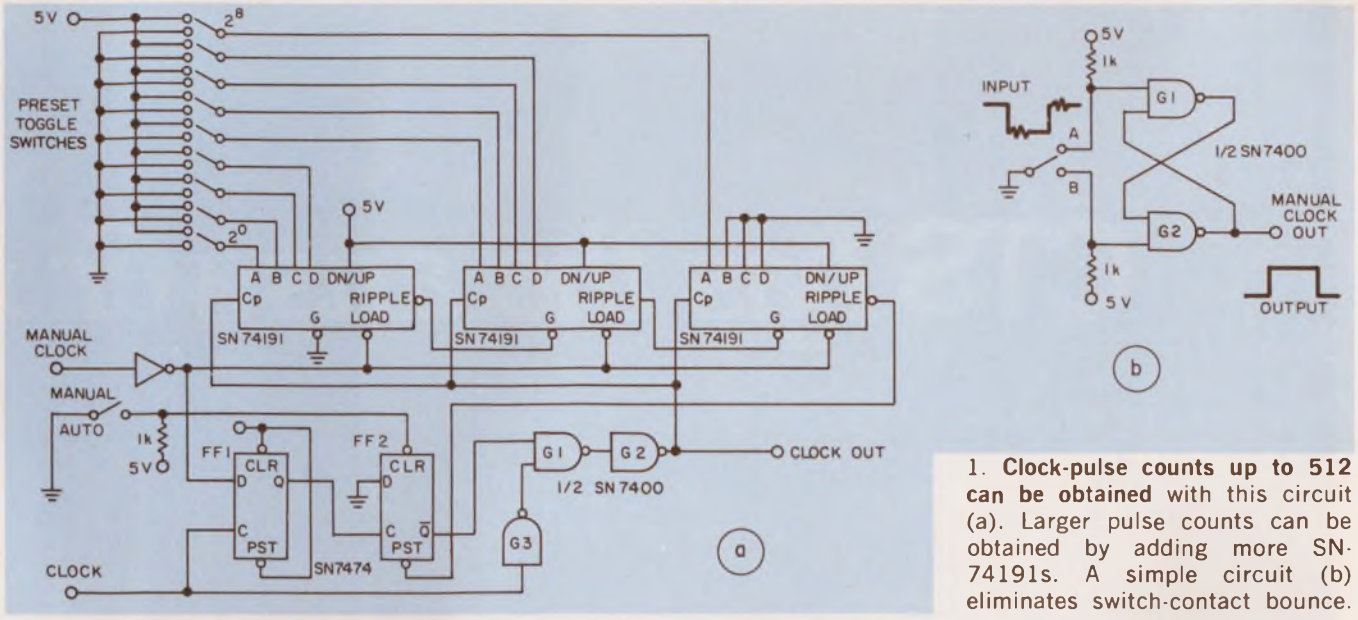
The idea behind this approach is to load the counter with the *complement* of the necessary binary number. Then the maximum count of the counter will be reached with the desired number of pulses. If the full capacity of the counter is not being used, the MSB+1 can be employed to inhibit any further clock pulses to the output, since this bit changes state after the maximum count is reached. If the full capacity of the counter is used, the terminal count on the "most significant" IC can be used.

Here is why the number to be loaded into the counter should now be the complement of the desired binary number minus one:

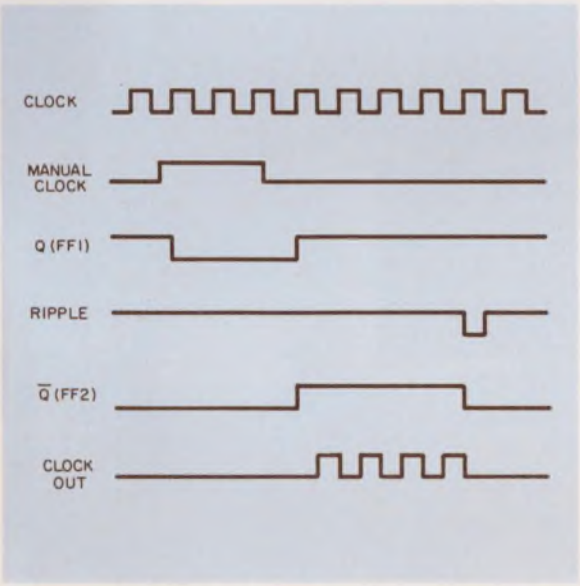
Suppose the maximum count available is 511 and the number of desired clock pulses is 3. The complement of 3 is (511 −3) = 508, and this is the number to be loaded into the counter with the toggle switches.

Since the counter counts up, the count of 511 will be reached with three clock pulses. But it will take an extra clock pulse to bring the MSB+1 (at Q_1 in Fig. 3a), high to inhibit further clock pulses. Thus four clock pulses would pass through G_1 in this case, not three.

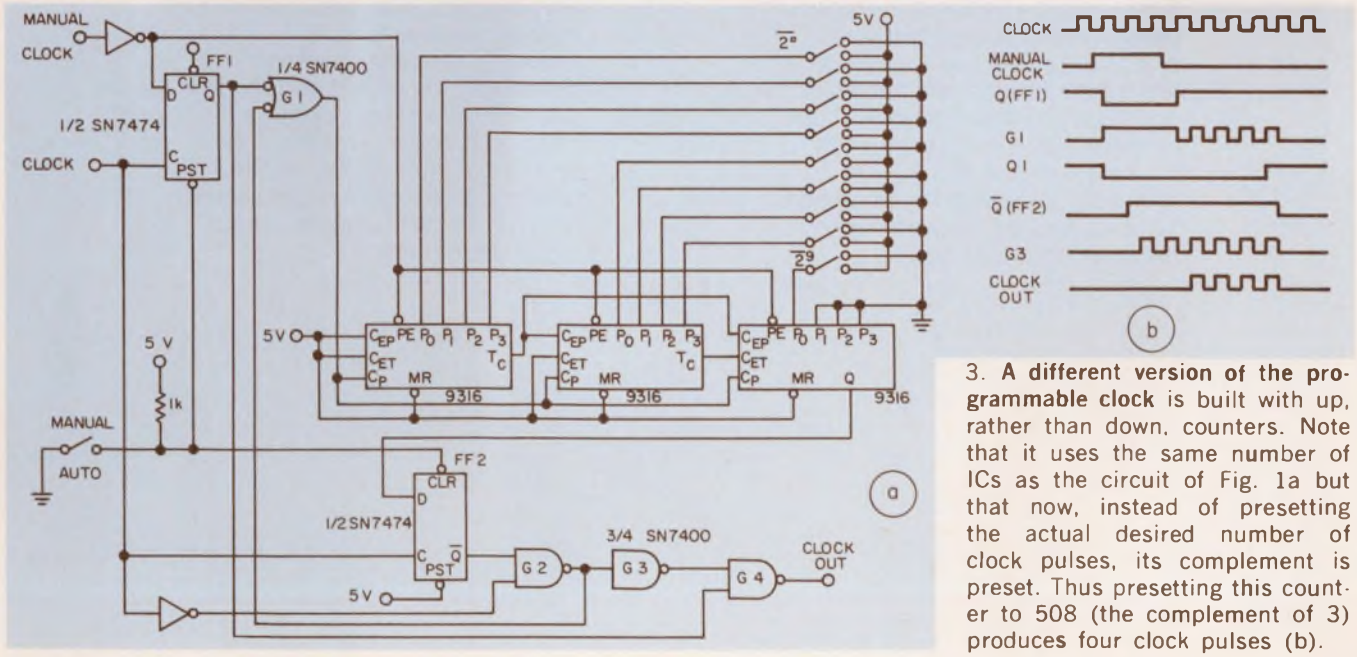
Flip-flop FF_1 not only synchronizes the manual clock with the clock, but because of the loading procedure of the 9316 counters (the leading edge of C_p must occur while $\overline{PE}$ is high and the falling edge must occur while $\overline{PE}$ is low), FF_1 and G_1 provide the necessary delay and inversion for C_p. FF_2 synchronizes the clock with MSB+1. ■■



1. **Clock-pulse counts up to 512 can be obtained** with this circuit (a). Larger pulse counts can be obtained by adding more SN-74191s. A simple circuit (b) eliminates switch-contact bounce.



2. **Four clock pulses are obtained** from the programmable clock of Fig. 1a by presetting it to 4 with the toggle switches. The continuous clock can be derived either from the system clock or from an external source.



3. **A different version of the programmable clock** is built with up, rather than down, counters. Note that it uses the same number of ICs as the circuit of Fig. 1a but that now, instead of presetting the actual desired number of clock pulses, its complement is preset. Thus presetting this counter to 508 (the complement of 3) produces four clock pulses (b).

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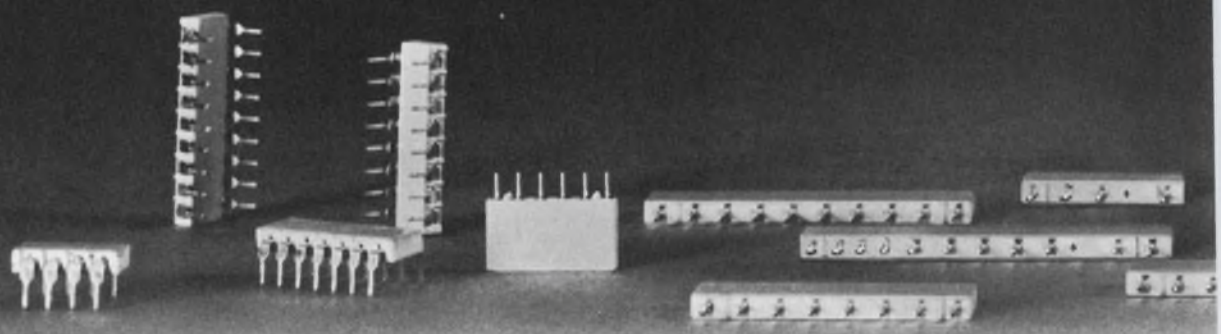

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Management-bound engineers require recognition and guidance to grow; supervisors can help to develop their attitudes and methods.

How do you recognize and cultivate a budding manager? For us it starts when we recruit people. We put them before a technical committee that shoots them questions. Although we haven't yet learned to adequately assess each person's management ability at this stage, we do get an idea of their behavior and confidence under pressure.

To help bring out some of the interviewee's qualities, we conduct a two-way interview. We figure that if the engineer is willing to be tested, the man doing the testing should be willing, too. Aside from the usual questions about the company's training program, educational benefits, and facilities, we expect a really sharp candidate to ask us direct questions like:

- What can I learn from you as a manager?
- You guys haven't capitalized much in the past two years; are you serious about being in this business?
- You talked about acquisition strategies; what other businesses might you get into that could enhance my career?

After we hire a man, we look for him to make an individual technical contribution. We challenge him immediately to use his school course work to design whatever product the company is engaged in. Of most interest to us concerning an engineer who shows managerial ability is how he handles his aides; how he accepts responsibility for the work of others; and how flexible he is.

Human relations the first bench mark

The first bench mark in an engineer's career is the way he handles the aide or two who assist him. Some technicians are engineers in their own right; they're sort of the mustangs of the industry. A prospective future manager can learn quite a lot from these guys if he keeps his mind open to suggestions.

But he also has some decisions to make at this point. When the time comes for merit review, the engineer will have to say whether his aides have performed well or performed poorly. This is the first time management ability, manifests itself. It's very easy in that situation to become friends instead of a supervisor. It's very easy to call in Charlie and say, "Well, you've done well the past six months, so I'm giving you a ten percent raise." If management buys that, then Charlie's going to be happy. But if Charlie's a thinking guy, he might say to himself: "This guy's a pushover. I sat on my duff half the time and still got a raise. I think I'll try it three-quarters of the time and see if I can get away with it." Very often engineers strike out as managers at this level because they can't separate friendship from business.

That's one aspect of the management of technicians. Another is, can our prospective manager plan an efficient work load for his aide(s)? What does he do? Does he sit in his office and not worry about what Charlie is doing? Does he pass his designs out in well-documented form and tell Charlie to construct this bread board or perform these tests or take this data and return it to him so they can talk about it. Or does he go out and sit at the oscilloscope and do the work himself

Don Sorchych

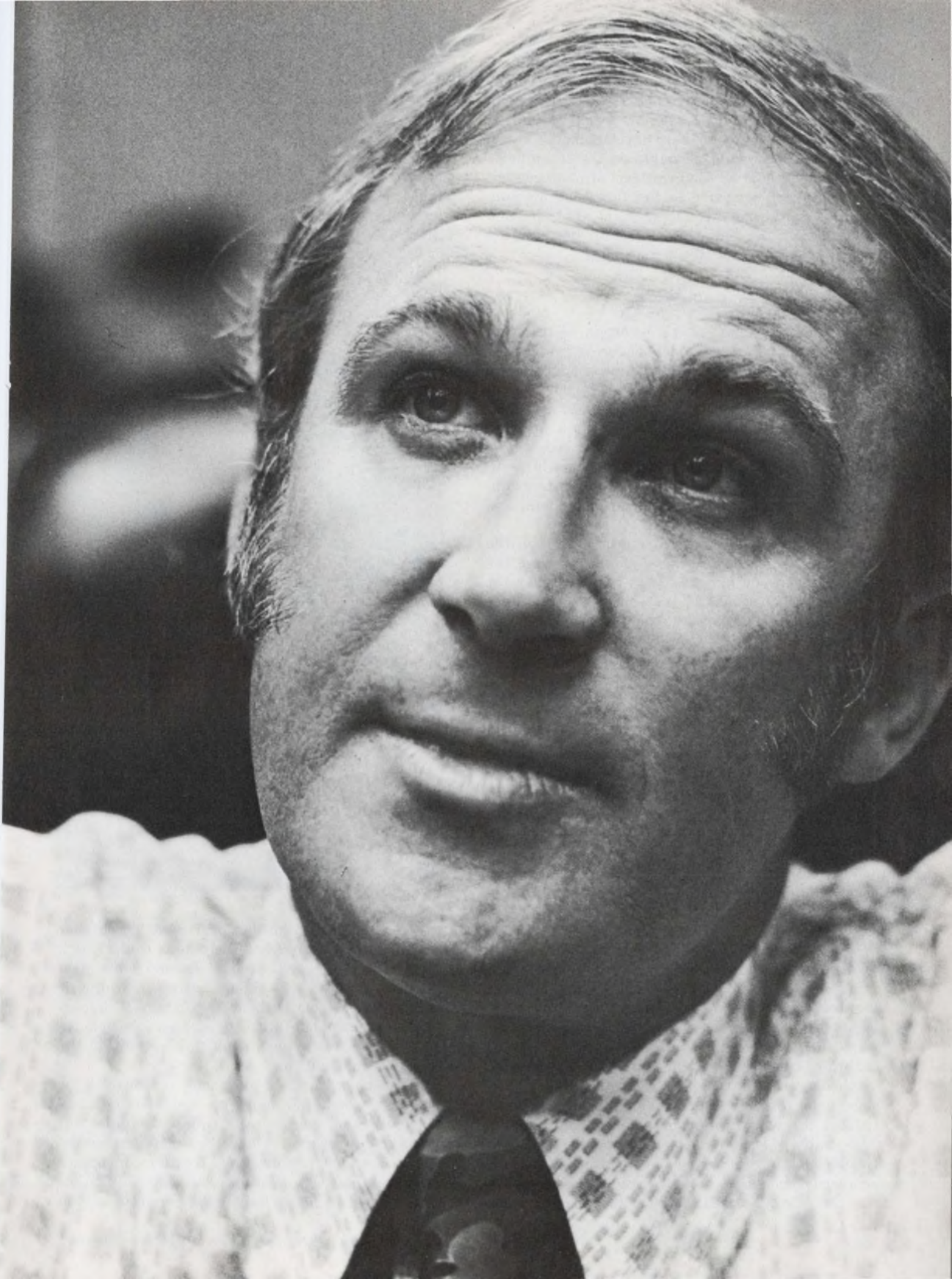
Education: B.E.E., University of Illinois.

Experience: Four years in Naval aviation electronics; for the past 12 years at Harris Semiconductor, he has worked on airborne telemetry systems; headed a circuit engineering group in the physical electronics department; led group that developed Harris' integrated circuit technology; appointed Director of Engineering; and then appointed Vice President and General Manager.

Personal: Married, two daughters; hobbies include hiking, hunting and fishing.

Employer: In 1967, following a Harris-Intertype acquisition, Harris Semiconductor became a separate division within the corporation; a new three-story IC manufacturing facility was dedicated in Melbourne, Fla.

Don Sorchych, Vice President, General Manager, Harris Semiconductor, Melbourne, Fla. 32901



while Charlie is watching over his shoulder, forcing the company to pay two salaries for one man's work? Perhaps engineers shouldn't try to use the argument that they're teaching Charlie when at this stage in their development, Charlie is the one who could probably do the teaching.

The supervisor at the next level of management must be very sensitive to the fact that his subordinate is developing management attitudes and methods. If the engineer is left to his own devices, he might pick the wrong ones.

Learning how to take the blame

The next position in the evolution of this prospective manager is project leader or project engineer. At this point he will have a small group of technicians and engineers and various equipment and resources under his control to carry out a well-defined mission to develop a product.

Now his decisions become tougher because he has professional engineers to supervise in addition to other employees. He has to learn to evaluate these people, judge them, develop them, and be responsible for their work.

Accepting blame is another crucial step in the making of the engineering manager because it's very difficult for him to accept responsibility for work that's not his. It just doesn't seem to be just. But he learns that the buck has to stop somewhere and if he assigns responsibility to a man for a project, he gets both the credit and the blame. In management, that's justice.

The man's supervisor should be very close to what's going on and help him develop his management skills through constructive criticism. I think that project engineering is a critical test of a man's management ability because there are many disparate parts to pull together. The project is an important function to any company, and if a fellow is an outstanding project manager, you can usually recognize that he is going to be a good manager well up into the management ranks, perhaps even up to corporate management.

Overcoming the overlay

As there are different kinds of projects, so are there different kinds of management methods to control them. The most complicated of these management methods is called "functional with overlay." In this case, the project engineer has to answer two bosses: the functional manager, who operates the project, and the overlay manager who protects the customer interest and integrates the whole program. Overlay management integrates the resources of a common goal. The project engineer's responsibility may be one specialized element of a total project; he's one key on the schedule path, and he has to perform to that time and dollar limit and so on.

His flexibility will be given a tough test because he, like most people, has been used to answering to only one boss.

An overlay management situation is frequently a source of conflict, particularly with new engineers; they don't understand the concept and they find it difficult to accept. So here, too, is another fork in the road to management. Which direction the project engineer takes depends on his ability or determination to overcome the situation.

Higher management requires the ability to judge scheduling, what's possible with the resources available, and a thorough knowledge of

the technological hurdles to overcome. The higher a manager goes the more likely he is to deal with the customer. So, he'll need to develop some marketing knowhow. He should also avail himself of specialized tools such as legal counsel or contract management. He'll need these people to make sure he's staying within the law, within the terms of the contract.

As a supervisor who has been responsible for the development of many up and coming management-bound engineers, I think it's important to know that every engineer has different needs, biases, knowledge, education, fixations, neuroses and everything else. You have to find a different key to open up each individual. Sometimes you

find the key, and sometimes you don't. Usually when you don't, it's a failure of both parties. Any time you have to terminate an employee, it's a failure of management.

