December 1970 / Volume 18 / Number 12

EEE

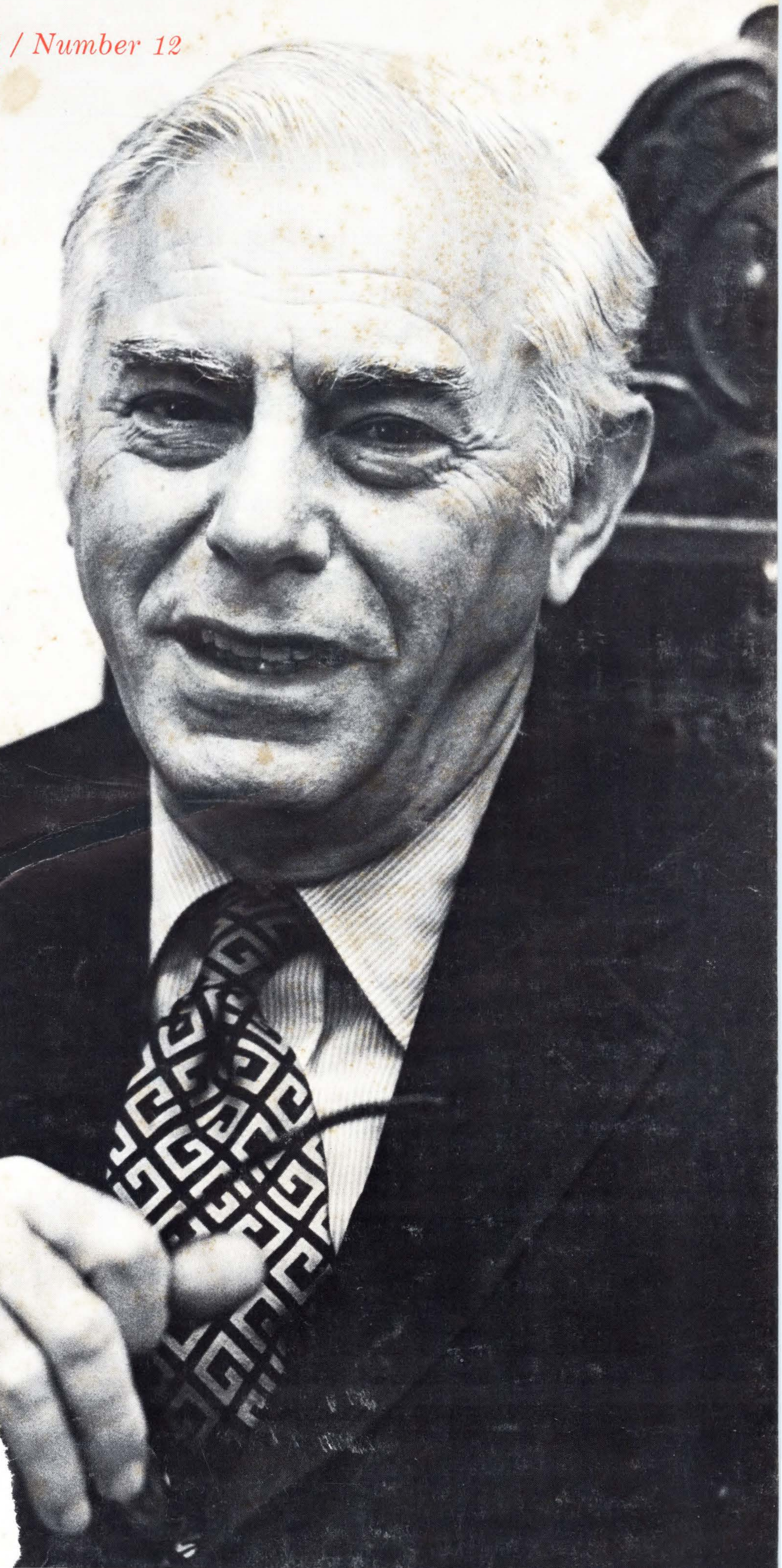
EXCLUSIVELY FOR DESIGN DECISIONS

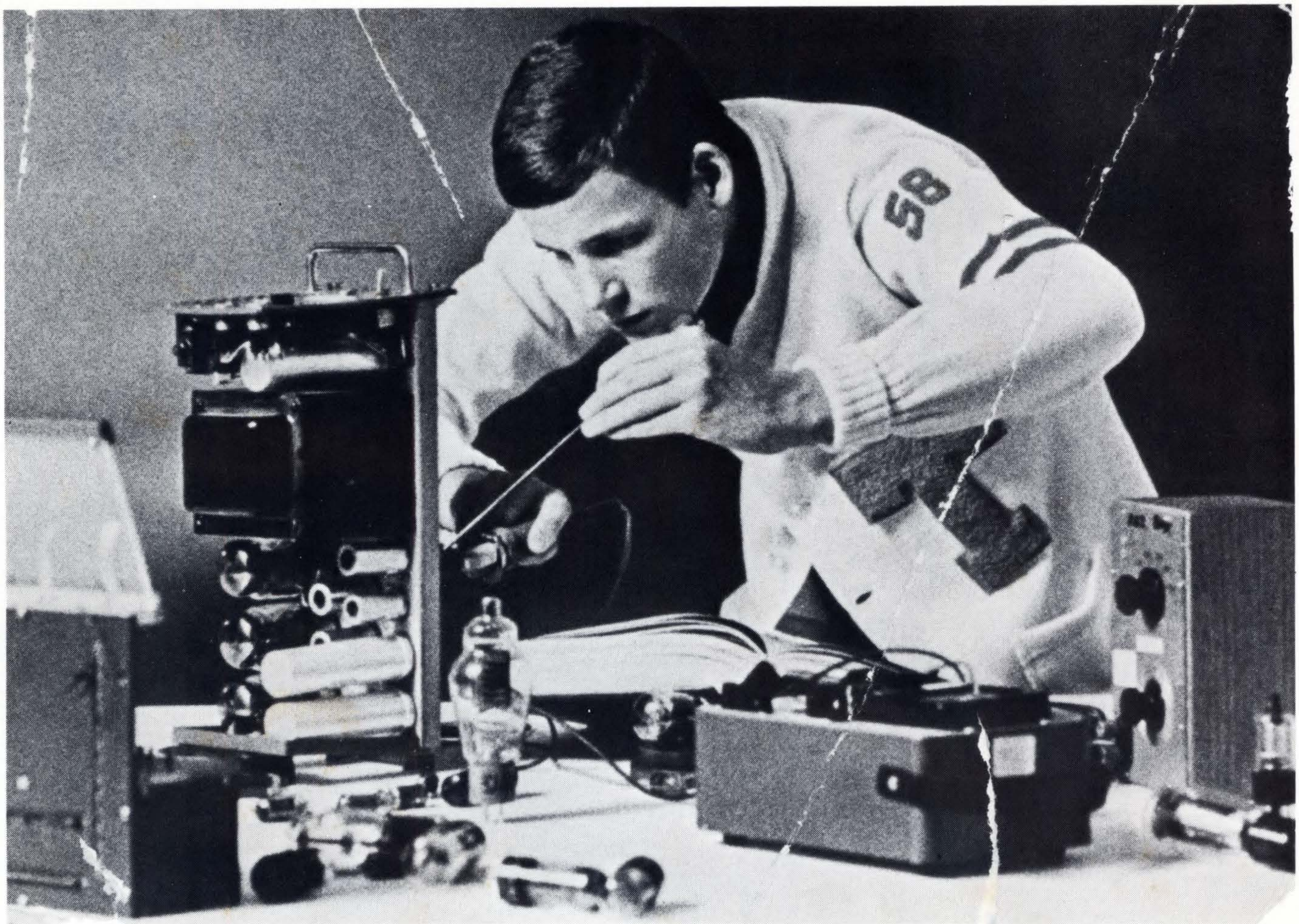
Benjamin Fox of Elco Speaks Out On The Demise of Discrete PC Connectors

How To Keep Out Motor Noise

Second Generation Analog Multiplier ICs

Semiconductor RAMs And Minicomputers





Are you still using the same scope you used in college?

If so, you've been missing out on the greatest achievements in scope technology. During the last five years, Hewlett-Packard has quietly but firmly assumed technological leadership in the oscilloscope industry with the revolutionary HP 180 Scope System.

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Scopes are changing.
Are you?

081/3

HEWLETT hp PACKARD

Circle 101 on Reader Service Card

DECEMBER 1970
VOLUME 18, NUMBER 12

EEE

EXCLUSIVELY FOR DESIGN DECISIONS

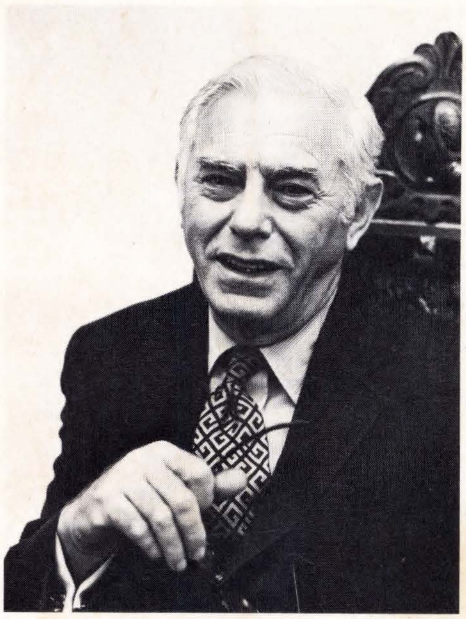

Photo by Robert Smull
Story on page 32

PROGRESS . . . in Design and Research

FEATURES

CIRCUIT DESIGN AWARD PROGRAM

DEPARTMENTS

EEE

EXCLUSIVELY FOR DESIGN DECISIONS

Executive, editorial, circulation and advertising address: Mactier Publishing Corporation, 820 Second Avenue, New York, New York. 10017. Telephone (212) 661-0450. Telex 12-6466.

Also publishers of Electro-Procurement, BM/E—Broadcast Management/Engineering, Broadcast Equipment Buyers Guide.

Editorial Objectives

EEE serves electronic design engineers exclusively. EEE restricts its editorial coverage to material that can help engineers make design decisions. Such editorial material is intended to **help an engineer:**

- Decide for one design technique or design philosophy over another;
- Decide for one measurement technique over another;
- Decide for one packaging technique over another;
- Decide for one systems approach over another;
- Decide for one material, component, packaged circuit or instrument over another.

EEE does not publish general-interest material that cannot contribute to a design decision. Nor does it publish material aimed at peripheral interests of an individual.

EEE is dedicated to articulate expression and clear visual presentation. It is pledged to encourage the exchange of sound engineering ideas.

EEE's editorial pages are open to engineers for bylined articles and correspondence.

A member of BPA ABP

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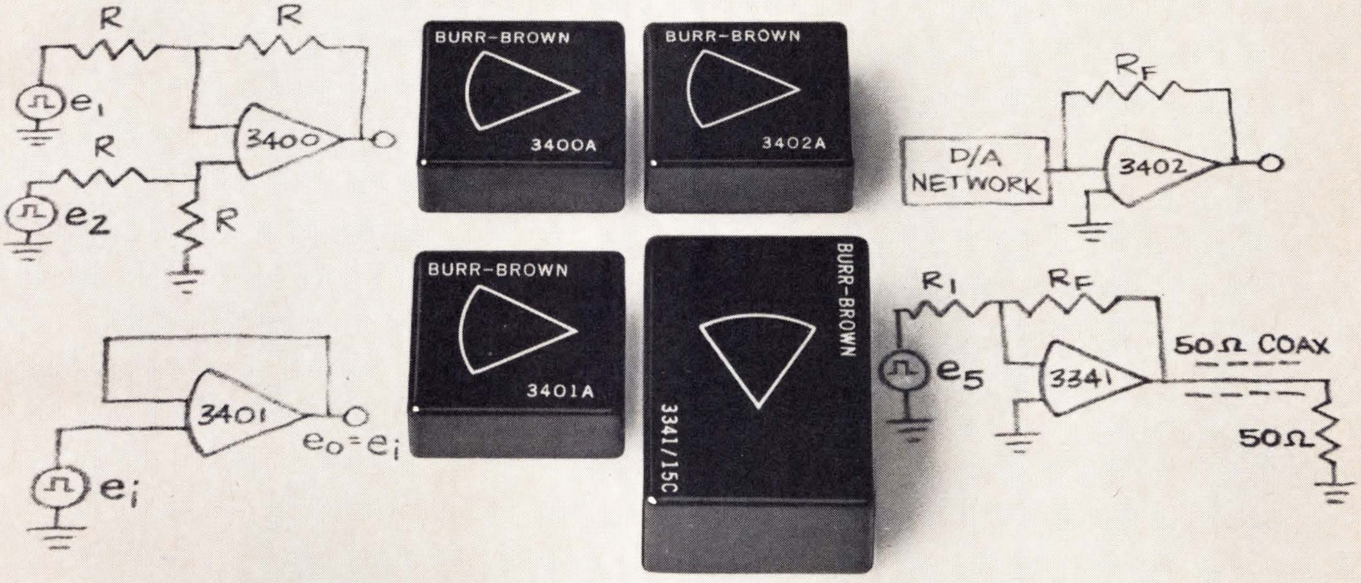
Subscription price to others: $15.00 one year, $25.00 two years. Please notify publisher promptly of any change in job function or address, enclosing your old address label. The publisher assumes no responsibility for opinions of contributions or for the validity of claims reported in advertisements or editorial items. Controlled circulation postage paid at Waseca, Minn. Copyright 1970 by Mactier Publishing Corporation. Title Reg. Pat. Off. Contents may not be reproduced in whole or part without consent of copyright owner. Printed at the Brown Printing Company, Waseca, Minn. EEE is reproduced in microfilm form by University Microfilms, Inc., of Ann Arbor, Mich.

Need a fast wideband op amp?



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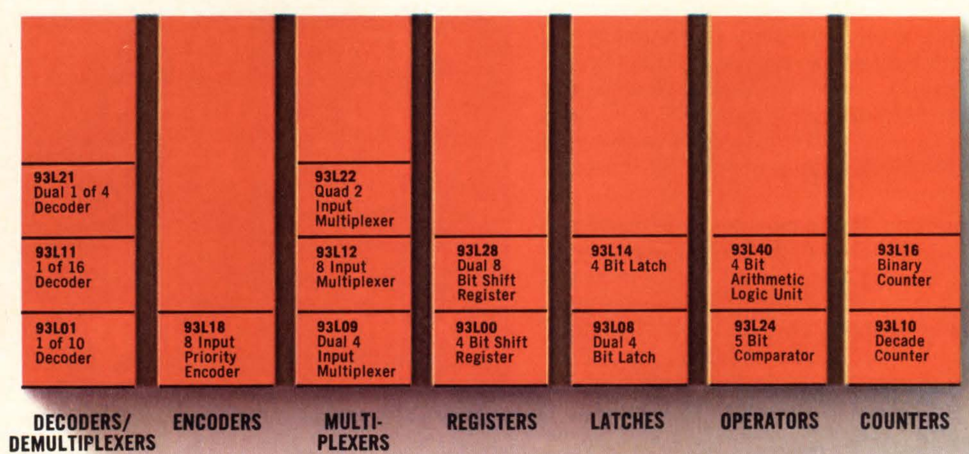
Our TTL family gives you freedom where it counts.

The Fairchild TTL family offers the freedom-loving designer the broadest range of speed/power trade-offs and an extraordinary variety of logic and memory and interface support functions.

FAIRCHILD TTL FAMILY

*Available January, 1971

Now you can design with Low Power TTL/MSI at even less cost than with Standard!



Our Low Power TTL now sells for the same price as Standard TTL and costs even less to use.

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- No board redesign (pin-for-pin equivalent to and compatible with Standard TTL/MSI devices).
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- Largest Low Power MSI/TTL family around.

Typical performance:

Gate Tpd = 20ns Gate Pd = 2mW
Binary Toggle Rate = 10MHz
MSI Clock Rate = 10MHz

You might re-examine your current design. If speed is not a critical factor, then look at our 93L Low Power series. If you care about costs, they have a lot to give. Our new catalog tells the whole story. Send for it.

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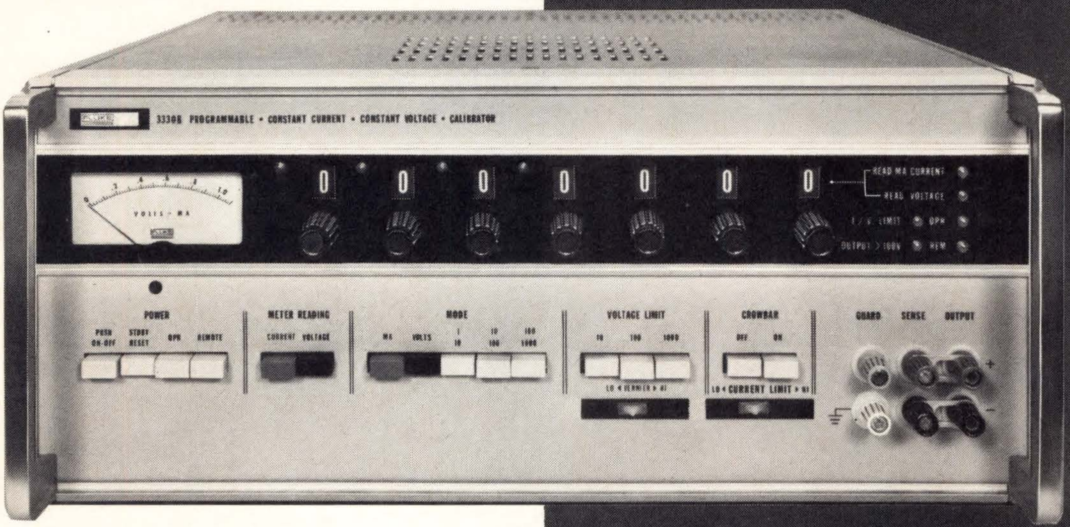
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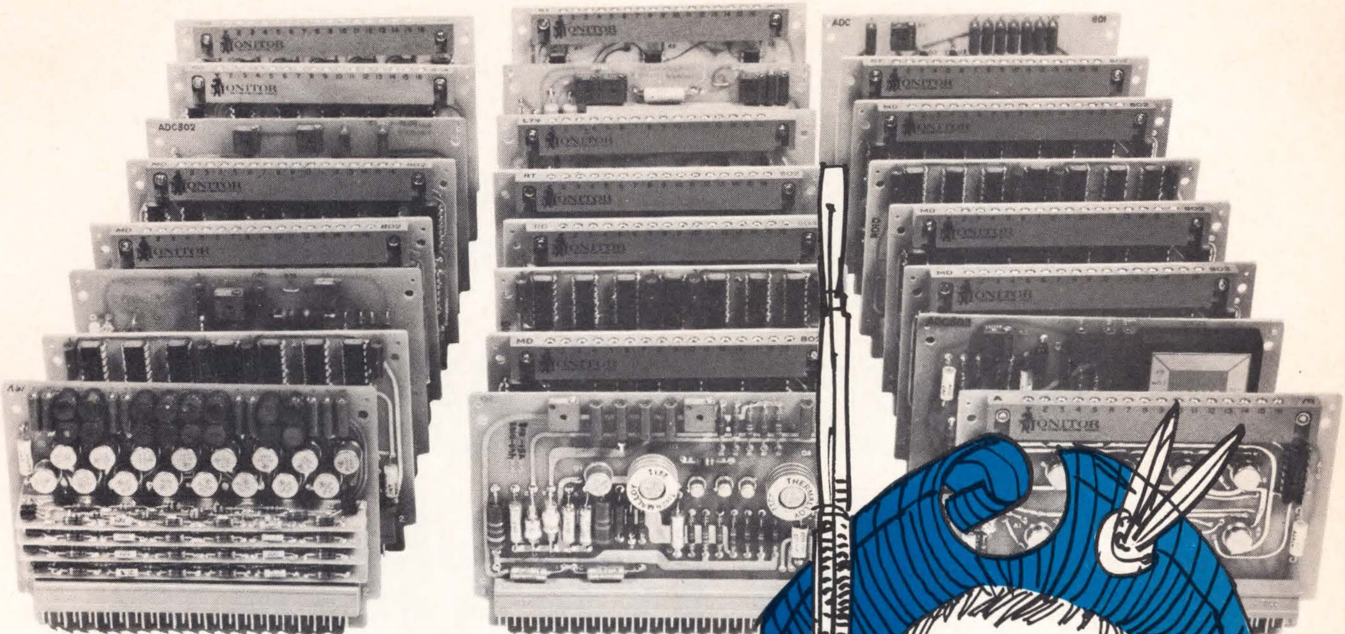

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Circle 106 on Reader Service Card

Editorial

What's wrong?

An old friend challenged us the other day. "Why is it," he chided, "that practically every cover of *EEE* features someone talking about what's wrong with something? Isn't there enough wrong in the world without your reminding us every month?"

There certainly is plenty wrong. The world seems to be falling apart. We're in an ugly war that many of us don't like. Our air and water are dirty. Our buddies are out of work while the rest of us sweat out the next layoff. Our schools gasp for funds while trying to cope with upheavals of angry youth. We have street battles because nature elected to create people with different skin pigments. And our kids take drugs.

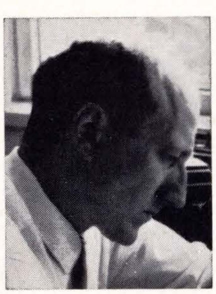
Now *there's* an escape. Or is it? We can't really escape. We can't hide unless we stop reading newspapers, stop listening to radio and watching TV, and halt our intercourse with people.

Sure, *EEE* could play Pollyanna. Sure, we could pretend all's right with the world in general and our industry in particular. We could publish cover features that glow about the rainbow on the horizon and beam about the ever-bright outlook. And our cover men could always smile. But who would believe us?

EEE is written for adults. And though adults, like children, deserve some dreams, it's not our job to beguile readers with fantasy. We can't hide from reality. We want to help adult engineers cope with a real world that isn't always pretty.

If there's a hole in your path, it won't go away if you blithely ignore it. We may be able to help if we warn you, and perhaps suggest remedies. And that's the role of the "What's Wrong With" cover Speak Outs as well as everything else in EEE.

What's wrong with that?



George Rostky

GEORGE ROSTKY
EDITORIAL DIRECTOR

For those of you who don't know FETs from filaments...

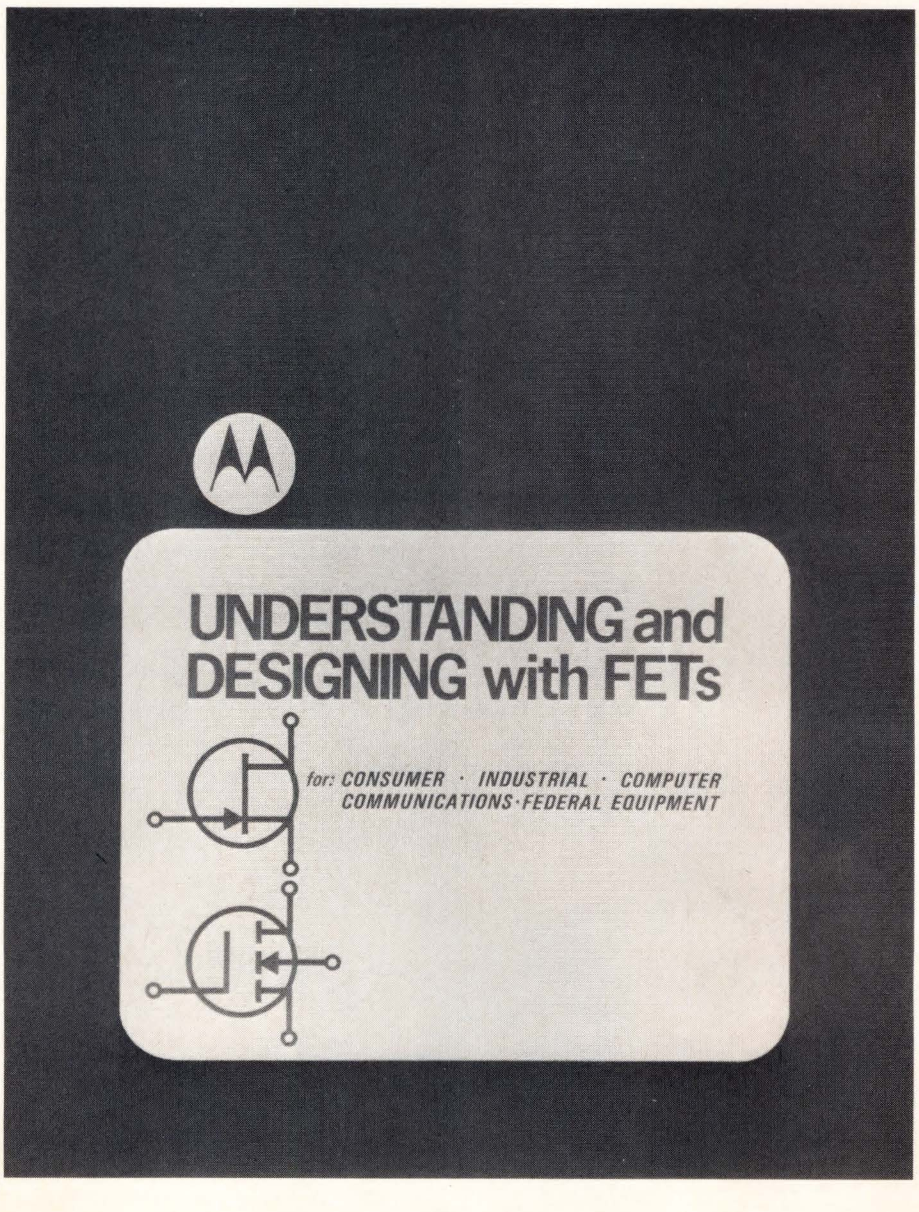
. . . a fresh, A-to-Z, solid-state primer that spells "FET" from unipolar to application.

Leading off with a ground-zero introduction: "What Is a Field Effect Transistor," the manual accelerates to explain FET theory, history, operation, types, advantages and disadvantages, and compares FETs to vacuum tubes and conventional bipolar transistors in terms of characteristics.

Classes of FETs are clarified: enhancement, depletion (Types A & B) and how they fit into switching, chopper, amplifier, voltage-variable resistor, current/limiter/source and microwatt logic designs.

Specific FET applications are also treated, such as: FETs in Chopper and Analog Switching, Low Frequency FET Applications, The FET In Digital Designs and A Unified Approach to Optimum FET Mixers are 4 of the many.

Your personal request on your company letterhead will bring you a copy of this valuable instruction — Box 20912, Phoenix, Arizona 85036. Find out what you need to know about FETs . . . write now!