Give subordinates "political immunity"

As a company policy we've tried many ways to improve the methods we use to reach our management objectives. No company can really afford to lose its feedback mechanism because the most healthy type of organization is one where there's a lot of give and take. Management should be able to say what it doesn't like about what's happening or what performance is bad; if there are reasons, other than alibis, for those negative things happening, then subordinate management should be able to say what it is with immunity.

We tried sensitivity training ("T" group) over a four year period. We processed about twelve men each time with a trainer. Although these sessions would get out of control occasionally (I don't think you want to put everyone into a T group), the experience does teach people that hostilities are a normal sort of thing and that conflict can clear the air and lead the way to the healing of wounds and a goal-oriented team effort. I found, among management personnel, the people that go into a T group in a very open way, learn something from it. It takes a very small attitudinal change to make a difference in relationships.

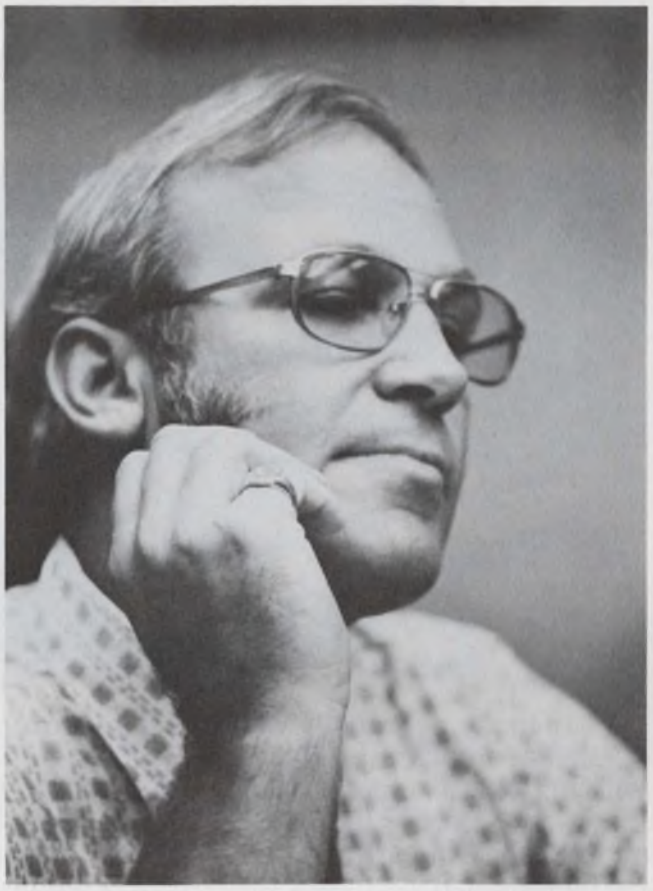
We don't use T groups any more because everyone has little things to hide and they don't want to get that interpersonal. Also, we had guys who tried to beat the game. What they do is develop a mental list of rules to live by, i.e., "That guy complained in there because I put my foot on his desk. I'm not going to do that anymore. I'm going to change that behavior". That reaction is sort of positive because this guy has a thing about people scratching up the top of his desk. But that's not really what you hope to get from a T group. You are, in fact, trying to accomplish a behavior change. So, why play games?

Another thing that we are doing now which is an experiment and is yet to be measured is an assessment center approach. We train a group of assessors from the highest level of management. The training is accomplished by industrial psychologists. The assessors learn the games and the methods of measurements. And then the assessors put a group of middle management people through these games and observe their performance. Some people don't like the games because they're very competitive. It is a pretty good simulation of what industry is really like.

In our limited experience with it we have yet to decide whether this is the tool we want to use in going forward. Assessors do give participants direct feedback, i.e., here is how you scored, and why; we think you have these strengths and we think you have these weaknesses, and we suggest this development method to help strengthen you.

We try to arrange it so that all assessors assess each individual through these exercises to get a composite picture. All the assessors and the trainer trade information, argue it out and decide what is the best judgment and that is what is written down and reported to the man.

Regardless of what training methods a company may use, it's very paternalistic to think that there's anything as powerful as self-development. How does an indivudal who decides he wants to become a professional manager go about it? There's an enormous body of literature on this but he should read with skepticism. The manager-to-be should be encouraged to continue the self-study habit, partly on company time, and partly on his own time. Maintain it and use it.



Also, observation of methods employed by bosses, peers and subordinates should constantly be evaluated for addition to a manager's own methods. And finally, constant and objective critique of past management methods, particularly with respect to failures, is essential. It's all too true in the management microcosm that a man who fails to learn from past mistakes is likely to repeat those same mistakes. ■■

The Uncomputers. An unabashed attempt to uncomplicate mathematics.

Until today, everybody who needed a computer to help with his job was faced with a far greater decision than a simple choice of hardware. He literally had to go back to school to learn a whole new language. Indeed a science. Just to be able to translate his job (which he knew well in the first place) into something computers and programmers could understand.

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INFORMATION RETRIEVAL NUMBER 39

ideas for design

Eliminate troublesome common-mode output voltages in IC video amplifiers

There are problems when the dc common mode output voltage is removed from a video amplifier. They include temperature drift and frequency-response degradation. The circuit shown in Fig. 1 avoids these problems. A series string of diodes shifts the voltage and the output voltage can be made independent of temperature.

Other approaches that the designer might be tempted to take—such as the circuits shown in Figs. 2a and 2b—do not compensate for the temperature dependence of the diode voltage drops, while the use of a current source (Fig. 2c) degrades the high-frequency response.

In the circuit of Fig. 1 the output of the IC amplifier is fed to emitter follower Q_1 which provides isolation. A resistive divider, R_1 and R_2, in the Q_1 emitter circuit shifts the output level. Emitter follower Q_2 isolates the load from the level-shifting network. If we assume that $V_{BE(Q1)}$, $V_{BE(Q2)}$ and V_D (the voltage drop per diode) are equal, then N, the number of diodes, can be calculated so that the output voltage is independent of temperature. (Diode strings, such as the CA 3039, or a transistor array, such as the CA 3046, satisfy these requirements.)

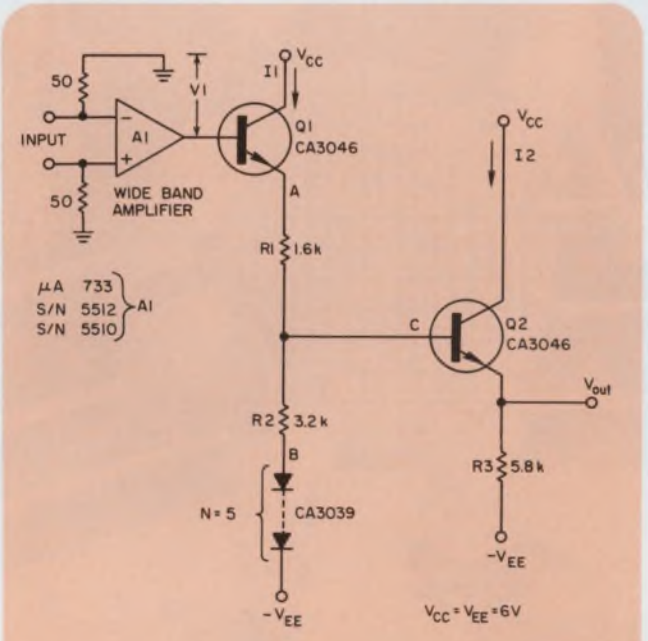
A design example will illustrate the technique. Assume that V_{BE} and V_D are both equal to 0.7 V while V_{EE} equals 6 V. Also let $V_1 = 3.0$ V and N equal 5. Then V_A equals 2.3 V and V_B equals −2.4 V. If I_1 is set at 1 mA, R_1 and R_2 are computed to be 1.6 kΩ and 3.2 kΩ, respectively. Thus V_C is 0.7 V and V_{OUT} is zero.

Next, assume a negative 2 mV/°C temperature coefficient for the diode and transistor junctions. And let the temperature rise from 25 C to 75 C. Then, at 75 C, $V_A = 2.4$ V, $V_B = -3.0$ V and $V_C = 6$ V. Hence V_{OUT} is still zero.

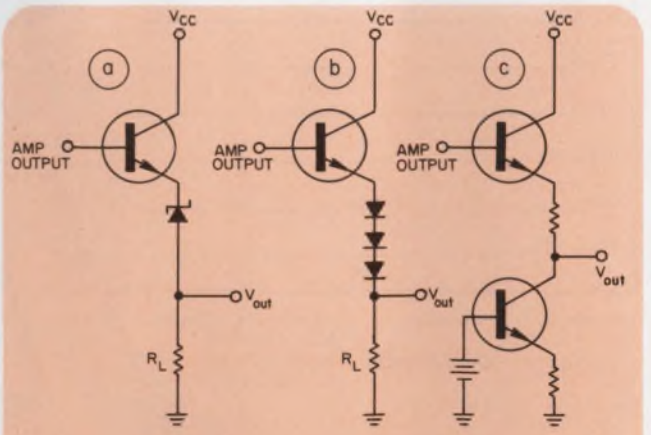
This circuit removes common-mode output voltages from 2.4 to 3.4 V, which are found in commercially available video amplifiers. One should apply appropriate bias at the input of the IC to make its dc output voltage correspond to an integral number of diodes.

S. Sareen, Design Engineer, Aertech Industries, 325 Steward Dr., Sunnyvale, Calif. 94086.

CIRCLE NO. 311



1. **Temperature drift and poor response are avoided** with this configuration. Q_1 changes the output level and Q_2 unloads the resistive divider.



2. **Circuits a and b remove the common-mode output** but are temperature-sensitive. Circuit c degrades the frequency response.

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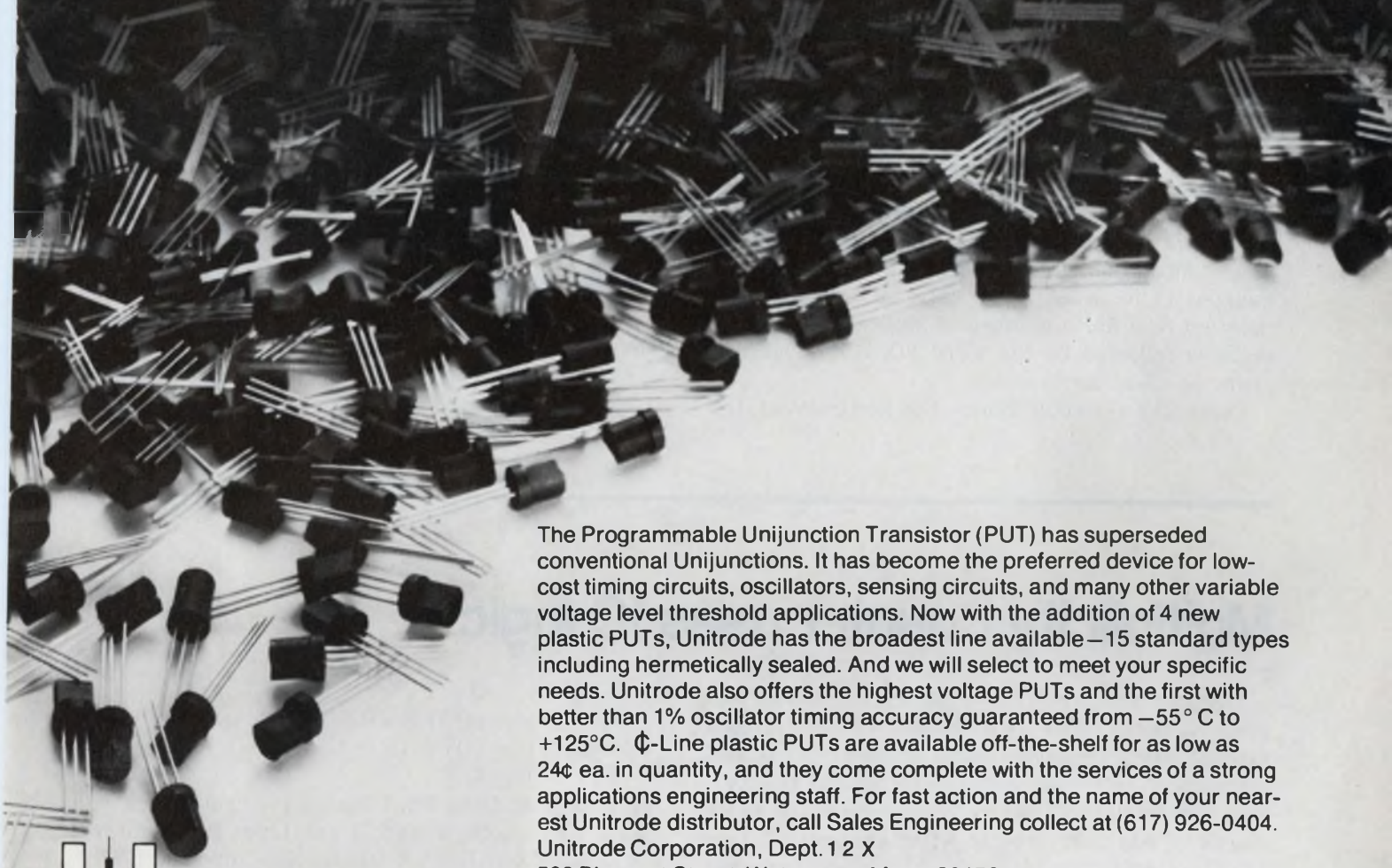

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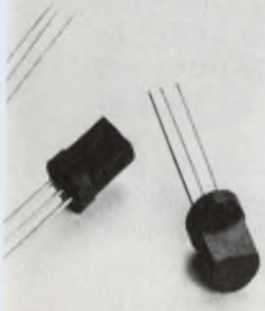

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BASIC program expresses any number as a rational fraction

Designers often find a need to express a number as a rational fraction. An engineer designing a frequency synthesizer, for instance, or one designing gear-train drives, can work only with rational fractions. The BASIC program in Fig. 1 takes any number (rational or irrational) and produces successively finer rational-fraction approximations. The number to be rationalized is requested as an input in line 10 as the variable S. Any number can be defined by changing line 10.

The printout consists of the coarsest approximation (the integer part of the number), followed by finer and finer approximations. Pi, for instance, is approximated as 3/1, 22/7, 355/113, etc., continuing until internal accuracy is exhausted. The input of a rational value causes printout of a finite number of successive approximations followed by the word EXACT. The program is then terminated.

Computer roundoff limits the accuracy of the result; the alogrithm is exact.

```
10  INPUT S
20  A1=B2=0
30  A2=B1=1
40  N=INT(S)
50  T=A2
60  A2=N*A2+A1
70  A1=T
80  T=B2
90  B2=N*B2+B1
100 B1=T
110 PRINT A2;"/";B2
120 IF S=N THEN 150
130 S=1/(S-N)
140 GOTO 40
150 PRINT "EXACT"
160 END
```

Successive approximations are computed by the BASIC program.

Peter Bice, Corporate Training Dept., Hewlett-Packard, 640 Page Mill Rd., Palo Alto, Calif. 94304.

CIRCLE No. 312

Multiplicity counter uses IC logic

Suppose you want to count active photomultiplier channels. MSI logic doesn't exist in a convenient form for determining an event count and converting it to an equivalent binary number. One economical solution is to implement the early stages of addition directly with logic gates (Fig. 1). The circuit provides a four-bit binary number for every set of eight lines. These four-bit numbers can then be combined by adders to provide a binary sum over any number of channels.

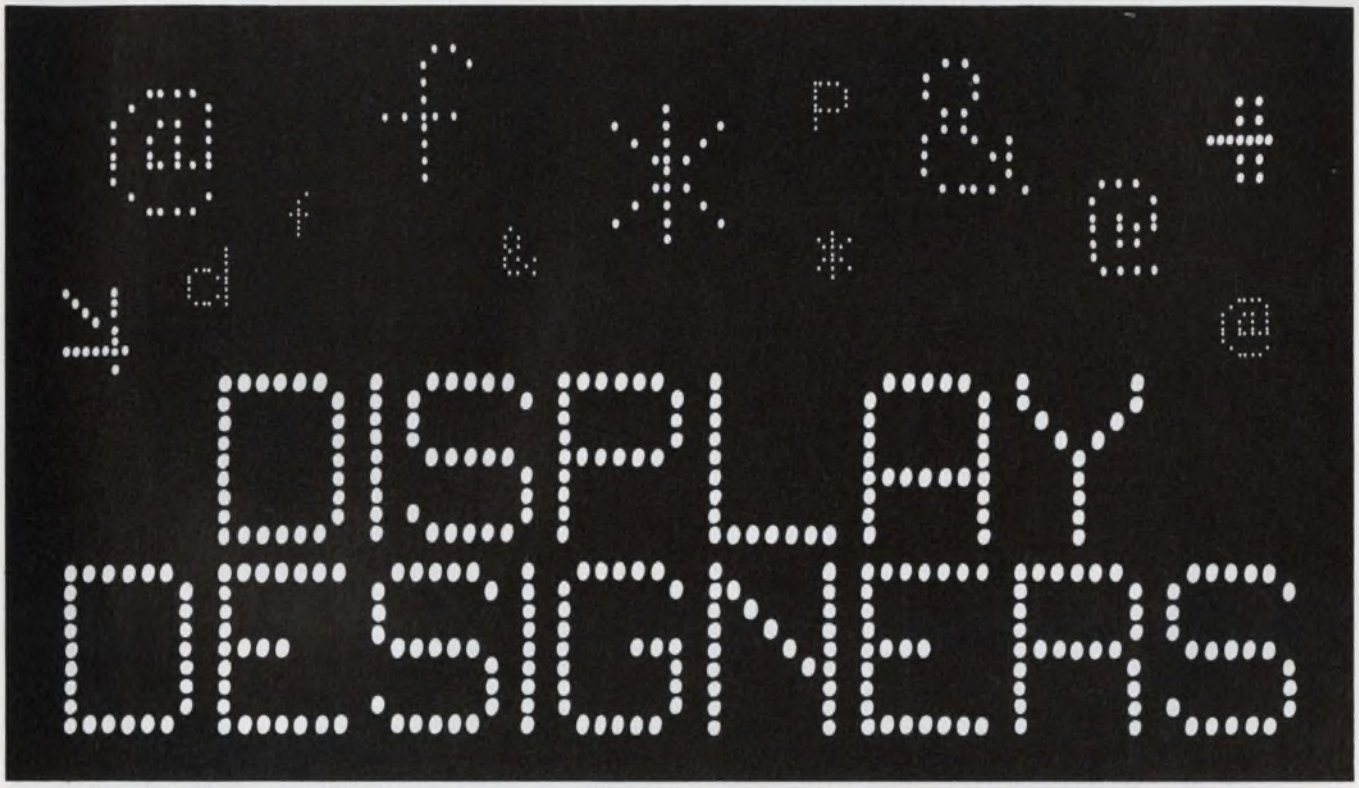
The logic solution is fairly simple. Four sets of two lines each are converted to four sets of 1, 2 sums. These are paired and converted to two 1, 2, 4 sums. These are combined in the last stage to form the final 1, 2, 4, 8 sum. Equations for three stages are:

$$\begin{aligned} &I\ (\text{“1”}) = A \oplus B \text{ (same for K,L;M,N;O,P)} && (1)\\ &J\ (\text{“2”}) = AB\\ &Q\ (\text{“1”}) = I \oplus K\\ &R\ (\text{“2”}) = I \cdot K + J \oplus L \text{ (same for T,U,V)} && (2)\\ &S\ (\text{“4”}) = J \cdot L \end{aligned}$$

$$\begin{aligned} &W\ (\text{“1”}) = Q \oplus T\\ &X\ (\text{“2”}) = (QT) \oplus (R \oplus U) && (3)\\ &Y\ (\text{“4”}) = (QT) \cdot (R \oplus U) + R \cdot U + S \oplus V\\ &Z\ (\text{“8”}) = S \cdot V \end{aligned}$$

It is clear from Eq. 1 that a (“2”) J output occurs when both A and B are true. When either A or B (EXCLUSIVE OR) is true, only the (“1”) output occurs. Similarly, in the second level Q (“1”) = A ⊕ B ⊕ C ⊕ D will be true if only one input is true or if three inputs are true. For example, let's say that A, B, C are true and D false, then I = A ⊕ B = “0”, K = C ⊕ D = “1”, then Q = I ⊕ K = “1”. R (“2”) will be true when either two or three inputs are true. Then either J (“2”) or L (“2”) can be true (EXCLUSIVE OR) OR both I (“1”) AND K (“1”) will be true. The same approach is used for the next step.