For those of you who do...

. . . a FET design kit oriented to your exact market-application need. — *Free* from your Motorola distributor!

Pick out your "market" — fill in the coupon — (one to a customer, please) return it to your local Motorola distributor. He'll see to it that you receive your devices plus complete data sheets outlining the outstanding performance of these industry favorites.

Motorola now offers nearly 200 individual FET types for virtually any application need — from consumer to military. Junction FETs, silicon-nitride MOSFETs, N or P-channel, for operation from dc to UHF in switching and amplifying applications. You can select from: 20 RF mixers and amplifiers to 400 MHz frequencies . . . 45 JFET choppers with drain-source resistance low as 10 ohms . . . 80 general-purpose amplifiers offering forward transadmittance high as 12,000 μmhos . . . 23 general-purpose switches furnishing drain-source resistance low as 150 ohms . . . 6 matched pairs with TC's to 10 microvolts/°C and subminiature Micro-T* capability for high density RF designs.

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- 2.0 pF max. C_{rss}
- Interchangeable Drain/Source

2N5718
- High dc input resistance
- 5.0 pF max. C_{iss} @ 15 V
- 1.5 pF max. C_{rss} @ 15 V
- 0.8 — 4.0 mA I_{DSS} @ 15 V

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Company________

Address________

City________ State____ Zip____

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Plastic JFET & Dual Gate MOSFET for Your Tuner/IF Applications

2N5669
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- 1.0 pF C_{rss}, 4.7 pF C_{iss} (typ.)

MPF121
- 17 dB min. G_{ps} @ 200 MHz
- Diode-Protected Dual Gates
- Silicon-Nitride Passivated
- 1% typ. Cross-Mod

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***IndustrialFET* Design Kit #3**

Complementary MOSFET Switches and General Purpose JFET

2N4351, 52
- Enhancement Mode (Normally Off)
- 300 Ω Drain-Source Resistance
- 1.3 pF max. C_{rss}
- Guaranteed Switching Limits

2N5457
- 1.0 — 6.0 V $V_{GS(off)}$ @ 15 V
- 1.0 — 5.0 mA I_{DSS} @ 15 V
- 2.5 V V_{GS} @ 15 V
- Drain & Source Interchangeable

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COUPON NO. 4:

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***ComputerFET* Design Kit #4**

MOS & Junction Chopper FETs For Multiplexing Applications

MFE3002
- 100 Ω $r_{ds(on)}$
- 1.0 pF max. C_{rss} @ 1 MHz
- 100 pA max. I_{GSS} @ 10 V
- 10 nA max. I_{DSS} @ 10 V

2N5638
- 4.0 pF max. C_{rss} @ 1 MHz
- 5 ns max. t_r @ 12 mA
- 30 $r_{ds(on)}$
- 10 pF max. C_{iss} @ 1 MHz

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COUPON NO. 5:

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***CommunicationFET* Design Kit #5**

Plastic JFET & Dual-Gate MOSFET For Front Ends and IF Strips

2N5485
- 18 dB min. G_{ps} @ 100 MHz
- 2.0 dB max. NF @ 100 MHz
- 5.0 pf max. C_{iss}, 2.0 pF max. C_{oss}
- 3,500/7,000 μmhos max. yfs.

MPF121
- 5-30 mA I_{DSS} @ 15 V
- 17 dB min. G_{ps} @ 200 MHz
- Diode-Protected Dual Gates
- Silicon-Nitride Passivated

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COUPON NO. 6:

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***FederalFET* Design Kit #6**

Hi-Rel Metal JFETs for Audio/Chopper/Switching Designs for JAN Availability

2N3821
- 6 pF max. C_{iss} @ 1 MHz
- 3 pF max. C_{rss} @ 1 MHz
- 0.1 nA max. I_{GSS} @ 30 V
- Low Cross/Inter-Mod Distortion

2N4220
- 2.0 pF max. C_{rss} @ 1 MHz
- 6.0 pF max. C_{iss} @ 1 MHz
- 100 pA max. I_{GSS} @ 15 V
- 2.5 V max. V_{GS} @ 50 μA

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Circle 108 on Reader Service Card

ACROSS THE Editor's Desk

Neatest calculation of the year

A write-up in *Investor's Reader,* a publication of Merrill Lynch, Pierce, Fenner & Smith, included the following memorable lines about Wang Laboratories:

" . . . An Wang, 50, adds, 'the total US market for electronic calculators is now about $1,000,000. We do $24,000,000 of this. Although the figures are not available, I believe that makes us No. 1 in sales'."

Can't go far wrong with a guess like that.

Encoder comments

Dear EEE:

Thank you for Jack Heaviside's excellent article in your July issue "Acquisition of Shaft Angle Data" (*EEE,* July, 1970, pp 59-66).

Heaviside, however, omits or at least brushes aside one of the encoder conversion techniques which is almost "faultless" in the sense that none of the disadvantages mentioned in his article is present and gives the shaft encoder a better competitive position against the synchro which the author prefers.

The technique is the "static" digital conversion of a Gray coded encoder disc (either optical or brush type) to binary or binary coded decimal form.

The conversion is performed by TTL logic without any clocking, sampling, counting, updating etc. The speed of conversion is the propagation delay of the logic only and is in the order of nanoseconds. The resolution is limited by the encoder only. It is accurate to the last significant bit and not ± of the last significant bit as in the counter type conversion.

For remote transmission of data between the encoder and the conversion electronics no coaxial cables are needed because there is no high pulse rate, frequency or modulated ac amplitude to be transmitted, but TTL logic levels only.

As far as the cost of a single channel is concerned let me give you as an example: a decoding electronics of our design for an 11-bit Gray to BCD conversion did require 40 quad-two input gates.

M. Benedek
Kollsman Instrument Corp.
Elmhurst, N.Y.

Dear EEE:

Since Jack Heaviside's company designs and manufactures synchro/resolver type angle measuring systems, a misleading (but natural) bias appears in his article. For example, the 12-bit, 4" diameter, $1200.00 (ball park values) shaft encoder mentioned by Heaviside can be purchased from our company in small quantities for under $600.00 in a 2-1/2" synchro/mount package (a different ball park?). It includes full integral plug-in electronics and provides a direct TTL compatible, natural binary output.

For a small additional charge (under $100.00) we can provide within the encoder a parallel-to-serial converter. Consequently, the encoder will require only five cables for proper operation.

Present electro-optical techniques use phototransistors rather than photocells or photodiodes, thereby providing relatively high-level outputs. A 12-bit Gray encoder with direct phototransistor outputs can be obtained from us for less than $350.00.

Heaviside discusses "Stunt Box" requirements for encoder code conversion. We provide as a standard option any one of five different conversion boards all priced under $100.00, all integrally packaged in the encoder, and each mounted on a 2-1/2" plug-in board. In addition, because of the nature of encoders, non-binary outputs are easily obtainable (i.e. 0-3599 or 0-999). No "routine custom modification" is necessary.

The "historical unreliability of encoders due to the relatively short life of their light sources" is, unfortunately, an unreliable statement. Present encoder lamps have an MTBF of 10^6 hours and a wearout life of 10^5 hours at operating voltages. In addition, solid-state light sources can now be obtained for the same price as lamps. Improved technology in this area has resulted in lamp reliability that actually exceeds the reliability of the encoder electronics. We rarely have lamp degradation or failures in our encoders.

Finally please note that 13-bit encoders of the same type are available for under $900 and a cost comparison at this resolution might be interesting.

There are certainly many applications where synchro/resolver systems are the right approach. However, the modern optical shaft angle encoder provides a reliable, low cost component that is being used more and more by design engineers. It should certainly be given a fair hearing.

Fred Gordon
Sequential Information Systems
Dobbs Ferry, N.Y.

Author's reply. The products cited by Fred Gordon and M. Benedik describe important, recent improvements in encoder technology, which would help justify the decision to use encoders in certain applications. But the issue at hand is not simply whether one device can be made cheaply or another re-

(Continued on page 14)

Mike Markkula
of Fairchild Semiconductor

This engineering / engineering management seminar will cover the positive aspects of designing with standard ICs. It'll analyze the degrees of flexibility that different standard ICs provide the circuit/system designer and it'll survey what can be accomplished with existing digital and linear ICs including bipolar and MOS MSI/LSI. The seminar's main goals are to show the IC user the ranges of capability offered by standard devices and the best ways from technical and economical viewpoints, to take advantage of these capabilities.

As with previous EEE Seminars, this special seminar permits key applications engineers at leading IC manufacturers to interface as a group with IC users. This helps attendees gauge the opinions of several leading IC engineers on each topic discussed.

PROGRAM:

Session One

Key innovators from leading digital/linear IC manufacturers will discuss groundrules for making standard available-off-the shelf ICs fit the requirements of various circuits and systems.

Session Two

The controversies concerning which

EEE Seminars Announces an Important New IC Seminar For Engineers and Engineering Management:

"Designing With Commercially Available Integrated Circuits"

of competing IC approaches is best for various systems will be examined.

Session Three

The present range of capabilities of most types of ICs (LSI/MSI, RAMs, ROMs, op amps, regulators, comparators, etc.) will be explored.

Date/Place

Tuesday, December 8, Sheraton-Blackstone, Chicago

8:45-9:15	Coffee/Danish
9:15-11:45	Morning Session
11:45-1:00	Luncheon
1:00-3:00	First Afternoon Session
3:00-3:15	Coffee/Coke Break
3:15-4:30	Second Afternoon Session

Registration Fee

Advance registration is $35 ($40 at the door if seats are available). Registration includes detailed program, materials, luncheon, coffee breaks. Fee is tax deductible. Cancellations honored one day before seminar.

To register, use the form below.

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☐ **Seminar on "Designing With Commercially Available Integrated Circuits," Tuesday, Dec. 8, 1970, Sheraton-Blackstone, Chicago, Ill. Fee: $35.**

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ACROSS THE

Editor's Desk

liably or whether another can facilitate a particular coding, the problem the systems designer faces is in finding an inexpensive combination of available devices to reliably satisfy every one of his functional and environmental requirements.

I would be delighted to present the case for the synchro/resolver if Gordon or Benedek or other readers would present the opposition argument.

J. B. Heaviside
North Atlantic Industries
Plainview, N.Y.

They liked it in Washington

A review of Bob Pease's "Speak Out" on what's wrong with Mil-Std-883 (*EEE*, January 1970) appeared in *Reliability Abstracts and Technical Reviews*, a monthly publication of the National Aeronautics and Space Administration.

The final lines of the NASA review comment: "The author's style is direct, blunt and dramatic — designed to capture attention. It lends itself to overplaying the attack, causing the reader to suspect that occasionally the technical argument gets subordinated to showmanship. This shortcoming notwithstanding, or perhaps because of it, the paper is highly readable — action-packed from start to finish."

Pease's reaction: "Wait till you see the movie."

Wanted: continuous power

One of the greatest man-bites-dog rumors we've heard in a long time has it that Consolidated Edison has been having trouble with its computers. The New York City-based power utility, plagued by equipment failures and large demands for electric power, has been forced to reduce generated voltage to avoid further power failures.

As a result, its computers lose data. So Con Ed, we hear, is looking for an uninterruptible power supply.

DAC felony

Dear EEE:

It came with a great shock to me that the usually sound and impartial *EEE* product comparison editors could so distort the facts as was done in your September issue (Designer's Guide: D/A Converters) comparing our monoDAC-01 (complete 6-Bit D/A converter on a single chip) with the RI1080 of Radiation. And it came as an even greater shock that the culprit was your peerless, always accurate and reliable, managing editor. Apparently, the old adage continues to hold true — "nobody's perfect."

Just for the record (and so that your readers might appreciate why I'm foaming at the mouth), we went to some trouble to develop, in addition to the requisite resistor network and switches, a compatible 25 V/μs internally compensated summing amplifier, plus a compatible built-in compensated reference diode, so that we would have a complete converter. Neither of the latter elements is present in the RI1080, yet in your September issue, (Designer's Guide: D/A Converters) you term it "a complete 8-bit DAC."

Compounding this "felony" is the further misleading assertion, "though the monoDAC-01 and RI-1080 are complete DACs, they may need external output amplifiers in many applications" (and after our Dan Dooley designed and included in the monoDAC-01 an output amplifier that slews 10 V and settles in 1 μs while driving a 2-kΩ and 100-pF load). That same September issue carried our full page ad claiming, among other features, a built-in amplifier on the chip. Your editorial comment, coming from such a usually reliable source, could have damaged our credibility and reputation. Engineers are skeptical enough of claimed breakthroughs. I assume, whether you are brave enough to print this or not, that you will return to your usual accurate reporting habits in the future.

Marvin B. Rudin
President
Precision Monolithics
Santa Clara, Calif.

Mr. Rudin is correct. The monoDAC-01 has an output amplifier on the chip whereas the RI-1080 does not. In the introduction to our Designer's Guide, we were trying to contrast monolithic DACs with modular DACs by pointing out that existing monolithic DACs (even those that include output amplifiers on the chip) offer relatively low output currents (around 5 mA in the case of the monoDAC-01) and will, therefore, need external amplifiers in many situations.

We cited the RI-1080 and the monoDAC-01, together, as examples of "complete" monolithic DACs because these are the only DACs that have the resistor network and switches on the same silicon chip.

Many engineers and manufacturers define a "complete" DAC as one that includes both the switches and the resistor network. We tend to agree with Mr. Rudin, however, that the term "complete" should be reserved exclusively for those DACs that also include an output amplifier and a reference element (except in the case of multiplying DACs). In any event, the terminology has become somewhat blurred and perhaps it is safer to spell out exactly what one means when talking about DACs. We regret that we inadvertently implied that the Radiation unit includes the same circuit features as the Precision Monolithics unit.

Progress in Design and Research

Two "second-generation" analog-multiplier ICs

PROGRESS IN MICROELECTRONICS

TWO COMPANIES, Motorola and Analog Devices, have introduced improved "second - generation" analog-multiplier ICs that largely overcome the disadvantages of earlier, so-called, analog-multipier ICs such as Motorola's MC1595.

The new ICs challenge not only the older monolithic multipliers, but also hybrid and discrete-component multiplier modules. Packaged modules have, so far, tended to dominate the multiplier market because they have been able to offer lower cost, superior performance and simplified assembly and alignment in typical system applications. Now the new ICs promise many of the same advantages.

When Motorola originally introduced the MC1595 just under two years ago, the IC-multiplier concept aroused considerable interest among system designers because of the wide range of potential applications (see *EEE*, May 1969, pp. 60-67). However, critics of the MC1595 pointed out some serious weaknesses of the device.

Perhaps the biggest disadvantage of the old MC1595 is that it needs a large number of external components for satisfactory operation in dc applications. Usually, it will require an external differential-input op amp, about fifteen resistors, four pots, and closely spaced power-supply bypass capacitors. For this reason, critics point out it's not really a multiplier, but, rather, a multiplying "current-cell" that can be used as the basis for a multiplier. Among the other commonly cited weaknesses of the MC1595 are its relatively poor power-supply rejection, the awkward power-supply voltages needed, and its dc output level of 12.5 volts (instead of zero) that makes it prone to common-mode errors. For these reasons, even Motorola admits that second-generation multipliers will eventually replace the MC1595 in many applications — except for those requiring extremely low cost and those requiring just a simple ac-coupled circuit.

Motorola's new multiplier is called the MC1594. (By some quirk of the Motorola system, the new multiplier has a lower type number than its forerunner.) The new Analog Devices unit is called the AD530.

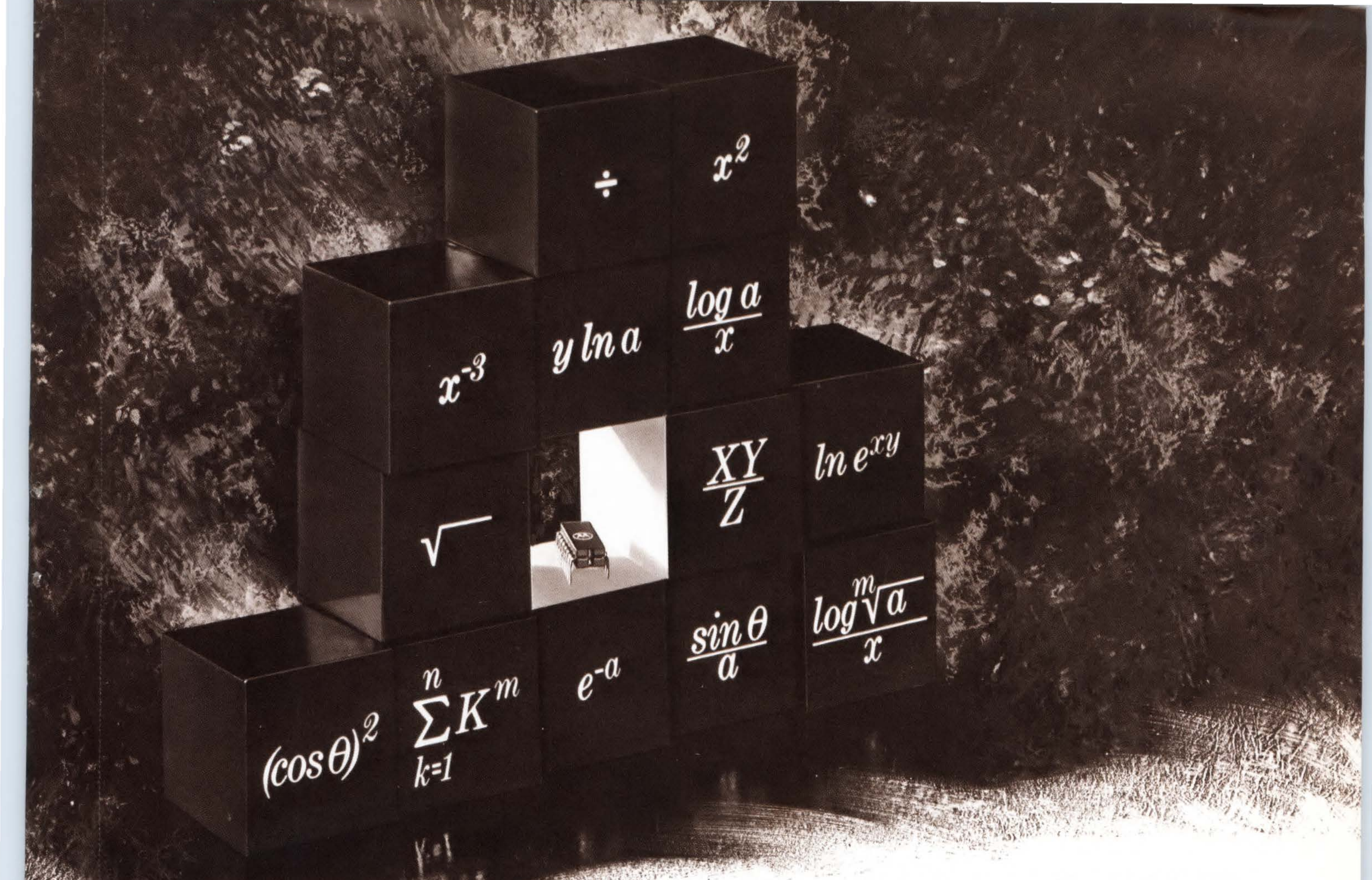
Both the MC1594 and the AD-530 operate from ±15-volt power supplies and do not require other voltages. Also, the two new multiplier ICs both have internal regulators and, therefore, do not require special, closely regulated, supplies. In fact, any system that uses op amps is likely to have suitable ±15-volt supply lines available. Another common feature of the two new multipliers is that they both have outputs that are balanced about ground (instead of 12.5 volts above ground as with the MC-1595). This minimizes common-mode errors and avoids the need for complicated level-shifting circuitry.

Different approaches

Motorola's MC1594 employs the same basic, variable transconductance, circuit that was used for earlier MC1595. But additional circuitry in the new multiplier provides current regulation to stabilize the operating conditions of the devices in multiplier. Also included on the MC1594 chip is a differential current converter to provide an output that's balanced about ground.

Like the MC1594, Analog's AD530 also has regulator cir-

(Continued on page 19)



Second generation IC "Multiplier Plus"

Plus What?... Plus built-in voltage regulator and current converter

Motorola's new MC1594/1494 introduces the second generation of monolithic IC four-quadrant multipliers based on the variable transconductance principle. The "multiplier plus" is easier to use than the familiar industry standard MC1595/1495, and it offers a new high level of performance.

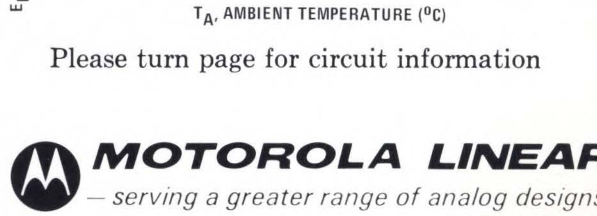
"Plus" features for cost reduction

The built-in current and voltage regulator eliminates the effects of power supply fluctuation and reduces the number of external components required. It regulates all current sources on the monolithic chip, effectively immunizing the multiplier to supply voltage fluctuations. It also provides two (+4.3 V) regulated voltages to bias the offset adjust potentiometers. Interaction among the pots during adjustment is eliminated. Changes in offset voltage caused by supply irregularities are eliminated. Four external resistors are eliminated.

At the other end of the multiplier the differential current converter provides a single-ended output current referenced to ground.

"Plus" features for Improved Performance

Linearity of 0.5% max (X or Y) for the MC1594 sets a new standard of excellence, and the MC1494 offers a fine 1.0% max error (X or Y). The "multiplier plus" is easier for the designer to use because it handles input and output voltages of ±10 V with ±15 V supplies. And power supply sensitivity is also significantly improved.

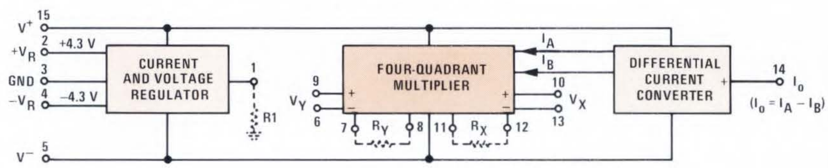


Please turn page for circuit information

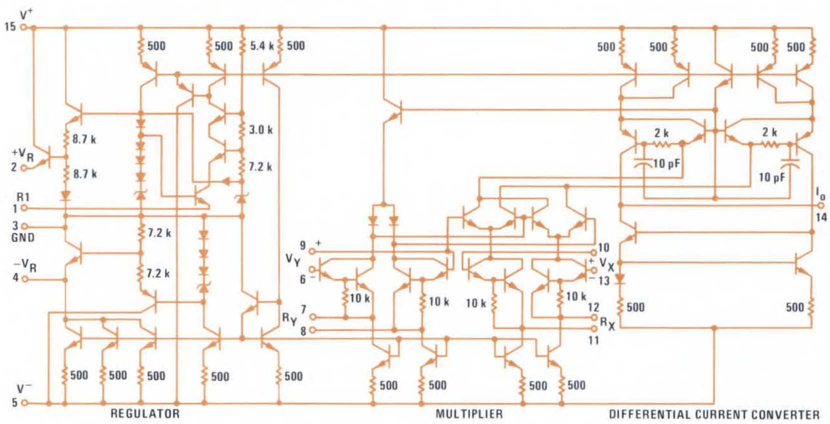
MOTOROLA LINEAR
— serving a greater range of analog designs!

Here Is The Second Generation Monolithic IC Multiplier Motorola's MC1594/1494 "Multiplier Plus"

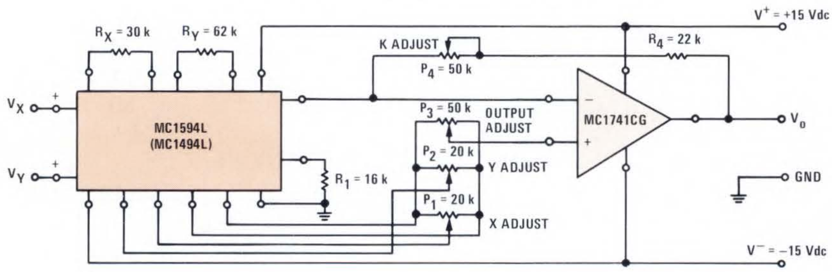
BLOCK DIAGRAM



COMPLETE CIRCUIT SCHEMATIC



TYPICAL MULTIPLIER CONNECTION



Check these performance features

- Excellent linearity
  0.5% max (X or Y) — MC1594L
  1.0% max (X or Y) — MC1494L
- Wide input voltage range — ± 10 V
- ± 15 V supply operation
- Single ended output referenced to ground
- Improved offset adjust circuitry
- Adjustable scale factor
- Power supply sensitivity — 30 mV/V (typ)

Learn all about the "Multiplier Plus" right away

The MC1594L and MC1494L are available now from your nearest Motorola distributor at 100-up prices of $12.00 - MC1594 and $8.00 - MC-1494. Both devices are in the 16-pin ceramic dual in-line package. For a 14-page applications-specifications data sheet, circle the reader service number or write Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

Circle No. 100

The circuitry shown external to Motorola products is for illustrative purposes only, and Motorola does not assume any responsibility for its use or warrant its performance or that it is free from patent infringement.

"Multiplier Plus"

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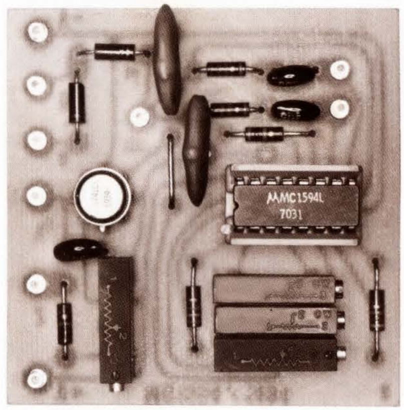

Complete MC1594 or MC1494 Evaluation and Experiment Kit DC and AC applications — All you need to build it for Multiply • Square • Divide • Square Root • Balanced Modulator • Amplitude Modulator • Phase Detector • Frequency Doubler.

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MCK1494 Kit . . . A $32.45 value at only $19.50 (substitute MC1494L multiplier)

Parts list MCK1594 and MCK1494

Quantity	Part Description
1	MC1594L or MC1494L
1	MC1741CG op amp
2	1N5241B Zener Diodes
2	510 ohm, ¼ W, 20% carbon resistors
1	16K, ¼ W, 5% film resistor
1	22K, ¼ W, 5% film resistor
1	30K, ¼ W, 5% film resistor
1	62K, ¼ W, 5% film resistor
2	20K, 15 turn cermet potentiometers
2	50K, 15 turn cermet potentiometers
2	0.1μF ceramic disc capacitors
3	10pF ceramic disc capacitors
1	16-pin dual in-line socket
1	PC board
10	terminals

Also contains complete "How To Do It" construction note and data sheet with applications information.

Specify by MCK1594 or MCK1494 — state quantity — enclose check (P.O. is OK for order over $20.00) — offer expires May 20, 1971 — limit, 5 (five) kits. Send order to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036.

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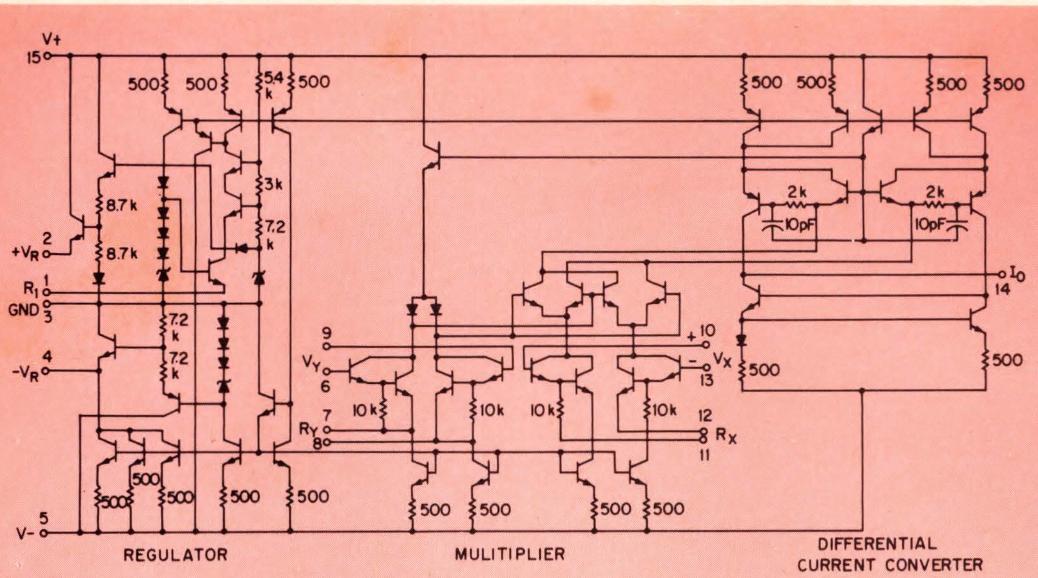

Motorola's new MC1594 analog-multiplier IC has basically the same multiplying circuit as the older MC1595 multiplier, but it also includes a regulator and a differential current converter. The added circuitry minimizes the number of external components needed for dc operation. The regulator circuit stabilizes internal operating conditions and provides regulated voltages for external offset trimming pots.

cuitry on the chip to stabilize device operating conditions. Unlike the MC1594, however, the AD530 includes an output amplifier on the chip.

The AD530's output amplifier has an output capability of ±10 volts at 5 milliamps. Thus, in most applications, the AD530 will not need an external amplifier. The MC1594, by contrast, does need an external amplifier in many applications because, while the current-summing amplifier provides the correct output voltage of ±10 volts balanced about ground, the circuit has a high output impedance of around 850 kilohms.

One useful feature of the MC-1594 is a voltage regulator circuit, included on the chip, which provides external regulated voltages for the offset adjustment pots. The AD530 does not have this feature and, therefore, the offset adjustment pots for Analog's unit must be connected to external regulated supplies for stable operation.

Another important difference between the two new multipliers is that the AD530 can be operated as a divider merely by strapping a pair of terminals. The MC1594 needs an external amplifier for operation in the divider mode.

The two companies have used different fabrication techniques for their new monolithic multipliers. Analog Devices uses thin-film resistors extensively throughout the AD530, whereas Motorola has designed the MC-1594 to use conventional diffused resistors. Analog claims that its use of thin-film resistors ensures long-term stability. However the Motorola design is probably less expensive to manufacture.

Of course, the two companies have different backgrounds in multiplier design — Motorola was the first company to introduce a commercial monolithic multiplier, while Analog Devices was a pioneer in the design of widespread discrete-component multiplier modules. Now Motorola has improved its original multiplier design, while Analog has adapted one of its discrete-component circuits for fabrication as an IC. The different experiences of the two companies largely explain the differences in their concepts of what should be included in an IC multiplier.

Looking at the specs

Both the Motorola and Analog units have absolute accuracies of 1 percent. In both cases, the accuracy spec is contingent on suitable adjustment of external trimming pots to determine scale factor and minimize offsets. Both units have 3-dB bandwidths of 1 MHz; though, for the Motorola unit, only the "Y' input offers this bandwidth. The MC1594's bandwidth at the "X" input drops to 800 kHz.

Though the new multipliers both include current-regulating circuits, their power-supply rejection still leaves something to be desired. Neither company has managed to get the power-supply susceptibility down to the levels offered by other linear ICs such as op amps. The MC1594 has a typical supply interaction of 13 mV/V for the positive supply line and 30 mV/V for the negative line. The AD530 has a typical supply interaction of 0.3 percent per percent (with ±15-volt supplies and 10-volt output, this works out to a higher number than for the Motorola unit). Of course, the figure for the AD530 includes the susceptibility of the built-in output amplifier but it does not include the effect of variations in the external offset-adjustment voltages.

The improvement in power-

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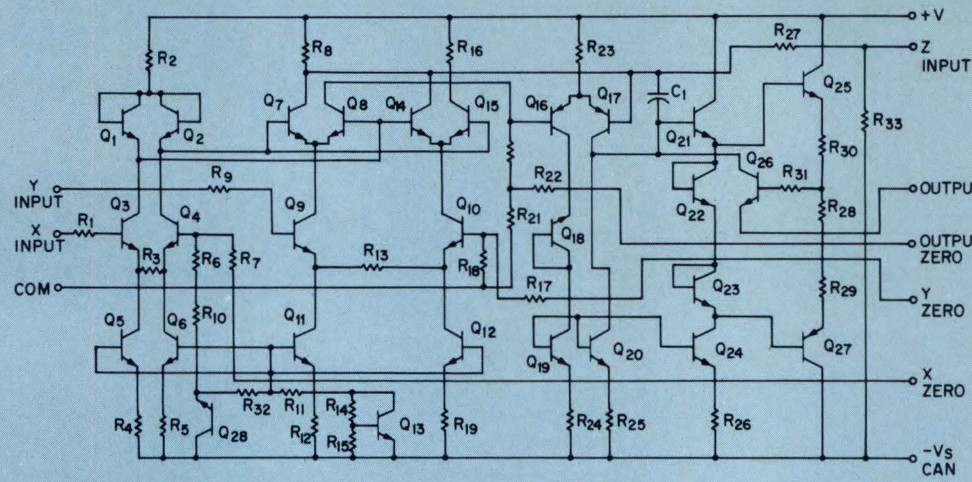

Analog Devices' type AD530 is an IC version of one of the company's earlier discrete-component multipliers. The circuit includes an output amplifier that can deliver ±10 volts at 5 milliamps. Device Q_{28} is a zener regulator that stabilizes the operating currents for the multiplier circuit. Unlike the Motorola circuit, the AD530 has a "Z" input allowing use as a divider without external circuitry.

supply rejection for the MC1594 versus the older MC1595 is not readily apparent from a comparison of the data sheets for the two devices. According to its data sheet, the MC1595 has typical power-supply susceptibility of 5 mV/V for the positive line and 10 mV/V for the negative line — lower numbers than for the new IC. But the older device's susceptibility was specified for a constant-current input to pin 3, whereas an external constant-current source is not required with the new multiplier.

Both units have surprisingly high input impedances. The MC-1594 has a typical input resistance of 300 MΩ at either input, while the AD530 has typical input resistances of 10 MΩ ("X" input) and 6 MΩ ("Y" input). Typical input bias current is 2 μA for the AD530 and 0.5 μA for the MC1594.

Possibly due to its thin-film resistors, Analog's multiplier has lower temperature drift than the Motorola unit. Multiplying-accuracy drift (dc) is 0.04%/°C for the AD530 versus 0.09%/°C for the MC1594. Similarly, the typical scale-factor tempco is 0.03%/°C for the AD530 and 0.07%/°C for the MC1594.

When comparing specs for the Motorola and Analog Devices multipliers, it should be remembered that the external amplifier may contribute to the overall errors for a complete multiplier using the MC1594. Another factor that complicates the comparison is that the two units have different operating-temperature ranges. So far, the AD530 is available only for the industrial temperature range of 0 to +70°C, though a military-temperature-range version will be available later. The MC1594 operates over the full military temperature range of −55 to +125°C. A lower cost version, MC1494, has an operating temperature range of 0 to +75°C.

The MC1594L is packaged in a 14-pin ceramic DIP (TO-116) and the AD530 comes in a 10-lead metal can (TO-100). A DIP version of the AD530 will be available later.

In quantities of 100 up, the MC1594L costs $12 and the MC-1494L costs $8. At the same quantity level, the AD530K costs $30 while a lower accuracy (2-percent) version, the AD530J, costs $20.

In addition to the two companies discussed here, it is rumored that other companies are about to introduce second-generation analog-multiplier ICs. For example, at a recent press briefing, Harris Semiconductor (formerly Radiation Inc) announced that it would introduce an analog multiplier early in 1971. ■

For more information on analog-multiplier ICs, circle inquiry numbers as follows: Motorola 424, Analog Devices 425.

First, low-cost autoranging DMM

PROGRESS IN INSTRUMENTATION

NON-LINEAR SYSTEMS, the company that gave the world its first commercial voltmeter (in 1953), a 5-digit, $4000 instrument, now has the first low-cost digital multimeter with autoranging. This is the feature that's been most notably absent from all low-

(Continued on page 22)

NEW

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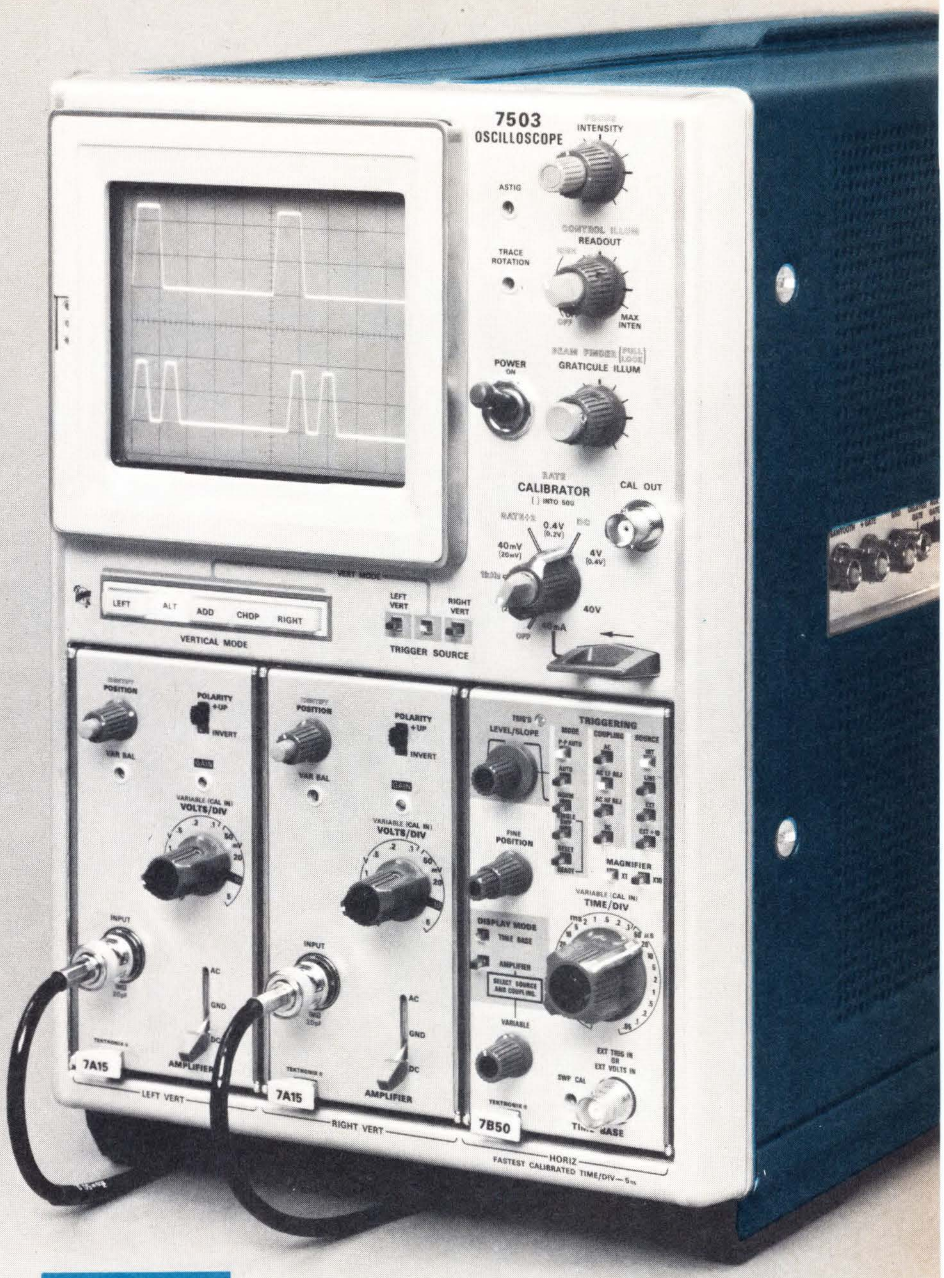

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Circle 111 on Reader Service Card

cost DMMs that have hit the marketplace in the past two years.

The instrument, which NLS calls the DART III (for Digital Auto-Ranging Tester) or, for those who don't like acronyms and Roman numerals, the LX-3, includes the resistance and voltage ranges that are common in other low-cost DMMs. But a set of five dc-current shunts (for ranges from 0.1 to 1000 mA) costs an extra $125.

Except for a manually selected 10-megohm range, this low-cost meter offers automatic ranging to the range offering best accuracy.

Like most 3-digit machines, the LX-3 has an additional "1" to allow overrange on all ranges but the top (1000V) voltage range. However, unlike almost other DMMs, including high-priced instruments, this one offers a full 100% overrange, compared with the typical 40%.

There are four basic resistance ranges (from 1 kΩ to 1000 kΩ) plus a manually selected 10-MΩ range, and four basic ac- and dc-voltage ranges (from 1 to 1000 V). An optional $75 probe permits measurement to 30.0 kVdc with 3-digit resolution or 19.99 kVdc with 4-digit resolution.

The instrument has a modest two readings per second for all functions. This rate is cut in half when one switches in a filter to provide 40 dB of normal-mode rejection at 60 Hz.

With options, the $495 machine can do almost anything one might expect of a more costly DMM though, of course, the price goes up. It's possible to have remote programming of filter and functions. It's possible, too, to print out readings (a $100 option).

A battery option (for $150) allows eight hours of continuous operation from self-contained, rechargeable nickel cads. And it's not necessary for a user to remember to flick a switch. The unit automatically switches to line operation and a battery-charge mode whenever it's plugged into the line. ■

For more information, circle 357.

Functions by the module

PROGRESS IN PACKAGED CIRCUITS

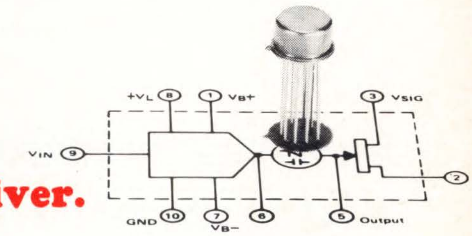
A LEADER IN the lab function-generator field is introducing modules that allow a user to put together just those functions he needs. Wavetek supplies the 120-021 generator module, the 120-022 sine-converter module, the 120-023 trigger module and the 120-024 regulator module. These units produce lab-quality sine waves, square waves, pulses, triangular waves and ramps. Frequency range is from dc to 100 kHz and waveshape symmetry is variable. The functions can be swept in frequency, frequency modulated and gated on and off.

The key module is the generator since all other modules are simply attachments to its inputs and outputs. The generator is basically a voltage-controlled oscillator capable of simultaneous square and triangular wave outputs. Frequency is determined by an external capacitor and a control voltage which ranges from 10 mV to 10 V. Wavetek furnishes this information in graphical form for the user. By varying the values of an external 4-resistor network, one can obtain output-waveform symmetries from 1:100 to 100:1.

The generator has a 10-minute frequency stability of ±0.01% + 10 mV and a 24-hr stability of ±0.25% + 10 mV, where the 10 mV is referred back to the control voltage. Thus this error could be severe at low control voltages. Temperature changes the frequency less than 0.05%/°C. But, of course, we must add the error contributed by our exter-

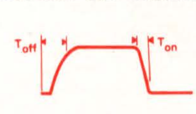
(Continued on page 24)

Our competitors may be upset, but customers are wild about our new $6* FET Analog Gate with Monolithic Driver.



The high cost of analog switching has just taken a nose dive. Our CAG30 low cost general purpose FET Analog Gate switches up to ±10 volt signals directly from DTL or TTL, and provides high logic noise immunity {typically 1.0V}.

The CAG30 turns off faster than it turns on, allowing multiplexing without crosstalk. The



CAG30 is a break-before-make switch with 60 ohms maximum on-resistance and full military temperature range. The built-in CDR5 monolithic driver is also available separately in an 8-lead low profile TO-5 package for $4.90* For your best buys in digital interface microcircuits, check Crystalonics. 38 stock types available.

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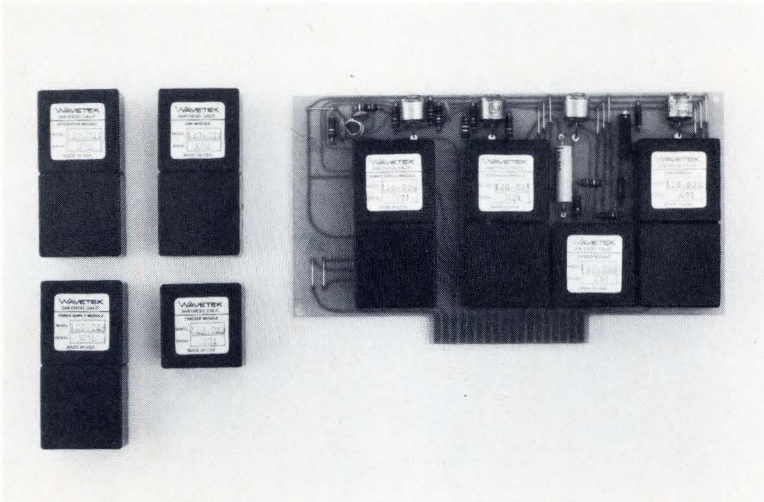
nal capacitor. 10-minute amplitude stability is ±0.05% and 24-hr amplitude stability is ±0.25%.

The trigger module is used with the generator to start and stop the signal with an external command. The trigger module actually controls the oscillation of the generator rather than merely gating the output. The sine converter shapes a symmetrical triangle into a sine wave with less than 0.5% distortion. The regulator module is a source of ±15 V for the other units.



Wavetek supplies the innards of a function generator either separately or on a PC card. The larger modules are 3 × 1.5 × 0.812 in. The smallest module is 1.51 × 1.5 × 0.812 in.

Using these new modules, the engineer can quickly instrument circuitry that ordinarily takes weeks of design, breadboarding and debugging. Two typical applications are a voltage-to-frequency converter and a tone-burst generator. The voltage-to-frequency converter simply requires a generator module while the tone-burst generator needs both a generator and trigger module. If the modules were on hand, both circuits could be knocked off in about a day.

The modules are supplied separately or mounted on a 4-1/2 × 8 in. PC card. Pricing is as follows: generator $98 (1-9), sine converter $87 (1-9), trigger $54 (1-9), regulator $78 (1-9), generator plus power supply on a PC card $324 (1-9), generator, sine converter and power supply on a PC card $411 (1-9) and all modules on a PC card $465 (1-9). ■

For more information, circle 414.

Low-cost semiconductor RAM boosts speed in new minicomputer

PROGRESS IN DATA HANDLING

A NEW 1024-BIT MONOLITHIC random-access memory, the Intel 1103, is the first commercially available IC RAM to be priced below the cost of core memories for storage capacities above around 10,000 bits. In quantities of 100-999 the 1103 has a unit cost of $38.40. In quantities of 100,000 or more the price is less than a penny a bit.

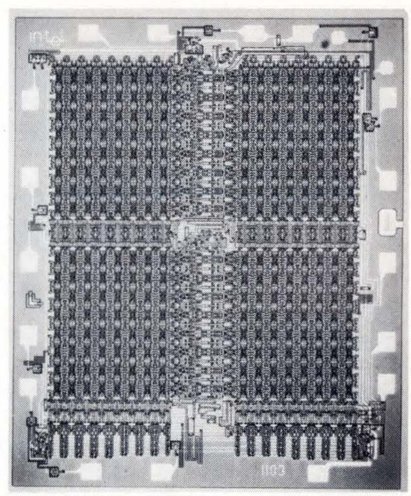
In addition to its competitive cost, the 1103 has a speed advantage versus cores. The dynamic MOS circuit boasts a respectable maximum access time of 390 ns and a read-modify-write cycle time of 600 ns. The relatively high speed, high circuit density and low cost largely result from the use of silicon-gate technology. Each 1103 chip is organized as 1024 × 1 bit and is fully decoded.

Another advantage of the 1103 is its low power dissipation — only 100 microwatts per bit in memories of 50 kilobits or more. This permits dense packaging and should give the 1103 an edge over bipolar circuits for all except the very fastest applications. Packaged in a plastic 18-lead DIP, the 1103 has an operating temperature range of 0 to +70°C.

New minicomputer

The cost and performance advantages of the 1103 make it an attractive replacement for core memories in computers and computer terminals — especially in situations that require slightly higher speeds than can be provided by cores.

Already, one minicomputer manufacturer has used the Intel memory to replace cores. Data General's new Supernova SC minicomputer uses the 1103-1 (a slightly faster and more expensive version of the basic 1103) for its main memory, to provide a read cycle time of 300 ns. The memory of the Supernova SC consists of 64 of the 1024-bit chips, providing a total storage capacity of 4096 words of 16 bits. The 64 memory IC packages occupy roughly the same amount of PC-board space that would be occupied by a core mat of the same capacity.



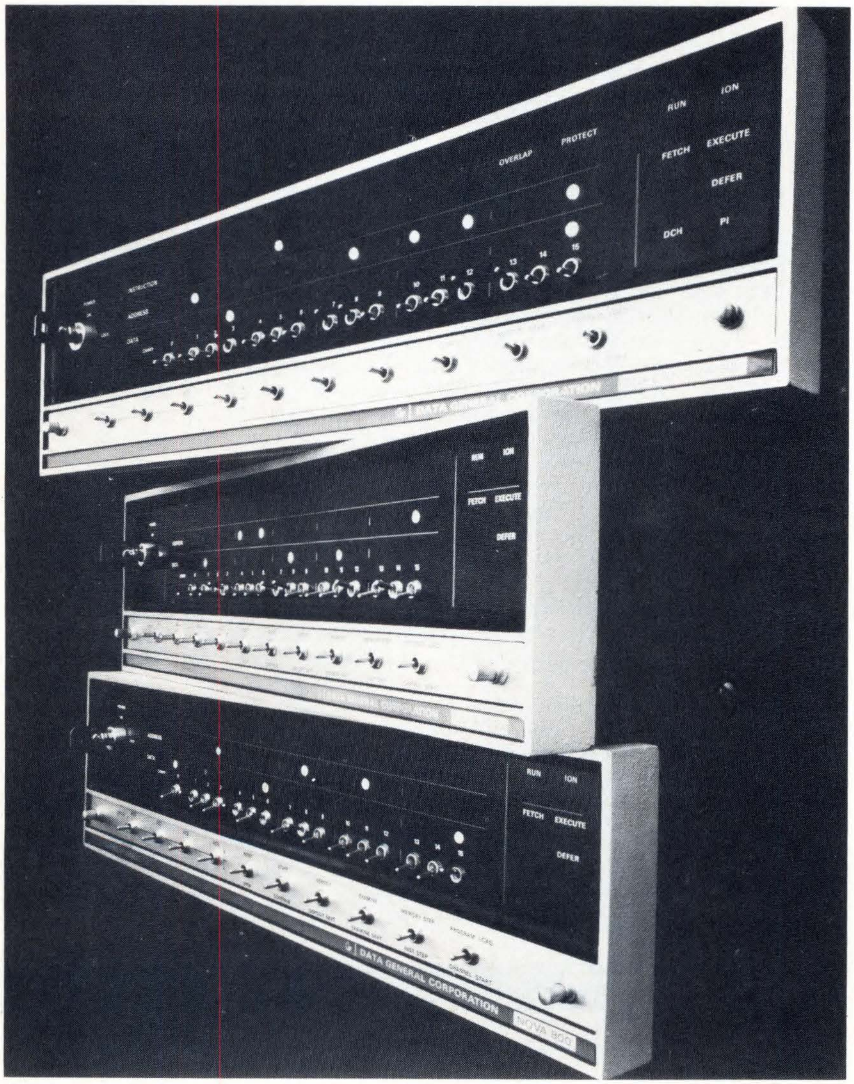
Intel's type 1103 dynamic MOS memory has a storage capacity of 1024 bits (plus decoding) on a single chip. In large quantities, the cost is less than a penny a bit.

According to Data General, the SC is the fastest minicomputer available. It is expected to find

(Continued on page 26)

its chief market in applications (such as some types of scientific research) that need speeds previously unavailable in small-scale computers. Because the SC uses basically the same processor as the earlier Supernova, it is possible for existing Supernova users to modify their units to upgrade performance. Software for the Supernova SC is compatible with that for older Data General machines.

One possible disadvantage of the dynamic MOS memory is that it's volatile and, therefore, important data could be lost in the event of a power failure. Dick Sogge, Data General's VP of Engineering, points out, however, that spare PC-board sockets are included in the Supernova SC so that some core memory can be added alongside the semiconductor memory. Important data could then be transferred from semiconductor memory to the core memory for more permanent storage. Both versions of the Supernova feature direct memory access (DMA).



Three new minicomputers from Data General. The one on top is the Supernova SC which features semiconductor main memory with a cycle time of 300 ns. The others are the Nova 1200 and the Nova 800.

The design of the Supernova SC takes full advantage of the speed and nondestructive-readout capability of the dynamic MOS memory. Unlike a core memory, the semiconductor memory needs no rewrite cycle. So designers of the SC were able to overlap an instruction execution cycle with the read cycle of the next instruction. As a result, the machine can execute arithmetic and logic operations in a single memory cycle (300 ns).