It does not pay, however, to continue the procedure beyond the level selected (eight inputs) as the function becomes increasingly complex.



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MM6061	5x7	128	Row	175	24 DIP
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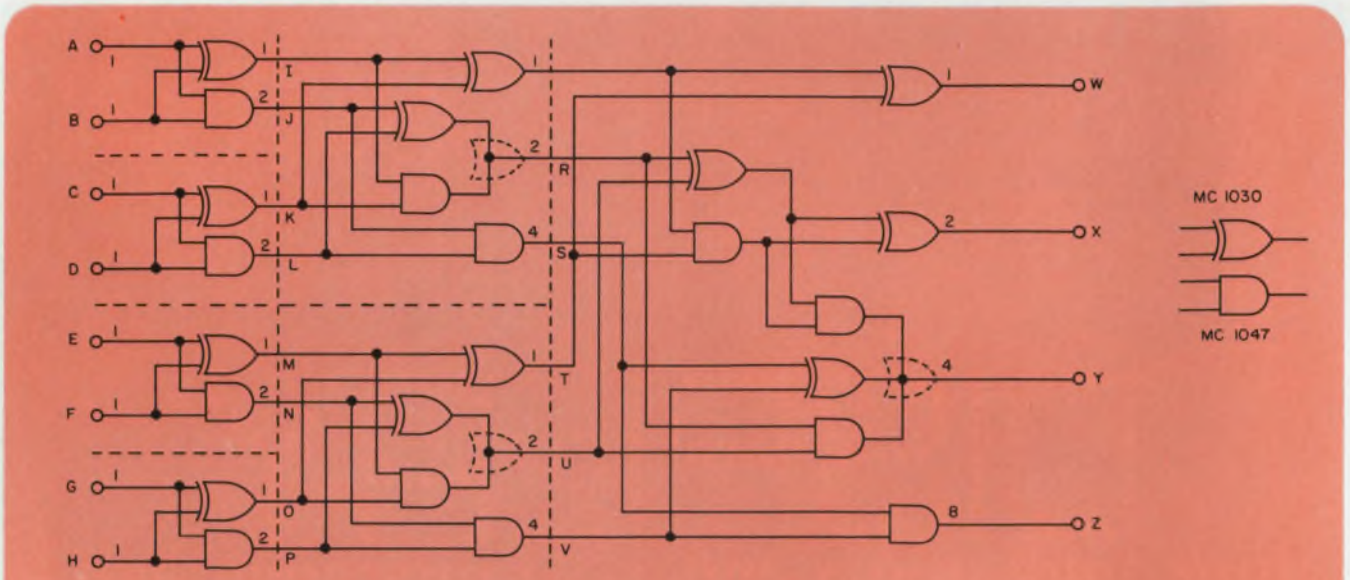
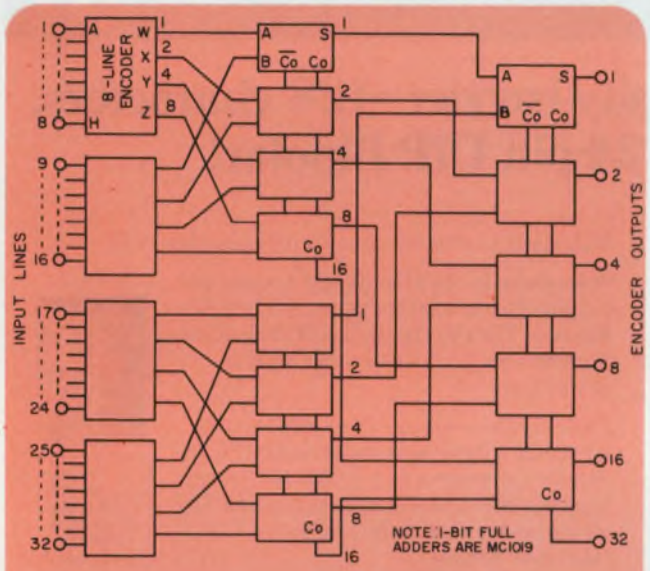
INFORMATION RETRIEVAL NUMBER 41



1. **Three levels of logic convert inputs** to a binary equivalent count.



2. **The eight-line modules are combined** to handle additional inputs.

For a greater number of input lines, multiple groups of eight-line encoders can be combined, as shown in Fig. 2.

If high-speed operation is not required, TTL ICs, such as these can be used in place of the ECL units:

	MECL	TTL	
EXCLUSIVE OR	MC1030	MC3021	7486
AND	MC1047	MC3001	7408
OR	—	MC3003	7432
Full Adder	MC1019	MC4026	—
Dual Full Adder	—	MC8304	74H183

With TTL, be sure to use an OR gate instead of the wired OR shown in Fig. 1.

Boris Bertolucci, Stanford Linear Accelerator Center, Electronics Instrumentation, P.O. Box 4349, Stanford, Calif. 94305.

CIRCLE No. 313

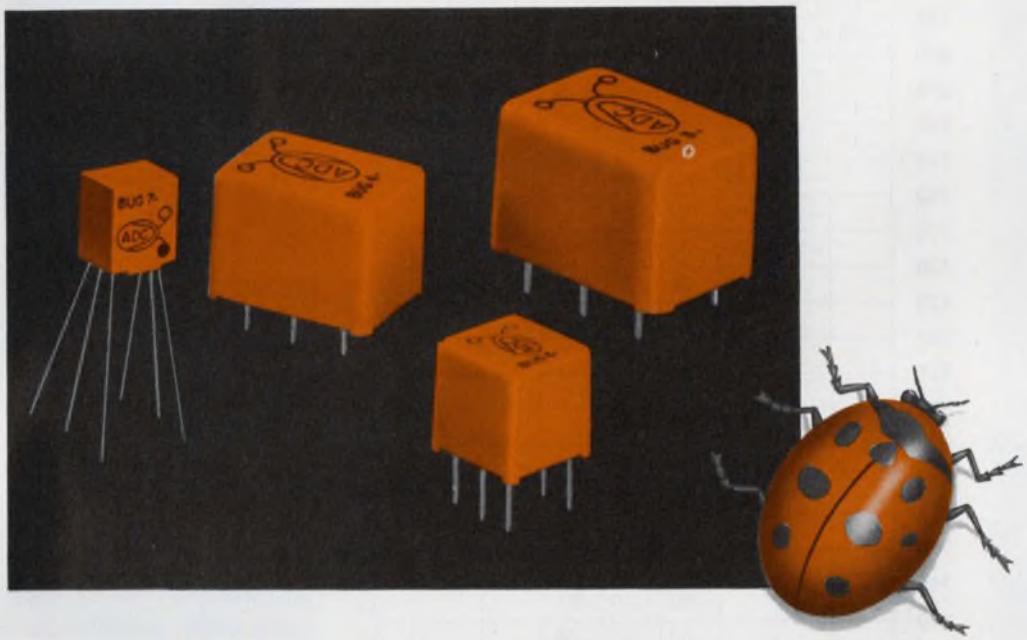
IFD Winner of August 3, 1972

R.J. Battes, P.O. Box 11604, Palo Alto, Calif. 94306. His idea, "Build a quartz-crystal-controlled digital clock with only six ICs," has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the Information Retrieval Card at the back of this issue.

SEND US YOUR IDEAS FOR DESIGN. You may win a grand total of $1050 (cash)! Here's how. Submit your IFD describing a new or important circuit or design technique, the clever use of new component or test equipment, packaging tips, cost-saving ideas to our Ideas for Design editor. Ideas can only be considered for publication if they are submitted exclusively to ELECTRONIC DESIGN. You will receive $20 for each published idea, $30 more if it is voted best of issue by our readers. The best-of-issue winners become eligible for the Idea of the Year award of $1000.

START YOUR OWN BUG COLLECTION...



WITH A FREE LADY BUG FROM ADC!

If you've been thinking that most commercial transformers are pretty much alike, these new ADC Lady Bugs will change your mind.

We've engineered Lady Bugs to provide the kind of reliability you've come to associate only with transformers meeting military specifications. More than that, we've made sure these ADC Transformers offer something you haven't seen in a while: economy. So, beginning now, you can have the transformer performance you've always wanted, and still keep costs in line.

ADC Lady Bugs come in 46 different electrical configurations with power ratings from 50 mw to 2 watts. There are four different case sizes, with the smallest being approximately one-third cubic inch.

We don't want to bug you, but if you have a real need for miniature transformers, we will send you an evaluation sample free — no strings attached. Just tell us what your requirements are on the coupon and send it back to us. Or, if you just want more information, please circle the number on the Reader Service card.

ADC PRODUCTS

Division of Magnetic Controls Company
4900 West 78th Street
Minneapolis, Minnesota 55435
TEL: (612) 835-6800 TWX: 910-576-2832 TELEX: 29-0321

4900 West 78th Street
Minneapolis, Minnesota 55435

Yes, I would like an evaluation sample of the new Lady Bug transformer. Here's my application:_____

We anticipate using_____units/year.

My needs are for_____30 days
_____60-120 days_____Future

NAME_____

COMPANY_____

ADDRESS_____

CITY_____STATE_____ZIP_____

TELEPHONE_____

INFORMATION RETRIEVAL NUMBER 42

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WJ–5118 SERIES YIG SPHERES

$4\pi M_S$ (Gauss)	Diameter — Inches								Linewidth, maximum (Oe)
	.037	.034	.032	.029	.026	.022	.019	.015	
200	–01	–02	–03	–04					1.5
225	–05	–06	–07	–08					1.5
250	–09	–10	–11	–12					1.5
275	–13	–14	–15	–16					1.1
300	–17	–18	–19	–20					1.1
325		–21	–22	–23	–24				1.1
350		–25	–26	–27	–28				1.1
375		–29	–30	–31	–32				1.1
400			–33	–34	–35				0.9
425			–36	–37	–38				0.9
450			–39	–40	–41				0.9
475			–42	–43	–44				0.9
500			–45	–46	–47				0.9
550			–48	–49	–50				0.9
600			–51	–52	–53				0.9
650				–54	–55				0.9
700				–56	–57	–58			0.9
750				–59	–60	–61			0.9
800				–62	–63	–64			0.9
850				–65	–66	–67			0.9
900				–68	–69	–70			0.9
950				–71	–72	–73			0.9
1000				–74	–75	–76			0.7
1050				–77	–78	–79			0.7
1100				–80	–81	–82			0.7
1150				–83	–84	–85			0.7
1200					–86	–87			0.7
1300					–88	–89	–107		0.7
1400					–90	–91	–108	–111	0.7
1500					–92	–93	–109		0.7
1600					–94	–95	–110		0.7
1700					–96	–97	–98	–99	0.7
1800									

Watkins-Johnson YIG spheres are guaranteed to be free of dirt, wax and other surface contamination at time of purchase. Sphericity is guaranteed to 0.0001, finish is typically 0.15 microns and diameter is accurate within ±0.0005. Variations of the spheres listed are available upon request.

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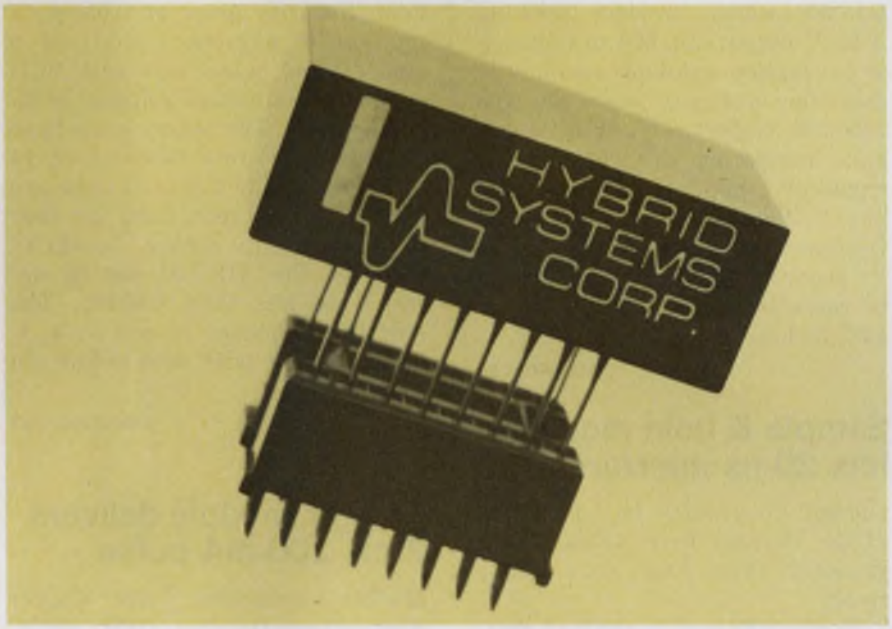
ITALY: Piazza G. Marconi, 25 00144 Roma-EUR • Tel: 59 45 54 • Cable: WJROM-ROMA • Telex: 60117

INFORMATION RETRIEVAL NUMBER 43

new products

Tiny 10-bit d/a converter plugs into 16-pin IC socket



Hybrid Systems Corp., 87 Second Ave., Northwest Park, Burlington, Mass. 01803. (617) 272-1522. $19.00 (1-9); stock to 2 wks.

Hybrid Systems has pulled out all the stops in packaging to produce a discrete-component, 10-bit d/a converter that occupies only 0.4 cubic inch. Called the DAC 371I-10, the 1.4 × 0.6 × 0.48-inch module plugs into a 16-pin DIP socket and includes current-steering switches, the ladder network and the reference circuit.

The module is an offspring of the company's small eight-bit converter, the DAC 371-8. But the new unit, which accommodates two extra bits, is only 0.1 inch longer.

Though small in size, the DAC 371I-10 delivers a fairly large full-scale output current of 4 mA. This is sufficient to drive a coaxial cable directly. And with an output impedance of greater than 1 MΩ, the unit behaves as a current source.

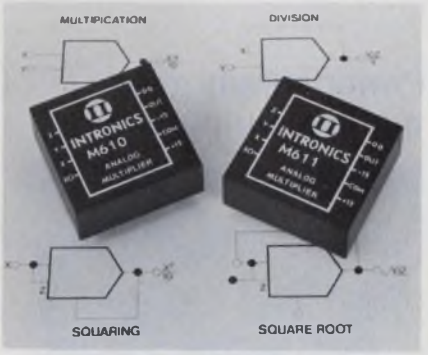
Output current may be converted to a voltage by terminating the output pin with a resistor to ground. When this is done, up to +1.25 V (compliance) can be obtained. An op amp may be used to boost the voltage further. The settling time of the output is a maximum of 1 μs to 0.1%, for a full-scale input step from all ZEROs to all ONEs.

As for performance, no sacrifices appear to have been made to obtain the miniature size. The new unit has been designed to be monotonic over its full operating temperature range of 0 to +70 C. Discrete thin-film resistors, used in the internal weighting network, contribute to the over-all accuracy tempco of 100 ppm/°C and provide extra stability. And the internal reference source has a power-supply sensitivity of only ±0.05%/%.

The digital inputs of the DAC 371I-10 are DTL/TTL compatible, and no buffering is required. Coding is straight binary. To insure reliability, all active components are hermetically sealed in metal cans. No plastic or silicone packages are used for the transistors or ICs. At a cost of only $19 each, the DAC 371I-10 should provide tough competition for monolithic and hybrid types, which are typically more expensive.

CIRCLE NO. 251

Modules multiply/divide with 0.25% accuracy

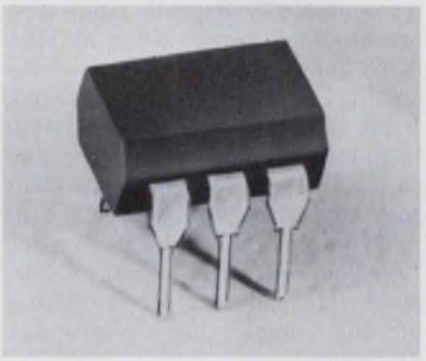


Intronics Inc., 57 Chapel St., Newton, Mass. 02158. (617) 332-7350. M610: $85; M611: $125.

The M610 and M611 modules can multiply, divide, square and take square roots. No external trimming is required. Specs include 300-kHz minimum bw, 0.25% accuracy (M611), 100 μV/°C offset drift, and 0.1%/°C scale factor drift (M611). These units are encapsulated in a 1.5 × 1.5 × 0.62-in. case, with gold plated pins for PC-board mounting.

CIRCLE NO. 252

Opto-isolators give 1.5 kV I/O isolation

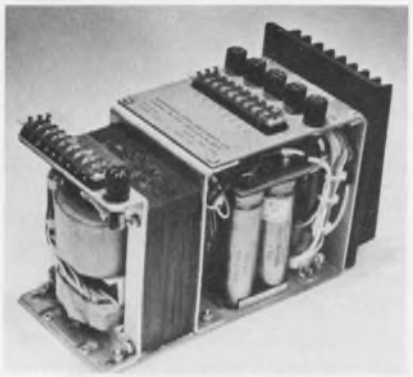


Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237. (212) 497-7600. $1.50 (1000); 2-3 wks.

For the OEM who must electrically isolate low-voltage logic circuits from high-voltage outputs, Dialight announces their new 551 series opto-isolators. Both Models 551-0002 and 551-0003 consist of a gallium-arsenide LED and an n-p-n silicon phototransistor mounted on a six-lead frame. The units are encapsulated within an electrically nonconductive plastic compound. Specs include: input-output isolation of ±1.5 kV; 250 mW total dissipation; and input diode current of 60 mA.

CIRCLE NO. 253

Power supply gives multiple outputs



Burroughs Corp., Electronic Components Div., P.O. Box 1226, Plainfield, N.J. 07061. (201) 757-5000. $211 (100s).

The BDS40832-PS1 power supply, which will find applications in terminal and display systems, develops the following dc-outputs: +5.0 V at 8.0 A, ±2.5%; −250 V at 0.08 A, +6.0%, −5%; +30 V at 0.04 A, +6.0%, −5%; +12 V at 0.175 A, +7%, −5%; −12 V at 1.0 A, ±5%. The supply can operate at 50/60 Hz, and input taps are provided for operation at 115/220 V input. Input is three-wire including separate earth ground. From 3/4 to full load, the regulation includes variations for 10% line fluctuation, ripple, component accuracy, and temperature effects. Stability is ±1% for eight hours after four hours of warm up with a constant full load. The +5 V section of the supply has overvoltage protection.

CIRCLE NO. 254

Small power supplies deliver up to 1.5 A

Acopian Corp., 131 Loomis St., Easton, Pa. 18042. (215) 258-5441. $49 to $105; 3 days.