Continuing the trend

Following hard on the heels of IBM's 360/145 (with bipolar semiconductor mainframe memory) and Four Phase Systems IV/70 (a desktop computer with MOS memory and logic), Data General's Supernova SC is the latest indication of the accelerating trend away from cores and towards semiconductor memories for computer mainframe applications.

In its basic configuration with 4-k $\times$ 16-bit semiconductor memory, DMA channel and Teletype interface, the Supernova SC costs $11,900 in unit quantity. Generous quantity discounts are available. Data General has also introduced two smaller minicomputers with core memories. These are the Nova 1200 (1.2-μs cycle time) at $5450 and the Nova 800 (800-ns cycle time) at $6950.

First deliveries of the Supernova SC are scheduled for June 1971. The smaller computers will be available earlier. Intel's type 1103 memory ICs are available from stock. ■

For more information on Intel's semiconductor RAMs, circle 409.

For more information on Data General's new minicomputer, circle 410.

Circuit in a pot

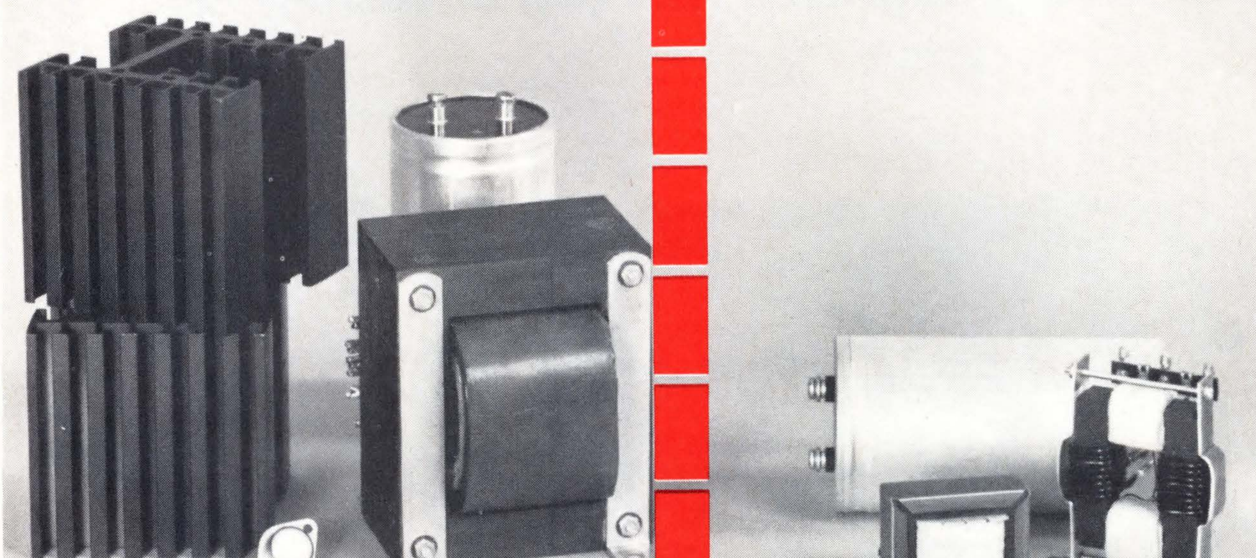
PROGRESS IN RESISTORS

IN A FINE example of standing on other people's shoulders, Amphenol Controls has developed a dual-inline package containing up to five fixed resistors and one trimming potentiometer, screened and fired together of the same cermet paste, with separate terminals for each resistor allowing a user to tie the components together any way he likes.

This development can be viewed as an extension of developments by Beckman (see "Circuit in a switch," *EEE,* Jan. 1968, pp 32-44), then Oak (see "Circuit in a switch: A second approach," *EEE,* Aug. 1969, pp 28-30), in which

(Continued on page 28)

Cut the Size of Your Power Supply in Half with Fast, High-Voltage Transistors from RCA.



Conventional 5 V, 25 A Supply

New 5 V, 50 A Supply

RCA

For details and application note, write: RCA, Commercial Engineering, Section 51L /UT14, Harrison, N.J. 07029 cermet resistors were screened and fired on the wafers of rotary switches. It can be seen, too, as an extension of the Bourns Trimpot in a dual-inline package (see "First cermet DIP pot," *EEE*, May 1969, p 28).

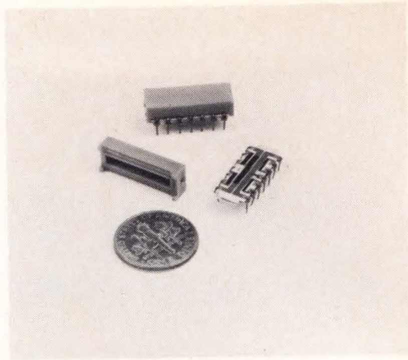
The Amphenol TRN3765 (for Trimmer/Resistor Network) offers some obvious advantages. First, it saves PC-board real estate, since six components can be mounted in the space that might be assigned to the trimmer alone. Second, it saves the time and cost of component preparation (like lead bending) and mounting and it cuts inspection and inventory costs as well as procurement paperwork. Third, it lends itself to automatic insertion.

Perhaps most important, since all components are in the same thermal environment and are made of the same cermet paste and fired together, they drift together and rather predictably with temperature. This is particularly useful except in applications where opposing (and canceling) temperature coefficients are desirable.

The temperature coefficient is quite impressive, even in standard units which offer 100 ppm/°C max. Specially selected units offer TCs of 50 ppm/°C (which is the best we've seen for cermets).

Fixed or trimmer resistances are available over the range of 10Ω to 1 MΩ, but it may be difficult to screen and fire five fixed resistors in one pass if somebody needs units at both ends of the resistance range.

Absolute resistor tolerance (and ratio accuracy with respect to the trimmer) is available to 10 percent standard, or 1 percent to special order. Power dissipation for the entire package is 3/4 W at 40°C, derated linearity to 0 W at 125°C. The unit, in a nylon package, has its TC specified over



Amphenol's DIP network has up to five cermet fixed resistors and a trimmer to cut installed network cost and improve overall TC. (Dime shows size, not price.)

the −25 to +85°C range, but Amphenol can spec the TC over the mil range of −55 to +125°C.

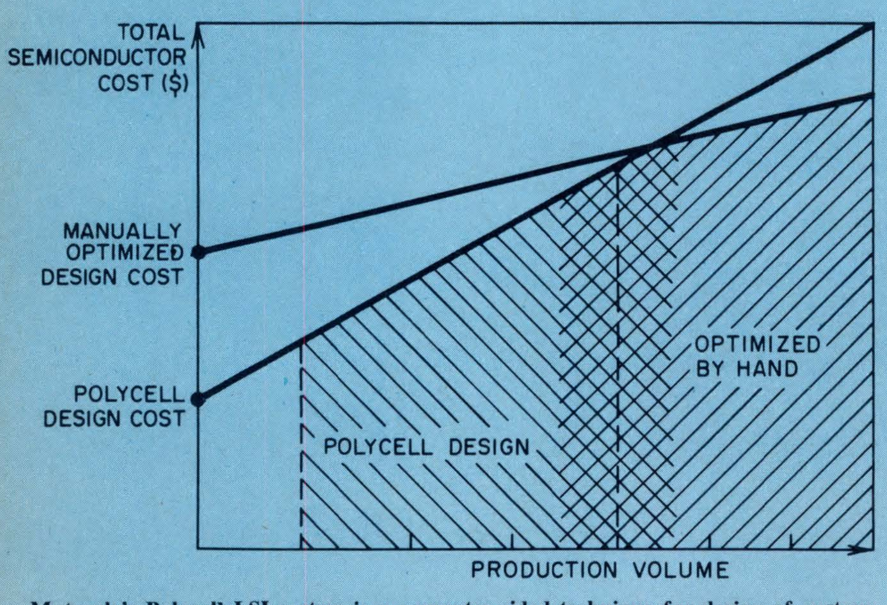
The unit in a standard DIP with "reasonable" resistance ratios costs about $3 in 5000-up, $2 in 25,000-up. ■

For more information, circle 408.

Cell-library approach cuts cost of custom LSI

PROGRESS IN MICROELECTRONICS

UNTIL RECENTLY, most system designers have tended to avoid using custom LSI circuits. The obstacles to wider use of conventional custom LSI arrays have been their high initial cost and their slow design and fabrication cycle. Only in relatively rare cases (notably for portable electronic calculators) has the potential market for the finished equipment been large enough to justify the high fixed cost of incorporating custom arrays.



Motorola's Polycell LSI system is a computer-aided technique for design of custom arrays using predesigned library cells as basic building blocks. The new approach cuts nonrecurring design costs by approximately 50 percent. For extremely high production volumes, however, conventional custom arrays tend to have a lower total cost because manually optimized designs result in increased yield and lower unit production costs.

Now, however, some of the larger IC houses are offering an alternative approach to custom design of MOS arrays. The new approach largely overcomes the disadvantages of conventional custom designs. Companies like Texas Instruments, Fairchild and, more recently, Motorola now offer custom LSI arrays that are rapidly designed from a "library" of standard cells. Individual predesigned cells are selected and arranged to form a suitable mask pattern for subsequent fabrication of the custom IC. Of course, the geometry and performance parameters can be stored on computer tapes to allow extensive automation of the design and test routines for a wide range of custom circuits.

The cost picture

The big advantage of a cell-library design approach is that it's cheaper and faster than the conventional "design-from scratch" approach. This is because much of the detailed design work is eliminated by the use of standard "building blocks" and because much of the routine work can be performed automatically. Motorola engineers estimate that their new Polycell LSI system can cut non-recurring costs by 50 percent or more when compared with manual optimization. While exact price and delivery depend, of course, on the specific circuit and on how much of the design work is done by the customer himself, Motorola spokesmen say that a typical Polycell design will cost from $5000 to $20,000 and prototype parts will be available in 10 to 14 weeks.

One minor disadvantage of cell-library based designs is that they are restricted by the repertoire of available library cells. Thus some custom circuits may prove difficult to implement efficiently and the resulting chip layout may be less compact than if the equivalent circuit had been manually optimized by a skilled designer starting from scratch. For this reason, it appears that for extremely large production volumes a completely custom design will result in lower unit cost.

As IC manufacturers expand their cell libraries and exploit new process technologies, however, it is likely that the production-cost gap will narrow, making the cell-library approach attractive for a still wider range of applications.

Currently Motorola has a Polycell library of 30 different cells ranging from inverters, buffers and expanders through multi-input NOR and NAND gates, exclusive ORs, latches and a range of flip-flops. All the existing cells are high-threshold p-channel MOS, though other types will be added later.

Prototype units designed by Motorola's Custom LSI Design Group are fabricated on the same production line that will later produce the units in volume. This ensures that prototypes will be truly representative of what can be expected from production units. All designs are verified by a logic-simulation computer program before mask fabrication. This same simulation program can also be used to check test sequences specified by the customer or developed by Motorola.

Share the work

Normally in designing a Polycell array, Motorola starts with a customer's logic diagram. But if a system designer wishes to cut costs or retain closer control over the finished product, he can interface with Motorola at other points in the sequence of steps between preparation of a logic diagram and testing of the finished product. For example, he may wish to specify his own library cells or prepare his own testing programs.

In any event, Motorola prefers that potential customers initially contact a Motorola field salesman so that they can familiarize themselves with the procedures and capabilities of the Polycell system before submitting documentation and requesting cost estimates. Preliminary design evaluations and cost estimates can normally be completed within 24 hours.

For more information on Motorola's Polycell LSI system, circle 411.

Better thumbwheel shoots down EEE criticisms

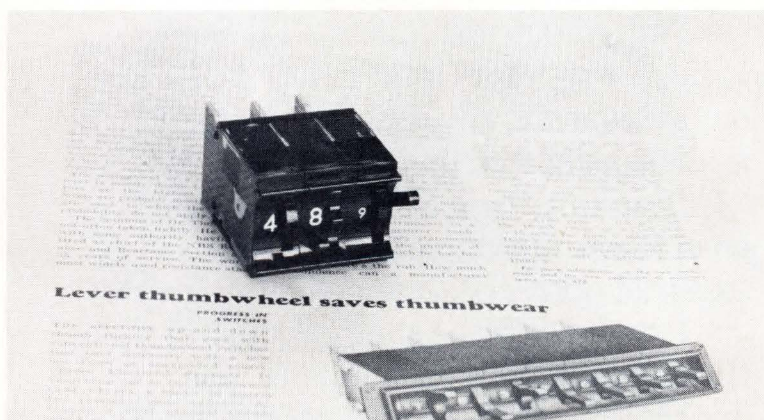
PROGRESS IN SWITCHES

WHEN CHERRY ELECTRICAL Products introduced the first lever-actuated thumbwheel switch (beating Digitran by a few months), *EEE* liked it — with reservations (see 'Lever thumbwheel saves thumbwear," *EEE*, May 1969, pp 22-16).

EEE hailed the convenience of Cherry's Leverwheel and the speed of setting and resetting. But it found faults.

First, the displayed numerals were too small, with a height of 0.11 in. Second, the detent action left something to be desired. The detent was so stiff that a man was too likely to overshoot or undershoot a desired digit.

Both problems have been licked in the newest version of Cherry's Leverwheel. The numerals are now 0.2-inch high, making for fine legibility. And the detent has been improved so there's no overshoot. ■



New thumbwheels from Cherry (left two digits) have numerals 0.2 in. high, offering much better legibility than company's original thumbwheel (right digit) with 0.11-in. numerals. Detent action of new lever-action thumbwheel (left) is much improved, too.

Interested now? Circle 406.

National TTL/MSI tha

Delivery isn' the only rea

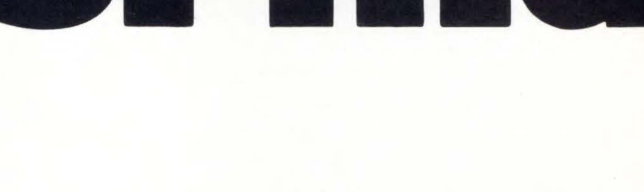
Say good-bye to slow bus systems.

National is introducing Tri-State logic. A first-of-its kind family of TTL devices specifically designed to speed up bus-organized digital systems.

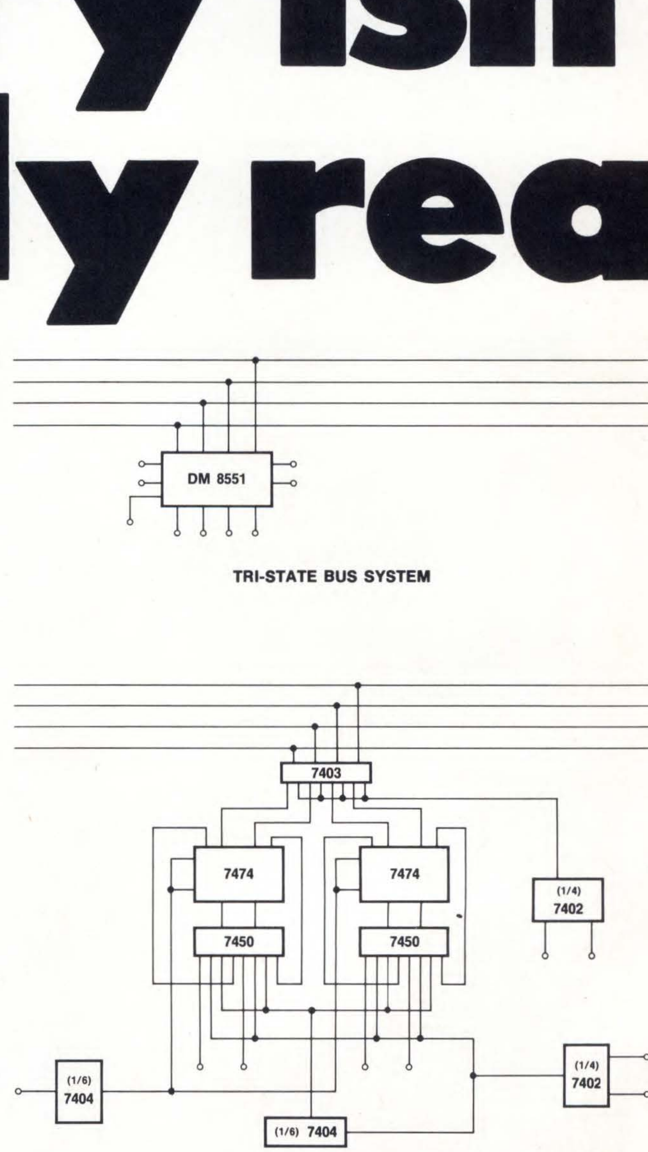
Tri-State logic allows you to work with fewer packages and without external open collector gates.

Our first off-the-shelf product in this new family is the DM8551 bus or-able quad D flip-flop. A unique device that lets you connect outputs of many circuits to a common bus line.

The DM8551 is organized as four D-type flip-flops operating from a common clock. The outputs are normal low-impedance, high-drive TTL types. Up to 128 can be tied together because, unlike other TTLs, the DM8551 can be gated into a state where both the



TRI-STATE BUS SYSTEM



STANDARD BUS SYSTEM

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upper and lower output transistors are OFF. The output, therefore, appears as a high impedance. It neither delivers current nor demands significant current from the outputs to which it is connected. You get the economy of bus connection without losing output waveform integrity.

The DM8551 design eliminates the false clock-signal problem usually associated with D-type flip-flops. Internal data input disable lines feed the Q output back into the D input so there's no change of state during clocking.

Output disable lines are used for gating into the OFF state. NOR gate logic was chosen for this function since it is possible to select up to 128 DM8551s with only two BCD-to-Decimal decoders (DM8842s). You get maximum decoding capability at minimum cost.

In addition to the DM8551, we're also introducing the DM8230 Tri-State Data Flow Gate for signal routing and the DM8831 Tri-State Party Line Driver for multiple signal driving. (They're also available off-the-shelf.)

Of course, Tri-State logic is only one reason National sells so many TTL/MSI circuits. Call any National distributor for prices and specs on twenty-seven other reasons.

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National

Benjamin Fox of Elco Speaks Out On The Demise of Discrete PC Connectors

The conventional PC edge connector is dying. That shouldn't come as a surprise, but it does. We focus so much on the revolution in the components we mount on PC boards that we tend to overlook the changes they effect in the way we hook our boards together.

As a result, our interconnection changes come more slowly. But they come, nevertheless, inevitably. Look at a five-year-old circuit board, then look at a new one. The change is dramatic. But the connector is the same. We're pushing it to the limits of its capabilities. And that can't go on.

If we expect to grow, or even survive, we'll have to replace our old connection methods with new ones. The conventional edge connector is the current victim of our changing needs, but it's merely one. Others will follow.

The edge connector is yielding to techniques that are more compatible with automatic production and high-density packaging of increasingly complex electronic systems. At first, we're seeing a change in contact density — even on edge connectors.

Contact spacings of 200 mils and 156 mils are becoming a thing of the past. More and more we're seeing contacts on 100-mil centers and even 50-mil centers. That's a beginning, but we can't go much further in that direction.

So we find two-piece plug-and-receptacle connectors replacing edge connectors. Now the number of contacts isn't limited by practical density of card-edge contact pads. We can have several rows of contacts instead of one or two. (Already, the military prefers two-piece connectors for reliability reasons.)

But even that transition is just a start. We're moving more and more to two-piece connectors with built-in receptacles in metal plates and PC mother boards. These changes we're already seen. In some segments of the electronics industry, they're widespread. They'll become common throughout our industry and other changes will join them. Why? The major challenge that's forcing us to change is cost competition.

The breath-taking rate of semiconductor developments in the past decade slashed the cost of circuit functions. Our interconnections didn't keep pace. Five years ago we could look at the electronic components on our PC boards — transistors and ICs — and find them so expensive that the cost of connectors didn't matter.

Now that we can buy IC gates for a quarter, the connectors look expensive. So we had better find better ways. This doesn't mean we need cheaper connectors but, rather, less costly interconnection techniques for a complete system.

We're subjected to technological pressures, too. As we develop faster and faster active components, we need packaging components and techniques that minimize interconnection lengths to keep time delays down.

At higher frequencies, the effects of electromagnetic fields become significant. Crosstalk

between unshielded connections and electromagnetic interference from external sources become problems. And reflections due to impedance mismatches can ruin circuit performance.

So we're forced to pay much greater attention to transmission-line problems of our connectors. At a minimum, we must avoid long, exposed single conductors. In some applications, we may be forced to use coax cabling.

But coaxial connections post difficulties for automatic production and assembly — even with large cables with diameters of half inch or more. The problems become staggering as we face requirements for cables with outer diameters of 30 mils and less.

Sure, there have been some approaches to the problem. There are techniques for wire-wrapping coax terminations and we can use some strip-line techniques in PC boards. But we still don't have a widely accepted, simple solution. One thing seems certain: today's discrete PC connectors don't lend themselves well to the short-pulse, high-frequency techniques we'll need.

How can we meet these two challenges? How do we tackle the problems of economy and circuit performance?

First, we'll see the gradual disappearance of the female discrete PC connector. We'll find greater flexibility and economy as we move toward non-discrete receptacles built into metal plates and mother boards.

The major attraction of metal-plate connectors is their adaptability to automatic assembly and interconnection. Machine insertion of contact-filled insulators into holes in the plates provides inexpensive receptacles with precisely positioned termination points. Further, we can easily establish multiple contacts to common volage points and ground.

It's easy to mechanize interconnections with automatic or semi-automatic wire wrapping. Or we can even use manual wire-wrapping techniques. The key to successful automatic wire wrapping is in accurate positioning of receptacle termination tails. Of course, it's possible to mount discrete PC connectors on metal plates or racks, but it's difficult. The process is not as amenable to mechanization as is the use of near-integral built-in receptacles in the plate. It's much tougher to maintain uniform contact spacing with several discrete connectors than it is to locate contact holes precisely in a plate.

We all know the advantages of wire wrapping. It can be used with a small number of contact tails or a huge number. It eliminates the need for skilled soldering personnel and it gets rid of problems of cold-solder joints. Even more important, we can accommodate wiring changes quickly and easily by changing machine programs, even with highly automated equipment. We can even handle minor changes in layout and number of terminations easily. It's typically cheaper to implement the entire process of assembly and interconnection with metal-plate connectors than with an array of discrete connectors.

For many high-volume PC-connection problems, the mother-board approach is even better. With wire wrapping or any other solderless connection systems, we still wire to only one contact tail at a time. We can save a tremendous amount of time if we can insert all the contact tails into one large PC board, then make all the interconnections simultaneously in one grand soldering operation. But now we lose our flexibility. So we have to be awfully certain that our designs are firm.

All but the simplest wiring changes require new artwork and new mother boards. Repairs, when possible, are more difficult. And contact density tends to be limited by the need to run printed wiring on the mother board between contact tails.

This situation has led to the use of multilayer boards. They allow for a great deal of wiring density but they're complex. Repairing multilayer boards is staggeringly difficult and expensive. And we must still provide reliable connections between layers.

So it's clear that the potential advantage of making many interconnections on mother boards in one or a few soldering operations can be offset by difficulties we don't run into with wrapped wire. We can alleviate one problem with mother boards by pressing contact tails into plated-through holes, making a good layer-to-layer connection without soldering.

Regardless of the particular mother-board approach we use, we must still align contact tails properly with the individual daughter boards. It's possible to use discrete PC connectors if we're very careful with contact-tail positioning. But, with many discrete connectors, it's almost impossible to get the required accuracy.

There's a compromise possible, a hybrid approach, but it still leads away from the discrete connector.

There's a way we can keep the flexibility of wire wrapping and the ease of interconnection with a mother board. Contact tails that poke through the mother board can be soldered directly to the printed circuitry, wire wrapped or both soldered and wrapped.

This hybrid approach uses PC interconnections where the likelihood of design change is remote and wire wrapping where design changes are likely or where we can dodge the difficulties of multilayers. In any hybrid approach we still must position contact tails carefully, so we're still led away from discrete connectors.

We've all observed the effects of ICs replacing discrete transistors on our PC boards. We have more circuitry on a board and, though we need fewer boards for a particular system function, we need many more contacts on a board.

This leads to two-piece connectors, which escape the restriction of only one or two rows of contacts. And it leads to the need for contact with very low insertion force — the so-called zero-insertion-force connectors.

But it leads, too, to problems we haven't licked yet. High-density packaging poses real difficulties for wire wrapping or any other automatic-connection method — especially as we approach contact spacings of 50 mils. We face the same problems with mother boards because there's a limit to narrowness of PC lines, line spacing and contact pads. Perhaps LSI will help. Since it has so many monolithic connections inside the package, it may reduce the number of external connections required, and perhaps cut external connections enough to make non-mechanized techniques practical.

What about the future? What are we likely to see tomorrow?

Somewhere in the distance we may find connectors that don't use metal contacts. One that's likely is the optical connector which, I suspect, would get its start in digital applications.

Here, an array of light-emitting diodes on a card is aligned with a corresponding array of photodetectors on a second card. By turning individual light sources on and off, we can transmit digital data readily. And we get complete electrical isolation, so a fault in one module can't damage the next.

Another possibility: we may be able to cut the number of interconnections we need by multiplexing. LSI should be able to furnish the additional circuitry we'd need for time sharing or frequency multiplexing.

We'd propagate signals on one or a small number of "party lines," probably in coax cable or other shielded transmission lines. So we'd use fewer lines, hence fewer connections.

In all the more modern in-use techniques as well as the far-out schemes, discrete connectors play no role. Sure, there's an important economic factor that keeps them going: they're now widely used. Replacement and repair considerations will keep them around for many years. And there will always be new applications — typically for low volume and low complexity — for which they're suitable and available at attractive prices.

There will certainly be fewer discrete connectors per system. But there will be many more systems, thus many more connector applications, so we'll actually have more connections.

In a sense, discrete PC connectors are like vacuum-tube sockets in the wake of the solid-state revolution. Their heyday is past, but they will linger on. **EEE**

Who is Benjamin Fox

If there's a word that the president of Elco can't seem to use, it's "can't." Ben Fox sees the impossible as merely another challenge — one he'll accept if he feels it's worth while. In fact, when he left a job he held 23 years ago because it no longer posed a challenge, he founded Elco Corporation in response to a dare by some of his friends. He started the company, which enjoyed a sales volume of almost $29 million this year, with a mere $31,000, and that was chipped in by himself and seven friends.

He felt then that connectors weren't good enough, that they weren't adequately reliable to insure trouble-free equipment operation. So he invented the Varicon connector which, today, is used all over the world. Since then, many more of his ideas and those of his colleagues have made Elco one of the leading connector companies in the industry.