Miniaturized power supplies with significantly increased output currents are now available from Acopian Corp. Representative models are the 5E150, with an output of 5 V at 1.5 A, and the D15-35, which provides tracking ±15 V outputs at 350 mA. Previously, highest available currents at the same voltages were 500 and 150 mA, respectively. Most models have regulation of ±0.05% and ripple of 1-mV rms. Standard input is 105-125 V ac, 47-420 Hz. Designed for mounting directly on PC boards, the units are housed in cases measuring 3.5 × 2.5 × 1.25 inches.

CIRCLE NO. 255

Sample & hold module has 20-ns aperture

Optical Electronics Inc., P.O. Box 11140, Tucson, Ariz. 85706. (602) 624-8358. 5020: $109; 5021: $101; stock.

Model 5020 sample and hold module is characterized by 20-ns aperture time and 2-ns aperture uncertainty time. Model 5021 features 3-ns total aperture time and 300-ps aperture uncertainty time. Both models are packaged in a 1.8 × 1.2 by 0.6-inch high module and feature: 300 V/μs tracking mode slew rate (Model 5020), 100-MHz minimum tracking mode bw (Model 5021), 1 μV/μs memory decay rate (Model 5020) and 100-ns max. settling time to 0.1% (Model 5020).

CIRCLE NO. 256

16-bit a/d converter has adjustable linearity

Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706. (602) 294-1431. $225; 2 wks. ARO.

The ADC100 integrating a/d converter is designed for use in industrial process control, data logging, and high-accuracy instrumentation. The unit features maximum linearity error of 0.005%, a maximum accuracy drift of 5 ppm/°C and is available with BCD or binary coding and unipolar or bipolar inputs. The binary units have user-selectable resolutions of 12, 14 or 16 bits, while the BCD units are available with four digit or four digit plus sign coding. Linearity error of the ADC100 can be adjusted to less than 0.002%. The ADC100 is housed in a 2 × 4 × 0.4-in. module with dual-in-line pin spacing.

CIRCLE NO. 257

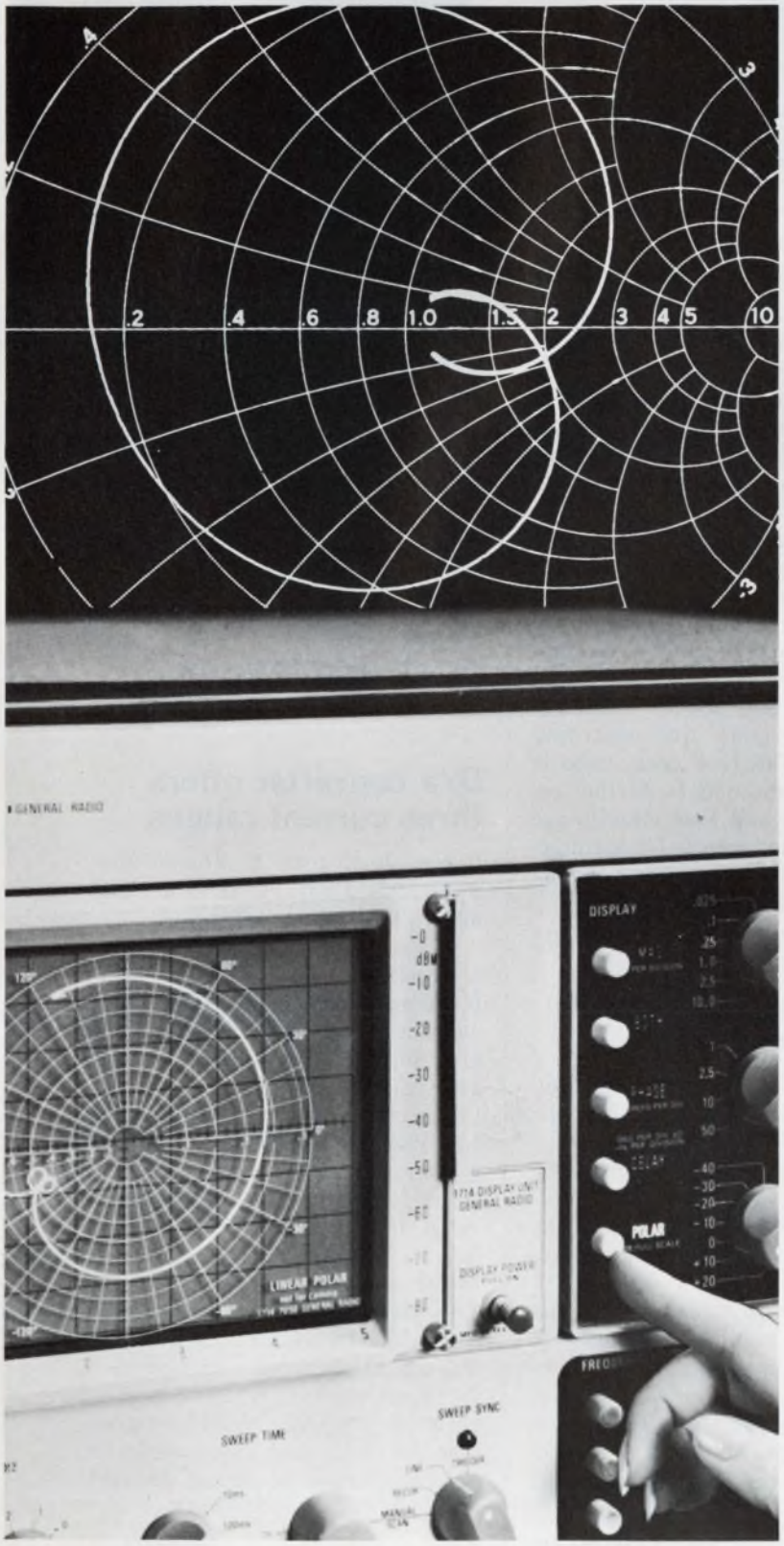
Trigger module delivers 2-ns, 100-mA pulse

Mullett Associates, 349 Culver Blvd., Playa Del Rey, Calif. 90291. (213) 823-6757. $175 (single qty); stock.

Current pulses of 2 ns width and 100 mA amplitude are produced by this self-contained trigger generator. Model 2906 has no external power requirements and no controls to adjust. Power is consumed only when a pulse is generated. Life of the internal 9-V battery is 2 × 10^{11} pulses. Output waveshape is virtually independent of input drive pulse.

CIRCLE NO. 258

Complete
RF Network Analysis with POLAR DISPLAY



WHEN you need concise measurement data on antennas or rf cables, you'll see the value of polar (Smith-chart) displays of impedance versus frequency.

WHEN you want accurate measurements of structural return loss, you'll appreciate the ability to switch quickly from a rectilinear to a polar display.

WHEN you have to characterize active devices, you'll find invaluable the large 360-degree display with a full 100-dB dynamic range.

WHEN you must compare two unknowns or compare two ports of multiport unknowns such as power splitters or phase shifters, you'll want the speed and simplicity of polar displays of the vector difference.

WHEN you want all this from 400 kHz to 500 MHz with 0.005-dB resolution, you'll want the 7145-dollar 1710 RF Network Analyzer with polar display from General Radio — the GR 1710...

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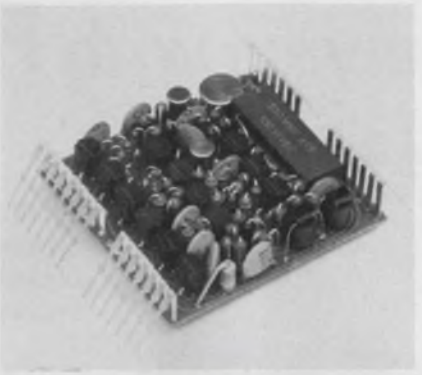
INFORMATION RETRIEVAL NUMBER 45

MODULES & SUBASSEMBLIES

Sample/hold settles to 0.01% in 1 μs



Zeltex, Inc., 1000 Chalomar Rd., Concord, Calif. 94520. (415) 686-6660. $149; stock to 2 wks.

Zeltex's sample/hold module, ZD452, settles to 0.01% in 1 μs. The FET-input buffer amplifier provides 10^{11} Ω input impedance, and less than 50 pA of input bias (either input). The analog inputs are fully differential, making the ZD452 a sample/hold op amp. Gains may be selected by changing input/feedback resistances. Other specs include a 40 V/μs slew rate and a 5-ns aperture time. A complementary current-mode switching gate (Schottky diode) virtually eliminates ground line switching transients. The hold decay rate is 100 μV/ms, and may be further reduced. Logic and bias circuits are zener regulated to provide optimum performance over a power supply range of ±12 to ±18 V.

CIRCLE NO. 259

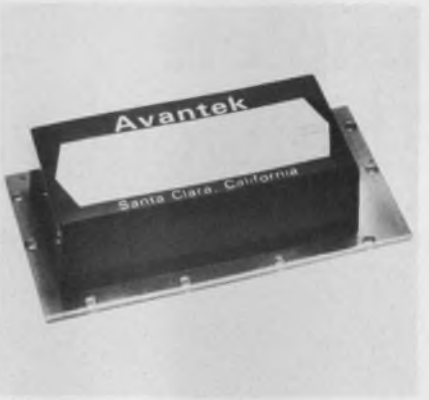
Power supply modules give triple outputs

GPS Corp., 14 Burr St., Framingham, Mass. 01701. (617) 875-0607. Start at $39 (100s).

The GPS Corp. announces its new line of triple output power supplies. Each of the PS 170s and PS 180s features output voltages of +15 V dc, −15 V dc and 5 V dc. There are six models to choose from stock in O.E.M. quantities. All supplies are short-circuit protected for any combination of pins. The PS 170s and PS 180s are miniature, encapsulated, plug in modules that are both rugged and lightweight.

CIRCLE NO. 260

Amplifier delivers 16 dBm to 500 MHz



Avantek, Inc., 2981 Copper Rd., Santa Clara, Calif. 95051. (408) 739-6170. Under $200; 3 wks.

Avantek, Inc., has broadened its line of popular unit amplifiers. The UA-141 offers 14-dB min gain, +13 dBm output power and a maximum noise figure of 5.5 dB from 2 to 100 MHz. The UA-144 is a push-pull module featuring 85-dB spurious-free dynamic range for a 1-MHz bw between 30 and 500 MHz, and 16 dBm output. Guaranteed specs include: flatness (max) of ±1 dB and VSWR (max) of 1.5 Input power is +15 V at 80 mA for the UA-141 and +12 V at 80 mA for the UA-144.

CIRCLE NO. 261

D/a converter offers three current ranges

Cycon, Inc., 1080 E. Duane Ave., Sunnyvale, Calif. 94086. (408) 732-8311. $114.

Cycon's new CY2247 12-bit digital-to-process current converter features a choice of three output current ranges (1 to 5 mA, 4 to 20 mA, 10 to 50 mA) through simple pin-strapping. The 2 × 4-in. module is intended for industrial process control applications and is guaranteed monotonic and linear to ±1/2 LSB over a temperature range of 0 to 70 C. Offset drift is less than 0.001%/°C, and scale factor drift is less than 0.002%/°C. The circuit's inputs are directly compatible with TTL/DTL levels. V_{cc} can range from +12 to +30 V. A 10-bit version, CY2147, and an eight-bit version, CY2047, is available, as is a companion series of process current-to-digital converters.

CIRCLE NO. 262

The only digital ohmmeter that gives you the accurate lowdown.

From 200 ohms down to 10 microhms, that is. Automatic measurements with a basic accuracy of ±0.02% plus 1 digit. Plus 0.01% linearity, 10 microhm resolution, automatic cancellation of thermal emf's, and ac rejection of better than 80 db at 60 Hz. Test leads can have up to 10 ohms resistance with *no* effect on accuracy.

We call it our SP 3789 Low Resistance Digital Ohmmeter, and it is the ideal instrument for use in design and production work where small resistance value need to be measured. Compact, fully solid state, with a highly visible 4½-digit LED readout, it may be operated in a single measurement or continuous measurement mode.

The SP 3789 Low Resistance DOM consists of the SP 3780 Digital Converter and the SP 3790 Low-Ohm preamp plug-in. The converter is available separately for those who want to make their own plug-ins.

Electro Scientific Industries
13900 N.W. Science Park Drive
Portland, Oregon 97229
Telephone: (503) 646-4141
Telex: 36-0273

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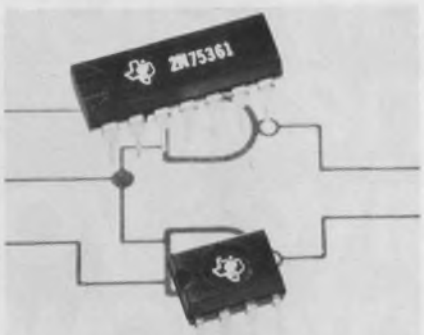
INFORMATION RETRIEVAL NUMBER 47

Dual TTL-to-MOS driver priced from $2.05



Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. P: See below; 3 wks. (production qty.).

A low-cost dual bipolar to MOS level shifter driver and interface IC, termed the SN75361, accepts standard TTL/DTL input signals and creates high current, high voltage output levels suitable for driving both clock and address inputs for the TMS4062 (AMS6002) and the TMS1103 MOS RAMs. Price in 100-pieces is $2.25 for the 14-lead version and $2.05 for the eight-pin package. The SN75361 operates from the TTL 5-V power supply and the MOS V_{ss} power supply. The IC is designed for nominal 16 to 20 V V_{ss} operation but can be used over a wide V_{ss} power-supply range. The driver in the standby mode features a nominal 10 mW of power dissipation.

CIRCLE NO. 263

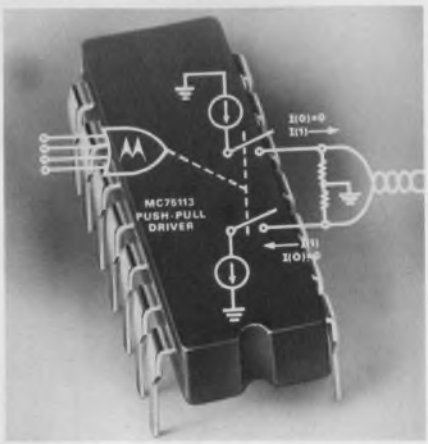
ECL 10 k drvr, rcvr interface TTL, MOS

Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700. Plastic: $4; ceramic: $4.50 (100 up); stock.

Two ECL-10,000 high-speed logic interface devices, the 10124 quad differential line receiver and the 10125 quad receiver, interface TTL with MOS. The 10124 consists of four drivers on one monolithic chip. It can also function as a TTL-to-ECL translator. The versatile 10125 can be used as a differential line receiver in a TTL system, a quad ECL-to-TTL translator, a MOS-to-TTL sense amp or as a quad level detector.

CIRCLE NO. 264

Line driver eases party-line operation



Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, Ariz. 85036. (602) 273-3466. $3.10 (100 up).

A driver IC transmits data at high speeds over long distances. Termed the MC75113, it can be used in systems where numerous drivers and receivers share a common twisted-pair line. All drivers connected to the line appear as an open circuit unless they are in the ON state. The MC75113 features a TTL-compatible four-input OR gate, outputs currents of nominally ±20 mA; output current mismatch of 3 mA maximum and propagation delay of 25 ns.

CIRCLE NO. 265

Npn power transistors in low-cost package

SGS-ATES Semiconductor Corp., 435 Newtonville Ave., Newtonville, Mass. 02160. (617) 969-1610.

Six power transistors in the plastic molded versawatt package are priced from $0.72 to $0.88 (100-999). Three types 2N6098 (BDX-70), 2N6100 (BDX72), and 2N-6102 (BDX74) have leads formed for direct TO-66 socket plug-in; the 2N6099 (BDX71), 2N6101 (BDX-73), and 2N6103 (BDX75) are straight lead versions. All six types offer low saturation voltage, high current capability and a 75-W power dissipation at their maximum specified voltage. The SGS-ATES plastic devices are guaranteed against damage due to thermal fatigue. In addition, the homotaxial process guarantees that devices are completely free from secondary breakdown.

CIRCLE NO. 266

Etched or stamped parts?

Buckbee-Mears offers both to help you save money.

Many precision parts can be made by either photo etching or stamping. BMC offers both, which means you can be sure we will recommend the most economical method to produce your part. That's mighty important if you're concerned about costs.

There are other advantages. With our ability to etch parts in large volume, we have built-in second source protection for stamping. That means no expense for a second set of tools. We can get you in production fast by etching your prototypes. Then, when volume is sufficient, you can switch to stamping.

All with one supplier, Buckbee-Mears.

Most component manufacturers must take suppliers into their confidence. Since we are completely independent, you can be sure your proprietary designs are safe with us.

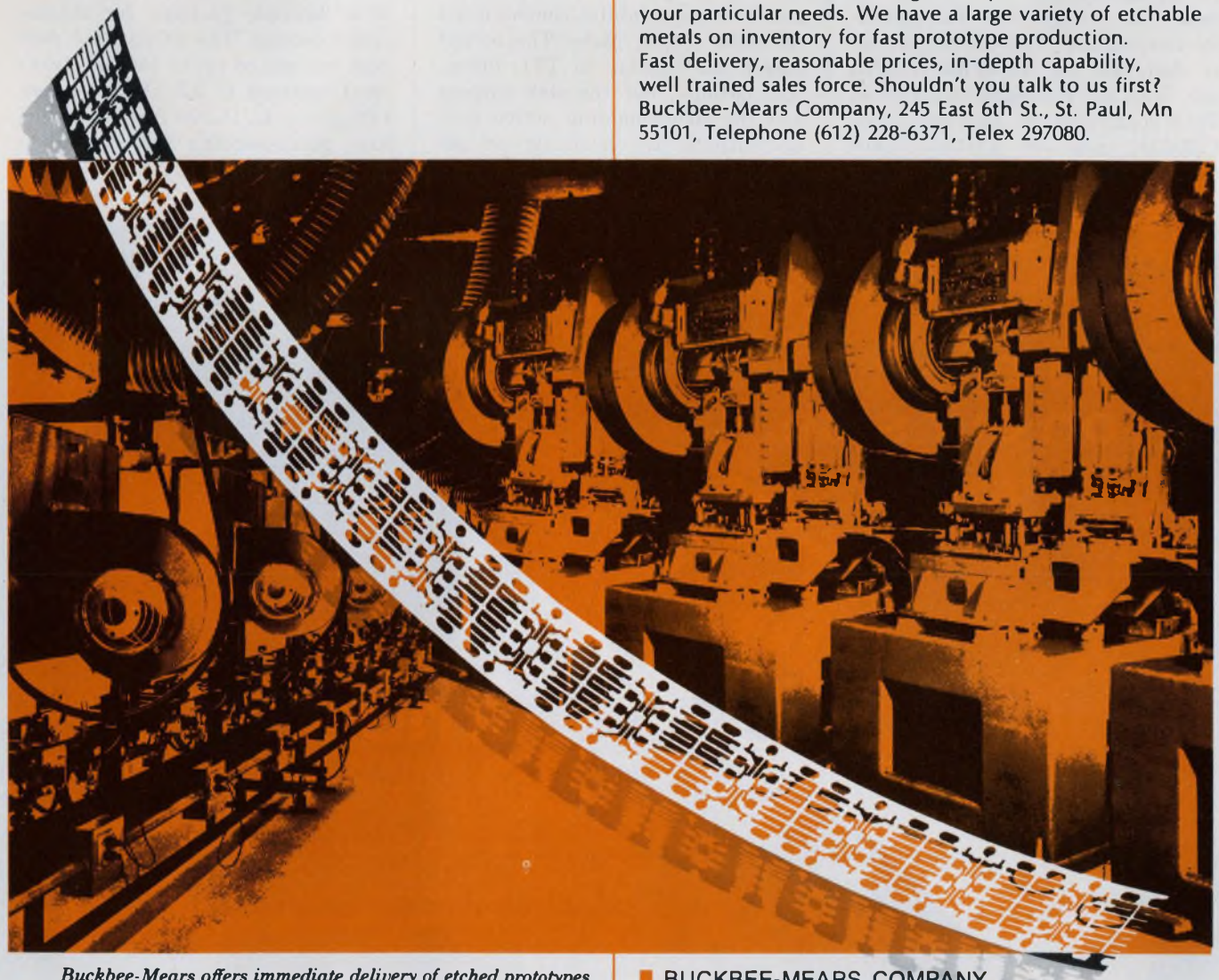
If you need precision parts, call or write our marketing department. Better still, see your regional BMC sales consultant. He's a real pro, specially trained to solve your production problems. And he can make an expert cost analysis on etching versus stamping for you.

Buckbee-Mears is the world's largest volume producer of precision etched, stamped and electroformed parts.

You can expect us to deliver, on time, what we say we can deliver. You'll save money with BMC, too, because we can choose from a wide range of capabilities to solve your particular needs. We have a large variety of etchable metals on inventory for fast prototype production.

Fast delivery, reasonable prices, in-depth capability, well trained sales force. Shouldn't you talk to us first?

Buckbee-Mears Company, 245 East 6th St., St. Paul, Mn 55101, Telephone (612) 228-6371, Telex 297080.



Buckbee-Mears offers immediate delivery of etched prototypes, and can, without interruption, shift to identical stamped parts to meet low per-piece cost, long run requirements.

BUCKBEE-MEARS COMPANY

bmc

INFORMATION RETRIEVAL NUMBER 49

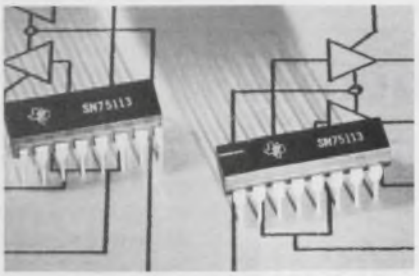
MOS clock line drivers list 1 A, 30 V output

Cermetek, Inc., 660 National Ave., Mountain View, Calif. 94040. (415) 969-9433. CH009C: $10.40; CH-0013C: $9.75 (100 up); stock.

Hybrid MOS clock line drivers offer peak output currents of 1.0 A and output voltage swings of up to 30 V. Typical rise and fall times are under 50 ns when driving 1000-pF loads. The CH0009 series may be direct-coupled to the driving source, or it may be used in capacitor-coupled use. The CH0013 series is designed for capacitor-coupled use. Both are packaged in a 12-lead TO-8 configuration. The lower-cost CH0009C and the CH0013C are rated for a range of −25 to +85 C.

CIRCLE NO. 267

Line driver eases data-bus operation

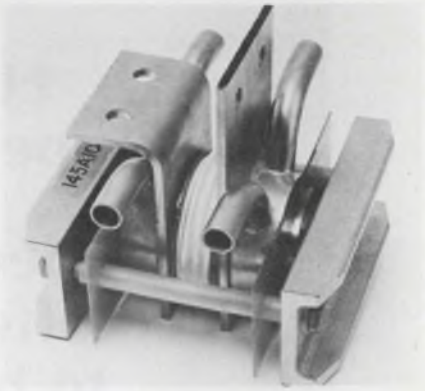


Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741. SN75113N: $3.10 (100 up).

The SN55/75113, a dual tri-state line driver, has a high output impedance inhibit state that makes it possible to connect many drivers together on the same transmission line for data bus operation. The device has individual inhibit control inputs for each output pair and a common inhibit control input for both output pairs. The output stages are similar to TTL totem-pole outputs, but the sink outputs and the corresponding active pull-up outputs are available on adjacent package pins.

CIRCLE NO. 268

SCRs, diodes handle up to 1500 A



Westcode Semiconductors, 282 Belfield Rd., Rexdale 605 Ontario, Canada. (416) 677-5881.

A family of high-power SCRs and diodes—designated Westcode type D1200—incorporate a 2-1/2-inch (50-mm) diameter silicon slice and come in a capsule package or in a flat-base package for single-ended cooling. The SCRs have current ratings of up to 1500 A, transient voltages to 3.5 kV and surge ratings up to 16,000 A. The diodes have corresponding values of 1500 A, 3 kV and 33,000 A, respectively.

CIRCLE NO. 269

With the Xerox MD40 you get a bit more.

0101
1101
0010
1

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

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

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

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

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

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

To get more information call (213) 679-4511, ext. 2208 or 1210, or write to Xerox, A3-73, 701 South Aviation Blvd., El Segundo, California 90245.

XEROX

INFORMATION RETRIEVAL NUMBER 52

INSTRUMENTATION

Line-powered DPM is industry's smallest

Datel Systems, Inc., 1020 Turnpike St., Canton, Mass. 02021. (617) 828-6395. $246; stock.

With a total size of 3 × 1.75 × 2.25-in. and an over-all weight (including the I/O connector) of 6 oz, the Model DM-1000 appears to be the smallest line-operated DPM on the market today. Two input voltage ranges are available, ±199.9 mV or ±1.999 V. Input impedance is specified up to 1000 MΩ with an input bias current as low as 1 nA. Both high and low analog inputs can sustain up to 300 V cm. Other input characteristics include true floating differential input plus a CMR of 70 dB at 60 Hz and a NMR of 40 dB at 60 Hz. Model DM-1000 has an accuracy of ±0.05% and can resolve to 100 μV. Input settling time is 50 μs and up to 200 readings can be made asynchronously or synchronously. Operating temperature range is 0 to +60 C with a tc of ±50 ppm/°C.

CIRCLE NO. 270

4-1/2-digit voltmeter measures to 30 nV

Keithley Instruments, Inc., 28775 Aurora Rd., Cleveland, Ohio 44139. (216) 248-0400. $1995.

A new autoranging digital nanovoltmeter features a 4-1/2-digit display in which the last digit shows tens of nanovolts on the lowest range. The Model 180 measures from below 30 nV to 2 V. It permits fast measurements with 0.01% resolution and an accuracy of ±0.03% of reading ±0.02% of full scale. Input/output isolation of greater than 10^9 Ω enables floating measurement up to 500 V, yet the output can be near ground potential. The Model 180 input is protected to overloads of 50 V instantaneous or 30 V rms. Normal mode rejection is greater than 90 dB and common-mode rejection ratio is better than 120 dB. Zero stability is better than 30 nV/°C.

CIRCLE NO. 271

3-1/2-digit DPM is systems oriented

Analog Devices, Route 1 Industrial Park, P.O. Box 280, Norwood, Mass. 02062. (617) 329-4700. $93 (100s); stock.

The AD2003 is a systems-oriented 3-1/2-digit DPM featuring differential amplifier input and fully latched BCD outputs. The 5 V-powered unit provides common mode rejection of 80 dB min, normal mode rejection of 40 dB and minimum common mode voltage of ±2.5 V. This DPM accepts readings of bipolar, differential input signals over a full scale range of 0 to ±199.9 mV with a maximum error of 0.05% ±1 digit. Polarity and overload indications are provided. BCD outputs are DTL/TTL compatible. The AD2003 can be externally triggered to make up to 16 readings per second, or be programmed to hold readings indefinitely. Size is 1.8 × 3 × 2-in.

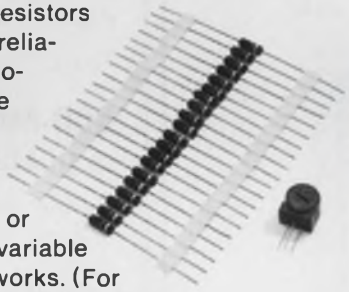
CIRCLE NO. 272

If TRW can produce precision attenuator switches in volume

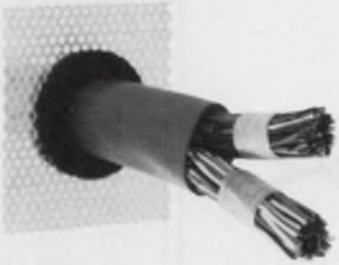
...think what TRW can do for you in fixed and variable resistors, low cross-talk cable and film capacitors.

TRW/Cinch ceramic substrate attenuator assemblies illustrate Cinch's abilities to control the contact spring forces precisely during fabrication, and to weld tiny gold dots to the spring materials. Advanced manufacturing techniques such as these have helped make Cinch a leading world producer of connectors, sockets, and other electromechanical devices. (For further information, circle 000 on the reader service card.)

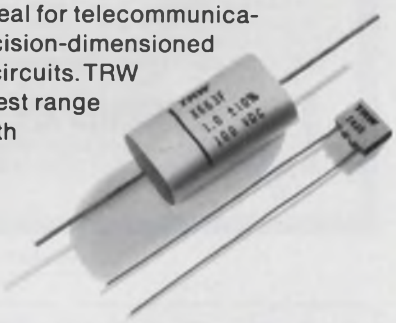
TRW/IRC resistive products cover the spectrum—from 20-year life Metal Glaze™ resistors with superior stability and reliability to Circuitrim® potentiometers in every conceivable size and style. TRW/IRC is your complete source for all types of fixed resistors (carbon composition, thick or thin film, and wirewound), variable resistors and resistive networks. (For further information, circle 000 on the reader service card.)



TRW/Holyoke wire, cable, and cable assemblies are produced in unlimited variety to meet critical requirements. These include such demands as lowest cross-talk for telecommunications, minimum impedance discontinuities for RF, and enhanced flame retardancy for home entertainment wiring. Shown is a 52-pair telephone cable, an example of a long-life, high-reliability requirement. (For further information, circle 000 on the reader service card.)



TRW metallized film capacitors are available to fit almost any design requirement. Typical are the tape-wrapped X663 (ideal for telecommunications use) and the precision-dimensioned X440 for high-density circuits. TRW makes by far the broadest range of film capacitors—both metallized and foil—in terms of dielectrics, case styles, shapes, capacitances, and voltages. (For further information, circle 000 on the reader service card.)



What else do we make? Just about every type of electronic component in the books from actuators to zeners. Plus amplifiers, chokes, connectors, diodes, filters, inductors, miniature motors, oscillators, printed circuits, rectifiers, RF modules, transformers, transistors, tuners, color convergence yokes... and more.

One source—your local TRW representative—offers you all of these product lines and can supply almost all of your needs. With a direct pipeline to all of our plants, he can assure you fast delivery, applications assistance, custom designs, and special engineering help whenever you want it.

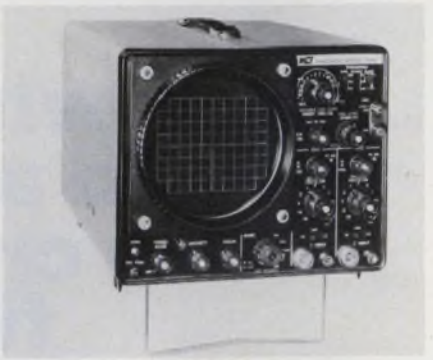
Think what TRW can do for you. Then call or write TRW Electronic Components, 10880 Wilshire Blvd., Suite 1700, Los Angeles, CA 90024. Phone (213) 475-6777.

TRW®

ELECTRONIC COMPONENTS

INFORMATION RETRIEVAL NUMBER 55

$500 buys dual-trace triggered-sweep scope



Dynascan Corp., 1801 W. Belle Plaine Ave., Chicago, Ill. 60613. (312) 327-7270. $499.95.

The 1470 is a dual-trace, triggered-sweep scope that offers dc to 10-MHz bw, 10 mV/cm sensitivity and maximum sweep of 0.2 μs/cm. It permits dual display of waveforms in six modes: Channel 1, Channel 2, Chopped (for low-frequency waveforms), Alternate, Add and Channel 2 Invert. The 1470 requires two probes, which are available separately. B & K offers two models: The PR-20, a combination 10:1/DIRECT probe complete with convenient spring-loaded clip-on tip. The PR-16 is similar to the PR-20, but does not have the clip-on feature.

CIRCLE NO. 273

500-MHz freq. counter is portable, has 5 digits

Analog Digital Research Inc., 1051 Clinton St., Buffalo, N.Y. 14206. $729.

The CM2OR is a portable digital frequency counter. The unit operates from standard line voltage, a snap-on rechargeable battery pack or from any external 12 V dc source. Features include: 5-digit LED display; automatically-placed decimal point; overflow indicator; 1-MΩ input covering the range from 5 Hz to 15 MHz; and a 50 Ω-input covering 10 to 500 MHz. A slide switch selects the input, and automatically repositions the decimal point. Input sensitivity is 30 mV rms from 5 Hz to 15 MHz, 50 mV rms up to 300 MHz, increasing to 100 mV rms at 500 MHz.

CIRCLE NO. 274

Electronic Design's Nov. 23 issue commemorating The age of the transistor

Order your copy now!

A collector's item celebrating the 20th anniversary of Electronic Design with the 25th anniversary of the transistor. This issue is a compendium of major milestones in design -- a quarter century of design activity in such areas as consumer electronics, packaging and materials, computers, communications, components and instrumentation. This special issue is must reading for every designer. No engineer should be without it. Order extra copies now, for yourself and your associates, by filling in the order blank below.

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INSTRUMENTATION

Bridge spans 10^{16} Ω, measures to 0.2%

General Radio Co., 300 Baker Ave., Concord, Mass. 01742. (617) 369-4400. Under $1000.

The 1666 is an ultra-wide-range precision resistance bridge from General Radio. Four ±0.02% bridge circuits and 6-digit resolution give it a total measurement range from 10^{-6} to 10^{12} Ω. The unit easily measures both open (leakage) and closed (contact) resistance of relays and switches, forward and reverse diode resistances, transformer winding resistance and insulation conductance, resistance thermometers and dielectrics. Comparisons between similar resistances can be made to a resolution of 2 ppm. The GR 1666 is rugged, completely self-contained, and weighs just 21 pounds. Eight D-cells provide both test potential (sufficient for the entire measurement range) and power for the ultra-sensitive dc detector.

CIRCLE NO. 275

4-digit DPM displays engineering units

Newport Laboratories, Inc., 630 E. Young St., Santa Ana, Calif. 92705. (714) 540-4914. $325; stock.

Model 400P panel-mounted digital process monitor features digital displays (to ±3999 counts) of engineering units. The unit inserts directly into the data loop without affecting the transmitter accuracy or performance. The Model 400P incorporates signal conditioning for proper zero suppression and full scale variations. True differential inputs are buffered, isolated and gated. Readings may be updated at the rate of 1 to 60 per second and any reading may be held indefinitely, on command.

CIRCLE NO. 276

Curve tracer measures, displays IC parameters

Tektronix, Inc., P.O. Box 500, Beaverton, Ore. 97005. (503) 644-0161. $1175 (mainframe).

Tektronix, Inc. announces the 577 curve tracer, a measurement system for ICs as well as transistors and other components. The system is divided into three parts: display module, mainframe and test fixture. Modular construction permits a range of options. The system displays parameters of linear ICs such as op amps, comparators and regulators; displays parameters of transistors, FETs, tunnel diodes, SCRs, zener diodes; plots and displays IC characteristics for a whole range of operating conditions, not just single points; and provides storage display.

CIRCLE NO. 277

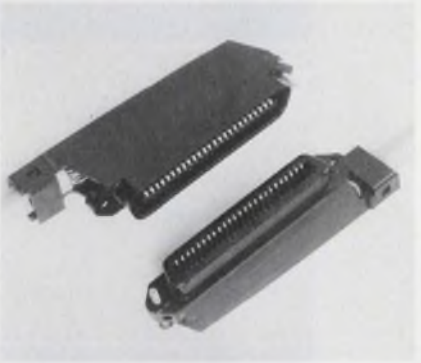
Distortion analyzer is programmable

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. (415) 493-1501. $3600; 12 wks.

Model 334A-H25 distortion analyzer has all the capabilities of the standard Model 334A plus complete programmability of all functions, ranges and settings. Remote control is by parallel BCD TTL logic. A dc output and an interrogation circuit have been added so that an external controller can determine the status of the instrument during measurements. The unit can be manually controlled with back-lighted front-panel pushbuttons. As a distortion analyzer, the instrument measures total harmonic distortion from 0.1 to 100% FS in seven ranges. The fundamental frequency range is 10 Hz to 100 kHz; harmonics are indicated up to 1 MHz. Frequency resolution is three digits over the full frequency range.

CIRCLE NO. 278

Connector terminates 50 wires simultaneously

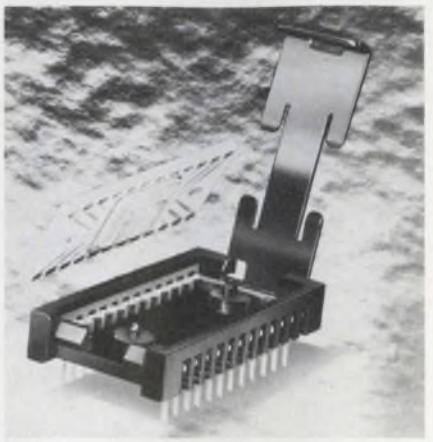


AMP Inc., 449 Eisenhower Blvd., Harrisburg, Pa. 17105. (717) 564-0101.

With a single stroke of a special tool, 50 wires are simultaneously cut to length and terminated to the Champ 25-pair cable connector. Designed specifically for the 25-pair cables commonly used in the communications industries, the Champ connector is intermateable and interchangeable with similar connectors currently in use. The all-plastic connectors are molded from an SE-1 rated thermoplastic and can be furnished with or without an integral 90° cover and strain relief made of the same material. Located on 85-mil centers, the replaceable, preloaded contacts are gold-over-nickel plated high conductivity beryllium copper with a unique dual-slot termination. In the actual termination process, an unstripped wire is pressed into both contact slots by the specially designed tooling. The front slot of the contact completely displaces the insulation and extrudes the wire with a wiping action to assure electrical contact, while the rear slot provides a lesser degree of extrusion providing insulation support and strain relief. Excess wire is automatically cut off during the terminating process by the tool. Wiring changes can be readily made in the field with a one-wire-at-a-time hand tool or with a portable hand-operated tool that simultaneously terminates and cuts to length all 50 wires. A semi-automatic power tool is available for production use.

CIRCLE NO. 279

Leadless IC receptacle uses tin contacts

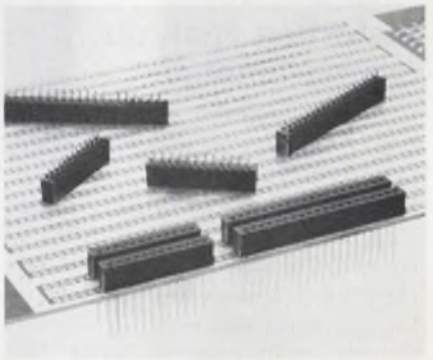


Burndy Corp., Richards Ave., Norwalk, Conn. 06852. (203) 838-4444.

Hypoint, a leadless IC receptacle, uses tin contacts to accept an IC package with solder pads. Each Hypoint tin contact has a chisel point which penetrates the IC solder pads to form a highly reliable, gas-tight connection which performs as well as gold-plated contacts. The receptacles come in 24, 28 and 40 contact positions.

CIRCLE NO. 280

DIP strip connectors span 24, 28, 40 leads



Standard Applied Engineering Inc., 2165 S. Grand Ave., Santa Ana, Calif. 92705. (714) 540-9256. $0.35 to $0.45 (1000 up); stock.