Ben is a living example of the freedom and opportunities we all talk about. He came to the United States from Belgium in 1928, immediately after graduating with a BEE from the Institute Normal Electrotechnique in Brussels. A few days after his arrival in New York City, he was working for Western Electric, despite the fact that he spoke almost no English. Today he has superb command of English, French, German and Russian and a partial mastery of Italian.

Ben's early loves included radio and telephony and, in the formative years of Elco, one of his principal challenges was mechanization of component manufacturing for the fast-growing radio/telephone industries. As a result, Elco was the first company to assemble vacuum-tube sockets automatically. Others kept struggling with manual assembly.

At home, Ben is a different man. He loves to relax with the many hobbies that keep him busy — stamp collecting, music, woodworking and photography.

He travels extensively in this country and abroad and, thanks to his mastery of languages, he's at home all over. He's remembered, also, because he's a superb raconteur It gives him no end of pleasure when a joke he tells in Europe comes back to him in Willow Grove, modified and well worn through extensive re-telling, but recognizable.

How To Keep Out Motor Noise

by W. F. Madle and R. O. Ander

Vibration and noise in motors and gearmotors may be dealt with in two ways—before the fact, and after. Knowing what aspects of design affect noise and vibration will help in specifying motors at the outset. An understanding of causes of noise and vibration plus curative measures will help when the problems crop up.

There are primary and secondary causes to be considered. Motors are mechanical devices driven by electromagnetic forces, so consideration of their ills must be divided this way. In some cases, electromagnetic effects are primary causes of mechanical effects. The reverse may also be true.

Let's start with the mechanical side. Typical causes of vibration and noise are (1) dynamic unbalance, (2) bearings, (3) fans, and (4) gear trains. A closer look follows.

Dynamic unbalance

This situation occurs when there is lack of symmetry in some portion of the rotating member. The cause can be uneven wire build-up in a wound armature, casting voids in a rotor or fan assembly, or rotor eccentricities. Any of these faults can cause relatively severe unbalance.

The user can satisfy himself that vibration is due to dynamic unbalance by observing the motor or gearmotor immediately after power is shut off. If vibration is still present during coasting, the problem is probably one of dynamic unbalance, except in the special case of a hysteresis-synchronous motor.

Bearing noise

Usually a problem that occurs only with ball-bearing motors, this type of noise may arise even from carefully-processed, electronically-tested bearings. In fact, even under optimum conditions, fractional-horsepower motors with ball bearings meeting acceptable quality-control levels usually create noise levels of at least 40 decibels and sometimes as much as 60 dB (using "A" scale weighting. Ref. ASA Standard, measured in 20-dB ambient). Vendor engineers have found that they can reduce this noise level by using special noise-damped ball bearings. Fig. 1 shows the construction of this type of bearing.

Sleeve bearings have much lower inherent noise levels than ball bearings. If sleeve bearings can meet necessary load and service requirements for a given application, they should be preferred over the ball type. There is, however, a problem with sleeve-bearing construction—control of thrust-washer noise.

The intermittent scraping sound from thrust washers is very difficult to control, so use of a ball-thrust arrangement is often specified where absolute minimum noise is required. Since sleeve bearings require clearance for proper operation, they are sensitive to radial vibration (e.g., with a highly saturated motor or with a high degree of unbalance). Under these latter conditions, and especially if high temperature has thinned the bearing oil film, a knock or pounding noise will occur. Motor manufacturers must control sleeve-bearing clearance to close limits to control this condition.

Fan noise

The fans in high-speed motors (2000 rpm and higher) can cause considerable noise, especially when high-velocity air passing through a fan is directed on a rotor or a series of slot openings causing pulses against a stationary part. This results in a sound having a frequency equal to the number of fan blades or slot openings times the number of revolutions per second. This effect can be reduced by changing the fan design or by increasing the clearance between fan and housing.

Even in low-speed motors (600 rpm or less, say), fans can be a major source of noise. Noise resulting from air movement caused by motor fans is usually very low in frequency (30 Hz or so), and hence, not too annoying to human ears. However, the swish or rumble emanating from an air exhaust can be irritating. This can usually be corrected by changing the number, shape, or angle of the blades.

Gear trains

Type of gearing and the accuracy with which it is made are factors determining whether or not gear trains contribute substantially to overall noise level. Worm-type gearing with sliding contact, for example, should be the most quiet type of gearing—unless it is of low ratio (under

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Authors: W. F. Madle and R. O. Ander are chief engineers of the Mechanical and Electrical Divisions, respectively, of the Bodine Electric Company, Chicago, Ill.

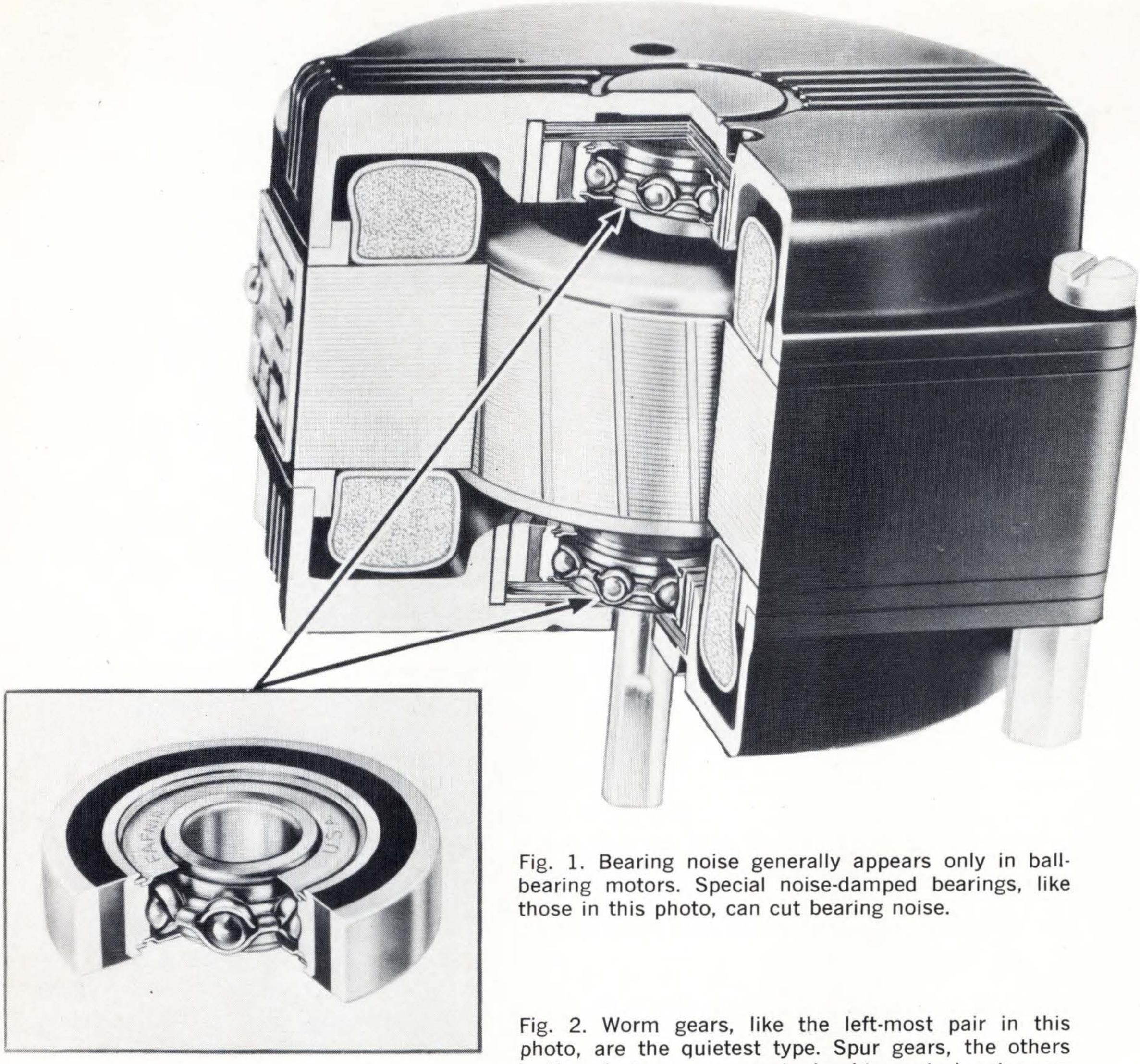
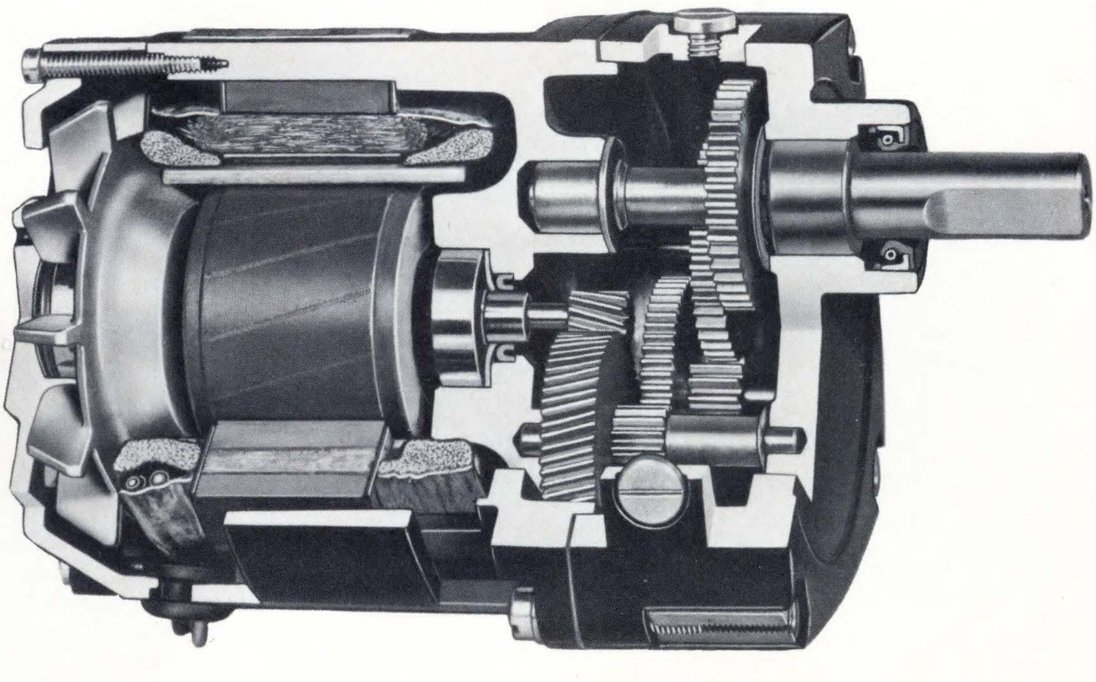


Fig. 1. Bearing noise generally appears only in ball-bearing motors. Special noise-damped bearings, like those in this photo, can cut bearing noise.

Fig. 2. Worm gears, like the left-most pair in this photo, are the quietest type. Spur gears, the others in the photo, can generate hard-to-control noise, especially if the gear ratio per stage is very high.



10-to-1), in which case even slight machining errors or rapid load changes can cause some noise. Fig. 2 shows a motor with worm-type gearing.

Helical gearing also should be quiet in performance because of the smooth transfer of load from tooth to tooth. Spur gearing, on the other hand, is usually the most difficult to control. This is especially true if the maximum ratio per stage of gearing is used. Under such conditions, the small number of teeth in contact at any one time causes a rather abrupt load transfer with resulting noise which is even worse under load and usually increases in intensity as load is increased.

Magnetomechanical sources

Electric causes of noise are primarily sparking and winding problems, whereas magnetic causes have to do with flux uniformity. Saturation usually occurs when a motor is designed with an extremely strong winding (highly saturated magnetic circuit) to "squeeze" out more power without going to the next larger frame size. The magnetic path of any motor is designed to carry a certain amount of flux without undue magnetic stress. Saturation will not only result in increased leakage, but will set up excessive stresses on the weakest portion of its path, usually the stator teeth, with a resultant increase in noise and vibration.

Electromagnetic forces produced either by stator harmonics or rotor harmonics alone are normally not disturbing. Their frequency is either low (twice the line frequency) or high (approximately twice the slot frequency). However, forces due to a combination of stator and rotor harmonics may generate noise levels that are disturbing. Tests have indicated that only certain ratios of stator teeth to rotor conductors are virtually free of those particular harmonics which generate noise.

On induction motors, the length of the air gap influences motor noise. Wherever quiet operation is important, the motor designer can resort to a larger gap, which retards transmission of field harmonics, thus reducing their effect on saturation of stator teeth and resulting motor noise. (Quieter operation for brush-type motors is gained by increasing the air gap at the tips of the salient-pole structure.)

Quieter motor operation occurs when the rotating core is skewed. This permits rotor conductors or the armature winding to enter the magnetic field at an angle, reducing those variations in the circuit reluctance which generate vibrations of the stator or armature teeth. Assembly problems, however, dictate practical limits to the angle of skew that can be used. Skewing also worsens the speed regulation and reduces efficiency of the motor.

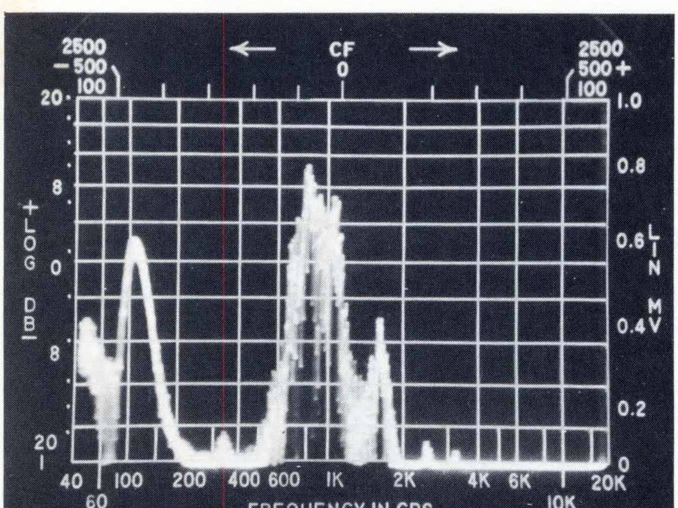


Fig. 3. Spectrum analysis of vibration from a fractional-horsepower motor shows two centers of noise intensity.

Electromechanical sources

Windings of induction motors are placed around the teeth of a slotted stator to produce a sinusoidal flux configuration. The greater the number of stator teeth, the more closely an even sinusoidal distribution pattern can be obtained.

The degree of quietness achieved in motor operation depends not only upon the strength of the field flux, but also on how it is distributed within the air gap. Ideally, distribution should be sinusoidal.

Even so, there are always certain "hot spots" of electromagnetic radiation at one or two locations around any motor, especially around induction motors. As an example, a manufacturer of automatic telephone-answering equipment and message annunciators complained of an annoying 120-Hz hum being picked up by the sensitive heads of his tape equipment. It was found that the interference could be minimized by simply rotating the motor 90 degrees. This rotation necessitated only the use of a different flange on the motor, which turned out to be cheaper, so the manufacturer actually realized an improvement in quality with a decrease in cost.

Permanent split-capacitor motors, which have two windings for more even flux distribution and a true rotating field, are quieter in operation than are split-phase induction motors, which run on one winding with a pulsating field.

When induction motors are operated at 60 Hz, saturation or magnetic unbalance may cause noises that are higher harmonics of the line frequency. Motors operating at 25 or 30 Hz would generate less objectionable sounds, but these motors tend to vibrate more than they would at 60-Hz operation and may require resilient mountings to dampen the vibration.

Quiet operation of a brush-type motor depends on good commutation, which in turn depends on a proper ratio of field to armature ampere-turns. If brushes are to ride smoothly and quietly, sparking must be held to a minimum. The correct grade of brush material will permit an even film buildup on the commutator, and consequent reduction in sparking.

The noise level of a brush-type motor is directly related to the number of armature slots in the motor. A large number of such slots is preferable, and an even number of slots evenly spaced is conducive to smooth, quiet running.

User reduction of mechanical noise

Once the user is aware of the more important causes of mechanical and electrical noise and vibration, he is in a good position to practice some general noise-control procedures. As a rule, his approach to noise reduction can take two major forms: he can reduce noise at its source, and he can reduce the airborne noise level. We'll consider both approaches in that order.

Before any effort is made to reduce noise and vibration at the source, the motor user must fully understand the *frequencies* of noise and vibration involved. This is probably the most overlooked factor in noise- and vibration-reduction poblems. Fig. 3 shows a spectrum analysis of the vibration produced by a small fractional-horsepower motor. Note that it is divided roughly into two groups. Equipment used was a sonic analyzer and an accelerometer.

Low-frequency disturbances

Mechanical low-frequency disturbance is confined to rotor or armature unbalance, which occurs at the rotational frequency of the motor. In the case of a 60-Hz, 1800-rpm motor, rotational frequency would be 30 Hz and therefore would not be audibly objectionable. However, vibrations generated by this frequency might excite annoying resonant frequencies in other parts of the motor installation unless preventive measures were taken.

Resilient mountings and couplings provide the most effective approach to minimizing effects of low-frequency disturbances. But elements like rubber, felt, cork or springs are sometimes used under the feet, or between the base and body of the motor and are almost as effective as the more expensive resilient mountings.

The ideal mounting is soft enough so that the natural frequency of the motor and support system is lower than the lowest important disturbing frequency. However, because of such considerations as varying deflection of the mounting under varying load, this ideal mounting condition cannot always be obtained.

In general, the best rule to follow is to use a mounting that is as resilient as possible. Where vibration still presents a problem, weight may be added to the motor assembly in a further effort to reduce vibration effectively. By doubling the weight of a motor assembly, for example, the user can reduce the amplitude of vibration by 50 percent.

Still another mounting problem that can give rise to low-frequency vibration occurs frequently in portable equipment where thin sheet-metal mounting surfaces can actually act as diaphragms, giving a sounding-board effect. To solve a problem of this type, some stiffening assemblies, resilient mountings, or crimping methods must be employed to dampen vibrations.

High-frequency disturbances

Major sources of high-frequency disturbances (above 50 Hz) are ball bearings and windings. When brush-type motors are involved, brush noise also is a factor.

Ball-bearing noise usually is the most troublesome disturbance in induction motors, and almost always occurs in the 1- to 4-kHz range. Noise in this frequency range is usually inherent in the design of the motor, and can be most effectively attenuated with acoustic materials.

Reduction of air-borne noise

Two of the simplest ways of diminishing the irritation of air-borne noise emanating from a motor are sometimes never considered, even when they are easy. One is to put greater distance between noise source and listener. The other is to change the position of the noise source relative to the listener.

Acoustical sound absorbent materials can be used to deflect and reduce the noise level and are particularly effective when high-frequency noise is involved. However, when such materials are employed, care must be taken to avoid obstructing motor-ventilation openings.

Different types of attenuating structures—walls, barriers, and total enclosures—also can be used to control air-borne noise. Almost any degree of reduction in such sound, for example, can be achieved with a total enclosure, or a combination of several enclosures. (A barrier, while not as effective as an enclosure, does help shield high-frequency sound. However, only a moderate reduction in noise level can be expected with a barrier.)

Where a total enclosure is to be installed, the user should remember that ventilation must be provided to dissipate motor heat. And in this regard, he must also be careful in the design of ventilation ducts, and line them with acoustical material, so that the noise reduction gained by an enclosure will not be lost by sound transmission through the ducts.

We have surveyed most of the important causes of noise and vibration normally encountered in motor operation, and have suggested various means by which such noise can be reduced or eliminated. There are, however, too many variables to cope with in areas of motor application, mounting, and the use or lack of sound-absorbing or reflecting surfaces near the motor to allow us to pinpoint every trouble spot. Motor manufacturers who are given all possible installation and application data prior to designing motors for specific applications will be able to provide the most "noise-free" motors. Since such data are not always available, however, and since every motor with moving parts will produce some element of noise, no matter how slight, part of the onus passes to the user, whose depth of understanding and ingenuity will best serve to achieve optimum noise reduction in most applications. **EEE**

Design Schmitt Triggers Exactly

by Peter Bice

This procedure allows a designer to specify Schmitt-trigger parameters initially, then calculate the exact component values needed. Commercially available components can be selected and the effect of these new values can be calculated. In all these calculations the model used is exact; the customary assumptions of infinite beta and negligible shunt loading are not made.

Schmitt-trigger design is often a hit-and-miss procedure with the designer trying component values and seeing what performance results. This procedure is awkward and wasteful in time and productivity. Not only is the designer unsure of where he is, but he doesn't know how to get from there to his goal. Since many parameters are interrelated with component values it is difficult to change one parameter without affecting others. This new procedure ends cut-and-try methods.

Design procedure

Figure 1 shows the typical Schmitt-trigger layout. The design procedure begins after selecting:

1. Z, the value of the load resistance.
2. U and L, the upper and lower trip points for V_{in}.
3. V_1 the base-emitter voltage of a forward-biased transistor.
4. V_2, the available supply voltage.
5. B_1, the effective beta of the transistors.

Our first step is to calculate the value of R_1. Note that when transistor Q_2 is on, its base is at voltage U, the upper trip point (i.e., as soon as $V_{b1} > V_{b2}$, Q_1 must turn on). Select R_1 so that Q_2 is just barely saturated with its base at U. For this to occur:

$$R_1 = Z\left(\frac{U - V_1}{V_2 - U + V_1}\right)$$

The next step is to select R_4. For now, a common-sense choice would be $R_4 = 10\ R_1$.

We now have two more unknown values, so we need two conditions to specify them. One condition occurs when Q_1 if off, and Q_2 is on. The base voltage of Q_2 must be U volts or, equating currents:

$$\frac{V_2 - U}{R_2 + R_3} = \frac{U}{R_4} + \frac{U - V_1}{B_1 R_1}$$

Rearranging terms, we get:

$$\frac{B_1 R_1 R_4 (V_2 - U)}{U B_1 R_1 + R_4 (U - V_1)} = R_2 + R_3$$

This is the most convenient form of the expression, since R_2 and R_3 are unknowns.

The last condition to be met occurs when Q_1 is on and Q_2 is off. As V_{in} falls toward L, the lower trip-point voltage, Q_1 begins to come out of saturation. The emitter voltage of Q_2 falls, and the base voltage of Q_2 rises. Switching doesn't occur until the latter is V_1 volts greater than the former. This situation must occur with an input voltage of L volts.

When Q_1 is about to switch, it is out of saturation and its base is at L volts. We can consider it to be a current source of $(L - V_1)/R_1$ amperes, shunting a voltage source in series with R_2.

Author: Mr. Bice is with Hewlett-Packard's Microwave Division in Palo Alto, California

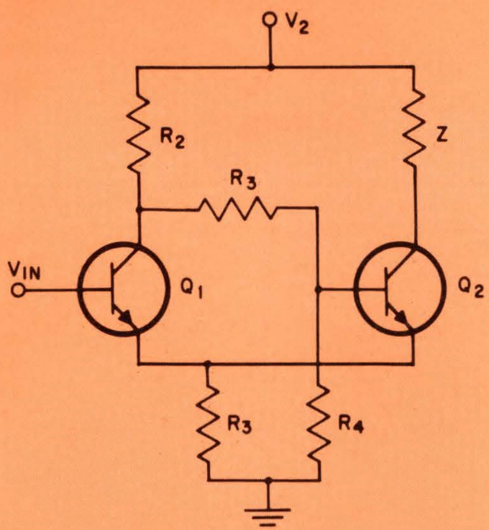


Fig. 1. Typical Schmitt trigger.

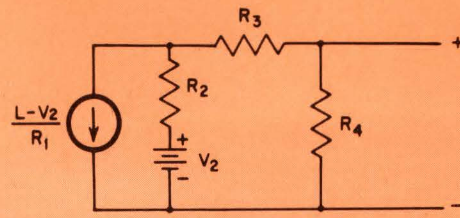


Fig. 2. Schmitt-trigger equivalent circuit with $V_{in} = L$ and Q_1 "on." The output voltage must be L volts when switching occurs.

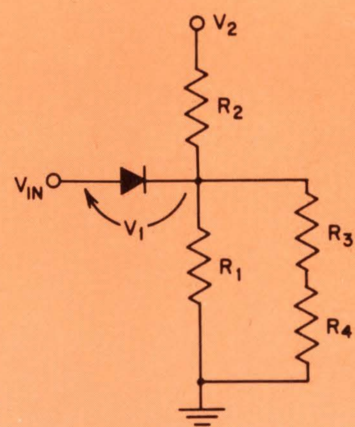


Fig. 3. Schmitt-trigger equivalent circuit with Q_1 saturating.

```
10   PRINT "INPUT Z,U,L,VCC,VBE,BETA,R4/R1"
20   INPUT Z,U,L,V2,V1,B1,A1
30   LET R1=Z*(U-V1)/(V2-U+V1)
40   LET R4=A1*R1
50   LET A=R4*(V2-L)
60   LET B=R4*(L-V1)/R1
70   LET C=B1*R1*R4*(V2-U)/(B1*U*R1+R4*(U-V1))
80   LET R2=(A-C*L)/B
90   LET R3=C-R2
100  PRINT "R1="R1
110  PRINT "R2="R2
120  PRINT "R3="R3
130  PRINT "R4="R4
140  PRINT
150  LET V=V1+V2/(1+R2*(1/(R3+R4)+1/R1))
160  PRINT "SATURATION INPUT IS "V"VOLTS"
170  PRINT
1100  PRINT "INPUT NEW VALUES FOR R1,R2,R3,R4"
1110  INPUT R1,R2,R3,R4
1120  LET U=(V2/(R2+R3)+V1/B1/R1)/(1/(R2+R3)+1/R4+1/B1/R1)
1130  LET L=R4*(V2+V1*R2/R1)/(R2*R4/R1+R2+R3+R4)
1140  PRINT "U="U;"L="L
1150  END
```

Fig. 4. BASIC program for Schmitt-trigger synthesis and analysis.

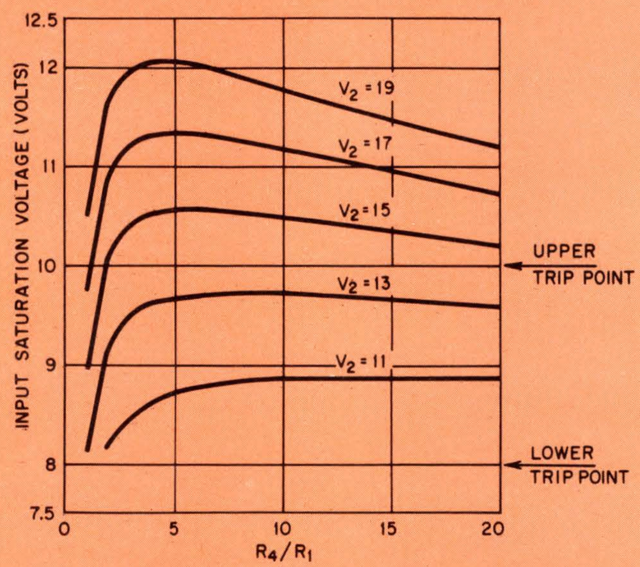


Fig. 5. Example of Schmitt-trigger program application. Circuit parameters are: U = 10 V, L = 8 V, Z = 1000 Ω, V_1 = 0.7 V and transistor beta = 50.

Figure 2 shows an equivalent circuit. From this circuit we get the final condition:

$$\frac{\left(V_2 - \frac{L - V_1}{R_1} R_2\right) R_4}{R_2 + R_3 + R_4} = L$$

Or, rearranging:

$$R_4 (V_2 - L) = R_2 \frac{R_4}{R_1} (L - V_1) + L (R_2 + R_3)$$

where everything except R_2 and R_3 is known.

Now we have two equations in two unknowns and simply have to solve them simultaneously. This chore is made easier by making some substitutions:

$$A = R_4 (V_2 - L)$$

$$B = \frac{R_4}{R_1} (L - V_1)$$

$$C = \frac{B_1 R_1 R_4 (V_2 - U)}{U B_1 R_1 + R_4 (U - V_1)}$$

Then:

$$A = BR_2 + LC$$

$$C = R_2 + R_3$$

So:

$$R_2 = \frac{A - LC}{B}$$

$$R_3 = C - R_2$$

So now we have component values corresponding to a given set of operating conditions for a Schmitt trigger. Some of these component values can come out negative; if they do, try using R_4 different from $10R_1$. It may be, however, that no circuit can be designed using that set of input conditions.

We can now find the input voltage which will saturate Q_1. This voltage must be greater than L, and may or may not be greater than U. Figure 3 shows the equivalent circuit when Q_2 is off and Q_1 is saturated. The expression for the input voltage at saturation is:

$$V_{SAT} =$$

$$V_1 + V_2 \left[\frac{R_1 (R_3 + R_4)}{R_1 (R_3 + R_4) + R_2 (R_1 + R_3 + R_4)} \right]$$

This saturation voltage will change as R_4 or V_2 is changed. If its value is unacceptable, try changing one or both of these parameters.

BASIC program for Schmitt-trigger design

Figure 4 shows the listing of a BASIC program which performs these computations and prints component values and saturation voltages. Furthermore, our program accepts standard resistor values and prints the new trip points. This program permits the user to set component tolerances.

Figure 5 is an example of what can be done with this routine. This plot shows the variation of input-saturation voltage as a function of R_4 and V_2, for a given set of circuit parameters. Note that the optimum value of R_4 for this case can be inferred from the plot. Similar data can be found for other parameters in the same manner. **EEE**

Products Of The Month

Semiconductors

Boldface numbers following each product refer to those you can circle on the reader inquiry card for further information.

Complementary MOS ICs, MC2501-3, gates and flip-flop. Quad 2-input NOR gate, dual 4-input NOR gate dissipate 10 nW; dual flip-flop dissipates 50 nW, typ. Operate on any supply from 4.5 to 20 V. Gate propagation delay, 100 ns; flip-flop toggle rate, 4 MHz. $5.40 up (100 up). MOTOROLA. **274**

COS MOS 16-bit memory, SCL5510, contains all "1" states. User writes in desired "0" states. Fusible links knocked out by current pulses. Cycle time, 400 ns; Diss, 50 nW. SOLID STATE SCIENTIFIC. **275**

Series 74 shift register, US7495A, with selective left or right shift mode control. 4-bit parallel-input, parallel-output device. 14-lead DIP $4.65 (100-999). SPRAGUE. **276**

Buffer register, 8201, for parallel-in, parallel-out applications. Ten clocked "D" flip-flops. Four configurations possible. Propagation delay, 30 ns; setup time, 10 ns max. Transfer rate, 20 MHz. 24-pin flat pack. $8.39 (100 up). SIGNETICS. **277**

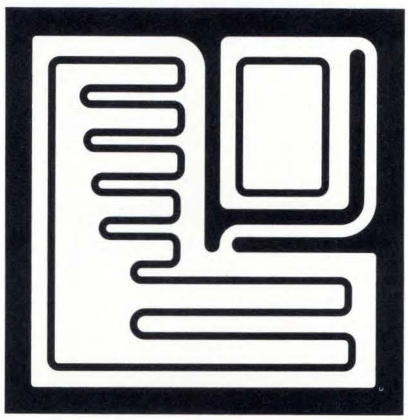
TTL multivibrators, 9600-2, replace Fairchild devices. Guaranteed max pulsewidth variation 0.6% over entire temp range. Mil and industrial versions. $2.25 (dice). $3.00 up packaged (100 up). ADVANCED MICRO DEVICES. **278**

FET chips, 21 types, junction and MOS. Both p-channel and n-channel devices. Also bipolar chips and flip chips. 50¢ up (100 up). INTERSIL. **279**

Balanced modulator/demodulator, SG-1596, for modulation, detection, and chopper applications. Carrier suppression to 65 dB; CMRR, 85 dB. Temp −55 to +125° C. $4.40 (100 up). SILICON GENERAL. **280**

FET analog gate, CAG13C, directly controlled by logic circuits. Two separate FET switch circuits. Switches signals to 9 V. On resistance, 50 Ω max. $40 (100 up). CRYSTALONICS. **281**

Complementary power Darlingtons, five new series, current ratings 4 to 100 A. Gain to 2500. Voltage ratings, 60, 80, 100 V. For amplifier and regulator circuits. $3.20 per complementary pair. MOTOROLA. **283**



Frequency synthesizer, SH8095-8, four ICs. System comes on 1-in. by 1-in. flatpack. Useful to 200 MHz. Consists of emitter-coupled logic prescaler, programmable divider, voltage-controlled tuner and oscillator, and programmable reference divider and reference oscillator. $187 for 4-IC set (100 up). FAIRCHILD. **282**

Beam-lead arrays, new series, contain 50 to 1000 phototransistors. Light current, .75 mA min, dark current, .1 μA max. Breakdown voltage, 45 V. TEXAS INSTRUMENTS. **284**

Power transistors, 2N3055, second source for regular and mil versions. TO-3. $5.20 (100 up). SENSITRON. **285**

Silicon pin diodes, A5C110 series, switching time max, 5 ns. Series resistance, 1 Ω max; voltage, 70 V min; diss to 300 W., max cap, .32 pF. $3.50 up for 10 chips. Also available in pill packages. AERTECH. **286**

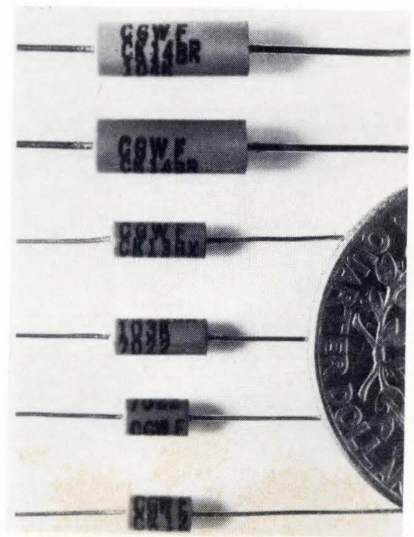
Silicon rectifier, KV-PAC, PIV ratings to 15 kV. Avg rectified current, .4 A per leg. Reverse current at PIV, 10 μA at 25° C. SEMTECH. **287**

Teardrop thermistors, new series, ratings to 500 V. Resistances, 100 Ω to 20 kΩ, tol, .5 to 20%. CAL-R. **288**

Capacitors

Beam-lead capacitors, MD400 and MD401, for negligible insertion losses at frequencies up to Ka-band. MD400-series use silicon dioxide to minimize dielectric losses. MD401 are polarized and use tantalum oxide for higher cap values. 50 Vdc with cap tolerance of ±20%. MD400 capacitance range 0.57-12.0 pF. MD401 7.5-155 pF. TEXAS INSTRUMENTS. **259**

Glass-ceramic capacitors, Glass-K BX/BR, for semi-precision performance from −55°C to +125°C. Capacitance (CYK-12) 10 to 1 × 10^5 pF. Qualified to Mil-C 11015/20 and Mil-C-39014/5. Tolerance 10% or 20%. 100 Vdc and 50 Vdc. Dimensions (CYK-12) 0.160 in × .090 in. dia. Lead dia 0.016 in. CORNING. **260**



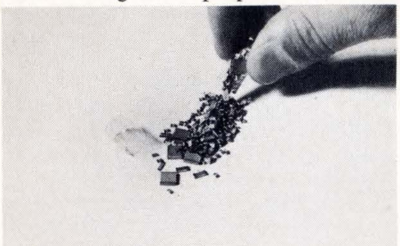
This Month's ICs

Complementary MOS ICs, $5.40. MOTOROLA. **274**
COS MOS 16-bit memory. SOLID STATE SCIENTIFIC. **275**
Series 74 shift register, $4.65. SPRAGUE. **276**
Buffer register, $8.39. SIGNETICS. **277**
TTL multivibrators, $2.25. ADVANCED MICRO DEVICES. **278**
FET chips, 50¢. INTERSIL. **279**
Balanced modulator/demodulator, $4.40. SILICON GENERAL. **280**
FET analog gate, $40. CRYSTALONICS. **281**
Frequency synthesizer, $187. FAIRCHILD. **282**

This Month's Transistors and Diodes

Complementary power Darlingtons, $3.20. MOTOROLA. **283**
Beam-lead arrays. TEXAS INSTRUMENTS. **284**
Power Transistors, $2.50. SENSITRON. **285**
Silicon pin diodes, $3.50. AERTECH. **286**
Silicon rectifier. SEMTECH. **287**
Teardrop thermistors. CAL-R. **288**

Chip capacitors, Vee Jem, with dimensions from 0.050 × 0.040 in. to 0.638 × 0.255 in. and thicknesses of 0.015 to 0.065 in. 1 pF to 1 × 10^6 pF in NPO and general purpose dielectrics.



Silver-palladium terminations. 50 Vdc and 100 Vdc from −55°C to 125°C. Standard tol 5%, 10%, 20% and 0.5 pF in low-pF units. VITRAMON. **258**

High-voltage disc, with excellent temperature stability and anti-corona performance. All units epoxy coated. 1000- and 2000-pF capacities std. Capacity tolerance 20% with 2% dissipation factor. Insulation resistance 20 × 10^3 MΩ. Voltage rating 10 kV. Corona V of 3000 Vrms at 60 Hz. AEROVOX. **261**

Monolithic ceramic-chip resistors, with values from 10 Ω to 10 MΩ. Tolerance ±1% to ±10% at 1/4 watt. Tempco 100 ppm. Available as individual chips or glass enclosed with leads. Terminations are noble metal alloys. CROWNOVER ELECTRONICS. **254**

Resistors

Microminiature film resistor, ML103, with less than half the overall size of the RN-50 resistor. Dimensions 0.110 × 0.095 in. Resistance 10 Ω-250 kΩ. Power rating 0.06 watt at 125°C. Tempco ±50 ppm/°C. Tolerance ±1% std, up to 0.1% special order. CADDOCK ELECTRONICS. **255**

3/8-in. square wirewound trimmer, 2300, for pc card mounting, with side or top adjustment. Qualified to Mil-R-27208 (RT24). Resistance 10-20 kΩ at ±5%. Power 0.75 W at 85°C. Tempco 50 ppm/°C. AMPHENOL CONTROLS. **256**

10-turn precision potentiometers, 8100, with essentially infinite resolution. 7/8-in. dia. Resistance 5k-100 kΩ from −65°C to 125°C. Linearity 0.25% and smoothness 0.05%. Life 10 × 10^6 revolutions. $12 (1-9 qty). BECKMAN. **257**

Packaged Circuits

Price changes

BECKMAN has reduced prices of its 12-bit binary ladder networks by up to 42 percent. For example, Model 811-B12 now costs $40 (qty 1-9) instead of $70. **289**

DDC has announced substantial price reductions for its MADC and HADC series of A/D converters. For example, an 8-bit converter type MADC-8-3 now costs $200 (qty 1-9) instead of $400. **290**

ANALOG DEVICES has cut prices of its μDAC quad switches for D/A conversion. A set of components for an 8-bit D/A converter (two μDAC AD550 ICs plus an AD852 thin-film resistor network) now costs $65 (qty 100). **291**

Line-driving op amps, 3341/15C and 3342/15C, to drive 50-Ω coaxial line with ±5 V at frequencies to 20 MHz. Output rating ±10 V at 100 mA. Slew rate 1000 V/μs. Settling times 1μs to within 0.01%, and 200 ns to within 1% of final value. FET inputs. Inverting configuration. Voltage drift ±25 μV/°C (3341/15C) and ±50 μV/-°C (3342/15C). Input bias current −100 pA. Prices((1-9): $69 (3341/15C) and $59 (3342/15C). Stock (small qty). BURR-BROWN. **292**

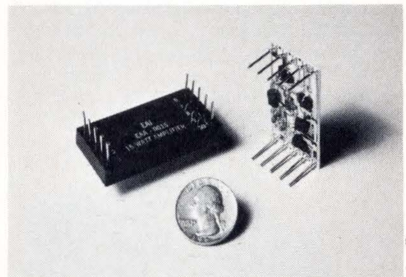
Hybrid FET-input op. amp, C-218, in sealed TO-8 package. Dimensions 0.140 in. high × 0.605 in dia. Bias current 5 pA. Useful for sample-and-hold and integrator applications. Evaluation samples available from company's reps or on letterhead request to company. $25 (1-9). Stock to 2 wks. BELL & HOWELL. **293**

Programmable gain data amplifier, 3600K, to operate on low-level signals, under computer control. Compact encapsulated package, 3 × 2.1 × 0.4 in. Interfaces with DTL/TTL. Gain ranges: 0-16 in steps of 1, 16-256 in steps of 16, and 256-3840 in steps of 256. Voltage drift ±1 μV°C. Gain accuracy ±0.1%. Linearity ±0.01%. CMR 100 dB. Noise 2 μV rms (10 Hz to 10 kHz). Settling time 300 μs (to within ±0.1% of f.s.). 3-dB response dc to 10 kHz. $245 (small qty). BURR-BROWN. **294**

Unity-gain power booster, 866, with thick-film hybrid construction. Output power 5 W. Output voltage ±16 V. Can drive 50-Ω loads to within 4 V of either supply voltage. Bandwidth dc to 10 MHz. Operating temp −55 to +125° C. All semiconductor chips inspected on LTPD basis per MIL-STD-883 and MIL-S-19500. Hermetically sealed package. $40 (1-9). BECKMAN. **295**

Power op amps, 410, 411 and 412, with continuous output ratings of 1000 W. Internal dissipation 1400 W. Overload and short protection. Output ±25 V at 40 A (410) or ±40 V at 25 A (411 and 412). Model 412 has short-term rating of 2000 W (50-A output). Power supply requirements ±35 V at 40 A (410) or ±50 V at 25 A (411 and 412). Slew rate 150 V/ms. Open loop dc voltage gain 20. Differential input impedance 10 kΩ. Common-mode input impedance 210 kΩ. Voltage drift 10μV/°C. Bias current 85 μA. Quiescent current 20 mA. Unit-qty prices: $796 (410 or 411) and $880 (412). Stock. ANALOG DEVICES. **296**

Class-B audio amplifier, EAA-0015, with continuous output rating of 15 W. Thick-film hybrid microelectronic construction. Molded package, 2.05 × 1.05 × 0.31 in. 3-dB frequency response 20 kHz. Total harmonic distortion 0.5% at 1 kHz full power. Requires 350 mV input for full output into conventional speaker load. $12 (1-99). EAI. **297**



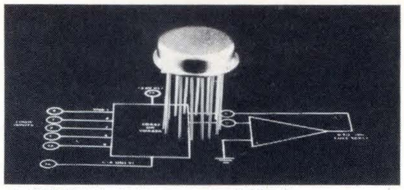
Sample-and-hold modules. VSSH series, for video signals. Input impedance 10^{11} Ω. Input signal range ±5 V. Aperture time 300 ps. Acquisition time 10 ns (VSSH-F), 36 ns (VSSH-M) or 100 ns (VSSH-S). Small-signal bandwidth 100 MHz ("F"), 40 MHz ("M") or 25 MHz ("S"). "Hold"-mode drift 2 mV/μs ("F"), 0.67 mV/μs ("M") or 0.2 mV/μs ("S"). Compact modules, 1.65 × 2.8 × 0.6 in. Choice of two operating ranges: 0 to +70° C, or −55 to +85° C. Price (1-9): $395 or $495 (depending on temp range). Stock to 3 wks. DDC. **298**

FET analog gate, CAG30, in hybrid microcircuit complete with driver. Switches signals up to ±10 V. DTL/TTL compatible. Logic noise immunity typically 1.5 V. Operating temp −55 to +125° C. Max "on" resistance 60 Ω. Propagation delay time 0.5 μs (logic "0") or 1 μs (logic 1). Break-before-make switch. 10-lead TO-100 package. $6.00 (100-249). TELEDYNE CRYSTALONICS. **299**

High-speed A/D converters, IAD-M series, with resolutions up to 8 bits. Word conversion speed 1 MHz (IA-1308M), 2.5 MHz (IAD-1306M) or 4 MHz (IAD-2204M). Resolutions 8 bits, 6 bits and 4 bits, respectively. Accuracies ±0.2% (±1/2 LSB), ±1% and ±3%, respectively. 4 × 4 × 1.25 in. From $525 to $855 in 1-9. 3 wks. INTER-COMPUTER ELECTRONICS. **300**

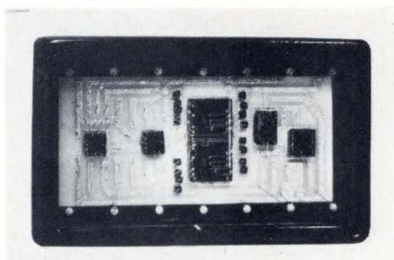
Low-cost 6-bit DAC, CDAS2/A, with thin-film hybrid microelectronic construction. Consists of ladder network and 6-bit switching network. Sealed low-profile 12-lead TO-8 package. Operates directly from logic. Typical settling time 1 μs. Operating temp −55 to

(Continued on page 46)



+125° C. Max error 1% f.s., guaranteed over full temp range. Full-scale output 6 mA. Built-in matched feedback resistor for use with external amplifier. Also available in 5-bit version. $37.50 (1-49) and $25 (100-249). Stock. TELEDYNE CRYSTALONICS. **301**

Thin-film hybrid DAC, MN303, for 8-bit BCD inputs. Includes monolithic IC switching networks. precision thin-film resistor networks and IC output



op amp. DIP-compatible 14-pin package, 0.45 × 0.75 × 0.14 in. Slew rate 0.5 V/μs. Tempco ±10 ppm/°C. Power consumption 400 mW. Operating temp 0 to +70° C. $79 (1-12). Stock. MICRO NETWORKS. **302**

High-speed 12-bit DAC, MP1812, available in all standard unipolar or bipolar 12-binary-bit or 3-BCD-digit configurations. Settling time 10 μs to ±0.02% f.s. Tempco 40 ppm/°C. Output slew rate 10 V/μs. Output current 20 mA. Short protected. Built-in dc reference can be bypassed for special applications. Operating temp 0 to +70°C. Calculated MTBF 50,000 h. Electrically and mechanically shielded module, 2 × 2 × 0.39 in. $89 (unit qty). 2-3 wks. ANALOGIC. **303**

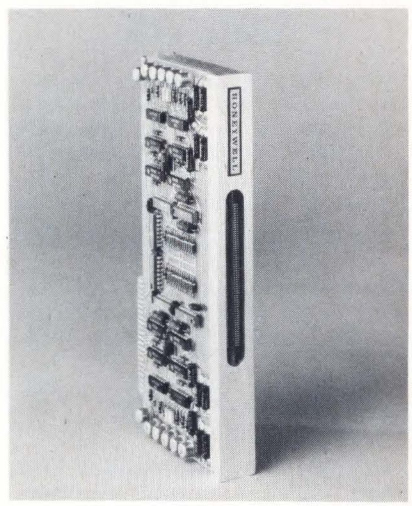
Economy A/D converters, ADC-H series, with resolutions of 8 or 10 bits. Compact encapsulated packages 2 × 4 × 0.4 in. Choice of input voltage ranges and output codes and formats. Conversion time 15 μs ADC-8H) or 18 μs (ADC-10H). Quantizing error ±1/2 LSB. Differential linearity ±1/2 LSB. Zero error ±0.6% (adjustable to zero). Gain error 1% (adjustable to zero). Relative accuracy ±0.2% (ADC-8H) or ±0.05% (ADC-10H). Zero tempco ±25 ppm/°C. Gain tempco ±40 ppm/°C. Input impedance 3.3 kΩ (also available with high-input-impedance voltage follower). Operating temp 0 to +70°C. $195 (ADC-8H in 1-9) and $225 (ADC-10H in 1-9). Stock. ANALOG DEVICES. **304**

Digital high-low detector to produce HI/LO limit signals for alarm, control, data-logging, testing, sorting, grading, calibration and batching. Input BCD or natural binary data can be inserted electrically or by thumbwheel switch to set limits. Packaged as plug-in PC board, 10 × 3 in. Input is 4 decades (16 lines) of parallel absolute BCD or natural binary at DTL/TTL levels. Output is high, coincidence or low, on three separate lines at DTL/TTL levels. $75 per decade. Stock. THETA INSTRUMENT. **305**

Hybrid circuit modules for driving relays, incandescent lamps and LEDs. 3 different versions: dual driver, quad driver and power driver. Dual driver controls 2 loads of up to 300 mA at 28 Vdc. Quad driver controls 4 loads of up to 300 mA at 28 Vdc. Power driver can switch up to 1 A at 60 V. All drivers have DTL/TTL compatible inputs. Thick-film circuitry in ceramic packages, 0.690 × 0.750 × 0.265 seated dimensions. Prices (1-25): $13.20 (dual driver), $16.40 (quad driver) and $14.40 (power driver). Stock to 1 wk. CENTRALAB. **306**

Modular plated-wire memories, NM-1000 series, with read access time of 200 ns, read time of 300 ns and write time of 500 ns. Can be configured into systems of 4-k to 16-k words of 8 to 40 bits per word. Max capacity 163,840 bits. Min capacity 64,000 bits. Wire operates in NDRO mode. $0.037 to $0.11 per bit depending on quantity and word size. NEMONIC **307**

Low-cost core memory, ICM-100 with capacity of 1000 words. Organized in 8-, 9- and 10-bit formats to handle various combinations of read, write, restore, modify and clear functions in minicomputer-based random-access systems. 9 × 4 × 1 in. All logic,

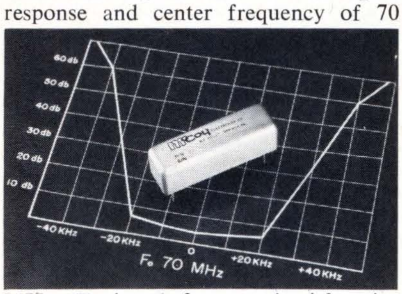


addressing, data buffering, control, selection, switching and sensing functions performed by ICs. DTL/TTL compatible. From $595 in qty. 30 days. HONEYWELL COMPUTER CONTROL. **308**

Hybrid i-f/agc amplifier, 58-592, with thick-film circuitry on two-level ceramic substrate. Sealed and shielded case, 1.4 × 1.9 × 0.4 in. Meets MIL-STD-883. Center frequency 4.5 MHz. Gain 90 dB. Gain stable from −55 to +100°C. Gain controlled over several decades of signal level. Can be gated off by external control voltage. Two isolated video outputs of 5 V pk. Agc provides control over dynamic signal range of 65 dB. Needs +12 V and ±5 V supplies. HALLICRAFTERS. **309**

Band-reject crystal filter, 6648A, with center frequency of 10.7 MHz. Designed for use in radar and missile systems to eliminate undesirable signals, mixer products and clutter interference without degrading sensitivity to low-velocity targets. Also available with other center frequencies from 1 to 30 MHz. 3-dB bandwidth ±1.6 kHz max. 60-dB bandwidth ±400 Hz. Center-frequency rejection 70 dB min. Passband ±1 MHz at −1 dB. Insertion loss 4 dB. Operating temp −20 to +75°C. 3 1/2 × 1 1/2 × 1 in. DAMON. **310**

Monolithic crystal filter with bandpass response and center frequency of 70



MHz. Designed for use in i-f strips and similar applications. 6-dB bandwidth ±20 kHz min. 60-dB bandwidth ±40 kHz max. Ultimate attenuation 70 dB min. Insertion loss 5 dB. Input and output impedances 50 Ω. 1-61/64 × 19/32 in. Custom designs available. McCOY/OAK. **311**

Voltage-controlled crystal oscillator, VCXO-541, available in standard versions for frequencies from 150 kHz to 4 MHz. Operating temp 0 to +75°C. No oven required. Control voltage −1 to +1 V. Output frequency deviation −0.01% to +0.01% of center frequency. Output 2 Vrms sinusoidal. Power supply +15 V at 20 mA. Output impedance 100 Ω. Input impedance 100 Ω. Metal case, 1 × 1.55 × 0.56 in., with mounting studs. SOLID STATE ELECTRONICS. **312**

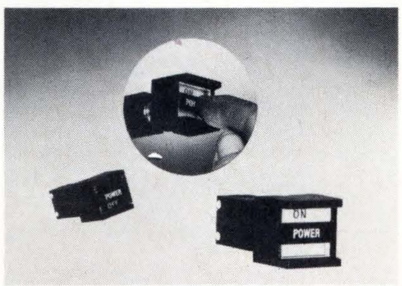
Crystal oscillators, 5404 and 5405 series, in plug-in packages that occupy the space of 1 or 2 DIPs. Available frequencies 5 to 15 MHz (5404) and 80 kHz to 4.9 MHz (5405). Intended for use as clock oscillators. Output square wave can drive TTL logic with fanout of 3 loads. Frequency accuracy ±0.005% (5404) and ±0.02% (5405). Accuracies hold over temp range of 0 to +65°C. Plastic packages plug into sockets by Barnes, Elco, Augat, etc. Prices (in qty 50 up): $16 (5404) and $19 (5405). Stock to 2 wks. M.F. ELECTRONICS. **313**

Fork oscillator, FS-11-1, in compact module for PC mounting. Complete oscillator contains driving circuit, drive and pickup coils. and temperature compensated fork. Available for any specific frequency from 400 Hz to 50 kHz. Compatible with TTL logic.