A line of DIP strip connectors, designed to be used in pairs, accommodates 24, 28 and 40-lead MSI/LSI packages. Contact spacings are on 100-mil centers while strip pairs are positioned according to package width. The 2300 series and 3000 series strip sockets have wire-wrap and dip solder leads respectively. A chamfered closed-entry cap aids insertion of delicate leads.

CIRCLE NO. 281

Everything you always wanted to know about Drive Motors.

Into these five booklets we've crammed 156 pages of the latest information on Kearfott's line of Drive Motors.

Kearfott, as you probably already know, is a primary supplier of drive motors. And has a reputation for quality, service and on-time delivery.

We can furnish you with drive motors in individual units or in packages to fit any of your aerospace or industrial applications. From counters to computers. From business machines to printers and tape readers.

Let's take a look at the type and range of motors we're talking about.

DC TACHOMETERS

Kearfott Tachometers are designed specifically for precision speed sensing and as rate generators to help velocity servos achieve fast response.

Features include: outputs to 100V dc/1000rpm; minimum ripple at high commutation frequency; high linearity; low friction torque.

These are ideal for computer tape transports where efficient data retrieval is a must. And for business machine and numerical control machine tools.

DC TORQUERS

You can get sizes 12 through 42, uncased for gimbal mount applications and cased for direct drive torque motor positioning.

Kearfott can also supply them with a variety of integral feedback elements such as potentiometers, synchros and tachometers—in a single housing.

You've a choice of standard design, inverted construction (inner member is magnetic and transfers power to an outer armature) and brushless Limited Rotation design.

DC MOTORS

These are Moving Coil Motors used for high-response DC servos such as High-Speed Printer and Capatan drives.

One of their unique features is that they need less cooling than equivalent competitive units. The reason: low internal impedance which allows a high cooling flow rate at low developed pressures.

Permanent magnet and wound-field types are available for standard aerospace and industrial applications, including high acceleration motors with integral tachometers for terminal printers.

AC MOTORS

Kearfott induction or synchronous motors of the hysterisis or reluctance type come in a broad range of frame sizes. And from sub-fractional power to 15 HP.

We can furnish motors that run on up to 440 volts ac, single, 2 or 3 phase. Induction motors that operate on 2, 4, 6, 8 or 12 pole design. And dual speed motors such as needed for driving memory discs in large computers.

You can also get: high-slip motors for aircraft requirements at 400 cps; synchronous motors for constant rotating speeds with varying loads; gear motors for extremely low speeds or speeds incompatible with the power supply frequency.

STEPPER MOTORS

If you want precision control—for example for small peripheral devices, small line printers and tape readers—Kearfott Steppers provide it via discreet steps and high slew rates. And in a wide choice of stepping rates and torque levels.

Typical Kearfott units have 15° stepping angles, compatible with all 24-tooth sprockets. They give high holding torque, high stepping speed and fast response.

Units with other step angles, such as 1.8°, 7.5°, 10°, 30°, 45° and 90° are readily available in frame sizes through 50.

But why not get all the details? Mail the coupon for our new booklets now. The Singer Company, Kearfott Division, 1150 McBride Avenue, Little Falls, N.J. 07424.

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Title _____

Company _____

Address _____

City _____ State _____ Zip _____

INFORMATION RETRIEVAL NUMBER 62

Crimp-contact connector resists fluid damage

ITT Cannon Electric, 666 E. Dyer Rd., Santa Ana, Calif. 92702. (714) 557-4700.

Type MIL-C-005015F circular crimp-contact connector uses fluid-resistant silicone elastomers to provide protection against a variety of fuels, oils, coolants and cleaning agents. It is a rear-release connector that has common backshells, termination methods, and performance with MIL-C-0026482F, Series II, and it is intermateable with like-size MIL-C-005015 and MIL-C-83723. It is available with wall-mounting, cable-connecting, box-mounting, jam-nut-mounting or plug versions.

CIRCLE NO. 300

Cable connector stresses miniaturization, density

Microtech, Inc., 777 Henderson Blvd., Folcroft, Pa. 19032. (215) 532-3388. $0.95; stock.

Outside diameters of 110, 120 and 140 mils, respectively, for a line of 4, 7 and 12-pin cable connectors demonstrate their small size. The connectors use 1/4-28, 5/16-24 and 3/8-24 threads for the 4, 7 and 12-contact connectors respectively. All bodies, pins and sockets are gold plated brass, the dielectric inserts are TFE teflon and the washers are silicone rubber.

CIRCLE NO. 301

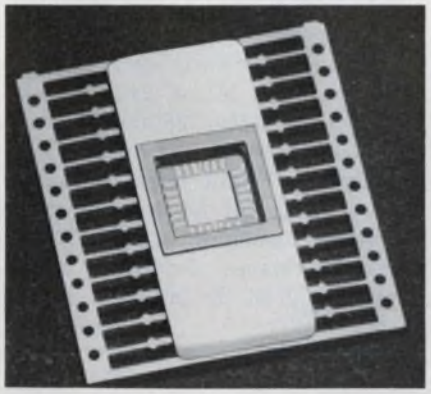
Flat cable connectors remove without strain

3M Co., Dept. EL2-29, P.O. Box 33686, St. Paul, Minn. 55133. (612) 733-1590.

Two versions of Scotchflex flat cable connector, designed to permit strain-free pull removal without disturbing the integrity of connections, are Scotchflex 3399-3000, a 26-contact connector, and Scotchflex 3417-3000, a 40-contact connector. Both connectors will transition from Scotchflex round conductor flat cable to standard 25-mil wrap or solder posts on 100-mil grid. They feature a two-part cover that allows the cable to be doubled back over itself and locked in place with a plastic keeper. Pull tests have been performed in excess of the connector removal force without disturbing the integrity of the connection either electrically or physically.

CIRCLE NO. 302

Substrate DIP has area 270 × 270 mils

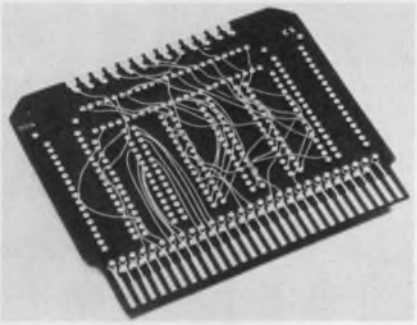


National Beryllia Corp., Sealox Div., Greenwood Ave., Haskell, N.J. 07420. (201) 839-1600.

A 24-lead DIP for MOS and microcircuit packaging, the SP-2298, has a specially processed alumina body molded with a F15-61T lead frame to provide a strong, thermally conductive, hermetic unit for reliable packaging. The over-all dimensions of the package are 1/2 × 1-1/4 in., with the largest reported die-mount area available in a 24-lead package of its size, 270 × 270 mils. The chip cavity, 10 mils deep, has an F15-61T (Kovar) seal ring.

CIRCLE NO. 303

Weldable sockets suit stitch-wired assemblies



Flex-Link Products, Inc., 1923 First St., San Fernando, Calif. 91340. (213) 365-9355.

A line of weldable stainless steel sockets designed for use with stitch wires assemblies are adaptable for plugging in dual-in-lines, discrete components and TO-5 packages. The sockets are gold plated over nickel and feature beryllium copper inserts.

CIRCLE NO. 304

Flatpack connector accepts 40-lead chips

National Beryllia Corp., Electronic and Light Electrical Products Group, Greenwood Ave., Haskell, N.J. 07420. (201) 839-1600.

A 40-lead flat-pack, SP-2258, is designed for hybrid and monolithic ICs. The package has a metal (F15-61T alloy) back, and a 230 × 230-mil die mount area. Over-all size of the package is 1.321 × 1.336 inches; nominal thickness, without cover, is 40 to 55 mils.

CIRCLE NO. 305

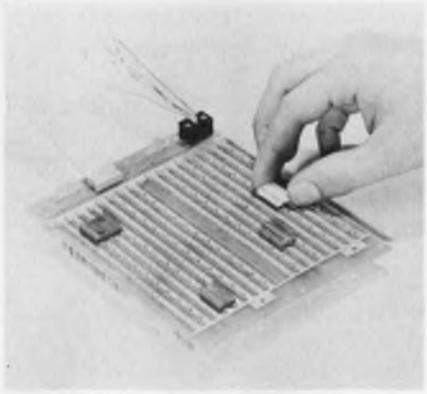
Milliwatt heat sinks fit various semiconductors

AHAM, P.O. Box 909, Azusa, Calif. 91702. (213) 334-5135.

A line of heat sinks dissipates milliwatts for low-power semiconductors. The AHAM HS100 Series is designed to fit various semiconductor case sizes, such as TO-5, TO-39, TO-18, TO-46 and TO-52.

CIRCLE NO. 306

Wrapped-wire panels boast high gripping



Excel Products Co., Inc., 700 Joyce Kilmer Ave., New Brunswick, N.J. 08901. (201) 249-6600.

Wrapped-wire pluggable printed circuit boards offer a spring clip of beryllium-copper alloy and high gripping power even after repeated plug-ins. Entry apertures are funnel-shaped for easy insertion of ICs.

CIRCLE NO. 307

Connector uses lanyard release disconnect

Glenair Inc., 1211 Air Way, Glendale, Calif. 91209. (213) 247-6000.

A lanyard-release quick disconnect coupling is an integral part of MS connectors MIL-C-26482, MIL-C-26500 and MIL-C-38999. The special coupling device is available in a swivel or rigid lanyard mount with a choice of bayonet twist-on or straight push-on action. Either style disengages instantly by a straight pull of the lanyard.

CIRCLE NO. 308

Acid dip cleans solder and tin-lead alloys

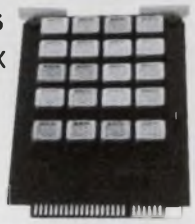
Enthone Inc., Box 1900, New Haven, Conn. 06508. (203) 934-8611.

An acid dip for immersion cleaning is designed to clean and brighten solder plate on PC boards that have become darkened or tarnished due to etching operations or after long periods of storage. Enplate AD-483 is supplied as a ready-to-use liquid that is operated at room temperature to 120 F for 30 to 60 seconds depending on the processing rate desired.

CIRCLE NO. 309

All-in-one-card RAM. Very fast access time: 125 ns. Very fast delivery: right off the shelf. Contains memory address register, decoding, storage sense amplifiers, write amplifiers, output buffers—everything needed for complete memory function. Up to 18K on a single card. For more words by more bits, just wire the cards together. Power consumption is less than one milliwatt per bit. Price is lower than any other card memory in this speed range. Give us a call. We'll quote price on the phone and ship one to you on a memorandum receipt that gives you a **Free Thirty Day Trial Period.**

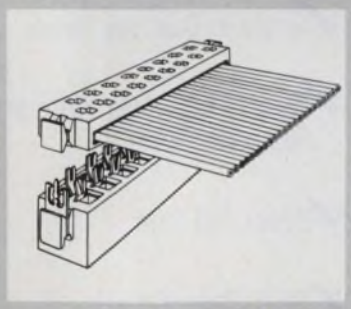
All this from the people who know memories. **Electronic Memories & Magnetics Corp.** Phoenix Semiconductor Facility, 3883 North 28th Avenue, Phoenix, Arizona 85017. Phone: (602) 263-0202.



INFORMATION RETRIEVAL NUMBER 67

QUICKIE CONNECTOR . . .

FOR THE RAPID, RELIABLE TERMINATION OF FLAT FLEXIBLE CABLE.

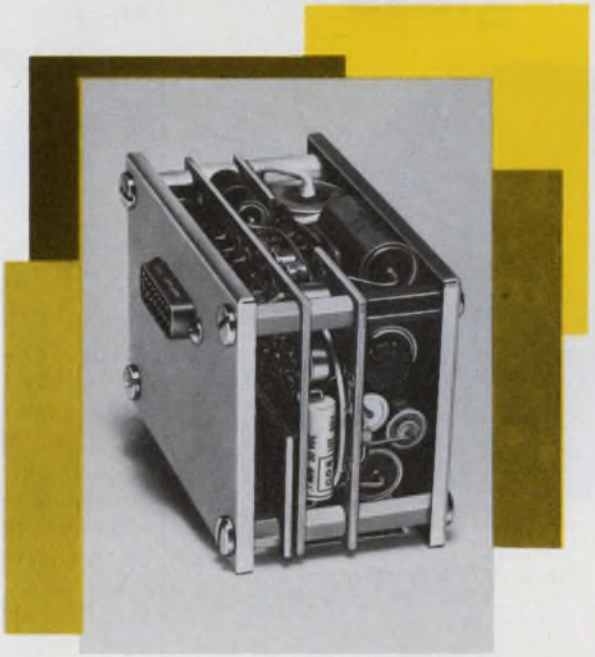


The Berg QUICKIE, a female connector, simultaneously terminates multi-lead flexible round cable *without* pre-stripping. The askewed tines of the contact effect a stripping action which terminates virtually any brand of cable, regardless of insulation material, in about 10 seconds. Design assures redundant electrical contact, and allows for visual inspection *before* assembly. QUICKIE can be used to interface cable on .050" centers to .025" square wire-wrapping posts on .100" sq. grid. Write for Catalog 125 or call:

BERG
ELECTRONICS, INC.
New Cumberland, Pa. 17070
Phone: (717) 938-6711

INFORMATION RETRIEVAL NUMBER 68

Rotron Power Conversion Devices



Custom-built to match your own voltage/frequency requirements.

What you need is what you get from Rotron. Because Rotron® will build a solid state converter to meet your most specific requirements — of size, weight, configuration, environmental conditions, and, of course, output. And, with many years experience in matching solid state converters to specific loads, Rotron will do it at reasonable cost.

For computer, aerospace, medicine, marine, instrument, tele-communications, and avionic equipment. AC to AC frequency converters, AC to DC converters (regulated or unregulated) with single or multiple voltage outputs. DC to AC inverters, with optional reverse polarity protection, high voltage protection and RF suppression to MIL specifications.

Before you compromise your system power requirements, learn how the power conditioning pros at Rotron can give you exactly what you do need, at a price you can afford. Contact Wes Riley at Rotron today.

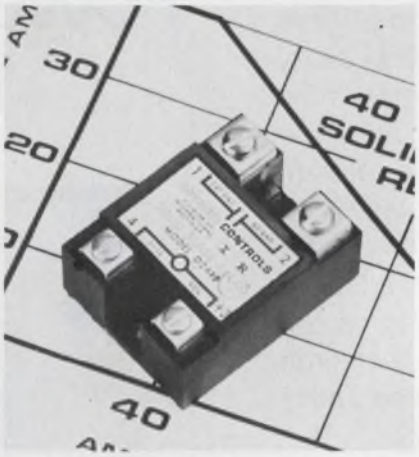
ROTRON INCORPORATED

POWER CONVERSION PRODUCTS DIVISION
ROTRON INC., Woodstock, N. Y. 12498
914-679-2401 TWX 510-247-9033

Pacific Div., Burbank, Cal. 91506 213-849-7871
Breda, Netherlands, Tel: 49550, Telex: 844-54074

INFORMATION RETRIEVAL NUMBER 69

Solid-state 40-A relay withstands 500-A inrush



Crydom Controls Div., International Rectifier Corp., 1521 Grand Ave., El Segundo, Calif. 90245. (213) 322-4987. Mod. D1240; $24 (100 up); stock.

Crydom claims that its new 40-A solid-state relay (SSR) has a higher load-current rating than any other SSR. Others on the market are limited to about 25 A when used with equivalent-sized heat sinks. Crydom's 40-A units can switch 120-V (Model D1240) or 240-V (Model D2440) ac loads and operate with 3 to 32-V dc control-signal inputs. Ac-input versions are designated A1240 and A2240, respectively. Units with lower load ratings are also available. The new SSR design achieves the 40-A nominal rating when operating with a 1°C/W heat sink (supplied by the user) in a 30 C ambient temperature. In fact the relay will safely carry as much as 60 A continuously when operated with a larger heat sink that can hold the case below 50 C maximum. The surge rating is 500-A rms for one cycle and 110 A for 0.5 s. Package size is 2.25 × 1.75 × 0.9 in. The device is particularly well suited for high inrush surge applications such as with motors, lamp loads or transformers. Internal design features include photo-isolation and zero-voltage switching. Since there are no contacts to arc the SSR can be used in explosion-prone environments. In addition, the device is compatible with IC or transistor logic levels and can be operated directly from computer outputs.

CIRCLE NO. 250

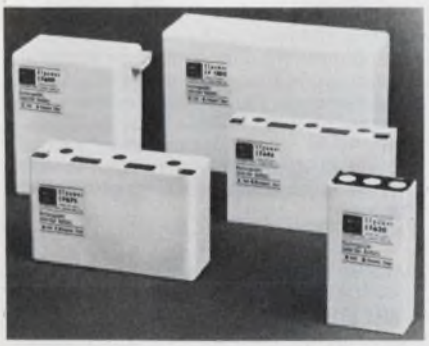
Tristimulus detector matches human eye

Photon Products, P. O. Box 1230, Cupertino, Calif. 95014. (408) 296-5226.

The Model T100 tristimulus detector set consists of three detectors—sensitive to blue, green and red—that precisely simulate the human eye's color perception according to the standard C. I. E. observer within 1%. The T100 uses silicon sensors that are spectrally corrected with computer-designed glass-absorption filters. The detectors have better than 1% linearity over a light-level range of six decades. Repeatability remains better than 0.5% of any reading per month or 2% per year.

CIRCLE NO. 320

Rechargeable battery uses gelled electrolyte



Elpower Corp., Div. of Eldon Industries, 2117 S. Anne St., Santa Ana, Calif. 92704 (714) 540-6155.

These gelled-electrolyte units are rechargeable batteries that can replace dry-cell batteries at considerably less cost than nickel-cadmium batteries. They can be connected in series or parallel and they can operate in any position. Standard sizes deliver 6 or 12 V with capacities from 3 to 8 A-hr. Because of the batteries' leakproof construction, the U. S. Postal Service allows them to be shipped by mail without special handling.

CIRCLE NO. 321

Thermister measures fluid flow

Fenwal Electronics, 63 Fountain St., Framingham, Mass. 01701. (617) 872-8841.

The Fenwall G-series thermistors have been used successfully in medical applications for respiratory and blood flow-measurment and in industrial applications for fluid pressures and air velocity measurement. These voltage-current (E-I), matched-pair thermistors operate in the self-heat mode. Typical units such as the G112, G126 and G128 have resistance values of 8000, 2000 and 100,000 Ω at 25 C, respectively.

CIRCLE NO. 322

Synchronous motor reverses electrically

North American Philips Controls Corp., Cheshire Industrial Park, Cheshire, Conn. 06410. (203) 272-0301.

The 86600-Series synchronous motors provide 5.5-oz-in. rotor torque at a rotor speed of 600 rpm. Hardened-steel gear trains provide a selection of shaft speeds down to 10 rpm with proportionate increases in torque. Maximum gear-train capacity is 200 oz-in. The design of the motor insures fast-start and stop operation, eliminating the need for prestart or clutching mechanisms. The motor is built to NEMA type 2-11 configuration and is electrically reversible. Although the standard is 120 V ac at 60 Hz, models can be furnished for 24 or 230 V ac.

CIRCLE NO. 323

Air flow actuates miniature switch

Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, Ill. 60085. (312) 689-7600.

A breath of air is said to actuate the Series E22-85HX miniature snap-action switch, which is rated 3 A, 125 V ac. The aluminum actuator is purposely long (2-3/8 in.) to allow switch operation on a low force (less than 2 g). The switch can be used to detect air flow from exhaust fans and blowers.