Operating temp −55 to +85°C. Typical reliability 90% for 200,000 h. 1-1/2 × 1/2 × 3/8 in. BULOVA. **314**

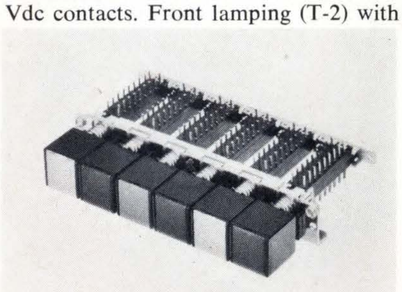
Switches & Relays

Lampless "lighted" pushbuttons, Rainbow, with prism in switch cap to reflect ambient light and display different color and different legend when



switch is depressed. Can include lamp. 3/4 × 1-in. cap. One or two form-Z 10-A 30-Vdc or 125/250-Vac contacts. Caps with one or two color bands and legends 70¢ (1000-up). Cap and switch assemblies $4-$6 (1000-up). MARCO-OAK. **262**

Lighted pushbuttons, PB-20, on 20 mm centers. Each switch lens can have legend with up to 36 hot-stamped characters. 0.45-A 115-Vac or 1-A 28-Vdc contacts. Front lamping (T-2) with



no tools. Push-push, momentary, interlock. CENTRALAB. **263**

Lighted pushbuttons, 0405, with Cue-Switch projection readout for multiple message display. Decimal or BCD input. Depressing and releasing switch projects next legend. 1/2-in. character or message hgt with 60-ftL avg brightness (using 6-V lamp) visible at 10 ft. $56 (1-49). IEE. **264**

Lighted rocker switch for mounting in 0.655 × 0.73-in. cutout. No-tool front relamping. Four lens colors, three lamp filters. Dpdt 5-A 125-Vac contacts with 10-mΩ initial resistance at 2-4 Vdc 1 A. SHELLY. **265**

Two-color push-push switch, 46-527, for positive indication that switch is up or down. Red ring around black button or black ring around red button disappears when button is depressed. Spdt 1/4 A 115 Vac. $2.35 (100-up), GRAYHILL. **266**

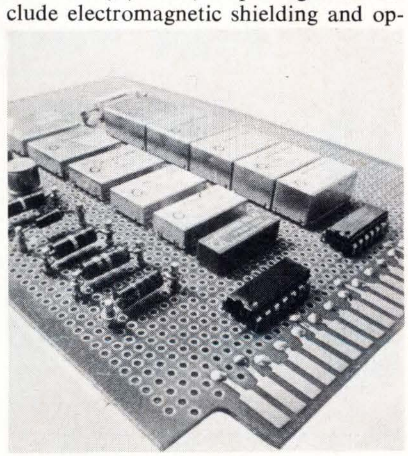
Hermetically sealed rotaries, 15-1900 for manual or solenoid operation. Variety of poles, positions, indexing. JANCO. **267**

Optical switch, OS100, with beam from infrared light-emitting diode passing through 60-mil air gap to Darlington phototransistor. 4-pin mini-DIP pkg, 0.25 in. high and deep, 0.35 in. wide HEI. **268**

Low-cost reed relays with coil bobbins molded directly to reed capsules, boosting flux density and sensitivity. Form A for 200 Vdc 1/2 A (switching) 10 W 1/2-Ω initial contact resistance. 1/2-ms operate. 20 million cycles at full load. Form C for 200 Vdc 1/4 A. Form A $1.60 (1-24) to 39¢ (100,000-up). Form C $3.96 (1-24) to $1.79 (100,000-up). ELECTRONIC APPLICATIONS. **269**

TO-5 relays, 10, company's first, in military and commercial versions. Operate 2 ms max, release 1.5 ms max. 4 ms for units with arc-suppression diode. ELECTRONIC SPECIALTY. **270**

Reed relays, PBR, re-packaged to include electromagnetic shielding and op-



tional electrostatic shielding. To six form A in 0.225-in. hgt. To 1/2 A (switching) 100 V 10 VA. PC mount. CLARE. **271**

All-solid state relays, 601, with 4-terminal isolation. 70 units in new line with peak price at $13 in small quantities, low prices at $5.80 in large quantities. For 1- to 10-A loads at −25 to +110°C. Zero-voltage switching option for rfi elimination. TELEDYNE. **272**

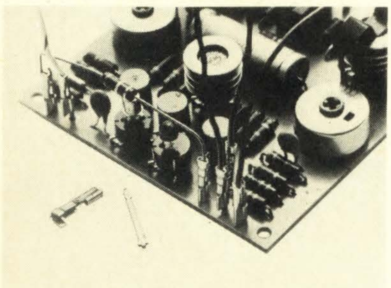
Edgewise meter relays, 3623XA, with 5-A plug-in load relays, non-parallax scale, dial illumination, mode lamps,

(Continued on page 48)

removable set-point knobs. Cad sulfide or silicon photocells with incandescent or LED light source. Pivot-and-jewel or taut-band suspension. SIMPSON. **273**

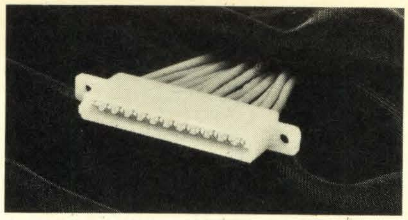
Packaging/Hardware

PC terminals and mating receptacles. Auto-Mate, with double-notch terminal and detented receptacle to maintain 3-5 lb withdrawal force. Drastically reduces accidental disconnects. Eliminates need



to insulate to meet UL standard. Terminal locks in 70-mil hole, takes two levels of wrapped wire. For AWG 16-24 or 22-32. MALCO **216**

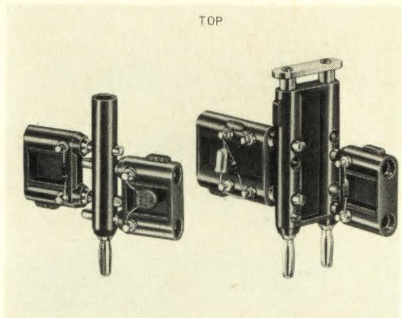
PC edge connector, Edgecon, with 12 removable crimp terminals (supplied



in chain-link form) that snap-lock into nylon body. MOLEX. **217**

Rf-connector adapters, 7377, for interseries and intersex mating. For many types, including N, TNC, BNC, GR874, GR900, SMA, etc. ALFORD. **218**

Isolation banana plugs, 3501 (single), 3502 (double), for series or parallel



network mounting during test. Crossholes on 3/4-in. centers permit side insertion of other banana plugs or shorting bars. POMONA. **219**

Connector right-angle strain relief, Quik-Ty, for lower exit profile of wire bundle, which is secured to unit with tie strap or lacing tape. Eliminates need to build up bundle diameter with tape to match I. D. of conventional cable clamp. 2.50-$4 (100-up). GLENAIR. **220**

Backplane solder preforms, Solder Link, for batch-reflow soldering of individual Wire-Wrap tails to PC board and interconnnection of tails. Often cuts number of tails needed and number of Wire-Wrap inteconnections. INTERLINK. **221**

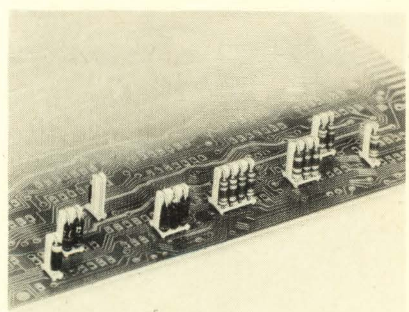
Microcircuit-soldering materials, all compatible. Include solder, creams, pastes, fluxes, inks, driers, cleaners. ALPHA METALS. **222**

Electroless copper bath, Enplate CU-404, to permit maintenance replenishment without need to discard plating solution. Greatly reduces usual stench. ENTHONE. **223**

Dip shells, DIP-PB, for hybrids and tiny discrete circuits. Black epoxy and DAP header and case with 14- or 16-pin tin-plated phos bronze lead frame with extended terminals for Wire-Wrap or solder. $25 (24-set prototype kit). AURA. **224**

Substrate heat sink with staggered fingers. Substrate circuit can be potted directly to heat sink. IERC. **225**

Component insulators, Verti-Mount, for vertical mounting on PC of small



axial-lead components like D0-7 diodes and 1/4w resistors. Standoff feet allow solder-fillet formation and flush cleaning of flux residue. ROBISON. **226**

Rfi suppressor, of flexible, lossy tubing that slips over wire, replacing ferrite beads. Attenuation rises smoothly with tubing length and frequency, without dips or nulls. At 1 GHz, conducted attenuation 20 dB/in., radiated attenuation 100 dB/in. LUNDY. **227**

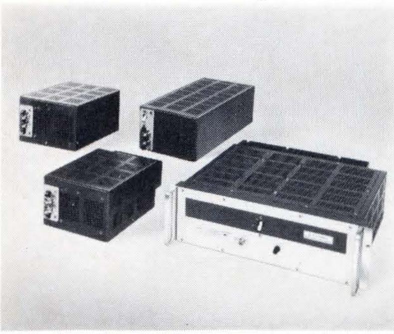
Power Supplies

Low-cost lab supply, PZ-135-A, with an output of 0-25 at 1 A. Regulation 50 mV load and 10 mV line. Ripple 1 mV rms. Electronic current limiting, floating output, 10-turn voltage control, remote sense and current-limit adjust. 1 yr warranty. 48¢ (single qty). VIKING ELECTRONICS. **250**

Power module, RO.15, for any output voltage from 5 to 100 Vdc at 0.15 A. Line and load regulation each 0.05%. Load transient recovery time 75 μs. Ripple 0.02% or 5 mV rms, whichever is greater. Output V adjustable to 10% of nominal. Tempco 0.03%/°C. Remote error sensing. Input 105-125 Vac, 50-420 Hz. 1-7/8 × 4 × 6-1/2 in. Weight 3 lbs. $94 (single qty). ABBOT. **251**

5-V module, PM524, for supplying 1 ampere to IC-logic gates. Line regulation 0.05%, ripple and noise 1 mV rms, tempco 0.02%/°C and operating range −25° to 71°C. Encapsulated module 2.5 × 3.5 × 0.875 in. 1 yr warranty. $43.95. CP. **252**

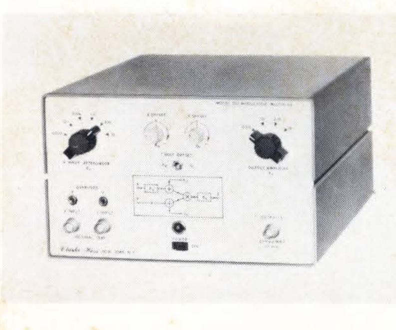
High-power modules, LW, with an efficiency greater than 50% at current ratings to 200 A and voltages to 48 Vdc. Line and load regulation each



2%. Ripple 300 mV or 2% output V, whichever is greater. Input 105-132 Vac, 57-63 Hz. Tempco 0.03% + 0.5 mV/°C. Remote sensing and remote programming. Self-restoring current limiting. Convection cooled with no external heat sink. 42 models in 4 package sizes. D, E and EE are sub-rack modular components. G is a full-rack unit. 5 yr guarantee. LAMBDA. **253**

Test Equipment

Four-quadrant mutiplier, 200, with the capability of being used as a modulator or amplifier. Multiplier



linearity 1% up to 20 V pk-pk. Less than 1° phase shift at 1.5 MHz. As a modulator can use any carrier up to 10 MHz at 95% modulation. Less than 1% envelope distortion below 2 MHz. Amplifier has 40-dB gain and 20-V pk-pk output to 4 MHz. Less than 1% distortion dc-2MHz. Z in 100 kΩ shunted by 20 pF. $455. CLARKE-HESS. **235**

Programmable-waveform generators, F270A and F280A, for a range of 0.01 Hz to 1.1 MHz. Delivers 11 V pk-pk into 50 Ω (manual mode) or can be programmed for 16 V pk-pk into 50 Ω. All manual controls remotely programmable by relay or DTL-TTL. Continous sine, square or triangle output. Single cycle or burst operation. Positive or negative square wave pulses and sine-squared pulses. F280A has fixed offset and 0 or 180° phase select. MICRODOT. **236**

Function generator, 5100, for amplifier response tests, recorder linearity checks and testing of servo-systems. Range 0.002 Hz to 3 MHz. Functions include: sine, square, triangle and positive and negative ramps. Output 20 V pk-pk open circuit. Frequency controllable by external V in either external or dial mode. KROHN-HITE. **237**

Battery-powered spectrum analyzer, 710/801, for a 10-Hz to 50-kHz range with 10-Hz resolution, 7 × 10-cm CRT display. Vertical and horizontal

scales can be linear or log. In linear mode, volts/cm from 30 nV to 30 mV and frequency Hz/cm from 10-5 kHz/cm. Log mode, amplitude in 10 dB/cm increments, frequency in 3-1/2 decades 10 Hz-50 kHz. SYSTRON-DONNER. **238**

Frequency multiplier, 4022A, for improving counter resolution in lf measurements. Multiplies input frequencies by 10, 100 or 1000. For cw or pulses from 5 Hz to 100 kHz. Gives high resolution for low frequencies without resorting to period measurement. Accuracy same as counter accuracy on the × 1 and × 10 ranges, × 100 and × 1000 below 500 Hz, is ±1 count ± counter accuracy. Above 500 Hz on the × 1000 range accuracy is ±2 counts ± counter accuracy. $760. HP. **239**

3-GHz counter, 8075, with 10-ns time interval resolution. Period, multiple period average, totalize, and frequency scaling capability. 8-digit display plus a ret oscillator with 3×10^{-9}/day aging rate and TTL interface. 3-GHz heterodyne converter displays input frequency directly. 40-ms max measurement time. Accuracy 4 parts in 10^8. $3595. DANA. **240**

Digital multimeter/counter, 8420, with push-button function selection and internal overload protection. 4 1/2-digit measurement of frequency at f.s. ranges of 10, 100, 1000 kHz and 10 MHz. Measures dc volts, ac volts and ohms. Resolution 0.01%. Accuracy: 0.01% Vdc, 0.1% Vac, 0.02% Ω and 0.02% for frequency. Accuracy guaranteed to 50% overrange. $695. CALICO. **241**

Low-priced DMM, 351, for measuring dc voltage, dc current, ac voltage, ac current and resistance. Basic accuracy of 1% and a minimum of 10% overrange. Automatically-positioned decimal point. Sample rate 60/sec. 3-digit display. 117 Vac at 7 watts. $195. NUMERIC LABS. **242**

Fused digital test probe, DTP11, with ±50 volts ac or dc over-voltage protection. Designed for 5-volt logic. Green light indicates logic 0 at ±0.6 V and below. Red light indicates logic 1 at 2.4 V and above. Both lights out 1-2 V. DTL-TTL compatible. Power derived from system under test. Lamp life 50,000 hr. $50. AP. **243**

Computer-controlled logic tester, CAPABLE, for checking out logic cards, cable assemblies, LSI, MSI and IC components. System includes a 208

computer with 8-k memory, autoload and power fail, 300-Hz photoelectric tape reader, 128-programmable I/O pins, control panel power supplies and ASR-33 teletype. $27,500. CAI. **244**

Display Devices

Rectangular direct-view storage tube, F-3046, with a brightness of 700 foot-lamberts. Resolution 75 lines/in. Storage time up to 5 minutes std or 30

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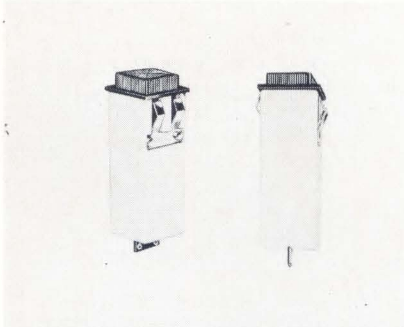
minutes opt. 4 × 5 in. display. ITT. **228**

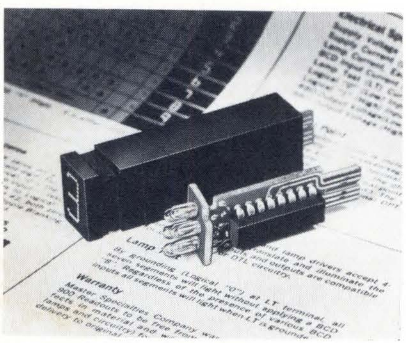
Flashing-indicator light, with a high brightness long-life neon lamp. Components for flasher soldered to an in-



ternal PC card. Flasher rate 130/min. Lens combines polished reflector with low-profile cap and bezel. Cap in red, yellow and white. 110-125 Vac operation. DIALIGHT. **229**

Low-cost LED readout, TEC-LITE SSR-70, with a 7-bar display, decoder-driver and current-limiting resistors within a 1.9 × 0.4 × 1 in. assembly. 8421-BCD input. Supply +5 Vdc ±5% at 175 mA/digit. 350-foot-lambert brightness. 0.270-in. characters. $42 (1-24 qty). TEC. **230**

Fiber-optic readout, 901 D2-D8, with a choice of 5 different built-in decoder-



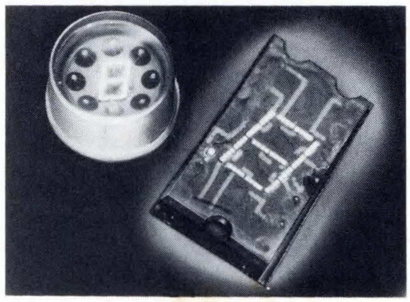
driver ICs that are compatible with TTL or DTL. Decoder-driver accepts 8421 BCD. Readouts use a dot pattern. 5-V lamp with 10,000-hr life gives 100-ft-lamberts. MASTER SPECIALTIES. **231**

Digital clock, 2400, with a six-digit solid state display using LEDs. Timing references 60 Hz. internal crystal or external source. BCD outputs plus 1-sec and 0.1-sec timing pulses. Interruption of power causes all indicators to display eights. 40°F to 120°F. $353. ERC. **232**

Digital microvoltmeter, 2000, with 0.01% accuracy, 1 μV/digit sensitivity and 0.15 μV/°C zero stability. ±19.999 mV full scale. Multi-pole active filter for flicker-free readings. Z in 1000 MΩ. Settling time 600 ms. Double shielding and high rejection of common-mode voltage. Size 0.1 ft.^{3} $585 (unit qty). NEWPORT LABORATORIES. **233**

Low-cost digital thermocouple indicator, 4320, with isolated-BCD output. May be coupled directly to printers, comparators and other data-acquisition equipment. Uses multiscope linearization for any of four thermocouple types. Full scale response time 1 sec. Accuracy ±3°F ±1 digit at room temp. Thermocouple break protection, automatic cold-junction compensation and common-mode rejection of 130 dB at 60 Hz. API. **234**

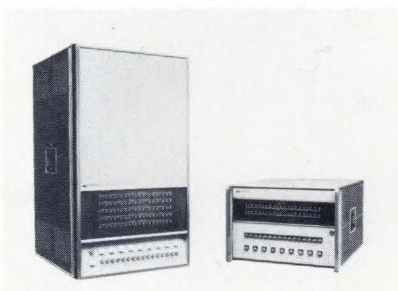
Solid-state displays, T1XL302 and T1XL301, with readouts composed of 7-segment, diffused planar gallium-arsenide LEDs. Produce A, C, E, F, H, J, L, P and U as well as 0 to 9. T1XL302 in 14-pin dual-in-line with 1/4-in. character. Characteristics similar to Monsanto MAN-1. Brightness



350 foot-lamberts at 20 mA. T1XL301 in TO-5 package with 150 foot-lamberts at 5 mA and 1.7 V. TEXAS INSTRUMENTS. **245**

Data Handling

Improved-memory minicomputers, 2114C and 2116C, similar to company's earlier type 2114B and 2116B computers but with twice the memory capacity in same size mainframes. 2114C is 16-bit machine with memory



cycle time of 2 μs. 2116C is 16-bit machine with cycle time of 1.6 μs. 2114C accepts up to 16 k of core memory in the mainframe while 2116C can have up to 32 k. $8500 (2114C with 4-k memory) and $20,000 (2116C with 8-k memory). Lease plan available. First deliveries scheduled for December 1970 (2116C) and January 1971 (2114C). HP. **315**

Small-computer system, Systems 82, for high-speed applications where large memory capacity is not required. Competes with PDP 11 and PDP 8 series. Computer features include 8 priority interrupt levels, real-time clock and power fail-safe/auto start. Optional hardware multiply/divide. Multiplexed I/O and register I/O available. Full memory cycle time 900 ns. Memory expandable from 4 k to 16 k in 4-k increments. CPU dimensions: 10-1/2 × 19 × 25 in. $11,000 in basic configuration with 4-k memory. SEL. **316**

Versatile computer terminal, CT-100, to plug directly into existing computer systems that service teletypewriters. No special modems or voice-response equipment required. Simultaneous entry

and printout of fixed and variable alphanumeric information. Unit includes 12-pushbutton keyboard, reader for plastic punched cards, strip printer and acoustic coupler. Optional devices include 54-key block alphanumeric keyboard, 55-key full ASCII keyboard and cassette tape recorder. ELECTRONIC ARRAYS. **317**

High-speed line printer, 101, with print rate of 165 chars/s or 60 132-character lines/min. Prints on standard paper and produces original and up to 4 copies. Serial or parallel data input. Accepts 63 ASCII characters. Transmission rate 3000 bits/s (serial) or up to 75,000 chars/s (parallel). 9-1/2 × 16 × 25 in. $2400 less OEM discounts. CENTRONICS. **318**

Desk-top character printer, TDS-1601, with simple print-head mechanism that prints 64-character ASCII subset at rates of 10 or 15 chars/s. Designed as

replacement for TTY 33 or TTY 35 in various terminal applications. Serial or parallel interface. Can be acoustically coupled to telephone handset or can be handwired to phone circuit using Bell System attachment. TRACOR. **319**

Digital cassette recorder with computer interface. Can be connected to I/O bus of PDP-8 to store or deliver data. Max read or write rate 480 chars/s with tape speed of 20 in/s. Each character can be maximum of 7 bits plus

1 parity bit. Parity bits can be generated internally if required. Start and stop times 20 ms each. Fully loaded cassette stores 80,000 characters. $2500. A. D. DATA SYSTEMS. **320**

Cassette tape transport, 250, designed for low-cost digital recording applications. Recording and retrieval rates 1000 8-bit chars/s. Read/write capability in both incremental and continuous operation. Standard tape speed 10 in/s, forward and reverse. Other speeds available. Start time under 400 ms. Stop time under 80 ms. Operates from ±5-V power supply. Designed for NRZ, phase, FSK and serial data formats. $525 (evaluation qty) and $250 (OEM qty). 30 days (evaluation orders) and from 60 days (production orders). COMPUTER ACCESS SYSTEMS. **321**

High-capacity mag-tape storage system, CartriFile 4196, with four tape transports in single unit. Each tape loop holds over 3 million data bits, allowing total storage capacity of 12 megabits for the complete unit. Bit rate of 18,000 bits/s allows transfer of 1000

16-bit words/s during read or write. 16-, 12- or 8-bit word transfers. Independent electronic control of 4 tape transports. Phase-encoded recording technique provides efficient use of tape medium. Available with interface circuitry and software for use with PDP-8, Nova, HP and other small computers. $6050. TRI-DATA. **322**

Cassette bulk memory, ST-2 Minicorder, with software for direct coupling to most major minicomputers. Stores over 2 megabits on double-width data track organized into 2047 blocks, each containing 1024 bits. Separate double-width address track permits location of data under computer control. No external controller required. Claimed "lowest cost bulk-storage medium available." Average cost 0.07¢ per bit. 8-7/16 × 9-1/2 × 3-3/16 in. 6-1/4 lbs. GENISCO. **323**

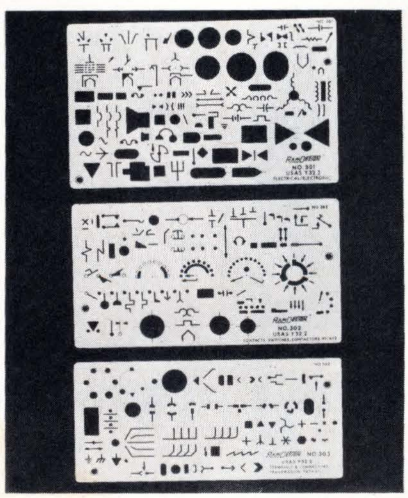
High-speed cassette transport, designed to operate at 30 in./s for reading, writing, rewinding and searching. Instantaneous transfer rate 1800 chars/s. Average transfer rate with 110 character blocks is 1000 chars/s. Each cassette stores 90,000 characters in 100 character blocks. Offered complete with electronics for read/write and all controls. Interface at logic levels. Uses Philips-style cassette. Packing density 500 bits/in., phase recorded. Uses light-emitting diodes to sense beginning and end of tape. REDACTRON. **324**

Low-cost oscillogram reader, GDDRS-3B, for reducing data from oscillograms, film and strip charts. Translates information into variety of outputs such as IBM keypunch or typewriter, punched paper tape, adding machine

and flexowriter. Features include back-lighted motorized paper transport, facilities for measuring on X and Y axes, channel counter, time index counter, channel counter keyboard and many optional refinements. Available in two versions: 3B-1 (single encoder) and 3B-2 (dual encoder). Base prices: $6275 (3B-1) and $8375 (3B-2). 3-4 months. GERBER. **325**

Special Products

Drafting templates, 300 set, for electrical and electronic schematics. Complete set consists of 3 templates: 301



(electrical and electronic symbols), 302 (contacts, switches, contactors and relays) and 303 (terminals, connectors and transmission paths). All symbols in correct relative size. Symbols conform to USAS Y32.2. $12.50 (300 set), $5.50 (301 only), $4.50 (302 only) and $3.50 (303 only). RAPIDESIGN. **326**

Mercury-cadmium-telluride IR detectors, for operation at room temperature or with thermoelectric cooling. Flat package with two leads. Spectral response 4-6 μ. Time constant 1.5 μs. Detectivity 1.5×10^8. Responsivity 40 VW^{-1}. Sensitive area 230 μ^2. Noise equivalent resistance 1 kΩ. MULLARD. **327**

Optical incremental encoder, 77, with encoder circuitry and lamps powered by single +5 or +6 Vdc supply. Output signals compatible with DTL/TTL. Available with complementary-pair outputs to drive diff-amp boosters that provide common-mode rejection to minimize noise. Accuracy ±1/50 count (pulse-to-pulse). Max shaft speed 5000 rpm. Cycles per turn 1500. Counts per turn 6000. 1-7/16 × 2-5/16 in. dia. 5-1/2 oz. DYNAMICS RESEARCH. **328**

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2.5-kVA autotransformer, FT1001, with a weight of 2.9 lbs as a result of the use of metal foil windings. 3.75 in. wide by 4 in. high. Efficiency 92% with an 0.8-power factor load. Regulation 3.2% no load to full load. Input 115 V 400 Hz. ELECTRO CUBE. **246**

Constant voltage transformers, for use in regulated dc supplies. Units for dc outputs of 5, 6, 12, 24, 28, 36, 48 and 120 V from 6 to 500 watts. Line voltage regulation 1% for 100-130 V, 60 Hz. Short-circuit current limited to twice rated current. SIGNAL TRANSFORMER. **247**

Pulse transformer, with dual-in-line package. Inductance 10 μH to 100 mH. Turns ratio 1:1 to 10:1 with up to 4 windings. 50¢ to $1 (production qty). POTTER. **248**

Instrument transformer, NANOTRAN, with a 50 to 1 reduction in micro-

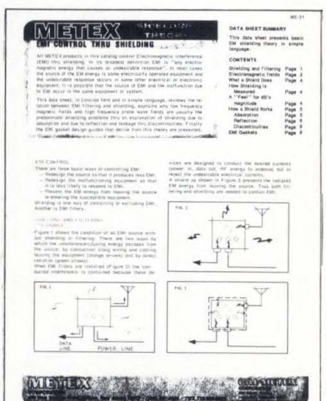
phonics and a 30% size and weight reduction. 190-dB common-mode rejection. Turns ratio 1:1 to 1:50. STEVENS-ARNOLD. **249**

New Literature

Unusual Literature

Shielding Theory
Metex

While this won't win prizes for proofreading, it stands high as a superb introduction to shielding theory and practice. Though it's modestly labeled a "data sheet," leading one to expect a list of specs on the company's shielding materials, it's really a fine tutorial text; the company's name is mentioned only in passing.