CIRCLE NO. 324

Chip capacitors serve gigahertz frequencies

GHZ Devices, 16 Maple Rd., Chelmsford, Mass. 01824. (617) 256-8101.

A series of high-Q, MOS chip capacitors though designed for operation to only 18 GHz are virtually lossless to 22 GHz. The GC-80000 Series capacitors are used for fixed-capacitive tuning, as filter elements, for capacitive coupling and for dc blocking and rf bypassing. They are available in 48 values, from 1 to 300 pF. A temperature stability of 190 ppm/C max, a tolerance of 10% and their low inductance contribute to the performance at microwave frequencies. Sizes are said to be smaller than other types. Dimensions of the smallest unit are 0.020 W × 0.020 L × 0.005 D in.

CIRCLE NO. 325

Thermister flakes solder directly to substrate

Thermometrics Inc., 15 Jean Pl., Edison, N.J. 08817. (201) 548-2299. $300 (lot of 100); stock to 3 wks.

Claimed to be a first, Thermometrics thermistor flakes provide a flat configuration with directly solderable electrodes for ease in production handling by the microcircuit manufacturer. The Series F20, F40, F80 and F120 Thermoflakes are thick-film thermistors without substrate backings. They are designed for direct mounting to sensing surfaces and substrates. When mounted on substrates, the units tolerate reflow soldering. Thermal time constants range from 38 to 75 ms based on pulsed measurements in still air at 25 C. Resistance coefficients range from −1.5%/C to −5.5%/C. Units with −4%/C are generally available from stock. Resistances at 25 C range from 250 Ω to 3 MΩ and are available in standard tolerances of ±35%. Mid-range resistances from 25 kΩ to 2 MΩ are stocked. Dissipation constants vary with the size of the Thermoflake. A 0.040 × 0.040 × 0.002 in. unit mounted on an aluminum oxide substrate has a dissipation constant of 0.8 mW/C.

CIRCLE NO. 326

Thermocouple unit can transmit long distances

Thermo Electric, 109 Fifth St., Saddle Brook, N. J. 07662. (201) 843-5800.

Model 35701 is an electrically isolated transmitter for long-distance transfer of thermocouple signals using ordinary copper wires. Wiring from the thermocouple to transmitter is short, since the unit mounts directly to a standard industrial thermocouple. The transmitter converts the thermocouple's voltage to a directly proportional 4 to 20-mA dc current. Thus, an ordinary milliampere-reading instrument can act as a temperature display. Accuracy is 0.2% in accordance with standard (ISA-J, K, T) calibration. Automatic reference-junction compensation is built-in.

CIRCLE NO. 327

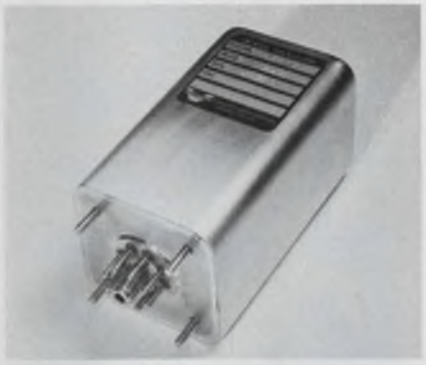
Solid-tantalum capacitor features small size

Sprague Products Co., 551 Marshall St., N. Adams, Mass. 01244. (413) 664-4411. Stock.

Subminiature solid-tantalum capacitors, designated 182D (cylindrical) and 183D (rectangular) are no larger than standard bare-chip, uncased units. They are available with axial and single-ended lead configurations and are packaged in polyester-film sleeving with epoxy-resin end seals. Capacitance values range from 0.010 μF at 50 V dc to 220 μF at 3 V with standard tolerances to $\pm 5\%$. Full rated-voltage operation is permitted from -55 to $+85$ C, and up to $+125$ C at two-thirds of the rated voltage.

CIRCLE NO. 328

Double oven stabilizes crystal oscillator



Vectron Laboratories, Inc., 121 Water St., Norwalk, Conn. 06854. (203) 853-4433. 6-10 wks.

With a double proportional oven control the CO-244V crystal oscillator provides an aging rate of less than 1×10^{-9} per day while short-term stability is better than 1×10^{-10} per second from 0 to 50 C. Sine-wave or logic-type outputs are standard at 1, 5 or 10 MHz. A wide range of other frequencies are also available. Voltage frequency control is featured to permit locking to an external reference or for remote fine-frequency control. Options include −55 to +75 C operation and supply voltages as low as 5 V dc.

CIRCLE NO. 329

Fork motor modulates optical beams

Philamon, Inc., 90 Hopper St., Westbury, N.Y. 11590. (516) 333-1700. 6 wks.

Iso-Fork, Series FOM 100, is an optical chopper that uses a vibrating fork to drive the device. The main features of the "motor" are that it requires no lubrication and has a life expectancy of over 100,000 hr. A frequency range of 400 to 800 Hz is standard. Frequency accuracies are better than 1%. Power consumption is typically less than 500 mW. These optical fork motors can operate from sea level to space vacuum over a temperature range of −55 to +85 C. Available shutter variations can produce square, pulsed, sine, scan or several other types of light modulation waves. The tine ends may also be fitted with lenses or mirrors.

CIRCLE NO. 330

DATA PROCESSING

Front loading disc drive holds 48 Mbits

Wangco Inc., 2400 Broadway, Santa Monica, Calif. 90404. (213) 828-5565. $3200.

The Series-F front-loading disc drive uses an IBM 2315-type single-disc cartridge and an integral fixed disc. A linear voice-coil type positioner is said to provide a track-to-track access time of 8 ms. A 24-Mbit version of this unit is also available. Disc rotation speeds provided are 1500 or 2400-rev/min. The track format affords interchangeability with comparable IBM disc-storage units.

CIRCLE NO. 331

Small tape transport rivals larger units

Kennedy Co., 540 W. Woodbury Rd., Altadena, Calif. 91001. (213) 798-0953. $2500 (large qty.); 30 days.

Sophisticated features of large high-speed tape transports are offered in the modestly priced Kennedy Model 9000. The unit provides crystal-controlled timing, marginal-skew check, overwrite editing, checkout controls and selectable addressing. Tape speeds are from 12-1/2 to 37-1/2 in/s. Recording density for nine tracks is 800 bit/in. Dual density is available for 7-track recording.

CIRCLE NO. 332

Cassette unit includes an RS-232 interface

Cipher Data Products, 765 Convoy Ct., San Diego, Calif. 92111. (714) 277-8070. $2450; 30-60 days.

Featuring an RS-232 bit-serial interface for synchronous systems, the Min-cette 2200 is a tape-cassette recorder with bidirectional read/write capability. It has a packing density of 800 bit/in. and a read/write speed of 600 eight-bit char/s. Among the commands to direct the unit, some important ones are read-a-record forward, write-a-record forward and space-a-record reverse.

CIRCLE NO. 333

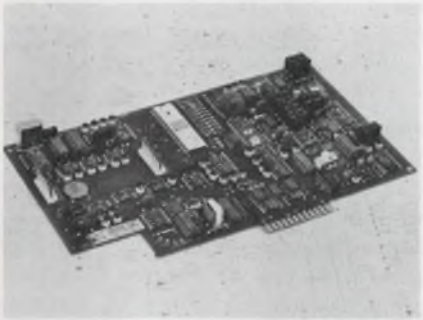
Unit punches cards from source data

Varifab, Inc., 1700 E. Putnam Ave., Old Greenwich, Conn. 06870. (203) 637-1434. $1095.

Model 404 automatically punches and prints numeric data on standard tab cards or multiple copy tab-card sets, from external cable signals. Typical signal sources include badge/card readers, time clocks, voltmeters and medical instrumentation. Output signals generated from the keyboard can control other devices such as adding machines. Alphabetic and numeric data are punched at 12 char/s.

CIRCLE NO. 334

LSI modem card lowers communications cost



Novation, Inc., 18664 Oxnard St., Tarzana, Calif. 91356. (213) 344-7191. $256; 30 days.

Model 202 plug-in card modem has a quartz-crystal clock, custom MOS/LSI circuitry and active filtering. The single card 1200/1800 baud unit is end-for-end Bell compatible. Standard features include automatic answer, line test, and equalization. Frequency shift keying is used—1200-Hz mark and 2200-Hz space. Data are accepted as asynchronous serial bits. A reverse channel option operating at five or 150 baud is available for terminal applications.

CIRCLE NO. 335

Device joins Varian Mini with CDC 7000

Sierra Data Systems, Inc., 168 E. Del Mar Blvd., Pasadena, Calif. 91105. (213) 792-2131. 2300: $7300; 2300A: $8700; 75 days.

The Varian 620 minicomputer and Control Data Series 3000, 6000 or 7000 computer I/O channels can be joined by Models 2300 and 2300A intercouplers. Model 2300 joins the 620/f with the CDC series for transfer rates up to 274,000 words/sec. Model 2300 uses the Varian priority memory access. 16-bit Varian words are truncated to 12-bit bytes; 12-bit CDC words become the least significant 12 bits of a Varian word. The 6000 and 7000 series must be equipped with CDC channel converters 6681 and 7681, respectively. The couplers are mounted on two Varian DM-135 boards which are installed at the customer site. Documentation consists of detailed specifications schematics and wire lists. Programs are furnished for troubleshooting and performance verification.

CIRCLE NO. 336

PDP-11 operating system uses less core

Data Systems Design, 1122 University Ave. Berkeley, Calif. 94702. (415) 849-1102. $1000.

TAG-11, available with Basic or Fortran, is claimed to be superior in many ways to DEC's DOS-11 operating system. It uses 8-k of core instead of DEC's 12-k minimum and can run from two to five times faster. IBM compatible format can be written on both disc and tape for media interchangeability. One mass-storage device such as a disc memory or a tape unit is required in addition to the core.

CIRCLE NO. 337

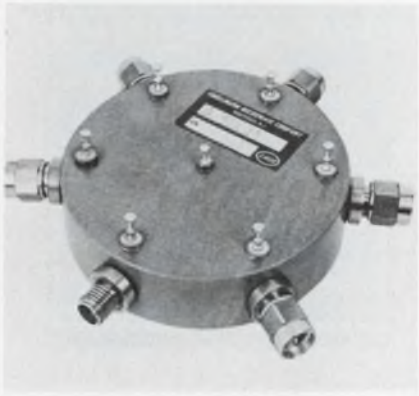
Video scan converter digitizes camera signal

Colorado Video, Inc., Box 928, Boulder, Colo. 80302. (303) 444-3972. $2500; 90 days.

CVI Model 260 accepts a standard 525-line composite video signal. A stationary image represented by the signal is sliced into vertical lines of 256 dots each. The brightness of each dot is converted to a 6-bit word. Thirty seconds are required to convert a matrix of 256 × 200 dots or one minute for a 256 × 400 matrix. The digital output can be passed to a computer (for image recognition) or sent over telephone lines by means of the 1-kHz analog output that is provided.

CIRCLE NO. 338

I-f stripline diode switches as stock line

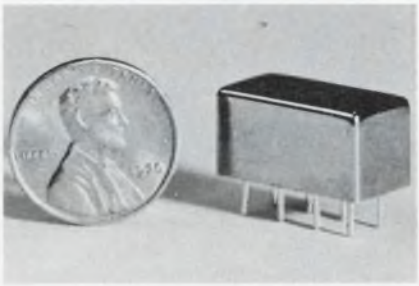


Engelmann Microwave, Skyline Dr., Montville, N.J. 07045. (201) 334-5700. $85 (without drivers); 4-6 wks.

The Series 2013 i-f stripline diode switches are said to be the first such series offered as a stock-product line. Switches are available in multiple-throw configurations from SPST to SP16T. Each type covers the full frequency range of 20-to-130 MHz. All units display greater than 60 dB isolation and typical VSWR of 1.5:1. Insertion loss is less than 0.5 dB, with switching speed less than 20 ns.

CIRCLE NO. 339

High performing mixer priced at $19.95



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

The SRA-6 doubly balanced mixer has these key features: broad bandwidth of 3 kHz-to-100 MHz; low conversion loss of 6 dB; and high isolation of 60 dB at low end of band, while greater than 50 dB at 10 MHz. The unit cost is $19.95 (1-24). Applications include up/down frequency converter, frequency doubler, phase detector and electronic attenuator.

CIRCLE NO. 340

Gain equalizers compensate TWT amps

Frequency Contours, Inc., 3140 Alfred St., Santa Clara, Calif. 95050. (408) 984-7820.

A line of low-loss, low VSWR gain-equalizers, termed the FC-1000 series, offer gain compensation or shaping for TWT amps and similar devices. The half-sine periodic response equalizers provide several modes of tuning to allow compensation for minor variations in production of TWTs. Rf power handling capability is 5 W cw (minimum).

CIRCLE NO. 341

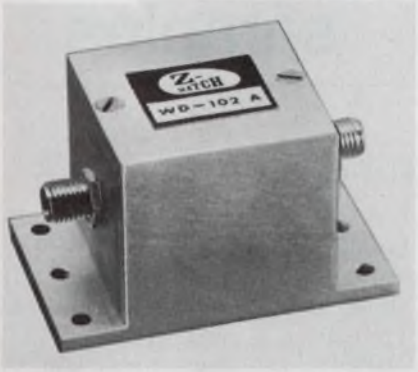
Sweep generators cover 32-to-90 GHz range

Hughes Electron Dynamics Div., 3100 W. Lomita Blvd., Torrance, Calif. 90509. (213) 534-2121. 44017H: $1000; 44056H: $1500; 44056H-001: $2200; 44066H: $2650; 44016H: $2950; 44076H: $3275; 45 days.

A line of sweepers, each using an IMPATT diode as the solid state source, operates over the entire frequency range from 32 to 90 GHz. The power supply (Model 44017H) can be used with each of the five different solid state sources in the line. In the 32 to 40 GHz range, two solid state source models are offered: Model 44056H with a 5-GHz bandwidth and Model 44056H-001 with an 8 GHz bandwidth. Both put out 5 mW of power. From 40 to 90 GHz, three models are offered. Each provides 10 GHz bandwidth and 5 mW power or 12 GHz bandwidth at the 3 mW power level. Model 44066H covers 40 to 60 GHz; Model 44016H covers 50 to 75 GHz; and Model 44076H covers 60 to 90 GHz.

CIRCLE NO. 342

Frequency doubler outputs up to 9 GHz



Vari-L Co., 3883 Monaco Pkwy., Denver, Colo. 80207. (303) 321-1511.

The Z-Match Model WD-102A frequency multiplier accepts input frequencies from 0.02 to 4.5 GHz and produces high-level outputs from 0.04 to 9.0 GHz. Input power is 10 to 20 dBm with fundamental and third harmonic suppression greater than 30 dB over the entire band. With impedances 50 Ω (nominal), typical input VSWR is less than 2:1 over the band and typical output VSWR is less than 2.5:1.

CIRCLE NO. 343

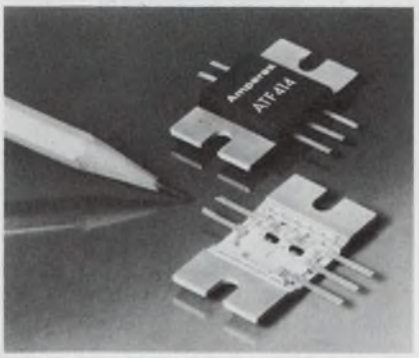
Rfi meter fully portable

Singer Instrumentation, 3211 S. La Cienega Blvd., Los Angeles, Calif. 90016. (213) 870-2761.

Weighing 54 pounds and operating from a rechargeable battery or regular ac power line, the Model NM-65T radio interference meter offers full hand portability. It covers the 1-to-10 GHz range and can function for 10 hours without recharging. The instrument measures field intensity, direct peak and slideback peak, and provides an i-f and four video outputs.

CIRCLE NO. 344

Uhf/vhf hybrid amps offer gains to 26 dB

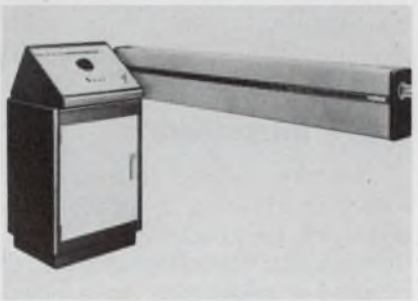


Amperex Electronic Corp., Solid State & Active Devices Div., Providence Pike, Slatersville, R. I. 02876. (401) 762-9000.

Four hybrid amps feature high gain and low distortion between 40 and 890 MHz. The low cost ATF-415 and ATF419 deliver 16 dB gain (±1 dB) with an intermodulation distortion of −60 dB. The ATF417 has a gain of 26 dB (±1 dB) with a noise figure of 4 dB. And the AFT414 offers a flat gain characteristic of 15 dB ±0.5 dB. Maximum VSWR for all devices is 2.0:1.

CIRCLE NO. 345

CO_2 laser boasts 50 W variable output power



Hadron Inc., 800 Shames Dr., Westbury, N.Y. 11590. (516) 334-4402. $4500; 30 days.

The Model 1050 laser, a flowing gas, air-cooled carbon dioxide type has a variable output up to 50 W multimode. The unit consists of a laser module—this includes a laser tube, air cooling system and gas fittings—and a support module that consists of the power supply and vacuum pump. The support module features variable control of the laser power from 10 to 50 W. The power supply can be pulsed at 120 Hz for perforating or for more efficient cutting.

CIRCLE NO. 346

design aids

Display guide

A display eye chart and display equipment buyer's guide compares the appearance of the company's displays, LEDs and Nixie tubes. It outlines factors which should be considered in the selection of equipment using displays. Sperry Information Displays.

CIRCLE NO. 347

CRT console wall chart

An actual size poster of the FOX 1 CRT console—communications center of the FOX 1 process management and control systems—features the CRT display and keyboard portions of the console. It is printed on a 35 × 35-inch heavy stock suitable for wall mounting. Available with the poster is a brochure describing the console's display capabilities. Using photographs of 15 actual displays, the brochure depicts the console's applicability to various industries and to various plant control needs. Foxboro Co.

CIRCLE NO. 348

Image intensifiers

Two new image-intensifier-tube wall chart/brochures contain data previously restricted by the U.S. Government. The six-page PIT-712 contains concise data on a selection of the company's special-purpose and magnetically-focused image intensifiers including gated "zoom" types, light shutter types, image stabilization types, large area types and single, double and triple-stage 40 and 90-mm magnetically focused types. The companion eight-page PIT-83 describes selected first, second and third generation electrostatically focused image intensifiers. Third generation types are characterized by the use of III-V photocathode materials, and second generation types by the use of microchannel plates. RCA Electronic Components.

CIRCLE NO. 349

evaluation samples

Flat cable

A range of flat cable includes 14, 16 and 24-conductors and is suitable for interconnecting DIL plugs, test clips and PC boards. The cables consist of 14, 16 and 24-PVC insulated cores laid in parallel in flat formation bonded together with nonmigratory gell PVC paste. The cores are color-coded and are easily separated and stripped for solder or crimp termination. Conductors are 0.4-mm diameter tinned copper wire and insulation is PVC 0.15 radial thickness. Insulation resistance between adjacent conductors is 10^4 MΩ. Jermyn.

CIRCLE NO. 350

Headed pin fasteners

A headed spring pin fastener combines the advantages of conventional straight Spirol pins with those of traditional headed fasteners. The headed pin performs the same function as rivets, drive pins, drive screws, conventional screws, clevis pins or special headed parts and can be used as a hinge, stop, conventional fastener, spring retainer, dowel or other device. C.E.M. Co., Inc.

CIRCLE NO. 351

Test jack

A nylon-insulated test jack for 0.080 in. diameter probes is ideal for instrument, meter, test or plug-in equipment and components. The jacks are available in colors, with beryllium copper pretinned contacts. Electronic Molding Corp.

CIRCLE NO. 352

Nylon wire tie

A one-piece, nylon twist-type fastener, initially designed for tying bundles of wires or other stranded materials, provides an unlimited variety of fastening applications. Fastex, Div. Illinois Tool Works Inc.

CIRCLE NO. 353

application notes

Liquid crystals

"Liquid Crystals," Publication No. JJ-14, describes liquid crystal compounds and their classifications —nematic, smectic and cholesteric. For application in the measurement of surface temperatures, as well as in the detection of surface temperature variations, the publication lists more than 100 liquid crystal mixtures. Eastman Kodak Co., Rochester, N.Y.

CIRCLE NO. 354

Three-phase motor guide

Ideafile No. 4 presents a discussion of problems inherent in the operation of three-phase part-winding-start motors as commonly applied in air-conditioning, refrigeration, heating, data-processing, and other equipment. One of the common problems discussed is the need for closer-tolerance overload protection in new, small motors whose normal running current is nearer to locked-rotor current than was true of earlier, more heavily insulated motors. Heinemann Electric Co., Trenton, N.J.

CIRCLE NO. 355

File management system

The MARK IV Technical System Description, a 44-page document, is adapted from "A Survey of Generalized Data Base Management Systems," which was prepared by the CODASYL Systems Committee for the Conference on Data Systems Languages. Part 1 of the publication is a complete, succinct technical description of the MARK IV File Management System. All of the changes and improvements made to the system since its introduction are discussed in this document. Part 2 is entitled "Feature List for the Survey of Generalized Data Base Management Systems," which is the format for the CODASYL report. Informatics Inc., Software Products Co., Canoga Park, Calif.

CIRCLE NO. 356

Thin film materials

The latest "Thin Film Materials Selector" lists, with prices, all the high purity metals and nonmetallic materials that MRC produces for sputtering and vapor deposition techniques. Included are MRC's MARZ grade metals, alloys and compounds; VP grade metals and alloys, most of which meet a 99.99% or better purity specification and IC grade nonmetallic compounds, which the company claims are the highest grade nonmetallics available, except for MRC's MARZ grade materials. New listings are: gallium arsenide and gallium phosphide single crystals for the growing LED market; coated COVAP filament evaporation sources with thick, uniform coatings of most every standard MRC metal or nonmetallic material; SUPER-STRATES, MRC's ultra-fine grained 99.6% alumina substrate for thin-film hybrid and microwave integrated circuits. Materials Research Corp., Orangeburg, N.Y.

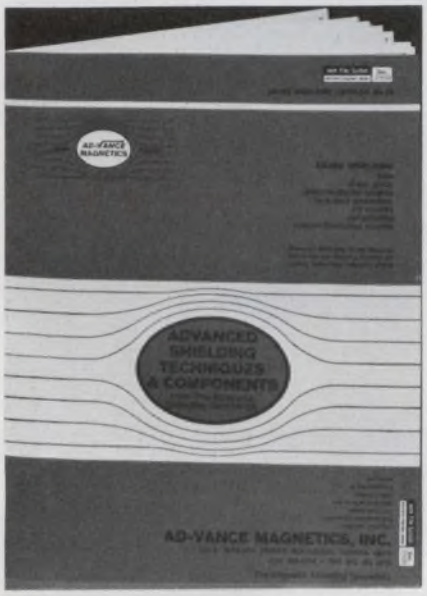
CIRCLE NO. 357

SCR bias

Tech Tips 3-2 explains in basic terms what happens when the gate cathode of an SCR remains positive while the anode cathode is negative (in a reverse blocking state). The result is a drastic increase in leakage current. The illustrated four-page note points out that the condition can exist in typical thyristor applications, such as a three-phase bridge circuit with a common dc gate cathode supply. It recommends against such designs, citing the reverse power losses which must be taken into account as well as possible effects on device reliability. Written by application engineer J. D. Balenovich, "Positive Gate Bias While an SCR is in a Reverse Blocking Mode" is the latest in the popular "Tech Tip" series of short articles on the selection, application, use and maintenance of discrete power semiconductors and subsystems. Westinghouse Electric Corp., Semiconductor Div., Youngwood, Pa.

CIRCLE NO. 358

new literature



Magnetic shielding

A 16-page, two-color catalog constitutes a comprehensive state-of-the-art manual on magnetic shielding. Detailed technical data is given on fabricating and shielding, using AD-MU ductile foils, sheet stock, tape data protectors, various components and custom fabricated shields. Physical characteristics of the four types of AD-MU alloys are tabulated to serve as guidelines in specifying the correct shielding. Other listings include 14 types of tape data protectors and 312 types of shields for photomultiplier tubes. Eight dimensional drawings of typical CRT magnetic shields are shown. Sixteen shields are illustrated. Ad-Vance Magnetics, Inc., Rochester, Ind.

CIRCLE NO. 359

Counting dials

Low-cost digital turns counting dials—designed for panel-mounted ten-turn precision potentiometers and other devices—are described in a bulletin. Included are material, operation, mechanical specifications, line drawings, a product photo and indication and rotation information on the satin chrome finished turns counting dials. Amphenol Connector Div., Controls Operations, Broadview, Ill.

CIRCLE NO. 360

PC laminates

A complete listing of high-quality copper-clad circuit laminates is given in a 12-page brochure. A table of application requirements vs uses, a grade selection table, technical specifications, Underwriters' Laboratories recognitions and ordering information is found in the illustrated publication. Also listed are the special features of the Micarta materials and sales locations in the U.S. and abroad. Westinghouse Electric Corp., Pittsburgh, Pa.

CIRCLE NO. 361

Aviation products

A new series of literature on the company's aviation equipment product line includes STAN, STAN II and AccuMAC integral weight and balance systems, cockpit voice and flight data recorders and music announcement reproducers. Fairchild Industrial Products, Commack, N.Y.

CIRCLE NO. 362

Digital voltmeter

A four-page bulletin details the Model D-2400 two-range or two-function digital voltage or temperature measurement and display unit. Described are the device's interchangeable plug-in modules, unique cold junction reference and 40,000 count resolution. Esterline Angus, Indianapolis, Ind.

CIRCLE NO. 363

Cooling systems

A complete family of compact, lightweight, modular cooling packages especially designed for cooling systems using power semiconductor devices is described in a catalog. A technical applications section in the catalog reviews the applicable cooling formulae to demonstrate the Cool-Pax's increased cooling effectiveness; and also provides the engineer with a simple guide to analyzing Cool-Pax applications and predicting thermal performance in his own systems. Thermalloy, Dallas, Tex.

CIRCLE NO. 364

Breadboarding system

Bulletin 101, a four-page folder, describes the Mini-Mount Breadboarding System. A variety of Mini-Mount patterns are available, including mounts for DIP IC packages, multilead ICs, transistors, trimmer potentiometers, capacitors, diodes and resistors. Christiansen Radio Co., Laguna Beach, Calif.

CIRCLE NO. 365

Solderless terminals

A 12-page, short-form catalog lists more than 1000 solderless terminals and connectors as well as crimping tools. The four-color, easy-to-read catalog includes illustrations and dimensions of each unit. Hoffman Industrial Products, Farmingdale, N.Y.

CIRCLE NO. 366

Power instrumentation

The Power Instrumentation Catalog, a 24-page, color-coded publication, includes information, specifications, dimensions and connection diagrams for the company's watt, var, power factor, current, voltage, frequency and phase angle transducers. In addition, specifications and other pertinent information on the company's demand computer, temperature transducer, power test console, digiwatt wattmeters and transducer calibrators are shown. Scientific Columbus, a unit of Esterline Corp., Columbus, Ohio.

CIRCLE NO. 367

Industrial transformers

The Industrial/Commercial Transformer and Inductor catalog details the company's line of components for industrial and commercial applications. The short-form catalog previews two lines of miniature plug-in power and audio transformers for PC board applications. Bourns Pacific Magnetics Corp., Romoland, Calif.

CIRCLE NO. 368

Thumbwheel switch data

Product Information Bulletin No. 641-1 describes a line of miniature 10-digit thumbwheel switches. AMP, Inc., Harrisburg, Pa.

CIRCLE NO. 369

quick ads

Thin-Trim® variable capacitors are designed to replace fixed tuning techniques. Applications include crystal oscillators, CATV amplfiers, communication and test equipment. Series 9410 has high Q's with five capacitance ranges from 1.0 - 4.5 pf to 10.0 - 50.0 pf. Johanson Manufacturing Corporation, Boonton, N. J. (201) 223-2676

INFORMATION RETRIEVAL NUMBER 161

Control Meter Relay Speed Indicating System for use in process & control machinery. Adjustable single/dbl set pt systems, accuracy ±2% full scale, repeatability 0.5%, speed ranges 10rpm to 12,000rpm. Dbl set pts adjust to 0° ea other. Servo-Tek Products Company, 1086 Goffle Road, Hawthorne, NJ 07506 (201) 427-3100.

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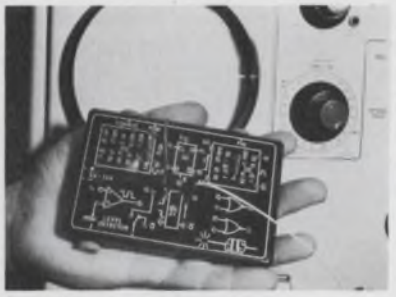

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INFORMATION RETRIEVAL NUMBER 163

NEW LITERATURE

IC testing

An applications booklet on the techniques of linear IC testing includes the analysis of transfer functions. The 12-page publication describes the Model 1420 tester and an optional unit that allows instant display of transfer function characteristics. The booklet details how the tester checks performance of linear ICs over the complete operating range of the device, providing inspection and evaluation to the exact specifications of the manufacturer or user. Sitek, Inc., Sunnyvale, Calif.

CIRCLE NO. 370

Digital printer

A technical data sheet describes the company's Series 7726 accumulating digital printer used to produce printed records for inventory control and cut-to-length applications. Standard features are listed for this printer/totalizer. Options include aperture card printout. Veeder-Root, Hartford, Conn.

CIRCLE NO. 371

Connectors

Cylindrical, subminiature rectangular, crimp-removable cylindrical and filtered contact connectors are presented in a catalog. Appropriately sectionalized by product groupings for convenient reference, the manual also includes information on the company's specialized connector lines for audio applications, military communications equipment, power and control interconnections. General Connector Corp., Newton, Mass.

CIRCLE NO. 372

Handbook of flat cable

A revised Handbook of Flat Cable prepared by the Institute of Printed Circuits contains 40 pages divided into eight chapters with 40 illustrations, 20 of which are photographs. The eight chapters cover distinguishing features, termination, connectors, wiring change possibilities, cable assemblies, installation and support, technical data, and signal transmission lines, plus a flat cable glossary. Price per copy is $5.00. Institute of Printed Circuits, 1717 Howard St., Evanston, Ill. 60202.

Flexible sound barriers

A brochure provides sound attenuation data, specification and application information on flexible sound barrier material. Duracote Corp., Ravenna, Ohio.

CIRCLE NO. 373

Precision potentiometers

Ten-turn, high-performance precision potentiometers for industrial and commercial applications are described in a bulletin. The bulletin outlines electrical characteristics of the company's 7/8-inch diameter MF 78 Series "pots." Other electrical, mechanical and environmental characteristics, specifications, line drawings, product features and a photo of the precision potentiometer are included. Amphenol Connector Div., Controls Operations, Broadview, Ill.

CIRCLE NO. 374

Wattmeters

An eight-page supplement to the General Catalog lists over thirty new Thruline rf directional wattmeters, Termaline rf load resistors and an attenuator. Prices are included with equipment photos and performance specifications. Bird Electronic Corp., Cleveland (Solon), Ohio.

CIRCLE NO. 375

LSI computer

The Space Ultrareliable Modular Computer (SUMC) LSI Computer Systems are described in a 12-page bulletin. RCA, Advanced Technology, Camden, N.J.

CIRCLE NO. 376

bulletin board

Collins Radio Co. has released **microwave and/or multiplex publications** including re-issues of unit instructions and subsystem/system maintenance methods, change notices and recommended field or factory modifications. The company's microwave and multiplex customers may receive up to one copy per station plus three administrative copies of each publication related to equipment previously purchased and on hand at no cost.

CIRCLE NO. 380

A versatile **programming language**—called **SNOBOL 4**—capable of operating with character strings, has been added to the software library of **Datacraft Corp.** It is priced at $400. The language can be used for applications in such areas as compilation techniques, machine simulation, symbolic mathematics, text preparation, natural language translation and linguistics.

CIRCLE NO. 381

An all-inclusive **RFI/EMI systems compatibility service for analyzing, measuring and solving noise interference problems** in a wide variety of electronic systems is offered by **Genistron Div., Genisco Technology Corp.** Services are available on a fixed price quotation basis. Other services provided are military testing per MIL-STD-461-462 and MIL-STD-704, design evaluation and shielding effectiveness studies, precision VSWR and impedance measurements, EMP hardness testing, EED measurements and evaluation, on-site field testing, FCC type acceptance testing and VDE and CISPER conformance certification.

CIRCLE NO. 382

The **National Cash Register Co.** and **Quantor Corp.** have entered into an agreement under which

NCR will provide maintenance service for Quantor equipment. Service will extend to the total line of **COM (Computer Output Microfilm)** and **microfiche equipment.**

CIRCLE NO. 383

The Mallory Capacitor Co., a div. of P. R. Mallory & Co. Inc., has announced price increases of 8% for its lines of FP, CG, CGS, TC, TCW and TCG **electrolytic aluminum capacitors** and **ac motor start capacitors.** The price increases are within the applicable guidelines of the Price Commission.

CIRCLE NO. 384

Price reductions

Sperry Information Displays Div. has announced a price cut on its **seven-segment planar gas discharge display and decoder/driver lines.** Display prices are reduced to $3.80 from $5.50 (1-99); $2.95 from $3.30 (100-499); $2.50 from $3.30 (500-999); $2 from $2.52 (1000-4999). Decoder/driver prices are reduced to $3.25 from $5.40 (1-99); $2.50 from $2.70 (100-499); $2 from $2.70 (500-999); $1.50 from $1.55 (1000-4999).

CIRCLE NO. 385

Materials Research Corp. has reduced prices 25% on its 1 × 1 × 0.025-in. **Superstrates** sputter-coated with 200 Å of chromium and 150 micro-inches of gold.

CIRCLE NO. 386

Zeltex, Inc., has announced a price reduction for its fast settling, ultra-high speed inverting amplifier, **Model ZA910M1.** In quantities of 1 to 24, the price has been reduced to $89 from $99.

CIRCLE NO. 387

Digital Computer Controls Inc., has reduced prices 25% on its **ME-1 core memory expansion unit.** The initial 4-k increment of add-on memory has been reduced to $2700 from $3500. Additional 4-k increments have been cut from $2375 to $1900.

CIRCLE NO. 388

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Design Data from

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A new publication by Federal Scientific, originators of the Ubiquitous® Spectrum Analyzer, covers general and specific signal processing techniques and theoretical constraints.

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- Theory of operation of time-compression analyzers
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CIRCLE NO. 176

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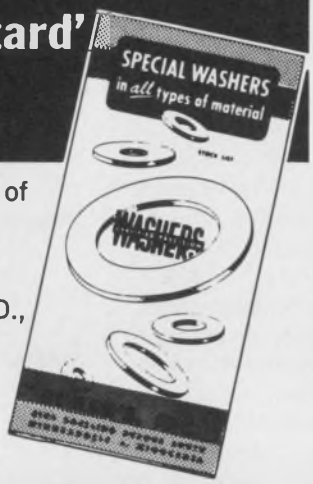

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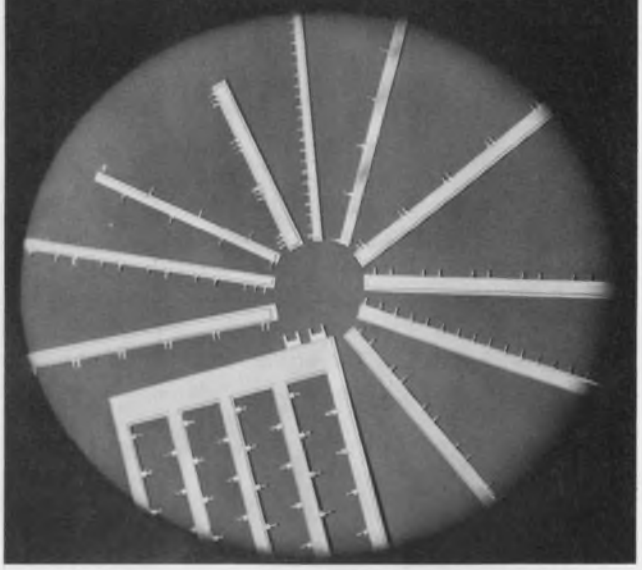

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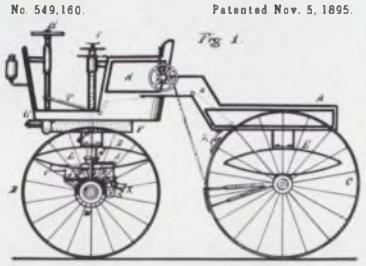

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product index

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MDR

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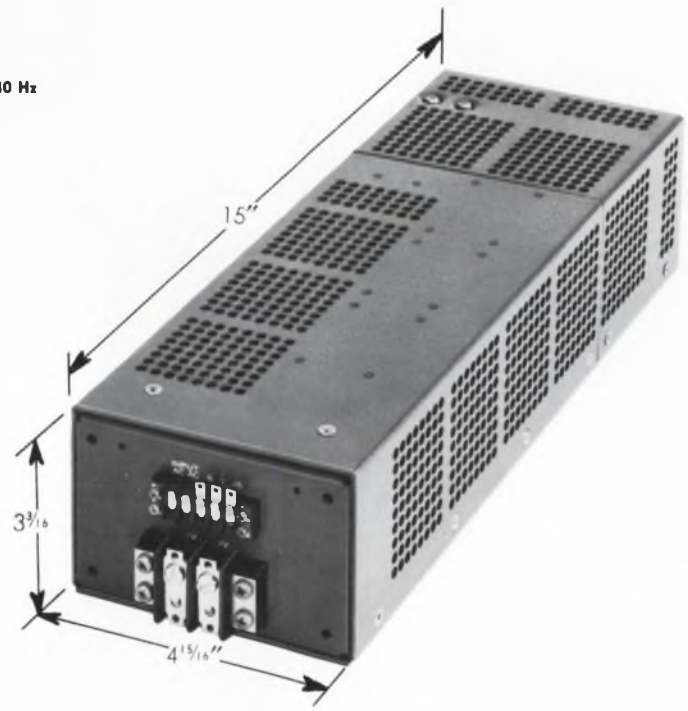
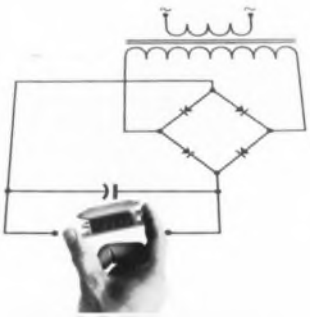
AC input: 105-132 VAC, 47-440 Hz
DC input: 145 VDC ±10%





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