The 12-page booklet suffers some from overambitiousness on the part of the author. He tries, not only to introduce concepts of shielding, but also, basic concepts of electronics. One could reasonably expect that a reader concerned with reducing electromagnetic interference already knows what frequency is and doesn't need to be told that 1 MHz = 10^6 Hz or 10^3 kHz (incorrectly presented as 10^6 kHz and 10^3 Hz).

Aside from such excursions into the too elementary, the booklet is fine. It discusses conducted and radiated interference and the cures for each, but it concentrates on radiated interference.

It covers the two basic effects of a shield — absorption and reflection — and shows how each is influenced by shield material and dimensions. It follows through with an analysis of the effects of the wavelength and source impedance of the interfering signal.

Throughout, the booklet combines the practical with the theoretical. Any designer with equipment that generates interference or suffers the effects of interference from foreign sources should find this work particularly valuable.

For a copy, circle **400.**

New Design Ideas
Unitrode

Some are not so new. But they're good. Basically, it's a collection of some two dozen circuit-design ideas that Unitrode has been publishing, one at a time, for almost four years.

In almost every case, the format involves presentation of a basic problem, its usual solution by classical or conventional circuitry, limitations of such a solution, then "a new approach." The new approach, as one can understand, always involves a component (in most cases, a silicon controlled switch) manufactured by Unitrode (and usually by other vendors as well).

Each "new approach" includes a circuit diagram, fully labeled with component values, a description of circuit operation and comments on performance.

In almost every case, the circuits have very wide appeal, but a few may be rather limited, especially today. For example, one may question the "wide use in the form of alphanumeric readouts, graphic display panels, and compact indicator lights . . ." of electroluminescent readouts. There are at least some observers who feel that EL readouts are all but dead.

Despite one or two limited-application circuits, the collection can prove most valuable.

For a copy, circle **401.**

Fujitsu Pulse Motors
Icon

This is very much a mixed bag. The content of this 82-page manual is largely commercial, as the title suggests, but there's a great deal of non-commercial material that's useful in designing around anybody's stepping motors.

The typography is varied, being clear and clean in most places, all but illegible in others. This is due in part to the varied quality of paper stock, some of which is fair and some a rather yellow newsprint stock. Finally, the proofreading and spelling leave a bit to be desired.

The writing itself is clear. The author discusses the applications, mostly in machine-tool control, of electrical and electrohydraulic stepping motors. He shows their key advantages over conventional servo motors in terms of their being digital devices rather than analog units requiring digital-to-analog conversion and complex closed-loop feedback circuitry.

The construction drawings are, of course, valueless except for the specific Fujitsu motors under discussion, but performance curves and scope traces of response characteristics provide good insight into design considerations for use with any steppers. The use of more than 360 scope traces shows similarities and differences that can be expected in start and stop characteristics and in step and pulse-train response of motors with different inertia ratings.

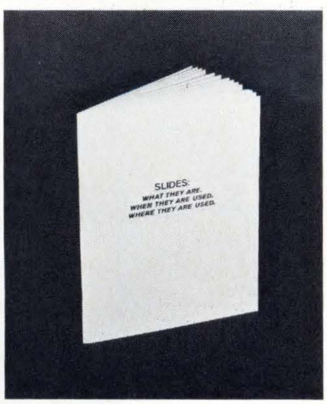
The general value of this manual lies not so much in itself but, unfortunately, in the fact that other stepper-motor vendors fail to provide such extensive information on their own units.

For a copy, circle **403.**

Slides
Grant Pulley & Hardware

Here's a surprise for those who think they know all they need to know (or want to know) about chassis slides. There's far more to slides — from the viewpoints of both selection and application — than most of us would suspect. This 28-page booklet is quick to point it out.

In 13 brief chapters, the authors cover slide applications and selection considerations. Most of the applications are rather obvious and several are quite specialized (like those involving slides in truck bodies and in helicopter systems). But sprinkled through the obvious, we find quite a few applications that are far from routine and, indeed, can prove to be simple solutions to design problems that appear complex.



The sections on design and selection can prove useful, even to a man with a good bit of experience with slides. He should find particularly useful the chapters on "How to Select the Correct Slide," "How to Avoid Designing a New Slide" and "Increasing Slide Life."

For a copy, circle **391.**

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EEE readers have voted Leonard Accardi winner of the $100 Savings Bond for October. The winning circuit design is "Modified 710 maintains accuracy at high input voltages." Mr Accardi is with Kollsman Instrument in Elmhurst, N.Y.

Schmitt trigger uses two logic gates

To Vote For This Circuit Circle 494

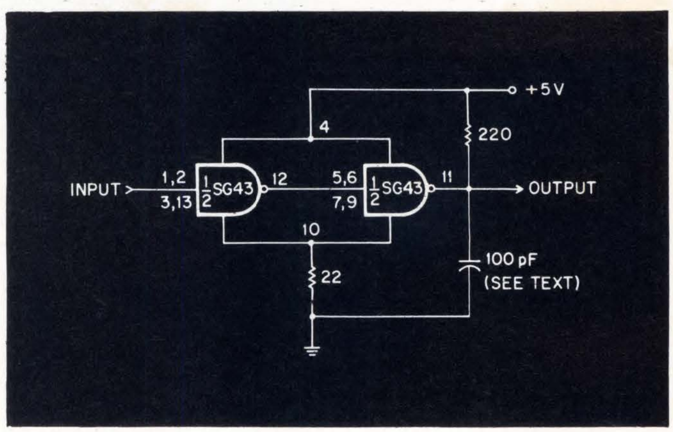
by Charles J. Ulrick
Collins Radio
Cedar Rapids, Iowa

Two TTL INVERTERS and a few components are used in the figure to form a Schmitt trigger. The gates may be any type of TTL inverter. They are connected in series with a small-value feedback resistor in the common power-supply ground lead.

The cascade connection of the gates causes them to always be in opposing logical states. This causes a constant voltage drop across the 22-Ω resistor. This drop results in a constant offset voltage. The addition of a second resistor at the output terminal corrects this situation. The extra current drawn through the output resistor, when the second gate is in the zero state, causes an increase in the feedback voltage. This enhances the switching speed of the first gate.

With the values shown, the circuit has a positive-going threshold of 2.4 V and a negative-going threshold of 2.0 V. Threshold values and hysteresis can be changed slightly by varying the external resistors.

The normal load capacitance at the output results in ac feedback. If the actual application does not provide sufficient output capacitance, it may be necessary to add a 100 pF from output to ground. ■



This Schmitt trigger is made from two TTL gates.

Combined shift-register clock driver and power supply

To Vote For This Circuit
Circle 495

by **M. E. Hoff, Jr.** and
H. Johansson
Intel
Mountain View, Calif

IN SYSTEMS USING a small number of MOS-shift registers, in conjunction with TTL or DTL logic, the shift registers may be the only components requiring a negative supply and a 2-phase clock. The cost of this extra supply may be saved by using the pulse-transformer clock driver shown in Fig. 1.

In Fig. 1, both clock phases, ϕ_1 and ϕ_2, and the negative supply for the shift register, V_{DD}, are generated by an external TTL or DTL clock. The clock-driver power supply operates from a 5 V supply.

For phase 1 clock pulses, Q_1 is driven into conduction. Q_2, normally held on by R_2, is cut off by the signal coupled through C_1. At the same time, a negative pulse from the transformer (T_1) secondary drives clock line ϕ_1, negative via diode D_1. When the output of the TTL gate driving Q_1 goes low, Q_1 is cut off and Q_2 is turned on by C_1. This sequence causes the clock line (ϕ_1) to be returned to +5 V and completes a ϕ_1-clock pulse cycle. At the same time the clock pulse is generated, D_2 charges C_3 producing the negative supply voltage V_{DD}.

The ϕ_2 circuit consisting of Q_3, Q_4, T_2, D_3 and D_4 is identical to the ϕ_1-clock section. The ϕ_2 circuit also contributes to V_{DD}.

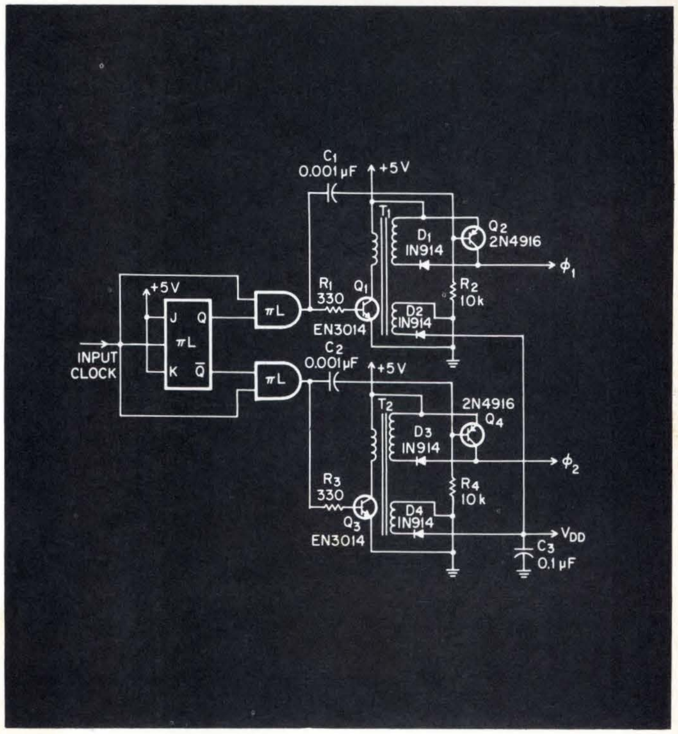


Fig. 1. This circuit supplies a two-phase clock voltage and a negative supply for MOS-shift registers. It interfaces with DTL-TTL logic and only requires +5 V.

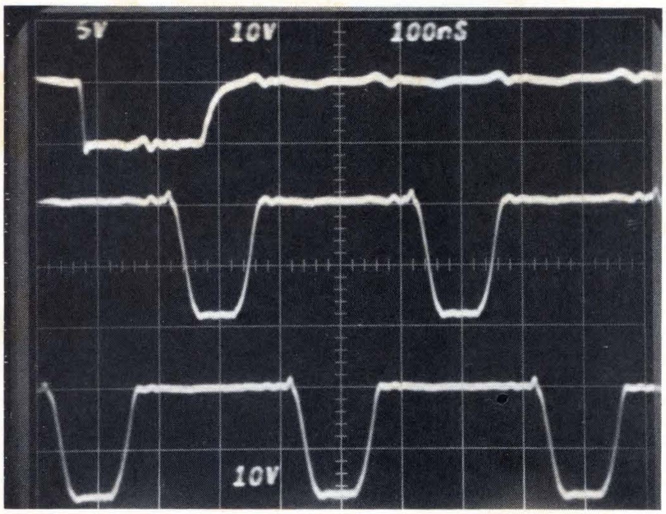


Fig. 2. In the photo, the top trace is data output and the next two traces are the two-phase clock signals. Data rate is 5 MHz and clock rate is 2.5 MHz.

For the widest frequency of operation, no loads other than shift registers (MOS) should be operated from V_{DD}. Shift registers draw current only during clock pulses, so that effective loading of each clock pulse remains independent of frequency.

This circuit has been operated without change of pulse width from a 40-Hz to 5-MHz data rate (clock rates of 20 Hz to 2.5 MHz). without loss of stored data. Fig. 2 is a photograph of waveforms in a typical circuit for driving two Intel 1402-type shift registers.

Each transformer consists of a 5-turn primary, a 15-turn secondary (V_{DD}) and a 8-turn secondary (V_{DD}) wound on a Magnetic Inc. D41408-UGX73 cup core.

An inexpensive frequency doubler

To Vote For This Circuit
Circle 496

by **Richard Slusher**
Mostek Corporation
Carrolton, Texas

THE STANDARD transition detector (Fig. 1), which detects pulse transitions in only one direction, can be made into a frequency doubler. This change can be instrumented by changing the NAND gate at the output of Fig. 1 to an exclusive OR gate (Fig. 2). This modification allows the new circuit to detect pulse transitions in either direction. The width of the output pulse is determined by the delay in the inverters. If longer pulse widths are desired, a feedback capacitor (shown by the dotted lines in

(Continued on page 56)

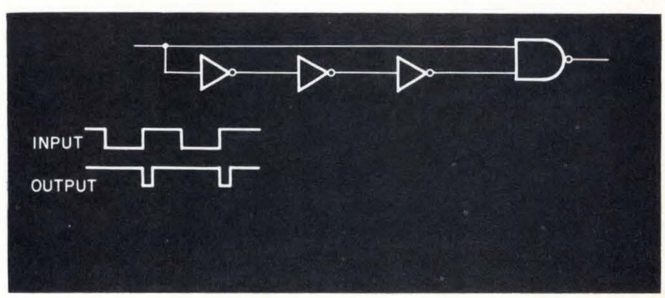


Fig. 1. This is the circuit of a transition detector using IC logic gates.

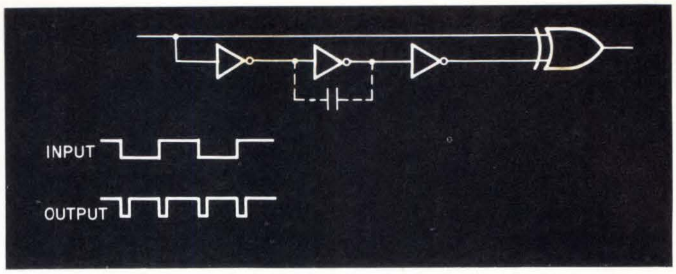


Fig. 2. Changing the output NAND to an exclusive OR converts the circuit to a frequency doubler.

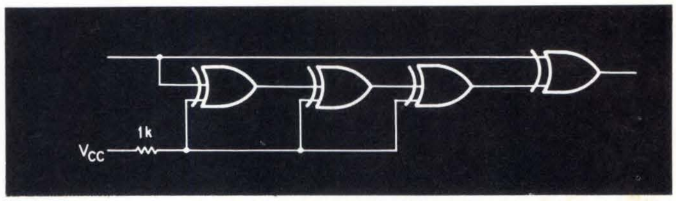


Fig. 3. The circuit of Fig. 2 can be instrumented in a single quad-exclusive OR IC.

Fig. 2) may be added. The availability of quad-exclusive OR gates enables the designer to implement the frequency doubler in one package as shown in Fig. 3. These gates are available in both TTL and DTL. ■

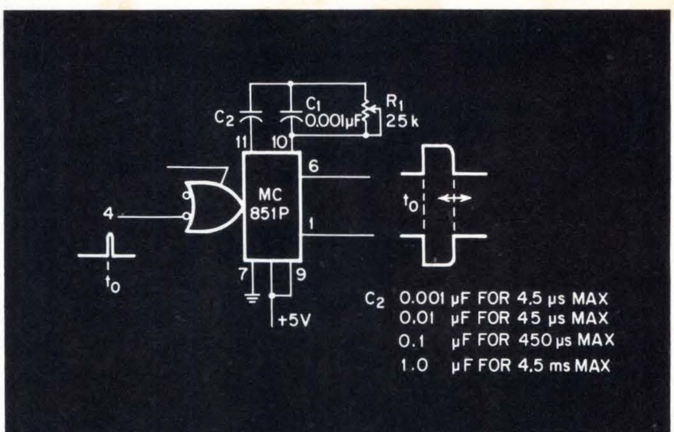
Wide-range variable pulse-width monostable

To Vote For This Circuit Circle 493

by Chester W. Stoops
NRL
Orlando, Florida

A SLIGHT CHANGE in the external circuitry of the Motorola MC851P monostable permits wide-range continuous operation. The unmodified MC851P gives complementary output pulses that can be adjusted by the addition of external capacitors. The use of the recommended range of external variable resistor permits a pulse-length adjustment of only ±15%. This new circuit variation considerably extends this range (4.5 μs - 4.5 ms).

The change, as indicated on the circuit diagram, permits operation over a continuously variable range. C_2 is varied in order to cover a wide range of pulse widths. C_1 prevents rounding off of the trailing edge of the pulse as R_1 is increased. With the value of C_1 shown (0.001 μF), minimum pulse length is 4.5 μs. Rise and fall times of the output pulse are better than 100 μs. ■



A simple modification of the MC851P monostable extends output pulse widths from 4.5 μs to 4.5 ms.

New Books

Precision Measurement and Calibration—Statistical Concepts and Procedures, Vol 1 (forty papers on various aspects of the subject, including the concept of statistical control of a measurement process and the use of statistical design in physical experimentation), edited by Harry H. Ku, National Bureau of Standards, April 1969, 436 pages, $5.50. Order SP-300, Vol. 1.

NASA Contributions to Bioinstrumentation Systems, Gershon Weltman et al., Spacelabs Inc. for NASA, March 1969, 97 pages, $1. Order NASA SP-5054, from Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.

NASA Contributions to Development of Special-Purpose Thermocouples (describes thermocouples to measure temperatures in solid materials and gases from near absolute zero to 5,000°F), C. Eugene Moeller et al., Midwest Research Institute for NASA, November 1968, 94 pages, $1.25. Order NASA SP-5050 from Superintendent of Documents, U. S. Government Printing Office, Washington D. C. 20402.

Some Evolving Conventions and Standards for Character Information Coded in Six, Seven and Eight Bits, John L. Little, May 1969, 22 pages, 35¢. Order Technical Note 478.

An Exploration of the Potential of P-N Junction Devices for Transducer Applications (evaluates response to stress of unmounted semiconductor devices), M. E. Sikorski et al., Georgia Institute of Technology for Navy, January 1969, 136 pages. Order AD-682 204.

Synthesis of Distributed Wide-Band Transistor Amplifiers by Computer Techniques for Application to Microwave Integrated Circuits, I. L. Chase and V. G. Gelnovatch, Army Electronics Command, December 1968, 45 pages. Order AD-681 902.

MOS Field-Effect-Transistor Technology (results of research on contact metallization technique compatible with low-temp, low-pressure circuit connection and other problems), J. L. Wallmark et al., RCA for NASA, September 1968, 68 pages. Order N68-35193.

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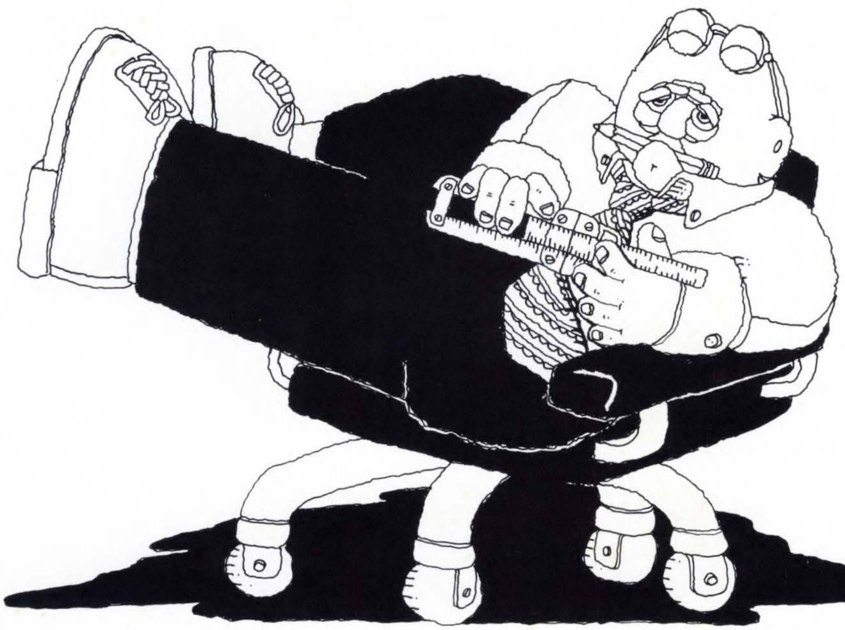
The Formula for Making Teledyne's New Dual Monolithic Transistor



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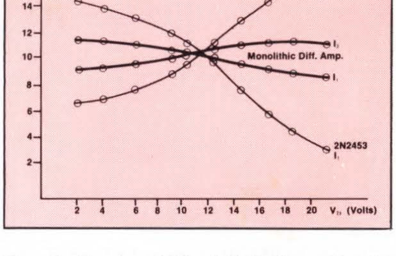

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2N2919	SA2919
2N2919A	SA2919A
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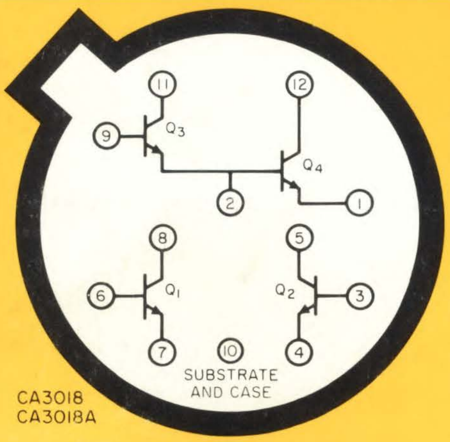

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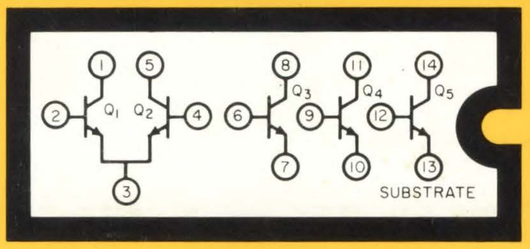

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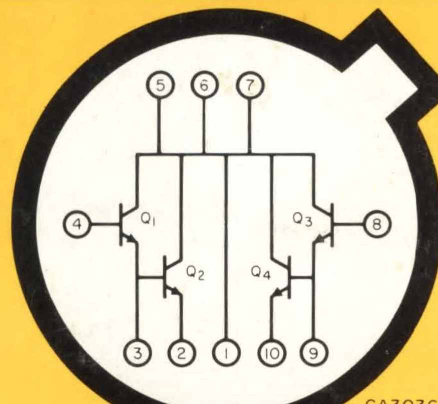

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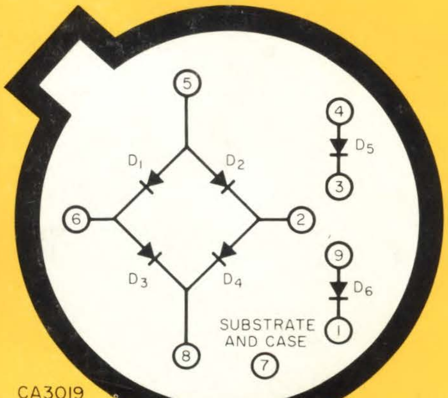
CA3054	14-lead DIL plastic	Dual independent differential amplifiers	388	1.25



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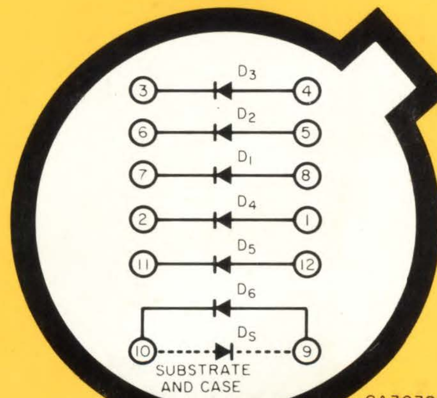

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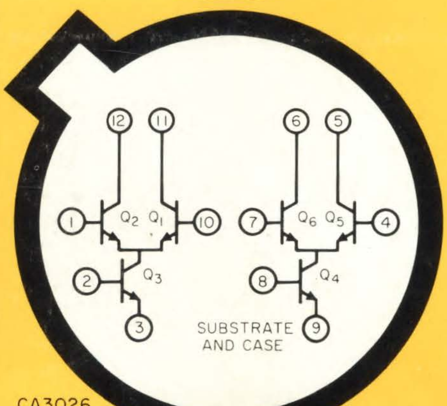

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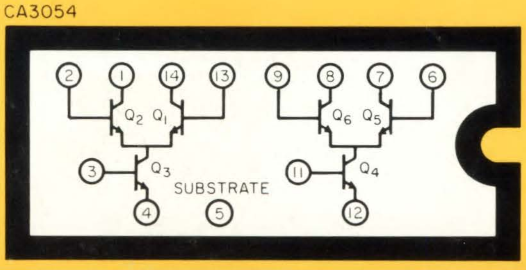

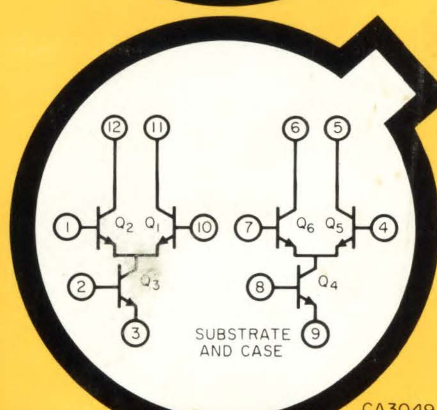

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